Bay Area Regional Climate Action Planning Initiative

Priority Climate Action Plan for the Northern and Central Bay Area Metropolitan Region

Bay Area Air Quality Management District
March 1, 2024

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Acknowledgements

This project has been funded wholly or in part by the United States Environmental Protection Agency (USEPA) under assistance agreement 5D-98T73201-0 to the Bay Area Air Quality Management District. The contents of this document do not necessarily reflect the views and policies of the USEPA, nor does the USEPA endorse trade names or recommend the use of commercial products mentioned in this document. The measures contained herein should be construed as broadly available to any entity in the San Francisco-Oakland-Berkeley Metropolitan Statistical Area (expanded to include Napa County and the southern portions on Sonoma and Solano counties) that is eligible for receiving funding under USEPA's Climate Pollution Reduction Implementation Grants (CPRG) and other funding streams, as applicable.

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The Air District thanks the following individuals for their contribution to this plan, as well as the more than 90 participants who attended Working Sessions held between October – December 2023.

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The following companies provided facilitation and technical support for development of the plan:

- BW Research
- Cascadia Consulting Group
- Chris Selig Associates
- HIP Investor, Inc.
- ICF Incorporated

The Air District acknowledges and assumes complete responsibility for the content of the Priority Climate Action Plan as outlined in this report, submitted in fulfillment of the USEPA grant requirements.

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Definitions and Acronyms

Acronym or Abbreviation	Definition
ABAG	Association of Bay Area Governments
AWG	Advisory Work Group
BAAQMD	Bay Area Air Quality Management District
BayREN	Bay Area Regional Energy Network
BARC	Bay Area Regional Collaborative
BARCAP	Bay Area Regional Climate Action Plan initiative
CBO	community-based organization
CCAP	Comprehensive Climate Action Plan
CCA	Community Choice Aggregator
CH_4	methane
CO_2	carbon dioxide
GHG	greenhouse gas
GWP	global warming potential
LIDACs	Low income, disadvantaged communities
MSA	Metropolitan Statistical Area
MTC	Metropolitan Transportation Commission
N_2O	nitrous oxide
NOx	nitrogen oxides
PCAP	Priority Climate Action Plan
SF_6	sulfur hexafluoride
USEPA	United States Environmental Protection Agency
VMT	vehicle miles traveled

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Executive Summary

The Bay Area Air Quality Management District (Air District) has partnered with local governments (cities and counties) and regional agencies across the San Francisco Bay Area region[1] (Bay Area region) to produce this Priority Climate Action Plan (PCAP) for the San Francisco-Oakland-Berkeley Metropolitan Statistical Area (MSA). Throughout development of the PCAP, the Air District conducted extensive coordination and outreach with other government agencies and engaged a range of stakeholders across the Bay Area region.

The Air District established an Advisory Work Group (AWG) in April 2023 to support this effort by engaging them in discussions and decision-making on key aspects of the PCAP, including coordination and engagement with other agencies, organizations, and low income, disadvantaged communities (LIDACs), measure selection, and development of deliverables, as well as provision of information and data and advising on technical analyses. The AWG is composed of representatives from:

- Bay Area regional agencies (Air District, Association of Bay Area Governments (ABAG) through its program Bay Area Regional Energy Network (BayREN), Bay Area Regional Collaborative (BARC), and MTC),
- the cities named in the MSA (City of Berkeley, City of Oakland, and City and County of San Francisco) and
- the counties comprising the MSA (Alameda County, Contra Costa County, Marin County, Napa County, San Mateo County, and the portions of Solano County and Sonoma County that are within the Air District's jurisdiction).[2]

OUTREACH AND ENGAGEMENT

Nearly all cities and counties in the Bay Area region have adopted local climate action plans. At the state level, the State of California has adopted aggressive greenhouse gas (GHG) reduction targets and adopted a statewide 2022 Scoping Plan for Achieving Carbon Neutrality (Scoping Plan) that includes a statewide strategy to achieve those targets. The PCAP development process included a review of climate action plans and reflects the priorities and targets in the State Scoping Plan.

The Air District conducted extensive outreach to local governments in the Bay Area region to understand their priorities and implementation-ready projects for the PCAP, to request the results of recent community engagement efforts, and to further develop the PCAP measures during a series of Working Sessions. In total, over 50 cities, towns, and counties participated in at least one outreach effort.

The very short timeline for completing the PCAP did not lend itself to the type of in-depth community partnering and engagement that has become best practice in the Bay Area. To accommodate the aggressive timeline, the Air District reviewed results of recently conducted community engagement activities and created a synthesis document of the identified community needs and priorities. The Air District established a Roundtable of external advisors from regional and local community-serving organizations to review, discuss, add to, and overall improve the synthesis. The Roundtable members

[1] Includes Alameda County, Contra Costa County, Marin County, Napa County, City and County of San Francisco, and San Mateo County, and the southern portions of Sonoma County and Solano County that are included in the Bay Area Air Quality Management District's jurisdiction, reflected in this map.

[2] The federally-designated San Francisco-Oakland-Berkeley MSA includes Alameda County, Contra Costa County, Marin County, City and County of San Francisco, and San Mateo County. The Air District received approval from the USEPA to expand the PCAP to cover the entire Air District's jurisdiction, including Napa County and portions of Solano County and Sonoma County with the exception of Santa Clara County which is included in a separate MSA for the CPRG effort.

contributed their in-depth understanding of Bay Area LIDACS, which are referred to in this document as frontline communities – communities that bear the brunt of the impacts from fossil fuel dependence and are often the first to experience climate impacts – and their insights into community needs and expertise in the topic areas to evaluate and contribute to the draft synthesis.

The Air District convened a public workshop to provide information about the PCAP effort and provide input on draft measure concepts. In order to address potential barriers to participation throughout the engagement process, the Air District offered stipends to community-based organizations (CBOs), convened meetings virtually, and created a website for the project where participants and the public could access meeting materials and project updates.

GHG INVENTORY

The Air District has prepared a GHG emissions inventory for the Bay Area region for the base year 2022. The inventory comprises emissions of climate pollutants from major and minor sources, including those of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), and many high-global warming potential (high-GWP) gases that are substitutes of ozone-depleting substances. The GHG emissions inventory is split across six major sectors – Transportation, Commercial & Residential, Electricity Generation, Industrial, Waste Management, and Agriculture. The total GHG emissions for the Bay Area region for year 2022 are ~60 million metric tons of CO_2-equivalent. The Transportation and Commercial & Residential sectors combined account for half of the regional GHG emissions.

The two priority sectors included in the PCAP are passenger vehicles and residential buildings. Together, emissions from these sectors make up more than 25% of the Bay Area region's GHG emissions. They are the top two sectors most commonly identified by local government staff as highest priority and are top priorities for mitigation in the 70+ local climate action plans that have been adopted by Bay Area jurisdictions. They have similarly been identified as community priorities across the region and in the State of California's Scoping Plan. According to the Scoping Plan, "by prioritizing climate action in transportation electrification, VMT reduction and building decarbonization, local governments will be addressing the largest sources of emissions under their authority and meaningfully tackling climate change, as well as aligning with State climate goals and protecting public health and welfare."[3]

PRIORITY GHG REDUCTION MEASURES

The PCAP includes two priority measures – one from each identified priority sector:

- Safe, Accessible, Clean, and Equitable Multi-modal Transportation
- Holistic Building Decarbonization for Clean, Healthy, and Secure Housing

The over-arching goal of the transportation measure is to reduce GHG and other polluting emissions from personal vehicle travel while increasing transportation choices in frontline communities. This priority measure will reduce single occupancy vehicle miles traveled (VMT) by creating or building out mobility hubs to make it easier for trips to be made by transit, biking, walking, scooter, wheelchair or other mobility devices, including e-micro-mobility, and encourage electric vehicle (EV) charging and EV carshare at or near the hubs. Implementation will focus on creating or expanding mobility hubs in frontline communities and incorporating policies that produce, preserve, and protect affordable housing and stabilize businesses to prevent displacement.

[3] California Air Resources Board, 2022 Scoping Plan for Achieving Carbon Neutrality; Appendix D Local Actions

The goal of the building decarbonization measure is to speed the transition away from residential natural gas use to healthy and low-emission housing. This measure will accelerate electrification and energy efficiency retrofits in existing homes, prioritizing homes located in frontline communities, to achieve an equitable transition to clean, healthy, and secure housing. The measure will include incentives and direct installations, workforce development and contractor support, housing security and policy support, and a Community Work Group to ensure community members' needs are prioritized.

LOW INCOME / DISADVANTAGED COMMUNITIES (FRONTLINE COMMUNITIES)

Frontline communities in the Bay Area region bear the brunt of the impacts from fossil fuel dependence and are often the first to experience climate impacts. The priority measures are designed to provide significant benefits and minimize harm to frontline communities. For the PCAP, the Air District used the USEPA's IRA Disadvantaged Communities map (which combines Climate & Economic Justice Screening Tool (CEJST), EJ Screen, and any geographic area within tribal lands), as well as the Air District's identified AB 617 communities and the Metropolitan Transportation Commission's (MTC's) Equity Priority Communities to identify frontline communities. The Air District developed an online map to visually depict these layers across the Bay Area region.[4]

The Air District followed a multi-pronged engagement approach to ensure that PCAP development was shaped and informed by the priorities of frontline communities in the Bay Area region. In implementing the engagement plan, the Air District first learned from recently completed engagement efforts. Then the Air District conducted targeted engagement of regional community-serving organizations and CBOs through a Roundtable of community-serving organizations, partner-led meetings, and a series of Working Sessions. The PCAP includes a discussion of the potential benefits and disbenefits that may accrue to frontline communities from implementation of the two priority measures.

NEXT STEPS

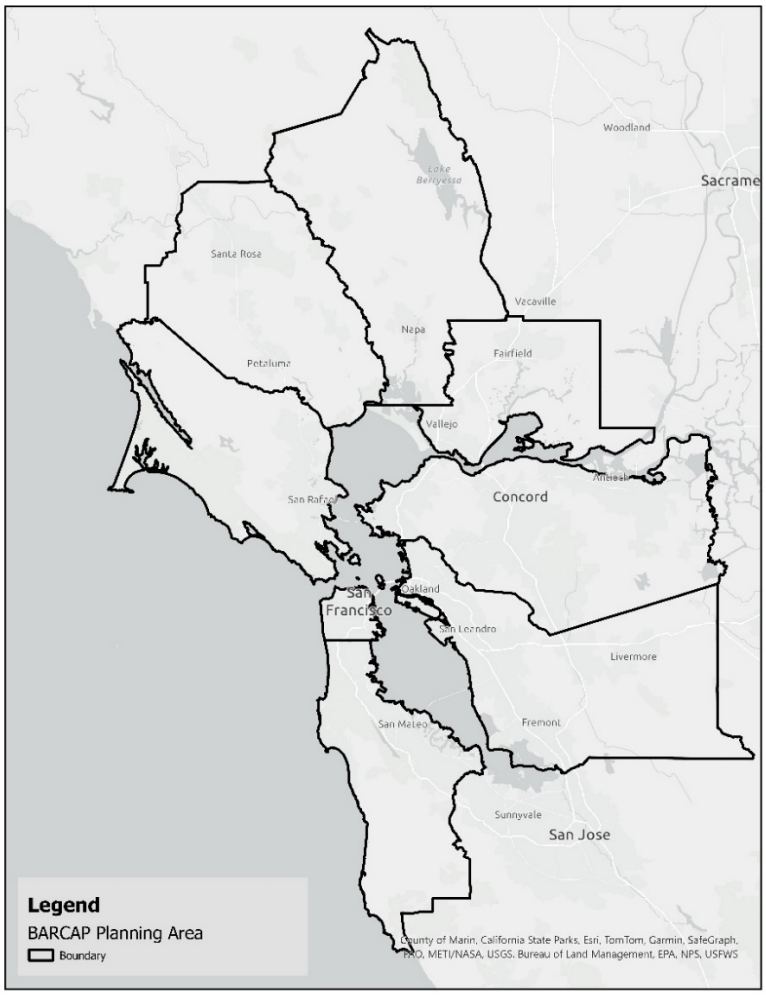
This PCAP is the first deliverable under the USEPA CPRG planning grant awarded to the Air District. The next deliverable due to USEPA in 2025 is a regional comprehensive climate action plan (CCAP) to reduce GHG emissions across all sectors of the economy. In late spring 2024, the Air District will begin engagement for the CCAP, building upon the foundation of the PCAP through meaningful community engagement. Work with technical and facilitation consultants is already underway in preparation for the CCAP.

[4] For the purpose of the PCAP, frontline communities are defined using: 1) USEPA IRA Disadvantaged Communities, 2) AB 617 communities, and 3) MTC Equity Priority Communities, and visualized together in this map.

1. Introduction

The Bay Area Air Quality Management District (Air District) has partnered with local governments and regional agencies across the San Francisco Bay Area region[5] (Bay Area region) to produce this Priority Climate Action Plan (PCAP) for the San Francisco-Oakland-Berkeley Metropolitan Statistical Area (MSA). The PCAP builds upon the region's climate leadership and rich foundation of existing climate-related plans, programs, projects, and policies to identify and support core policies, practices, and technologies in the transportation and building sectors that will help accelerate the Bay Area's transition to a more equitable and zero-carbon future. Implementation of the PCAP will reduce emissions of greenhouse gases (GHGs), criteria air pollutants, and hazardous air pollutants; create high-quality jobs; spur economic growth; and enhance the quality of life for Bay Area residents, particularly those in frontline communities.

Figure 1.1: Map of the Bay Area Region



[5] Includes Alameda County, Contra Costa County, Marin County, Napa County, City and County of San Francisco, and San Mateo County, and the southern portions of Sonoma County and Solano County that are included in the Bay Area Air Quality Management District's jurisdiction, reflected in this map.

THE CLIMATE POLLUTION REDUCTION GRANT (CPRG) PROGRAM AND THE BAY AREA REGIONAL CLIMATE ACTION PLANNING (BARCAP) INITIATIVE

In July 2023, the Air District received funding from the U.S. Environmental Protection Agency's (USEPA) Climate Pollution Reduction Grant (CPRG) Program to develop regional climate action plans. The CPRG Program provides funding to states, local governments, tribes, and territories to develop and implement ambitious plans for reducing GHG emissions and other harmful air pollutants.[6] The first plan is this Priority Climate Action Plan (PCAP), which includes two near-term, high-priority, implementation-ready measures to reduce GHG emissions from residential buildings and passenger vehicles, which together make up one-quarter of the Bay Area region's GHG emissions. Once the PCAP is submitted to USEPA, eligible applicants[7] can apply for funding to implement the measures in the plan. The second plan is the Comprehensive Climate Action Plan (CCAP) covering all sectors, which will be submitted to USEPA by September 2025.

The CPRG planning grant enabled the Air District to launch the Bay Area's first region-wide climate action planning effort, the Bay Area Regional Climate Planning (BARCAP) initiative, with the PCAP and the CCAP at its core. This regional approach to climate planning will identify areas where regional collaboration and action can accelerate our ability to meet our ambitious climate goals. This effort provides an opportunity to harmonize the many strong yet disparate climate planning efforts in the region together with state and regional climate goals into a regional climate planning effort that reflects common top priorities. The BARCAP approach elevates and centers the priorities of frontline communities in the planning process and builds on the extensive work that cities and counties in the region have been doing for years.

THE REGIONAL CONTEXT

The Bay Area has a strong tradition of climate leadership. Nearly all cities and counties in the Bay Area are engaged in some form of climate action planning, with local climate action plans adopted by over 70 cities and counties and numerous policies and programs to reduce GHG emissions adopted and implemented by all 100+ jurisdictions in the region. The Air District's 2017 regional Clean Air Plan[8] focuses on reducing regional GHG emissions, primarily through regional agency-led initiatives. The Metropolitan Transportation Commission's (MTC) Plan Bay Area 2050[9] aims to reduce GHG emissions through transportation and land use strategies. Additionally, the State of California's 2022 Scoping Plan lays out a strategy for making the State carbon neutral by 2045. According to the Scoping Plan, "by prioritizing climate action in transportation electrification, VMT reduction and building decarbonization, local governments will be addressing the largest sources of emissions under their authority and meaningfully tackling climate change, as well as aligning with State climate goals and protecting public health and welfare." These state, regional, and local efforts have all incorporated robust engagement

[6] https://www.epa.gov/inflation-reduction-act/climate-pollution-reduction-grants

[7] Eligible applicants are limited to lead organizations for CPRG planning grants; other municipal agencies (including local air pollution control agencies), departments, or other municipal government offices; and councils of government, metropolitan planning commissions, or other regional organizations comprised of multiple municipalities located within the geographic area covered by the PCAP.

[8] https://www.baaqmd.gov/~/media/files/planning-and-research/plans/2017-clean-air-plan/attachment-a_-proposed-final-cap-vol-1-pdf.pdf

[9] https://www.planbayarea.org/

with community and environmental justice community organizations, reflecting the state and region's strong commitment to equity in climate planning.

The centering of equity in climate planning is motivated by a widely held understanding among elected officials, the business community, and the public at large that climate change is already having and will increasingly have serious impacts on the Bay Area's economy, environment, and public health. Communities of color and low-income communities often experience the first and worst impacts of climate change. Increasing average temperatures, fluctuations in precipitation, decreasing snowpack, rising sea levels, and increased incidence and severity of wildfires are just some of the impacts the Bay Area is experiencing from climate change. In addition, fossil fuel combustion to power the region's cars, buildings, and economy contributes to unhealthy levels of air pollution (in addition to GHG emissions) with communities of color and low-income communities disproportionately impacted. A transition to a clean energy economy – one that does not rely on fossil fuels – can provide significant health benefits and create new high-quality[10] jobs to advance a more equitable future for residents of the Bay Area region.

The Bay Area is also one of the most diverse regions in the nation. Fifty-nine percent of residents are people of color,[11] including many different racial and ethnic groups. The region is home to speakers of more than 160 languages, nearly half (43%) of which speak a language other than English at home.[12] The geographic area covered by the PCAP includes a population of approximately 5.5 million and 81 cities that range from very small and rural, to the large and cosmopolitan city of San Francisco. Specifically, the PCAP covers Alameda County, Contra Costa County, Marin County, Napa County, City and County of San Francisco, and San Mateo County, and the portions of Solano County and Sonoma County in the Air District's jurisdiction.[13]

OVERVIEW OF DEVELOPMENT OF THE PCAP

The Air District has striven to make the development of the PCAP and the BARCAP overall an inclusive regional planning process focused on reducing GHG emissions and elevating the priorities of frontline communities.

The Air District established an Advisory Work Group (AWG) in April 2023 composed of representatives from:

- Bay Area regional agencies (Air District, Association of Bay Area Governments (ABAG) through its program Bay Area Regional Energy Network (BayREN), Bay Area Regional Collaborative (BARC), and MTC)
- the cities named in the MSA (City of Berkeley, City of Oakland, and City and County of San Francisco)
- the counties comprising the MSA (Alameda County, Contra Costa County, Marin County, Napa

[10] The USEPA uses the term 'High-quality' for the CPRG effort. Workforce development efforts in the Bay Area region and California use the term 'high-road'. Both terms refer to jobs that pay a sustaining wage with adequate benefits and provide training and upward mobility, among other factors.

[11] "An Equity Profile of the Nine-County San Francisco Bay Area Region," Policy Link and USC Program for Environmental & Regional Equity, page 16. Note that this data includes Santa Clara County, which is not included in the San Francisco – Oakland – Berkeley MSA.

[12] BAAQMD Plan for Language Services to Limited English Proficient Populations, September 2023

[13] While Santa Clara County is often considered as being a part of the San Francisco Bay Area, for the purposes of the PCAP, Santa Clara County has been excluded, as the USEPA has designated it a part of the San Jose-Sunnyvale-Santa Clara MSA.

County, San Mateo County, and the portions of Solano County and Sonoma County that are within the Air District's jurisdiction)[14]

The Air District and the AWG met regularly to discuss coordination and engagement with other agencies, organizations, and frontline communities; make decisions on key aspects of the project such as measures selection and development; and provide input on technical analyses. ABAG is a sub-awardee, partnering with the Air District on key program elements, including measure development and local government and stakeholder outreach and engagement.

The Air District sought input from local governments beginning in April 2023 through surveys, individual and group meetings, and a series of four Working Sessions with stakeholders to design the PCAP measures in October-December 2023. In total, over 50 cities, towns, and counties participated in at least one PCAP-related outreach event. In addition, the Air District engaged in targeted outreach and engagement with community choice aggregators (CCAs)[15] and the local investor-owned utility, PG&E, through individual meetings and their inclusion in the Working Sessions.

The Air District designed and facilitated, with the support of ABAG/BayREN, a series of measure design Working Sessions, which brought together more than 90 stakeholders across the four sessions, representing local government and regional agencies, community-based organizations (CBOs), community-serving organizations, equity organizations, transportation agencies, CCAs and a utility, subject matter expert organizations for transportation and building decarbonization, and multiple representatives from organized labor and workforce training, non-profit housing, non-profit retrofit organizations, bike, environment and other stakeholder organizations. The sessions produced a set of design principles to guide measure development and two detailed measure descriptions. They also initiated discussions on potential implementation funding proposal ideas and partners.

In November 2023, the Air District held a public workshop to receive feedback on the draft measure concepts.[16] Feedback from the public workshop was added to the Working Session discussions that contributed to the PCAP measures.

The very short timeline for completing the PCAP did not lend itself to the type of in-depth community partnering and engagement that has become best practice in the Bay Area. Therefore, the Air District relied on recently completed engagement efforts and established avenues for engaging frontline communities. The Air District reviewed results of recently conducted (within the past 3 years) community engagement activities provided by local governments and regional agencies. A Roundtable of regional community-serving organizations with deep familiarity with Bay Area frontline communities worked with the Air District to finalize a synthesis of these community engagement efforts. Roundtable members included Emerald Cities Collaborative, Greenlining Institute, PODER, and Transform. They also

[14] The federally-designated San Francisco-Oakland-Berkeley MSA includes Alameda County, Contra Costa County, Marin County, City and County of San Francisco, and San Mateo County. The Air District received approval from the USEPA to expand the PCAP to cover the entire Air District's jurisdiction, including Napa County and portions of Solano County and Sonoma County with the exception of Santa Clara County which is included in a separate MSA for the CPRG effort.

[15] Community Choice Aggregation programs allow local governments to procure power on behalf of their residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider. In the BARCAP geography, there are five community choice aggregators: Ava Community Energy, Clean Power SF, MCE Clean Energy, Peninsula Clean Energy, and Sonoma Clean Power.

[16] A recording of the public workshop, along with PPT slides, can be found here: https://www.baaqmd.gov/plans-and-climate/climate-protection/bay-area-regional-climate-action-planning-initiative

participated in the four Working Sessions mentioned above. Air District staff presented on the BARCAP at two CCA-led meetings of CBOs and community partners and held a pre-meeting with other CBOs prior to their participation in the Working Sessions.

More information on frontline community engagement can be found in *Section 4: Frontline Communities Benefits Analysis*. *Section 6: Coordination and Outreach* provides more detail on the AWG and the engagement of other key stakeholders.

OVERVIEW OF THE PCAP

This document includes the following required and optional components of the PCAP, with additional detail available in the appendices:

- Description of the regional GHG inventory
- Priority GHG Reduction Measures
- Identification of frontline communities, how they were engaged and how they may benefit from implementation of the Priority GHG Reduction Measures
- Workforce planning analysis
- Summary of outreach and interagency and intergovernmental coordination efforts
- Next steps

2. Greenhouse Gas (GHG) Inventory

This section describes the regional GHG emissions inventory, which is a foundational piece of the PCAP that quantifies major and minor sources of GHG emissions in the Bay Area region.

SCOPE

The Air District has developed a GHG emissions inventory for the PCAP (with a base year of 2022[17]). The inventory accounts for GHG emissions at the county level for the eight Bay Area counties[18] included in this planning effort (excluding those portions of Sonoma County and Solano County that fall outside the Air District's jurisdiction) across six major sectors – Commercial and Residential, Transportation, Industrial, Electricity Generation (direct emissions only), Waste Management, and Agriculture. These sectors are defined and discussed in more detail in *Appendix A* of this report.

For all sources, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are quantified, and emissions of several fluorine-bearing species representing hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3) are also included, wherever applicable. GHG emissions are reported in terms of CO_2-equivalents (CO_2e) and are developed using 100-year time-horizon global warming potentials (GWP) relative to CO_2 from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), which includes climate feedbacks.[19]

DATA REVIEW

The GHG emissions inventory is subject to an extensive data review and quality control process that is described in the Quality Assurance Project Plan[20] for the PCAP. Details of the GHG inventory quality assurance process are provided in *Appendix A* and are based on the Quality Assurance Project Plan.

INVENTORY METHODOLOGY

The Air District applied a 'production-based' approach to develop the GHG emissions inventory, which focuses on estimating emissions from sources that produce direct emissions in the region, as compared to attributing emissions to consumers (and end-users) of goods and services (consumption-based approach).

The Air District inventory method involves a combination of:

- a bottom-up approach where emissions are derived by combining activity data and/or throughputs with GHG emissions factors and local/regional controls
- a top-down approach where emissions are derived by scaling down from an existing (e.g., national and/or state) emissions inventory using a proxy (such as population, vehicle miles traveled, etc.)
- emissions verified and approved through the Air District's permitting program

[17] This choice of base year reflects the best available data, for a vast majority of the source categories, including up-to-date (current) activity data, throughputs, emissions factors, impact of implemented controls, or actual reported and approved emissions (not a projection), or access to up-to-date national and statewide emissions inventories.

[18] The Air District's complete GHG inventory includes nine counties, but the GHG inventory for the PCAP excludes Santa Clara County to align with the geographic scope of this PCAP.

[19] Table 8.7, Page 714, IPCC Fifth Assessment Report, https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

[20] Quality Assurance Project Plan for The Bay Area Climate Action Planning Initiative, Grant No..: 98T73201; *submitted on*: 12-27-2023; *approved on*: 01-04-2024; available on request.

More details on inventory accounting methods can be found in *Appendix A*.

GHG EMISSIONS

The annual GHG emissions for the Bay Area region for the year 2022 total 59.9 million metric tons of CO_2-equivalent ($MMTCO_2e$), as shown in *Figure 2.1* (subsector detail in *Table 1* and *Figure 1* in *Appendix A*). For context, this total represents about 16% of California's statewide GHG emissions for year 2021.[21] Transportation (35%) is the largest contributing sector to the annual total GHG emissions, followed by Industrial (33%) emissions. Other high contribution sectors include Commercial and Residential (15%) and Electricity Generation (12%).

The relative share of GHG emissions in the Commercial and Residential sector (primarily, combustion emissions from space- and water-heating activities, and use of refrigerants in buildings[22]) are consistent with those in the national inventory.[23] GHG emissions in the Electricity Generation sector (attributed at the point of generation rather than point of use) in the Bay Area region constitute a lower relative share as compared to the national GHG inventory, indicating a relatively less-carbon intensive energy generation profile.

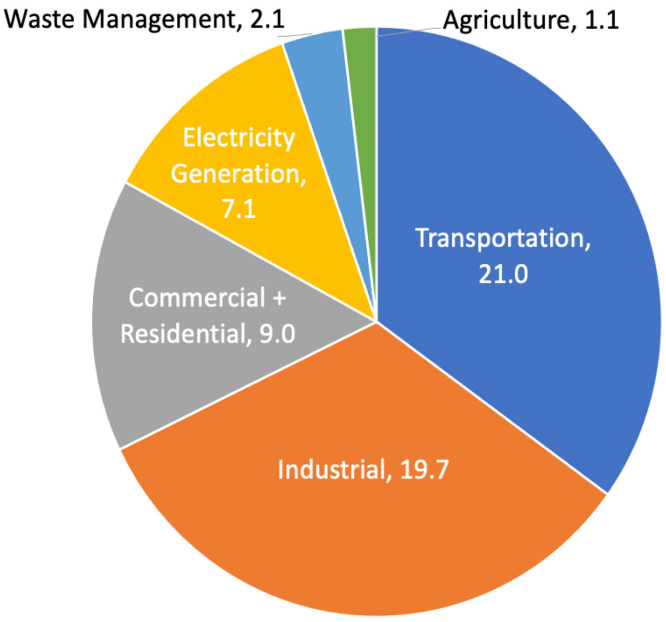


Figure 2.1. 2022 greenhouse gas inventory for the Bay Area region by sector. Total of 59.9 $MMTCO_2e$.

The regional distribution is different from the national inventory where the share of CH_4 and N_2O emissions, mostly from waste management, animal agriculture, and petrochemical production systems, is much larger (~18%). High-GWP gases like HFCs and PFCs comprise a significant proportion of emissions in the Commercial and Residential sector (~25%). The distribution of the different climate pollutants by sector in the Bay Area region is shown in *Figure 2.2* and *Table 2.1*.

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[21] California 2000-2021 GHG Inventory (2023 Edition), https://ww2.arb.ca.gov/ghg-inventory-data

[22] Electricity consumed in the Commercial and Residential sector is reported in the Electricity Generation sector.

[23] Inventory of U.S. Greenhouse Gas Emissions and Sinks, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

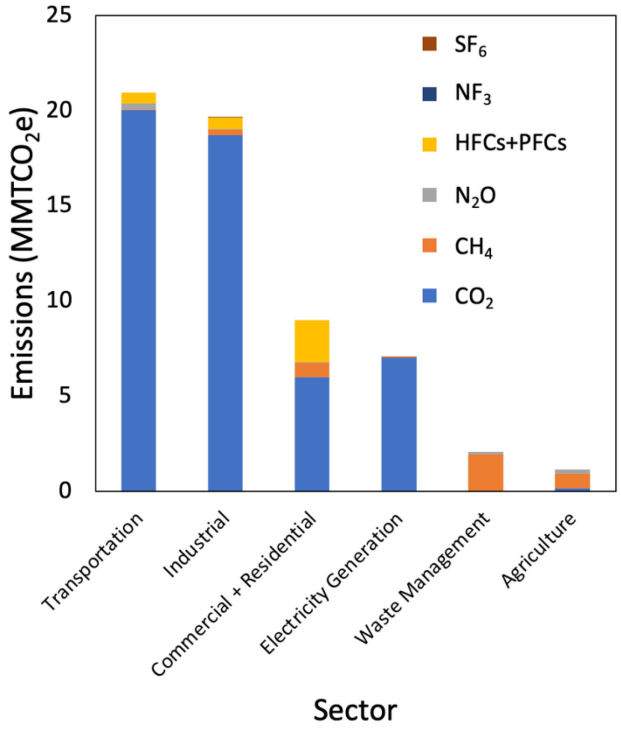

Figure 2.2. 2022 greenhouse gas inventory for the Bay Area region by sector and climate pollutant. Total of 59.9 $MMTCO_2e$.

Table 2.1. Distribution of GHG emissions across the six major source sectors by major climate pollutant type for the Bay Area region.

Sector/Gas	Bay Area Region Emissions ($MMTCO_2e$)		Sector/Gas	Bay Area Region Emissions ($MMTCO_2e$)
Commercial + Residential			**Transportation**	
CO_2	5.98		CO_2	20.02
CH_4	0.77		CH_4	0.04
N_2O	0.02		N_2O	0.32
HFC+PFC	2.21		HFC+PFC	0.58
Total	**8.98**		**Total**	**20.95**
Electricity Generation			**Waste Management**	
CO_2	7.02		CO_2	0.002
CH_4	0.01		CH_4	1.92
N_2O	0.005		N_2O	0.15
SF_6	0.03		HCFC	0.00001
Total	**7.06**		**Total**	**2.07**
Industrial			**Agriculture**	
CO_2	18.72		CO_2	0.16
CH_4	0.30		CH_4	0.74
N_2O	0.04		N_2O	0.24

SF_6	0.03		**Total**	**1.14**
NF_3	0.004			
HFC+PFC	0.58			
Total	**19.67**			
Grand Total	**59.88**			

Figure 2.3 shows the distribution of emissions by county across the Bay Area region. Contra Costa County stands out as the county having the most GHG emissions (~45%) in the Bay Area region. This, in large part, is because four of the five refineries (Industrial sector) and five of the six power plants (Electricity Generation sector) in the Bay Area region are in this county. The fifth refinery is in Solano County, which otherwise has relatively low GHG emissions, as its population is low and only the southern part of the county is in the Bay Area region. In the other six counties, the Transportation and Commercial and Residential sectors account for the majority of GHG emissions. A detailed breakdown is provided in *Table 2* in *Appendix A*, showing emissions by county and sector.

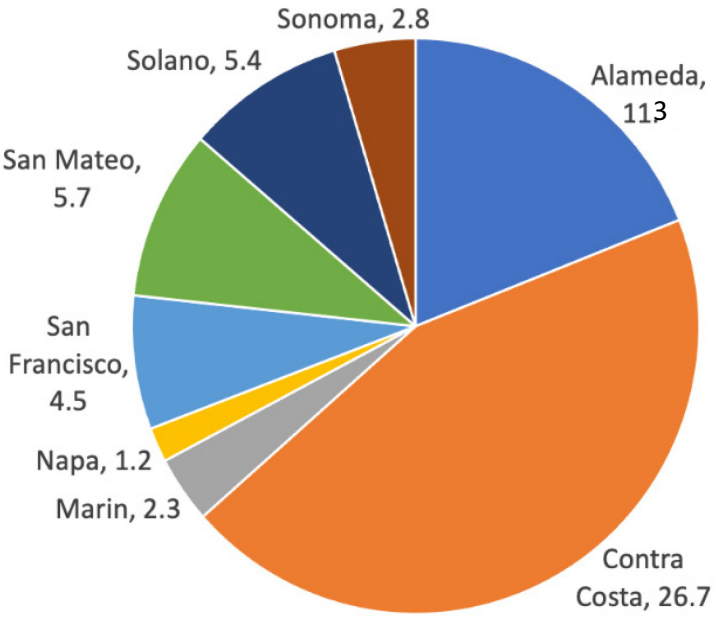

Figure 2.3. 2022 greenhouse gas inventory for the Bay Area region by county. Total of 59.9 MMTCO$_2$e.

DATA RESOURCES

National, state, and local datasets for activity and/or throughputs, emission factors, and emissions have been utilized to develop the Air District's GHG emissions inventory for the Bay Area region. The list below reflects a subset of the most frequently used and referenced datasets contributing to the development of the Bay Area region's GHG emissions inventory. Some of the more prominent data sources deployed in the development of this inventory include:

- Facility-specific GHG data published by the USEPA in the Facility Level Information on Greenhouse Gases tool (FLIGHT)[24]
- Data reported to the USEPA's Greenhouse Gas Reporting Program[25]
- California Air Resources Board's 2000-2021 Greenhouse Gas Inventory (2023 Edition)[21]
- United States Census and American Community Survey downscaled data for Bay Area[26]

[24] https://ghgdata.epa.gov/ghgp/main.do

[25] https://www.epa.gov/ghgreporting/data-sets

[26] https://www.census.gov/quickfacts/fact/table/CA/HSG010222

- Federal Aviation Administration (FAA) emissions modeling through the Aviation Environmental Design Tool (AEDT)[27]
- Natural-gas and electricity generation and use data obtained from the California Energy Commission[28]
- Natural-gas and electricity generation and use data obtained from the Energy Information Administration (EIA)[29]
- California Air Resources Board's statewide mobile source emissions inventory generated using the USEPA-approved EMFAC (EMission FACtor) model[30]
- County crop reports[31]
- Air District facility-scale permit-to-operate throughput and activity data (mostly confidential) that has been previously reviewed for quality assurance and published as a part of prior greenhouse gas inventories
- Air District facility-scale emissions data that have been self-reported by facilities

[27] https://aedt.faa.gov/

[28] https://www.energy.ca.gov/data-reports/energy-almanac

[29] https://www.eia.gov/state/print.php?sid=CA

[30] https://ww2.arb.ca.gov/our-work/programs/msei/on-road-emfac

[31] https://www.cdfa.ca.gov/exec/county/CountyCropReports.html

3. Priority GHG Reduction Measures

This section describes the measures that have been identified as 'priority measures' for the PCAP and for the purposes of pursuing funding through CPRG implementation grants. It is not an exhaustive list of the region's priorities. Instead, the selected priority measures included in this PCAP meet the following criteria:

- The measure is implementation-ready and can be completed in the near-term (by end of the five-year performance period for the CPRG implementation grants when all funds must be expended)
- The measure results in significant GHG reductions and significant benefits to frontline communities, with a process for being informed by communities
- The measure is regional in nature and necessitates the participation of multiple jurisdictions
- The measure is replicable and innovative and addresses funding gaps
- The measure advances the guiding values, or design principles, in *Table 3.1* which were developed by the Air District, AWG, Roundtable, and Working Session participants

Table 3.1. PCAP measure development design principles.

PCAP Measure Development Design Principles	
Climate equity: Provide direct, meaningful, desired, and assured benefits to frontline communities, with a particular focus on Black, Indigenous, and People of Color (BIPOC) communities.	**Health & safety**: Improves living conditions (indoor and outdoor air quality, traffic safety, and pedestrian safety), especially in frontline communities.
Cooperative: Build upon and integrate existing efforts to expand impact, rather than introduce duplication.	**Housing and community stability**: Supports people, especially renters and low-income homeowners, be housed and remain in their homes by increasing healthy, resilient housing with affordable electricity and accessible transportation options.
Coordinated: Build cooperation and peer working relationships among local government and community-based organizations that builds community capacity and empowers community leadership within and across counties.	**Jobs**: Creates lasting, high-quality, family-sustaining high-road jobs and other pathways to economic sovereignty in frontline communities.
Funding: Increases access to critical financing and funding mechanisms for frontline communities and other key stakeholders.	**Resilience**: Builds resilience, especially for frontline communities, through changing climate conditions in the near and long term.
Genuine affordability and access: Increases access to housing and transportation, especially for frontline communities.	**Strategic**: Uses one-time funding transformatively, considering both short- and long-term impact.

The two priority sectors included in the PCAP are passenger vehicles and residential buildings. Together, emissions from these sectors make up more than 25% of the Bay Area region's GHG emissions. They are the top two sectors most commonly identified by local government staff as highest priority when

surveyed early in the BARCAP process. AWG members echoed this prioritization. They are also identified in the State Scoping Plan as the highest priority areas for action by local governments.[32] Passenger vehicles and residential buildings are also reflected as major local GHG emission sources and top priorities for mitigation in the 70+ local climate action plans that have been adopted by Bay Area jurisdictions. The Air District's review of recently conducted community engagement by local governments and regional agencies found similar community priorities across the region, including active transportation, public transit systems, e-micro-mobility, and clean, healthy, affordable, and secure housing. In the Bay Area region, Roundtable members and other community-serving organizations have worked extensively with communities to understand their priorities for these two sectors and how to best advance climate equity in implementation.

BAY AREA REGION'S PRIORITY CLIMATE ACTION PLAN GREENHOUSE GAS REDUCTION MEASURE: SAFE, ACCESSIBLE, CLEAN, AND EQUITABLE MULTI-MODAL TRANSPORTATION

The Bay Area is a leader in transportation planning that is integrated, favors transit and active modes of transportation, and considers environmental and equity impacts. The Bay Area is unique in that it has a visionary long-range integrated transportation, housing, economic, and environmental plan – Plan Bay Area 2050[33] (PBA 2050), developed by MTC. PBA 2050 aims to have nearly half of all Bay Area residents (70% for low-income households) living within one half-mile of frequent transit by 2050, in order to make the region more affordable, connected, diverse, healthy, and vibrant, with a focus on equity outcomes. Implementation of PBA 2050's strategies, especially those that focus on active and shared travel modes, combined with PBA 2050's transit-supportive land use pattern, are forecasted to significantly decrease GHG emissions, meeting the state-mandated 19% reduction in per capita GHG emissions from transportation below 2005 levels by 2035 for the region. The PCAP measure described below is designed to implement key elements of PBA 2050, particularly in frontline communities, and help achieve this GHG emission reduction target.

BACKGROUND

Transportation is the largest contributor to GHG emissions in the Bay Area region, accounting for 35% of regional GHG emissions. Passenger cars and light-duty trucks make up more than half of those emissions. With many of the area's highways cutting through frontline communities, this vehicle travel also contributes to the health burden of these communities through the increases in air pollution that result from tailpipe exhaust and brake and tire wear. Although private vehicle trips have rebounded since COVID-19, as demonstrated by toll crossing numbers for the Bay Bridge, transit ridership across the Bay Area is still greatly suppressed, with Bay Area Rapid Transit (BART) only at approximately 37% of the average monthly ridership of the year before the pandemic.[34] This new reality for transit agencies across the Bay Area is one that creates significant funding challenges as they work to attract new and previous riders to their services.[35]

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[32] California Air Resources Board, 2022 Scoping Plan for Achieving Carbon Neutrality; Appendix D Local Actions

[33] https://www.planbayarea.org/plan-bay-area-2050

[34] BART ridership information accessed on 9/11/23 at https://mtc.ca.gov/tools-resources/data-tools/monthly-transportation-statistics

[35] In April 2020, MTC established the Blue Ribbon Transit Recovery Task Force to help transit agencies rebound from suppressed ridership in the wake of the COVID-19 pandemic.

The Bay Area's transit system is comprised of 27 different transit agencies operating with a transit fleet that includes bus, rail, and ferry service. The complexity of this network leads to challenges that include lack of accessibility due to poor first-mile, last-mile connections;[36] increased costs due to uncoordinated fare structures; and increased time for trips due to uncoordinated service schedules. These challenges are often felt more acutely by residents of frontline communities that have historically faced under-investment due to racism, socioeconomic status, and lack of access to decision makers. Additionally, residents in these communities are typically more reliant on public transportation to complete trips to work, obtain goods and services, and get to other places they need to go. This measure is aimed at reducing these challenges by co-locating a variety of transportation options in mobility hubs that will offer a safe, comfortable, convenient, and accessible space to seamlessly transfer between different travel modes and ultimately shift trips made in single occupancy vehicles to transit and active modes of transportation, reducing vehicle miles traveled (VMT) and GHGs.

Priority for Local Governments in the Region

Regional and local governments and agencies across the Bay Area region identified reducing VMT through transportation mode shift as a priority for the PCAP. Their commitment to addressing vehicle emissions through mode shift is demonstrated through their adopted active transportation[37] plans, climate action plans, and policymaking. They also raised this priority during engagement efforts led by the Air District and partners to inform PCAP development from April 2023 to October 2023.

Engagement conducted by MTC to inform an update of PBA 2050 identified active transportation and mobility improvements as a priority for communities throughout the Bay Area region as well. Engagement with the public, and specifically from frontline communities, identified priorities for transit, changes in travel behavior, and active transportation improvements.[38] For active transportation, there was a call to encourage and provide alternative mobility options, to increase safe bike and pedestrian infrastructure, and to prioritize that infrastructure over vehicles, making communities more accessible via active modes of transportation.

Through its Community-Based Transportation Planning (CBTP) Program, MTC and county transportation agencies work with communities that have been historically underserved by or excluded from the transportation process to identify mobility challenges and prioritize solutions. Nearly half of the CBTP-related recommendations focused on active transportation improvements, and more than one-third of the recommendations were related to transit.[39]

Frontline communities have shared with local governments similar transportation-related priorities for improved active transportation infrastructure and public transit systems, along with safety and

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[36] First-mile, last-mile connections describe the distance to get from your home to the transit stop and from the transit stop to your final destination (work, goods and services, etc.).

[37] Active transportation refers human-powered mobility, including biking and walking.

[38] https://mtc.ca.gov/sites/default/files/meetings/attachments/5833/8aiii_PBA50_Attachment_B_Draft_Blueprint_Round_1_Engagement.pdf

[39] https://mtc.ca.gov/sites/default/files/documents/2022-05/CBTP_Program_Evaluation_April_2022.pdf. The most common recommendations included new bike facilities, roadway intersection and sidewalk improvements, complete streets improvements, and shared mobility (e.g., bike or scooter share). The two most common transit recommendations focused on improving traveler information and improvements to stations.

affordability concerns, and interest in e-micro-mobility, [40] [41] which echo much of the feedback MTC received.

Priority Reflected in Regional Planning

This priority measure creates mobility hubs – places in a community that bring together different types of low-emission, safe, and accessible transportation options. By locating new or expanded mobility hubs in the frontline communities within MTC's priority development areas (areas within existing communities identified and approved by local cities or counties for future growth), the measure supports two high-impact PBA 2050 strategies (Strategies H3 and EC4),[42] bringing more transportation options to areas that have been identified for increased densities of residential and commercial growth. Increasing connectivity to transit and improving access to active transportation will allow more trips to be completed without the use of personal vehicles and will help the region reach its ambitious targets for VMT reduction and reducing GHG emissions.

Plan Bay Area 2050 includes strategies that support active transportation. PBA 2050 strategy T8 calls for building a Complete Streets network that promotes walking, biking, and other micro-mobility options through sidewalk improvements, car-free slow streets, and 10,000 miles of bike lanes or multi-use paths. Strategy T9 advances the regional Vision Zero policy through improved street design and reduced vehicle speeds. Both strategies complement and enhance mobility hubs implementation.

Existing Efforts

Throughout the Bay Area region, a variety of programs focus on shifting single occupancy vehicle trips to transit and active modes of transportation and reducing emissions from alternative modes. They include projects such as incentives for e-bikes, electric vehicle (EV) charging infrastructure, bike/car share, and other clean, shared, zero-emission transportation projects. The main program this measure builds upon is MTC's Regional Mobility Hubs Program,[43] which coordinates, funds, and provides technical assistance for the development of mobility hubs. Mobility hubs serve as community anchors that enable travelers of all backgrounds and abilities to access multiple travel options – including shared scooters, bicycles, cars, and transit – as well as supportive amenities in a cohesive space, oriented to the traveler. MTC has funded twelve mobility hub projects to date throughout the Bay Area since the launch of the program in 2021,[44] and developed a Mobility Hubs Implementation Playbook[45] to provide technical assistance to public agencies and community organizations interested in providing safe and accessible alternatives to single-occupancy vehicle trips.

In addition to the Regional Mobility Hubs Program, MTC has developed a variety of plans and policies that support the implementation and success of mobility hubs. These include:

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[40] E-micro mobility (Electric micro mobility) includes any small, low-speed, electric-powered transportation device, including electric-assist bicycles (e-bikes), electric scooters (e-scooters), and other small, lightweight, wheeled electric-powered conveyances.

[41] These priorities come from an analysis of outputs from recently conducted (within the past 3 years) community engagement activities provided by local governments.

[42] Strategy H3: Allow a greater mix of housing densities and types in growth geographies; Strategy EC4: Allow greater commercial densities in growth geographies.

[43] https://mtc.ca.gov/planning/transportation/mobility-hubs

[44] 2021 Pilot Awards approval: https://mtc.legistar.com/LegislationDetail.aspx?ID=5126761&GUID=89D47ED1-F31B-4A79-960D-B655A382FD7E&Options=&Search=; 2023 Grant Awards Approval: https://mtc.legistar.com/LegislationDetail.aspx?ID=6249612&GUID=94FDC2D8-7411-408C-A00B-85E06140E7FB

[45] MTC's Mobility Hubs Implementation Playbook is a comprehensive technical assistance guide with implementation strategies, tactical approaches, and management techniques.

- MTC's Regional Active Transportation Plan,[46] which guides MTC's policy and investment framework to implement the PBA 2050 active transportation strategies
- The Regional Active Transportation Network,[47] which focuses the Bay Area's efforts in providing active transportation connections in areas with the highest potential for shifting vehicle trips to biking and walking, where there is the greatest need for affordable transportation options, and where active trips can connect people with transit for longer distance travel
- MTC's Transit Oriented Communities (TOC) Policy,[48] which was developed to enable people to access and use transit more often for more types of trips by centering housing, jobs, services, and shopping around public transit

Additionally, there are a multitude of plans and pilot projects from counties and cities throughout the Bay Area region (community-based transportation plans, climate action plans, active transportation plans, general plans, etc.), that include key active transportation improvements needed to help shift trips away from single occupancy vehicle travel. These plans help to identify and prioritize active transportation improvements around planned mobility hubs and can inform measure implementation.

These efforts include:

- Active transportation plans, bicycle plans, pedestrian plans, and/or safe streets plans for all counties and most cities in the Bay Area region, with others under development
- Community-based transportation plans for more than 30 low-income communities across the Bay Area region that have been developed through a collaborative process with transportation agencies, residents, and community organizations, with funding from MTC. The plans include locally identified transportation needs and solutions to address them[49]
- The City of Oakland's Basic Mobility Pilot Project, which provides prepaid debit cards and transit passes to income-qualifying residents for transit, shared mobility, and other mobility-related services[50]
- TransForm and MTC's EV Carsharing and Mobility Hubs in Affordable Housing Pilot, which brings EV car sharing, EV charging infrastructure, and other travel options to affordable housing communities in the region[51]

Although the Bay Area is ahead of many other regions in California and across the country, more accelerated action is needed to reduce VMT and meet state and regional goals. This includes funding mode shift-supporting plans, policies, and infrastructure that will be required to meet the region's goal

[46] https://mtc.ca.gov/funding/investment-strategies-commitments/climate-protection/regional-active-transportation-plan

[47] The Regional Active Transportation Network (https://www.arcgis.com/home/item.html?id=43e128434c07450b8b8f6d6dc5791a51) supports Plan Bay Area goals by focusing the region's efforts on providing high comfort active transportation connections in areas with the highest potential for shifting auto trips to bicycling and walking trips, where there is the greatest need for affordable transportation options and where active trips connect people with transit.

[48] https://mtc.ca.gov/sites/default/files/documents/2022-10/MTC_Resolution_4530.pdf

[49] https://mtc.ca.gov/planning/transportation/access-equity-mobility/community-based-transportation-plans-cbtps

[50] https://www.oaklandca.gov/topics/universal-basic-mobility

[51] https://www.transformca.org/mobility-hubs-affordable-housing-pilot#:~:text=With%20funding%20from%20the%20California,%2C%20Richmond%2C%20and%20San%20Jose

of reducing per capita VMT to 19% below 2005 levels by 2035 and the state's goal of reducing per capita VMT to 25% below 2019 levels by 2030 and 30% below 2019 levels by 2045.[52]

Key Barriers and Gaps

A variety of barriers can prevent Bay Area residents from using transit and active transportation, and importantly, from switching personal auto travel to transit or active modes of transportation. These barriers are often felt more acutely by residents of frontline communities, as these areas often have historically faced under-investment due to racism or socioeconomic conditions and are typically more reliant on public transportation to complete trips to work, obtain goods and services, and get to other places they need to go. Barriers include:

- Transportation costs
- Inadequate or unsafe first-mile, last-mile connections to transit
- Issues connecting between different transit agency networks
- Increased time for transit trips due to uncoordinated transit schedules
- Lack of tree cover and vegetation for biking and pedestrian facilities, contributing to uncomfortable conditions due to extreme urban heat and potential flooding during heavy rains

PRIORITY GHG REDUCTION MEASURE: SAFE, ACCESSIBLE, CLEAN, AND EQUITABLE MULTI-MODAL TRANSPORTATION

The over-arching goal of this measure is to reduce GHG and other polluting emissions from personal vehicle travel while increasing transportation choices in frontline communities. This priority measure will reduce single occupancy VMT by creating or building out mobility hubs to make it easier for trips to be made by transit, biking, walking, scooter, wheelchair, or other mobility devices, including e-micro-mobility. Implementation will focus on creating or expanding mobility hubs in frontline communities and incorporating policies that produce, preserve, and protect affordable housing and stabilize businesses to prevent displacement, similar to the goals outlined in MTC's TOC Policy.[53]

Mobility hubs should include a variety of components to meet the needs of the community (determined through engagement with CBOs and participatory community processes), with the intent that the hub will serve as a community anchor that enables residents to access multiple transportation options and supportive amenities. While the optimal configuration of the mobility hub depends on the surrounding land use and community input, project components should include:

- First-mile, last-mile connectivity improvements, such as:
    - Bicycle and pedestrian facility improvements, incorporating complete streets and vision zero[54] in design
    - Micro-mobility, bikeshare/e-bikeshare
    - EV Carshare/EV Charging (on-site and in adjacent ½ mile area)
    - Urban greening along pedestrian, bicycle, and transit infrastructure
- Multi-modal connectivity improvements, such as:
    - Solar charging for e-bikes, e-scooters, and EVs
    - Bike racks/lockers (with proper sizing for e-bikes and e-cargo bikes)
    - Micro-transit service
    - Transit priority infrastructure improving on-time performance and bus transit access

[52] California Air Resources Board's 2022 Scoping Plan (https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf)

[53] https://mtc.ca.gov/planning/land-use/transit-oriented-communities-toc-policy

[54] "Vision Zero" is a nationwide movement to reduce traffic injuries to zero.

    - Improved transit waiting area infrastructure (e.g., bus shelters, lighting, etc.)
    - Improved signage, wayfinding, and real-time information for transit departure
    - Transit fare coordination
    - Transit schedule coordination
- Community amenities and services (e.g., common carrier package pickup lockers, retail kiosks, community centers, medical services, street furniture)
- E-bike incentives
- Discounted fare programs and discounted bike share passes for low-income and underserved populations
- Safety improvements
- Outreach and education to the community, with a special focus on youth, engaging CBOs to encourage the shift to active and low-carbon or zero-carbon mobility options

GHG REDUCTIONS

Table 3.2. GHG emissions reductions from implementation of the Mobility Hubs measure.

2025-2030 GHG reductions (cumulative)	2025-2050 GHG reductions (cumulative)
~172,000 MT CO_2e	~471,000 MT CO_2e

More detailed information is included in *Appendix C*, including the GHG emissions quantification methodology, GHG reductions by measure component, quantification methodology inputs, and more.

KEY IMPLEMENTING AGENCIES

Implementation of this measure involves a diverse collaboration of agencies across the region:

- Regional agencies to lead overall program management
- Regional and County Transit Agencies to coordinate stakeholders and projects within their jurisdictions and to implement project components on their properties
- Cities and counties to implement project components on their properties and right-of-ways
- Community choice aggregators and utilities to administer rebates and incentives
- Research institutions to partner on research efforts

Other organizations, including CBOs, may play key roles as well.

IMPLEMENTATION SCHEDULE AND MILESTONES

- 2024 – Program established and sites selected for mobility hubs
- 2024-2025 – Engagement with the community and CBOs to determine mobility needs
- 2025-2026 – Develop final construction plans and/or programs and obtain needed permits
- 2026-2027 – Begin implementation of non-construction-related components of mobility hubs (such as e-bike incentives or reduced fare programs)
- 2026-2030 – Phased construction of upgrades to mobility hubs
- 2027-2028 – Education and marketing to promote use of mobility hubs

AUTHORITY TO IMPLEMENT

Implementation of this measure involves voluntary actions. No additional authority must be acquired by implementing partners to implement the measure. Below is a list of key existing authorities related to the upgrades to properties and right-of-ways and administration of rebates and incentives, as well as anti-displacement policies.

- Transit Agencies have the authority to make upgrades to their properties.
- Cities and counties have the authority to make upgrades to properties and right-of-ways and implement anti-displacement policies.[55]
- Regional agencies, community choice aggregators, and utilities have authority to administer rebates and incentives.

GEOGRAPHIC SCOPE

The geographic scope of this measure covers frontline communities in Alameda County, Contra Costa County, Marin County, Napa County, City and County of San Francisco, San Mateo County, and the portions of Sonoma County and Solano County that are in the Bay Area air basin.

METRICS FOR TRACKING PROGRESS

Because projects will be located in or adjacent to frontline communities, the metrics below will focus on frontline communities. The following metrics will be used to track progress:[56]

- GHG emission reductions
- VMT reductions
- Change in transit ridership
- Change in bike/pedestrian activity
- Number of mobility hubs created and amount of each project component included (e.g., miles of bike lanes created, number of carshare vehicles and miles, number of e-bike incentives, etc.)

INTERSECTION WITH AVAILABLE FUNDING

This priority measure complements and potentially expands upon existing programs. The Air District has explored federal and non-federal funding sources to determine whether these sources could fund implementation of the measure and whether such funding is sufficient to fully implement the measure.

Potential Cost to Implement the Measure

MTC's 2023 Regional Mobility Hub Program solicitation[57] is used as a basis to estimate the potential cost of implementing the measure. Although the solicitation has a maximum award of $3 million per mobility hub, MTC received feedback from applicants and previous awardees that mobility hubs actually cost between $5 million and $10 million to fully implement, so an estimated cost of $7.5 million per hub is used. Assuming that 25 of the approximately 115 potential mobility hub sites in frontline communities and transit-oriented community designations could be upgraded within the 5-year implementation period, the total cost would be approximately $188 million.

E-bike incentives and discount fare programs are not included in MTC's program and represent an additional cost. Assuming that incentives are provided for 2,500 e-bikes through the measure and those incentives provide $1,000 toward an e-bike,[58] the total additional cost would be $2.5 million. Discounted

[55] Improvements to neighborhoods, such as investments to public infrastructure like the ones in this measure, can increase home values, which can in turn lead to displacement of long-time residents.

[56] The Air District will report on measure progress in its 2027 Status Report to USEPA.

[57] The solicitation includes some of the first-mile, last-mile improvements (limited to bike and ped facility improvements within ¼ mile of the hub), multi-modal connectivity improvements, and community amenities and services listed in Section 3 above.

[58] Based on Peninsula Clean Energy's E-Bikes For Everyone Program incentive amount (https://www.peninsulacleanenergy.com/ebikes/)

fare programs will result in additional costs but those costs are dependent on the scale of the fare program developed and are not calculated for this funding analysis.

Potential Funding Sources

Many of the federal programs identified below are general and/or competitive funding sources that fund a wide variety of projects, without earmarked dollars for specific activities that comprise the priority measure. As a result, this funding is much less certain than CPRG funding and, notably, funding cycles for these programs have closed.

Table 3.3. Federal, state, and regional grant programs to leverage for the Mobility Hubs measure.

Grant Program	Federal, State, or Regional	Total
Neighborhood Access and Equity Grant Program [59]	Federal – Inflation Reduction Act (IRA)	$3.2 billion (nationally competitive)
National Electric Vehicle Infrastructure Formula Program[60]	Federal – Bipartisan Infrastructure Law (BIL)	$384 million statewide (Competitive statewide solicitation from CEC and Caltrans)
Carbon Reduction Program[61]	Federal – BIL	$10 million for Bay Area plus $38.5 million to be spent anywhere in the state *($110 million statewide, assume Bay Area region accounts for 16% of statewide population)* Note: MTC received funding through this program and uses it for their 2023 Mobility Hub Program. For their 2023 solicitation (a 4-year grant cycle) they have used a $33million allocation.
California Active Transportation Program[62]	State	$850 million in proposed 2024-2025 budget (competitive statewide)
Charge! Program[63] - grant from Charging and Fueling Infrastructure Discretionary Grant Program[64]	Regional (BIL)	$15 million (competitive Bay Area Region)

The California Active Transportation Program (ATP) provides funding to increase the proportion of trips accomplished by walking and biking, increasing the safety and mobility of non-motorized users, advancing efforts of regional agencies to achieve GHG reduction goals, enhancing public health, and providing a broad spectrum of projects to benefit many types of users including disadvantaged communities. Although this funding would not apply to all the components of this PCAP measure, it

[59] https://www.transportation.gov/grants/rcnprogram/about-neighborhood-access-and-equity-grant-program
[60] https://www.fhwa.dot.gov/bipartisan-infrastructure-law/nevi_formula_program.cfm
[61] https://www.fhwa.dot.gov/bipartisan-infrastructure-law/crp_fact_sheet.cfm
[62] https://catc.ca.gov/programs/active-transportation-program
[63] https://www.baaqmd.gov/news-and-events/page-resources/2024-news/011124-dot-grant
[64] https://www.transportation.gov/rural/grant-toolkit/charging-and-fueling-infrastructure-grant-program

could be leveraged to fund the active transportation component of it. The next cycle of ATP funding is currently under development and final funding amounts are yet to be set. However, the State of California is facing a $38-$68 billion shortfall for 2024-2025 and the Governor has proposed a $2.9 billion reduction in funding for climate programs, including a $200 million reduction to the ATP. These shortfalls highlight the need for more federal funding for these types of projects.

BAY AREA REGION'S PRIORITY CLIMATE ACTION PLAN GREENHOUSE GAS REDUCTION MEASURE: HOLISTIC BUILDING DECARBONIZATION FOR CLEAN, HEALTHY, AND SECURE HOUSING

The Bay Area is uniquely positioned to demonstrate an equitable and accelerated transition to zero-emission homes through building decarbonization,[65] given its distinctive constellation of programs and first-of-its kind building appliance regulation. This priority measure accelerates electrification and energy efficiency retrofits in existing homes, prioritizing frontline communities, through an integrated approach that maximizes co-benefits, applies economies of scale and strategic targeting, sends important market signals, and helps build the workforce necessary for a full and just transition. This measure will provide a replicable model for moving beyond status quo of current retrofit efforts that have tended to be siloed and have achieved only incremental residential building decarbonization to date – to a comprehensive, strategic, multi-faceted pathway for achieving widespread home decarbonization that significantly reduces GHG emissions from residential buildings and benefits frontline communities.

BACKGROUND

Major GHG Emissions Source

Residential and commercial buildings in the Bay Area are a significant source of regional GHG emissions, surpassed only by transportation and industrial sources. Burning gaseous fossil fuels for energy in homes creates almost half of those building-related regional GHG emissions. Due to state and local policies and actions, the electricity grid in California – and particularly the Bay Area – is much cleaner than in most of the rest of the country.[66] As a result, there is a GHG reduction premium when switching from gas to electricity in the Bay Area that does not occur in many other locations. Residential building decarbonization can also decrease exposure to health-damaging air pollutants such as nitrogen oxides (NOx) and particulate matter that are by-products of fossil fuel combustion.[67]

Priority for Local Governments in the Region

Local governments across the Bay Area region identified equitable residential building decarbonization as a priority for the PCAP. Their commitment to decarbonizing homes is demonstrated in their adopted

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[65] Building decarbonization refers to a broad group of strategies to reduce GHG emissions from residential and commercial buildings. Energy efficiency and building electrification (or replacing fossil fuel-dependent appliances and equipment with electric ones) are two critical components. Throughout this document, residential building decarbonization will refer primarily to these two strategies. Other strategies for building decarbonization may include: the use of zero-carbon electricity, energy storage, demand flexibility, and the use of very low- or no-GWP refrigerants and refrigerant emission leak reduction. (https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-appendix-f-building-decarbonization.pdf)

[66] California's Renewables Portfolio Standard (updated by SB 100) targets 60 percent of retail electricity sales in 2030 and 100 percent by 2045. In the Bay Area, Pacific Gas and Electric Company (PG&E) and seven community choice aggregators (CCAs) have already exceeded these targets. According to its 2022 Climate Strategy Report, "PG&E delivers some of the nation's cleanest electricity to customers, with 93% from greenhouse gas-free resources in 2021. The associated emissions rate is nearly 90% cleaner than the latest national average among energy providers." The CCAs aim to deliver cleaner electricity than PG&E's benchmark.

[67] https://coeh.ph.ucla.edu/2020/04/29/study-gas-powered-appliances-may-be-hazardous-for-your-health/#:~:text=The%20UCLA%20Fielding%20School%20of,that%20exceeded%20both%20state%20and

climate action plans and policymaking. They also expressed it as a top focus for the PCAP in response to various engagement efforts conducted by the Air District and partners to inform PCAP development from April 2023 to October 2023 (e.g., surveys, interviews, meetings, etc.), with a particular emphasis on existing low-income homes. Frontline communities have shared with local governments that their key priorities related to home decarbonization include housing security and affordability (including tenant protections), health and safety upgrades, and reduced energy costs (or at the very least no increased costs) and reliability.[68] Communities of color and low-income communities regularly experience poor housing quality and disproportionate exposure to environmental hazards as the result of racist and discriminatory policies and practices.[69]

Local governments throughout the Bay Area have been leading the nation on building decarbonization, with their early actions, such as those focused on new construction, influencing similar efforts across California and the country. For the past several years, Bay Area policy and program activities have turned to focus on the challenge of decarbonizing the existing building stock.

Rich Constellation of Existing Efforts

Local government policies are just part of a broader constellation of programs by community choice aggregators, the local investor-owned utility PG&E, ABAG/BayREN and other regional agencies, local governments, and non-profits in the Bay Area region dedicated to incentivizing and subsidizing residential electrification and energy efficiency retrofits in a way that benefits all residents.

The Bay Area is also home to many innovative pilots focused on identifying the most effective and equitable solutions to advance residential decarbonization.

- **Home Electrification Equity Project (HEEP)*:*** Four cities in the Bay Area region are partnering with Habitat for Humanity East Bay/Silicon Valley, with funding from Google.org and ICLEI, to develop a data-driven approach to serve low-income homeowners by incorporating electrification into traditional "health and safety" home upgrade programs. Other partners include California State University East Bay, Rebuilding Together, and GRID Alternatives.[70]
- **Bay Area Healthy Homes Initiative (BAHHI):** The Air District leads this program that seeks to improve health outcomes and climate resilience for Contra Costa and Alameda County asthma patients and residents living in the areas most impacted by traffic-related air pollution. The program brings asthma services and home retrofits to address health triggers, electrify appliances and improve energy efficiency, and keep outdoor pollution out of the home through a unique partnership with Contra Costa Health Services, Alameda County's Asthma Start, ABAG/BayREN, StopWaste, and local energy non-profit Association for Energy Affordability.[71]
- **Just Transition Residential Electrification Pilot:** The City of Berkeley is working with the non-profit Rebuilding Together East Bay North to advance high-road, family-sustaining workforce opportunities through aggregated residential building electrification retrofits in existing affordable housing and/or low-to-moderate income households.
- **Neighborhood-scale electrification analyses and pilots:** The CCA Ava Community Energy and Gridworks analyzed eleven neighborhoods to assess the benefits and costs along with the

[68] These priorities come from an analysis of outputs from recently conducted (within the past 3 years) community engagement activities provided by local governments.

[69] https://www.nrdc.org/sites/default/files/2023-12/housing-justice-health-equity-building-decarbonization-ib.pdf; https://policycommons.net/artifacts/2683765/income-qualified-program-innovations-to-reduce-deferral-rates/3706414/

[70] https://icleiusa.org/wp-content/uploads/2022/11/ICLEI-USA-Action-Fund-Recipient_Home-Electrification-Equity-Project.pdf

[71] https://www.baaqmd.gov/community-health/bay-area-healthy-homes-initiative

practical feasibility and requirements of neighborhood-scale electrification, which involves targeted electrification and decommissioning of gas infrastructure in a specific neighborhood.[72] The City of Albany recently received funding through the US Department of Energy's Energy Efficiency and Conservation Block Grant program to pilot community engagement approaches for neighborhood-scale electrification. UC Berkeley's EcoBlock research project focuses on designing and implementing cost-effective retrofits at the block scale for full decarbonization and independence from the utility grid, including an effort in Oakland.[73]

While a good start, these efforts must be accelerated for existing homes to meet local climate goals (e.g., carbon neutrality, all-electric buildings combined with capped and/or decommissioned natural gas lines[74]) and support the state's goals for achieving carbon neutrality by 2045, reaching 3 million and 7 million all-electric and electric-ready homes (new and existing) statewide by 2030 and 2035, respectively, and installing 6 million heat pumps in homes statewide by 2030. In the Bay Area, the current number of homes relying on natural gas ranges from 20-88 percent depending on the county.[75]

First-in-the-Nation Regulatory Approach

The Bay Area is uniquely positioned to set a precedent for the rest of the nation in the building appliances space with the regulation adopted by the Air District to reduce health-damaging emissions of NOx from these appliances. The rule will prohibit the sale and installation of NOx-emitting appliances for indoor space and water heating in the Bay Area, focusing on replacement upon burnout using a phased approach that begins in 2027. A recent analysis by the Air District found that NOx and particulate matter emissions from home and water heating disproportionately impact communities of color.[76] Implementation of the rule is estimated to avoid up to $890 million per year in health impacts by reducing exposure to NOx and particulate matter.[77] While the purpose of the rule is to reduce NOx emissions, it will also likely deliver important GHG emission reduction co-benefits, as currently the only compliant technologies are electric appliances.[78] As a first-of-its-kind regulation, its success will determine the direction of subsequent regulatory efforts across California and the nation. A critical component to success is ensuring that important market players – such as technology developers, manufacturers and distributors, installers, contractors, and builders – are ready to support and comply with the regulation. Another is addressing concerns related to a potential inequitable burden of the rule on frontline communities. This regulatory approach could serve as a model for the rest of the nation,

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[72] Benefit-Cost Analysis of Targeted Electrification and Gas Decommissioning in California (ethree.com)

[73] https://ecoblock.berkeley.edu/about/

[74] This requirement focuses on all-electric buildings (or all-electric conversions) and the capping and/or decommissioning of all fuel gas plumbing lines by a certain date, which can be called "end of flow." For example, the City of Half Moon Bay adopted an end of flow ordinance in March 2022 focused on end of flow by 2045.

[75] This information is based on a national dataset, NREL's ResStock.

[76] Appendix E: Assessing Ambient Air Quality and Health Impacts from Natural Gas Building Appliances in the Bay Area (https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-6-nitrogen-oxides-emissions-from-natural-gasfired-water-heaters/2021-amendment/documents/20221220_sr_appe_rg09040906-pdf.pdf?rev=f05e1e6f12874600a0382b178b04ab0d), Appendix F: Exposure and Equity Assessment of Natural Gas Appliances in the San Francisco Bay Area (https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-6-nitrogen-oxides-emissions-from-natural-gasfired-water-heaters/2021-amendment/documents/20221220_sr_appf_rg09040906-pdf.pdf?rev=c7a8dc1225b243298e7bd9395a292844)

[77] Infographics – Proposed Amendments to Rules 9-4 and 9-6 (https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-4-nitrogen-oxides-from-fan-type-residential-central-furnaces/2021-amendments/documents/20200313_infographics_rules0904and0906-pdf.pdf?rev=1dc3359b09e4476087ddea65a5fa1cd0)

[78] The regulation itself is technology neutral, and natural gas-fired zero-NOx appliances may or may not be developed (https://www.baaqmd.gov/rules-and-compliance/rule-development/building-appliances#:~:text=2%2F6%2F2023-,Description%3A,fired%20water%20heaters%20and%20boilers).

once successfully implemented. When combined with the state of California's aggressive building decarbonization goals, policies, and regulatory direction, it is already sending strong market signals to appliance manufacturers, building developers, contractors, and building- and homeowners.

Key Barriers and Gaps

The aforementioned efforts across the Bay Area region have illuminated key barriers and gaps to rapid and equitable home decarbonization. This PCAP measure addresses several near-term critical barriers and gaps to create a more holistic approach for residential buildings that can be replicated elsewhere. This includes addressing:

- Possible cost barriers, such as incremental up-front costs of electric appliances as well as potential related infrastructure costs (e.g., panel upgrades, etc.)
- Significant levels of deferred maintenance and health and safety concerns that often hinder or significantly delay energy efficiency and electrification retrofits, especially in low-income housing[79]
- Inadequate number of trained and/or certified contractors, including from frontline communities
- Dynamics in the rental housing market that may deter participation in retrofit programs, including split incentives, fear of displacement (on the part of tenants), and fear of code enforcement for past violations and risk of additional costs to address newly discovered remediation needs (on the part of building owners)
- Lack of up-to-date data on costs and limited appliance model availability for specific use-cases (e.g., small space constraints)

PRIORITY GHG REDUCTION MEASURE: HOLISTIC BUILDING DECARBONIZATION FOR CLEAN, HEALTHY, AND SECURE HOUSING

The over-arching goal of this measure is to speed the transition away from residential natural gas use to healthy and zero-emission housing. This measure will accelerate electrification and energy efficiency retrofits in existing homes, prioritizing homes located in frontline communities, to achieve an equitable transition to clean, healthy, and secure housing.[80]

A program or programs to implement this measure should include:

Retrofits through Incentives and Direct Installations

- Retrofit homes to use electricity instead of natural gas, with a focus on exploring how to aggregate residential projects for economies of scale and strategic targeting (e.g.,

[79] Health and safety issues (such as mold, moisture, asbestos, etc.), structural issues, code violations, or other major issues may lead to homes being deferred from low-income energy upgrade services (like the federal Weatherization Assistance Program (WAP) and utility energy incentives programs) until issues are addressed (or remediated), especially if the total remediation cost exceeds the amount allocated for remediation in the program budget. In addition, most large decarbonization projects require permits and inspections for code compliance. For more information, see: https://policycommons.net/artifacts/2683765/income-qualified-program-innovations-to-reduce-deferral-rates/3706414/, https://buildingdecarb.org/wp-content/uploads/home_decarbonization_8.14.23.pdf, BEI-Berkeley_Residential+Funding+Gap+Analysis_Feb+2023.pdf (squarespace.com)

[80] This measure first and foremost seeks to benefit and serve frontline communities. Recent efforts focused on retrofitting low-income households who had high exposure to air pollution met unexpected hurdles which necessitated flexibility in approach to meet the goals of the effort. This language reflects the need to preserve flexibility while focusing on these communities for implementation of the measure.

neighborhoods with similar small multifamily buildings, in locations that PG&E has identified as most ready for neighborhood-scale electrification)[81]

- Build upon and augment programs that upgrade residential properties to address deferred maintenance and health and safety concerns (such as lead, asbestos, mold, etc.) to increase the amount of updated housing units in frontline communities ready for decarbonization; this issue is a critical concern raised by frontline communities that diminishes living conditions and one that must be corrected before energy efficiency and electrification retrofits can proceed[82]
- Implement efficiency measures for building envelopes and heating distribution systems, along with demand response, load shifting, and resident education measures (such as smart thermostats and enrolling households in load flex programs) to help save money on bills, reduce the size and cost of the retrofits, and lay the groundwork for future virtual power plants[83]
- Stack (or layer) new rebates, incentives, and financing for electrification, health and safety, and energy efficiency retrofits with existing federal, state, and local rebates, incentives, and financing in a user-friendly way to make retrofits affordable for low-income families, affordable housing owners, and non-profit housing developers who acquire and retrofit older housing
- Incorporate EV charging-readiness and measures to increase energy resilience, such as distributed solar and storage, where strategic and feasible
- Provide incentives to reclaim and recycle refrigerants from heat pump water and space heaters and other appliances using refrigerants at end of life to prevent emissions of these high global-warming-potential gases

Community Work Group

- Establish a group that includes CBOs, community members, and other partners to advise on and participate in implementation so that frontline community members' needs are prioritized

Workforce Development and Contractor Support

- Partner with and augment local workforce training programs for electricians, plumbers, and other decarbonization-related roles, particularly those that target workers from frontline communities, formerly incarcerated people, and people with other barriers to employment
- Seek to develop and implement regionally consistent workforce standards for retrofit projects to increase the number of family-sustaining/high-quality jobs
- Provide streamlined contractor support (e.g., increase awareness of and access to incentives, improve communication tools with customers)

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[81] Aggregating projects has the potential to reduce per-unit cost through price negotiations with installers and suppliers. It might also help lower barriers to future neighborhood-scale electrification along a common section of a natural gas line.

[82] See footnote 79. Given limited budgets for health and safety remediation in many programs, other funding is often leveraged to close the funding gap to complete the necessary upgrades. For more information, see https://www.mwalliance.org/sites/default/files/meea-research/deferrals_aceee_paper.pdf

[83] A virtual power plant (VPP) is made of hundreds to thousands of households and businesses that together have the potential to support the electric grid, through their thermostats, batteries, appliances (heat pumps, HVAC equipment, other appliances), EVs and chargers, and solar arrays. When these small-scale energy-resources are aggregated and coordinated with grid operators, they support grid reliability (and provide compensation for this service to households and businesses). VPPs can also lessen the need (and associated costs) for new energy resources and infrastructure. Source: https://rmi.org/clean-energy-101-virtual-power-plants/.

Housing Security and Policy Support

- Identify and implement housing security and anti-displacement best practices for retrofits and health and safety upgrades, with policy support from regional agencies, and best practices to engage and encourage rental property owners' participation in retrofits
- Provide policy support to local governments and CBOs to address implementation barriers as they emerge

GHG REDUCTIONS

Table 3.4. GHG emissions reductions and retrofits from implementation of the Residential Building Decarbonization measure.

2025-2030 GHG reductions (cumulative)	2025-2030 installations (cumulative)	2025-2050 GHG reductions (cumulative)	2025-2050 installations (cumulative)
~363,000 MT CO_{2e}	~269,000[84]	~7,267,000 MT CO_{2e}	~1,475,000

More detailed information is included in *Appendix C*, including the GHG emissions quantification methodology, GHG reductions by type of installation and year, cumulative installation numbers by installation type, and more.

KEY IMPLEMENTING AGENCIES

Implementation of this measure involves a diverse network of agencies across the region:

- Regional agencies, such as ABAG/BayREN along with eight counties, to lead on coordination, alignment, and overall program management, and the Air District to focus on policy development
- Local governments to assist with recruiting homeowners and property owners, convening multi-partner collaborations, and implementing best practices related to housing security
- Community Based Organizations to assist with engagement and outreach as well as implementation of energy efficiency and electrification upgrades
- CCAs, utilities, and ABAG/BayREN to administer rebates and incentives
- Research institutions and CBOs to partner on research efforts

Several other non-agency organizations may play key roles as well, including non-profit organizations that conduct retrofits, workforce development organizations, and non-profit housing developers.

IMPLEMENTATION SCHEDULE AND MILESTONES

Table 3.5. Implementation schedule and milestones for the Residential Building Decarbonization measure.

Year	Implementation Activity or Targeted Milestone
2024	• Determine program design and how best to leverage existing efforts for retrofits • Launch Community Work Group • Identify workforce training partners

[84] Roughly 54,000 are weatherization and deep envelope measures and 71,000 are efficiency measures like thermostats and lighting. Other types of installations include: a heat pump water heater, air-source heat pump, electric oven or induction stovetop, electric dryer. This number does not equate to total homes retrofit, as some homes may have multiple installations.

	• Begin to engage contractors to understand support needs • Research on rental property owner engagement • Identify best practices for renter protection • Identify and prioritize topics for policy development and adoption
2025	• Launch full program or beta offering for retrofits through incentives and direct installations while continuing research • Develop tool or approach for streamlined contractor support • Begin pilot project to implement landlord engagement research findings • Work with 4-6 cities and retrofit programs to begin implementing renter protection best practices related to residential building decarbonization
2030	• At least 10-20 cities implement renter protection policies related to residential building decarbonization • More than 250,000 installations between 2025-2030 related to residential building electrification and energy efficiency[85]

Achievement of these milestones is contingent upon sufficient funding to implement the measure.

AUTHORITY TO IMPLEMENT

Implementation of this measure involves voluntary actions. No additional authority must be acquired by implementing partners to implement the measure. Below is a list of key existing authorities related to the administration of rebates, incentives, and financing, as well as renter protections.

- ABAG/BayREN has the authority to administer rebates and incentives[86]
- Cities and counties have the authority to implement renter protections in their respective jurisdictions under California law
- CCAs and utilities have the authority to administer rebates and incentives

GEOGRAPHIC SCOPE

The geographic scope of this measure includes Alameda County, Contra Costa County, Marin County, Napa County, City and County of San Francisco, San Mateo County, and the portions of Sonoma County and Solano County that are in the Bay Area air basin, with a priority on frontline communities in those counties.

[85] This number does not equate to total homes retrofit, as some homes may have multiple installations including a heat pump water heater, air-source heat pump, electric oven or induction stovetop, electric dryer, efficiency measures (thermostats and lighting), and weatherization and deep envelope measures.

[86] ABAG is the administrator of BayREN, which is a Regional Energy Network (REN) that was authorized by California Public Utilities Commission D. 12-11-015. CPUC D. 12-11-015 authorized BayREN as a pilot to begin independently administering programs funded through ratepayers without oversight by an Investor-Owned Utility, such as PG&E, for the program year 2013-2014. Subsequent decisions continued to authorize BayREN to administer energy programs, and CPUC D.23-06-55 formalized the RENs as established program administrators, rather than pilots.

METRICS FOR TRACKING PROGRESS

The following metrics will be used to track progress.[87] They may be reassessed periodically with implementation partners based on data availability:

- Reductions in GHG emissions and NOx and $PM_{2.5}$ emissions from retrofits
    - In frontline communities, and in overall region
- Energy costs in low-income households overall and in frontline communities
- Number of retrofits by type (e.g., full electrification, partial, health & safety, energy efficiency)
    - In frontline communities, and in overall region
- Dollars spent on incentives and direct installs
    - In frontline communities, and in overall region
    - Average cost per install by equipment type
- Number of contractors trained to conduct retrofits
    - From frontline communities and areas with high unemployment, and in overall region[88]

INTERSECTION WITH FUNDING

This priority measure complements and potentially expands upon existing programs. The Air District has explored federal and non-federal funding sources to determine whether these sources could fund implementation of the measure and whether such funding is sufficient to fully implement the measure.

Potential Cost to Implement the Measure

The cost estimate for implementing the measure relies on cost per install and program administration data provided by ABAG/BayREN, Bay Area CCAs, and TECH Clean CA[89] when possible, with national average cost per install data filling in data gaps. It does not include the cost to address deferred maintenance or health and safety upgrades. Between 2025-2030, it will cost an estimated $1.4 billion, representing the cost of the appliance or equipment plus the construction or installation costs and enabling upgrades minus two federal incentives and one state incentive.[90] Estimated programmatic costs for 2025-2030 would be $147 million total, which includes program administration, marketing associated with a retrofit program, and the value of regional incentives administered by a regional agency.[91] Notably, this estimate represents the full cost of a retrofit (rather than the incremental cost with replacement upon burnout). The Air District's zero NOx-emitting appliance regulations focus on replacement upon burnout. For more detailed information, see *Appendix C*.

[87] The Air District will report on measure progress in its 2027 Status Report to USEPA.

[88] To the extent feasible, implementing agencies will assess whether these trained contractors are serving frontline communities.

[89] "Installation Costs for Zero-NOx Space and Water Heating Appliances" (forthcoming). Prepared by Rincon Consultants, Inc. for the Air District

[90] The following incentives have been included in the cost estimate: federal incentives (Home Electrification and Appliance Rebates (HEEHRA) and Home Efficiency Rebates (HOMES) Program) and one state incentive (Golden State Rebates). For more information on these incentives, see Appendix C.

[91] Regional incentives may reduce overall customer cost, and increase the program cost for the regional agencies and community choice aggregators (CCAs) who administer them.

Potential Funding Sources

There are several additional federal, state, and regional programs that can be leveraged to help fund this measure.[92] Together they do not fully cover the cost of implementation between 2025-2030.

Table 3.6. Additional federal, state, and regional grant programs to leverage for the Residential Building Decarbonization measure.

Grant Program	Federal, State, or Regional	Total
LIHEAP[93]	Federal – Bipartisan Infrastructure Law	$36 million for FY23-24 *($226 million statewide, assume Bay Area region accounts for 16% of statewide households)*
California Energy Commission's Equitable Building Decarbonization Program[94]	State	$147 million over 4 years from start of program *($639 million statewide, 23% allotted for Northern California (NorCal), assume all NorCal funding goes to Bay Area as a conservative estimate)*
TECH Clean CA - Residential Market Rate HPWH[95]	State	$5 million until expended *($32.7 million statewide, assume Bay Area region accounts for 16% of statewide households)*
TECH Clean CA - Residential Equity HPWH[96]	State	$6 million until expended *($37.9 million statewide, assume Bay Area region accounts for 16% of statewide households)*
TECH Clean CA – Single Family Residential Heat Pump HVAC[97]	State	$2 million until expended *($11.2 million statewide, assume Bay Area region accounts for 15% of statewide single-family households)*
ABAG/BayREN Home+[98]	Regional	$5 million per year
ABAG/BayREN BAMBE[99]	Regional	$5 million per year

[92] Estimates of available funding for California through the federal Weatherization Assistance Program were not readily available online. In addition, CCAs in the region provide local incentives that are not reflected in the table.

[93] https://www.padilla.senate.gov/newsroom/press-releases/padilla-announces-over-226-million-for-california-to-help-households-save-on-home-energy-costs/#:~:text=Senator%20Padilla%20has%20consistently%20advocated,families%20afford%20their%20energy%20bills

[94] https://www.energy.ca.gov/programs-and-topics/programs/equitable-building-decarbonization-program

[95] https://techcleanca.com/

[96] https://techcleanca.com/

[97] https://techcleanca.com/

[98] https://www.bayren.org/how-get-started/single-family-homeowners

[99] https://www.bayren.org/bambe-eligibility

4. Frontline Communities (Low-Income Disadvantaged Communities) Benefits Analysis

Frontline communities in the Bay Area region bear the brunt of the impacts from fossil fuel dependence and are often the first to experience climate impacts. The transition to a zero emissions future must not further harm these communities – and these communities must benefit from the transition through improved quality of life and increased access to opportunity. The priority measures are therefore designed to provide significant benefits and minimize harm to frontline communities, when implemented.

This section identifies each frontline community within the Bay Area region, and describes the Air District and partner's meaningfully engagement of frontline communities during PCAP development, the anticipated benefits or disbenefits of implementation of the measures on these communities, and how the Air District and partners will continue to engage with frontline communities into the future.

IDENTIFICATION OF FRONTLINE COMMUNITIES

The Air District identified frontline communities for the PCAP using several datasets:[100]

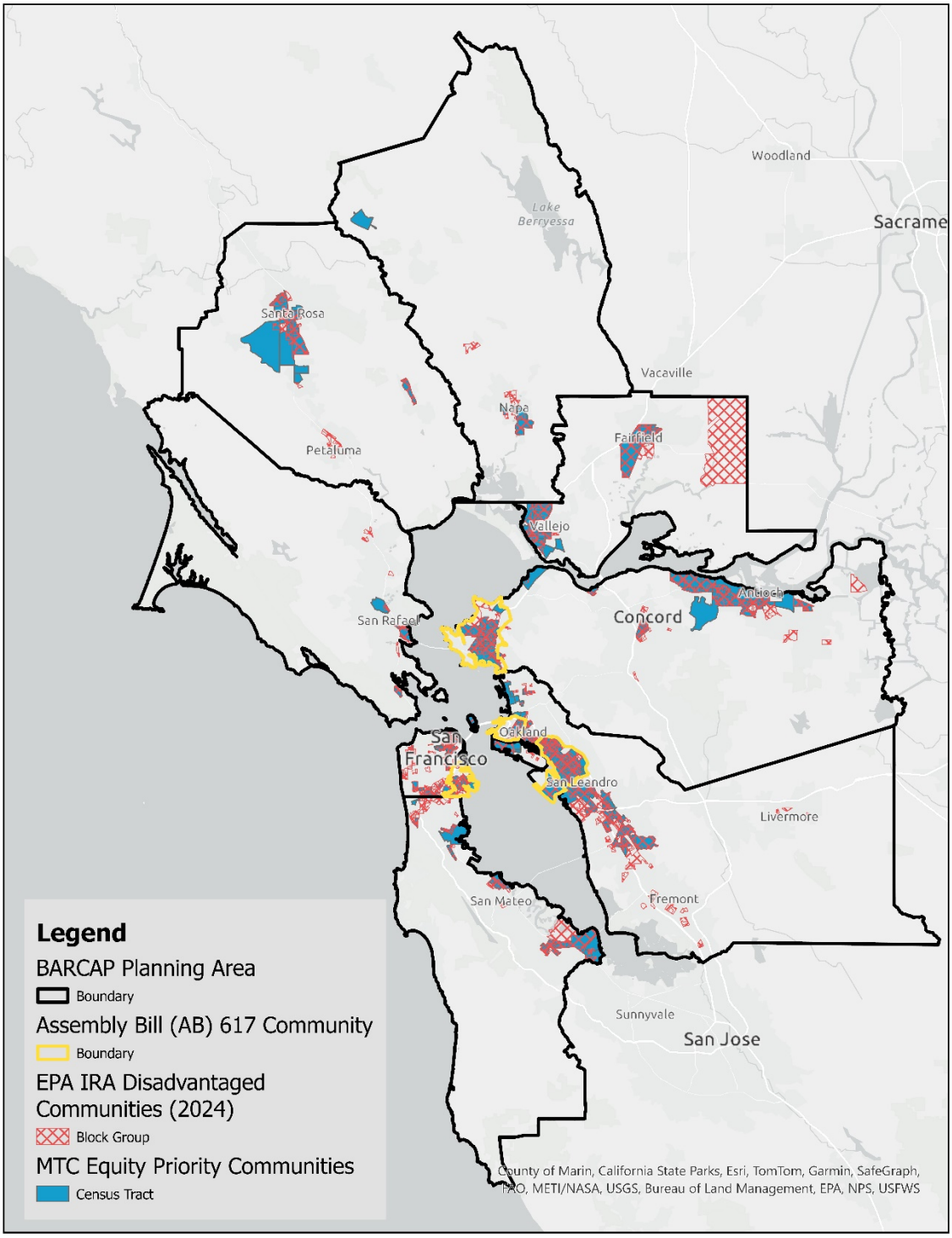
- ***EPA's IRA Disadvantaged Communities***,[101] which include census tracts identified by the federal government's Climate & Economic Justice Screening Tool (CEJST),[102] census block groups at or above the 90th percentile for any EJScreen Supplemental Indices compared to the nation or state, and any geographic area within tribal lands
- ***AB 617 communities***,[103] which are communities spanning multiple census tracts identified by the California Air Resources Board and the Air District as the communities most overburdened by air pollution in the Bay Area
- ***MTC's Equity Priority Communities***,[104] which are census tracts identified by MTC using a combination of factors, such as households with low incomes and people of color, that define these areas as having a significant concentration of underserved populations

These three tools cover many of the frontline communities in the region. The Air District recognizes that USEPA will only consider census tracts and block groups identified using CEJST and EJ Screen as LIDACs in the evaluation of community benefits for the CPRG Implementation Funding Grant applications. However, for the BARCAP planning effort, the Air District and the AWG felt it was important to consider a broader definition to inform measure development, and to ensure the implementation applications benefit locally and regionally identified frontline communities beyond those defined by the USEPA.

The Air District developed an online map to visually depict these layers across the Bay Area region.

[100] These datasets are compliant with federal non-discrimination statutes.
[101] https://ejscreen.epa.gov/mapper/
[102] https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5
[103] https://www.baaqmd.gov/community-health/community-health-protection-program
[104] https://mtc.ca.gov/planning/transportation/access-equity-mobility/equity-priority-communities

Figure 4.1. Map of Frontline Communities in the Bay Area Region



Appendix F includes a list of census tracts and block groups that are considered frontline communities for this planning effort. The priority measures cover and aim to provide benefit to these census tracts and block groups.

CLIMATE RISKS TO FRONTLINE COMMUNITIES

In addition to disproportionate exposure to air pollution and other environmental hazards, frontline communities face exposure to several climate-related hazards. The region faces moderate to very high climate risks of inland flooding due to high-precipitation events (and associated landslides), coastal flooding from sea level rise, extreme heat and heat waves, wildfire, and drought.[105] Nearly every community and system is impacted. Much of the region's transportation infrastructure is located along the San Francisco Bay where flooding is a major risk. Increased air pollution from extreme heat and wildfires threatens public health. Urban heat islands and a lack of air conditioning in much of the region exacerbate these conditions, especially for low-income communities.[106] Due to limited affordable housing in the core of the region, many households are moving further south, north, and inland, where building energy demand is often higher.

Frontline communities often experience these climate impacts first – and worst – and have fewer resources to withstand and recover from them due to decades of disinvestment and discriminatory policies.[107] [108] [109] For example, they are more likely to work and live in locations affected by extreme heat and face exposure to industrial pollutants when rising sea levels impact water tables at contaminated sites.[110] Exposure to climate hazards in frontline communities can result in property damage or loss causing displacement, increased financial precarity, exacerbated physical and mental health conditions, and lost labor hours, among other negative effects. These impacts can be lessened through economic development and increased financial resources, improved public health, and strengthened social structures to support the most vulnerable frontline communities in the region.[111] The PCAP measures seek to strengthen these communities' resilience to climate impacts in several crucial ways.

ENGAGEMENT OF FRONTLINE COMMUNITIES

The Air District followed a multi-pronged engagement approach to ensure that PCAP development was shaped and informed by the priorities of frontline communities in the Bay Area region. In implementing the engagement plan, the Air District first learned from recently completed engagement efforts. Then the Air District conducted targeted engagement of regional community-serving organizations and CBOs through a Roundtable of community-serving organizations, partner-led meetings, and a series of Working Sessions.

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[105] BARCMapping_v1_20231018_72dpi.pdf (ca.gov); San Francisco Bay Area Region Report (ca.gov)

[106] San Francisco Bay Area Region Report (ca.gov)

[107] https://greenlining.org/work/climate-equity/climate-resilience-and-mitigation/

[108] Socioeconomic characteristics that can be used to identify increased vulnerability to hazards include: income (very low income), vehicle access (without a vehicle), people with disability, age (under 5yo and older adults), race and ethnicity (communities of color, limited English proficiency), housing security (renters, severely housing cost burdened), as well as single parent households, people without a high school degree, those who are not US citizens, pre-existing health status, and a lack of access to information and services. (Adapting to Rising Tides Bay Area: Regional Vulnerable Communities Section and Communities and Housing « Adapting to Rising Tides)

[109] Several tools have been developed to highlight the resulting differential vulnerabilities of these communities, which are highly variable across the Bay Area region depending on location. These tools include the San Francisco Bay Conservation and Development Commission's Community Vulnerability Index, the National Risk Index (FEMA) and a Vulnerable Communities Platform currently under development by the Governor's Office of Planning and Research in collaboration with the Asian Pacific Environmental Network, the Greenlining Institute, and other organizations.

[110] BARCMapping_v1_20231018_72dpi.pdf (ca.gov)

[111] https://greenlining.org/work/climate-equity/climate-resilience-and-mitigation/

PRIORITIES FROM COMMUNITY ENGAGEMENT SYNTHESIS

When engaging communities in the Bay Area region, the Air District follows a meaningful and thoughtful process,[112] which is best practice in the Bay Area. The expedited PCAP timeline did not provide sufficient time for new community-informed and community-driven engagement necessary to ensure equitable outcomes. Many local governments and regional agencies have conducted robust and meaningful engagement to inform development of their climate actions plans, transportation plan, and related efforts. Rather than launch a brand-new engagement effort, the Air District opted to leverage these recent community engagement efforts.[113] The Air District synthesized the results of recently conducted, meaningful community engagement activities as described in documents provided by local governments in the Bay Area region, with a particular focus on results received from cities with frontline communities, and county and regional agency efforts focused on these communities. The synthesis culminated in a summary of findings about community priorities and concerns of the Bay Area region's frontline communities overall and with respect to the two identified sectors for the PCAP: residential building electrification and transportation mode shift. The process benefited from focused community engagement that had already been conducted related to these topic areas. A Roundtable of regional community-serving organizations added to the synthesis based on their knowledge and expertise from working with communities regionally in these two sectors. Needs and priorities of frontline communities identified through this process were critical to the development of the PCAP measures. More information on this process is available in *Appendix B*.

ROUNDTABLE

The Air District established a Roundtable of external advisors from regional and local community-serving organizations in the Bay Area region to review, discuss, add to, and overall improve the synthesis of community engagement efforts. The synthesis, compiled by Air District staff, was derived from documents generated through local government community planning processes. The Roundtable members contributed their insights into community needs and expertise in the topic areas to evaluate and contribute to the draft synthesis. They bring an in-depth understanding of Bay Area frontline communities and possess significant expertise in climate equity issues, particularly related to the two PCAP measure areas of residential building decarbonization and transportation mode shift. The members of the Roundtable are:

- Aminah Luqman, Oakland Program Manager, Capacity Building, The Greenlining Institute
- Antonio Diaz, Coordinating Director, PODER
- Megan Leary, Community Engagement and Policy Manager, Emerald Cities Bay Area Collaborative San Francisco Bay Area
- Zack Deutsch-Gross, Policy Director, TransForm

[112] The Air District is known for its decades-long relationship and partnership with the environmental justice organization West Oakland EIP. Through the experience gained from that partnership, the Air District knows well the importance of honoring environmental justice principle number 7 (www.ejnet.org/ej/principles.pdf) while working with the community. That principle demands that the community participates fully and as equal partners at every level of decision-making when working on a project or plan. That principle is followed currently as we develop the AB 617 emission reduction plans with the Bayview Hunters Point SF and East Oakland communities.

[113] This approach intended to obtain a preliminary understanding of what the Bay Area region's frontline communities have already voiced about their priorities and concerns, both generally and in response to climate action measures. This approach not only saved time, but it also protected the many crucial relationships between local governments and regional agencies and frontline communities in the region from harmful impacts of a rushed and potentially ill-informed new engagement process, preventing meeting fatigue and frustration stemming from frequent repetition of the same questions. It allows for strategically building upon thoughtful community-driven engagement in the region while allowing room for deeper public engagement for the CCAP.

A professional facilitator was contracted to help the Air District coordinate and to facilitate meetings with the Roundtable. The Roundtable met all together twice in October 2023 and a third time in individual meetings (due to scheduling challenges) in December 2023, with work on the synthesis document continuing in between meetings. The work of the Roundtable included: reviewing and refining draft design principles to guide PCAP measure development; discussing the draft community engagement synthesis document and developing implementation priorities to incorporate into the document; and prioritizing specific community benefits and disbenefits identified in the synthesis document to inform the frontline communities benefits analysis.

Three Roundtable members participated in a series of four Working Sessions with other critical stakeholders to design the PCAP measures during October – December 2023. (More information on the Working Sessions can be found in *Section 6* and *Appendix B*.)

OTHER ENGAGEMENT EFFORTS

Additionally, the Air District engaged representatives of frontline communities during development of the PCAP in the following ways:

- ***Working Sessions:*** The Air District and AWG members invited CBOs who work closely with frontline communities in the Bay Area region to attend a series of four Working Sessions to develop the PCAP measures. (For more information on the Working Sessions, see *Section 6*.) CBOs were offered stipends to support their participation. In advance of the Working Sessions, the Air District held a background webinar to share information on the CPRG grant, the BARCAP process and the Notice of Funding Opportunity, how the measure focus areas were selected, and the intent and structure of the Working Sessions. The Air District also hosted an information session specifically for CBOs to answer any questions they had before participating in the Working Sessions.
- ***CCA meetings with community partners:*** The Air District presented on the BARCAP to the MCE Community Power Coalition[114] – a network of social, racial, and environmental justice organizations – in June 2023, and to a meeting of Peninsula Clean Energy and its community partners in September 2023.
- ***Online resources:*** The Air District developed a webpage[115] on its agency website to share information about the planning effort and post materials from public meetings, like the background webinar and public workshop.
- ***Direct email:*** The Air District also established an email listserv for updates on the planning effort and an email account (climate@baaqmd.gov) for the public, including frontline community members, to send comments and suggestions.

See *Appendix B* and *Section 6: Coordination and Outreach* for more details on the engagement plan and a record of outreach activities.

[114] https://www.mcecleanenergy.org/energy-equity/#communitypower

[115] Bay Area Regional Climate Action Planning Initiative (baaqmd.gov)

IMPACT OF PCAP IMPLEMENTATION ON FRONTLINE COMMUNITIES

The anticipated benefits and potential disbenefits for frontline communities associated with implementation of the priority measures are summarized in this section. More detailed information is available in *Appendix D*.[116]

ANTICIPATED BENEFITS AND DISBENEFITS OF SAFE, ACCESSIBLE, CLEAN, AND EQUITABLE MULTI-MODAL TRANSPORTATION

The anticipated benefits from implementation of the measure include:

Table 4.1 Anticipated benefits from implementation of the Mobility Hubs measure.

Improved Public and Community Health	• Reduced use of passenger vehicles decreases traffic-related air pollution. • Potential physical health benefits of hubs that focus on active transportation alternatives like walking and biking, which encourage people to exercise as part of their daily routine and avoid the stress of traffic. • Safety improvements can help address fatalities and severe injuries, particularly in high-fatality or high-injury sections of bike/ped infrastructure.
Increased Transportation Access and Affordability	• Increased multi-modal connectivity results in increased use of transportation alternatives, with enhanced accessibility and the promotion of sustainable and healthier commuting habits. Increased access to diverse mobility options can help reduce barriers to accessing employment, educational opportunities, health care, and other key services and amenities. • Public transportation and active transportation offer a more affordable mode of transport for low-income households than vehicle ownership. • Discounted fare programs and discounted bike share passes for low-income and underserved populations and e-bike incentives can help keep transportation costs low for these communities.
Job Creation and Workforce Development	• Mobility hubs have the potential to produce and sustain high-road jobs and improve access to employment opportunities.
Climate Resilience Co-Benefits	• Urban greening along pedestrian, bicycle, and transit infrastructure can help shade surfaces and reduce travelers' discomfort and risk of heat illness during periods of extreme heat. It can also reduce risk to infrastructure of flooding during heavy rains.[117]

[116] The list of benefits and disbenefits is drawn from the list provided by the USEPA in their CPRG guidance document, with additions from priorities identified in the community engagement synthesis and Roundtable input. The synthesis and Roundtable provided the Air District with a deeper understanding of how the measures might impact frontline communities. The Air District, AWG members, and Working Session participants brought additional perspectives. A consultant conducted a qualitative analysis of the measures and identified key literature. Results of the qualitative analysis are provided in *Appendix D.*

[117] https://nacto.org/publication/urban-street-stormwater-guide/streets-are-ecosystems/complete-streets-green-streets/, https://www.c40knowledgehub.org/s/article/Reducing-climate-change-impacts-on-walking-and-cycling?language=en_US

Community Engagement, Awareness, and Capacity	• A community-informed approach can help build awareness and interest in mobility hubs and identify major challenges and opportunities.[118] Involving residents in the design process, understanding affordability implications of development in a neighborhood, and advocating for the needs of long-time, low-income residents are important to avoid displacement and champion community interests and support.[119] • Mobility hubs will include a variety of components to meet the needs of the community (determined through engagement with CBOs and participatory community processes). • Community outreach and education efforts will engage CBOs to encourage a shift away from single occupancy vehicles to other mobility options.

Implementation of the measure is designed to minimize potential disbenefits:

Table 4.2. Potential disbenefits that implementation of the Mobility Hubs measure is designed to minimize.

Potential Increased Housing Insecurity	• Potential transit-induced gentrification may lead to displacement of low-income populations that are likely to benefit most from transit access. Proximity to bike infrastructure is linked to higher property values, although the research is not conclusive.[120] Urban greening strategies tend to increase property values and may contribute to gentrification and displacement.[121] Implementation of the measure incorporates policies that produce, preserve, and protect affordable housing and stabilize businesses to prevent displacement and help increase housing security.
Increased Transportation Costs	• Fare integration, infrastructure updates, and operational adjustments may result in increased transit costs in the short-term, with expected long-term savings. Implementation of the measure includes discounted fare programs and discounted bike share passes for low-income and underserved populations.
Increased Safety Risks	• As the number of walkers and cyclists increases on or adjacent to a communities' roads, exposure to vehicles and potential fatalities and severe injuries may increase as well, if the infrastructure is not designed appropriately. Implementation of the measure includes safety improvements.

[118] https://octa.net/pdf/MobilityHubsStudyFinalReport.pdf

[119] https://housingmatters.urban.org/articles/how-transit-oriented-housing-can-advance-access-opportunity-while-curbing-climate-change#:~:text=When%20done%20thoughtfully%2C%20TOD%20could,the%20effects%20of%20climate%20change

[120] https://www.sparcchub.org/wp-content/uploads/2020/04/Climate-and-Displacement-Lit-Review-6.19.2020.pdf

[121] https://www.sparcchub.org/wp-content/uploads/2020/04/Climate-and-Displacement-Lit-Review-6.19.2020.pdf, https://doi.org/10.1016/j.landurbplan.2014.01.017

ANTICIPATED BENEFITS AND DISBENEFITS OF HOLISTIC BUILDING DECARBONIZATION FOR CLEAN, HEALTHY, AND SECURE HOUSING

The anticipated benefits from implementation of the measure include:

Table 4.3. Anticipated benefits from implementation of the Residential Building Decarbonization measure.

Improved Public and Community Health	• Electrification of appliances in homes can result in local indoor air quality improvements[122] and outdoor air quality improvements.[123] Unhealthy levels of air pollution have been linked with disease or damage to the lungs in the form of asthma, bronchitis, and emphysema. There is increasing evidence that air pollution contributes to heart attacks, strokes, diabetes, and dementia.[124] • Building envelope improvements can increase indoor air quality;[125] energy efficiency retrofits can protect against wildfire smoke[126] and other outdoor air pollution. Frontline communities regularly experience disproportionate air pollution exposure. • There are expected health benefits from addressing residential health and safety concerns such as lead, mold, and asbestos.
Better Housing Quality and Security	• Health and safety upgrades reduce exposure to unhealthy living conditions, such as mold and moisture, lead, asbestos, and structural deficiencies in homes. Frontline communities regularly experience poor housing quality. • The identification and implementation of housing security and anti-displacement best practices for retrofits and health and safety upgrades can help renters stay in their homes, while the identification and implementation of best practices to engage and encourage rental property owners' to retrofit buildings can help increase the quality of rental housing.
Decreased Energy Cost Burden and/or Increased Energy Security	• Energy efficiency retrofits reduce energy demand and utility bills. • Incentives, rebates, and direct installs focused on homes in frontline communities will reduce the cost of electrification retrofits in these communities. • Transition to electricity can help insulate frontline communities from anticipated gas price increases as more households in the region transition to electricity, leaving fewer customers to cover the fixed costs of the natural gas system.[127]

[122] https://doi.org/10.1088/1748-9326/ad08f8, https://doi.org/10.1016/j.scs.2022.1041282

[123] Appendix F: Exposure and Equity Assessment of Natural Gas Appliances in the San Francisco Bay Area (https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-6-nitrogen-oxides-emissions-from-natural-gasfired-water-heaters/2021-amendment/documents/20221220_sr_appf_rg09040906-pdf.pdf?rev=c7a8dc1225b243298e7bd9395a292844)

[124] https://www.baaqmd.gov/community-health/air-pollution-and-community-health

[125] https://doi.org/10.2172/1998661

[126] https://escholarship.org/uc/item/6dn8w9t2

[127] Impact of Electrification and Decarbonization on Gas Distribution Costs; American Council for an Energy Efficient Economy, June 2023

Job Creation and Workforce Development	• Pursuing residential energy efficiency and electrification upgrades will result in jobs in occupations such as HVAC mechanics and installers, plumbers, electricians, and general residential construction and modeling (including new jobs). • Participation of residents in frontline communities in workforce development programs will help ensure these communities benefit from job creation. The inclusion of workforce standards can help increase the number of high-quality jobs.
Climate Resilience Co-Benefits	• Energy efficiency retrofits can protect against wildfire smoke; electric heat pump installation can increase comfort and safety in homes during heat events by providing cooling that is typically not present in older homes along the California coast.[128] • Retrofits such as distributed solar and storage, where strategic and feasible, can help residents stay in their homes during power outages.
Community Engagement, Awareness, and Capacity	• Equitable and inclusive planning and decision-making can help address historic underinvestment and result in community-informed solutions. • A Community Work Group will advise on and participate in implementation of the measure to ensure frontline communities' needs are prioritized. • Implementation will include policy support to local governments and CBOs to address barriers as they emerge.

Implementation of the measure is designed to minimize potential disbenefits:

Table 4.4. Potential disbenefits that implementation of the Residential Building Decarbonization measure is designed to minimize.

Potential Increased Housing Insecurity	• Rental property owners may pass-through costs to retrofit their properties to renters, thereby increasing their rents. Rental property owners may use construction projects to displace residents or evict tenants due to long remodels. Implementation of the measure incorporates implementing housing security and anti-displacement best practices for retrofits.
Increased Energy Costs and Energy Insecurity	• Electrification upgrades can be expensive while an increased reliance on electricity may result in greater energy costs. Reduced electricity rates for homes that electrify[129] and energy efficiency retrofits that reduce energy demand can help address potential energy bill increases. Incentives, rebates, and direct install programs focused on frontline communities will reduce the cost of electrification retrofits and are included in implementation of the measure, along with energy efficiency retrofits. • Increased reliance on electricity may result in greater energy insecurity, including during power outages. Retrofits to improve energy resilience (e.g., distributed solar and storage) can increase energy security.
Unanticipated Health Impacts	• Poor-quality energy efficiency retrofits can worsen indoor air quality by trapping indoor air pollutants in the building, increasing health risks

[128] https://escholarship.org/uc/item/6dn8w9t2

[129] This is beyond the scope of this measure. PG&E has an electric rate home plan (E-ELEC) for ratepayers who have begun to electrify their homes with one of the following: electric vehicles, battery storage, electric heat pump for water heating or space heating or cooling (https://www.pge.com/en/account/rate-plans/find-your-best-rate-plan/electric-home.html)

	particularly for residents who have previously received poorer healthcare services and have lived in historically redlined neighborhoods.[130] Pairing building envelope measures with upgraded HVAC and/or electrification and using trained contractors can help address this issue; these practices are included in implementation of the measure.

ENGAGEMENT OF CBOS DURING IMPLEMENTATION

Community-based organizations will play key roles during implementation of the PCAP measures to ensure that frontline community members' needs are prioritized. Key agencies will determine the scope and design of mobility hubs through engagement with CBOs and participatory community processes. Community-based organizations will also participate in outreach and education efforts in frontline communities to encourage the shift from single occupancy vehicle trips to active and low-carbon or zero-carbon mobility options. A Community Work Group that includes CBOs, community members, and other partners will be established to advise on and participate in implementation of the Residential Building Decarbonization measure.

[130] https://doi.org/10.7930/NCA5.2023.CH12

5. Workforce Planning Analysis

The PCAP measures are designed to help create additional good, high-quality jobs in the growing residential building decarbonization and clean mobility sectors that can be filled by residents in the Bay Area region. These jobs are also referred to as "high-quality" jobs, or jobs that are family-sustaining and provide living wages, comprehensive benefits, and opportunity for career advancement.[131]

This section provides an overview of the most in-demand occupations for implementing the measures; a brief summary of potential skilled labor shortages; a high-level discussion of opportunities to create high-quality jobs and expand economic opportunities to frontline communities and underserved workers; and several workforce development strategies to support implementation. For a more detailed workforce planning analysis, see *Appendix E*.

Based on a review of the literature and interviews, the following five occupations are crucial to the successful deployment of the priority measures and are at high risk of potential supply shortages:[132]

- **Electricians** install, maintain, and repair electrical wiring, equipment, and fixtures. *(Residential Building Decarbonization, Mobility Hubs)*
- **Heating, Air Conditioning, and Refrigeration (HVAC/R) Mechanics and Installers** install or repair heating, central air conditioning, HVAC, or refrigeration systems, including heat pumps for space heating and hot-air furnaces. *(Residential Building Decarbonization)*
- **Plumbers and Pipefitters** assemble, install, alter, and repair pipelines or pipe systems that carry water, steam, air, or other liquids or gases. *(Residential Building Decarbonization)*
- **Construction Laborers** perform tasks involving physical labor at construction sites. *(Mobility Hubs)*
- **Carpenters** construct, erect, install, or repair structures and fixtures made of wood and comparable materials, such as concrete forms; building frameworks, including partitions, joists, studding, and rafters; and wood stairways, window and door frames, and hardwood floors. *(Mobility Hubs)*

POTENTIAL FOR SKILLED LABOR SHORTAGES

In Fall 2023, the number of residents employed in Bay Area region in these critical occupations was roughly:[133]

- Electricians: 13,400
- Plumbers, Pipefitters, and Steamfitters: 8,000
- HVAC/R Mechanics and Installers: 6,700
- Carpenters: 21,300
- Construction Laborers: 21,500

[131] https://www.usdn.org/uploads/cms/documents/workforce-guide_4.12.21_form.pdf

[132] This is based on a review of the literature and interviews with building decarbonization and transportation experts ("CALIFORNIA BUILDING DECARBONIZATION WORKFORCE NEEDS AND RECOMMENDATIONS." 2019 UCLA and Inclusive Economics. https://innovation.luskin.ucla.edu/california-building-decarbonization/; "Evaluating Benefits from Transportation Investments Aligned with the Climate Action Plan for Transportation Infrastructure (CAPTI)" 2023 San Jose State University and Mineta Transportation Institute. https://transweb.sjsu.edu/research/2227-California-Climate-Action-Plan-Transportation-Infrastructure)

[133] Data from JobsEQ. 2023Q4

When compared to the rest of the country, these occupations make up a smaller share of the total Bay Area workforce, except for carpenters, which have a higher concentration in the Bay Area than nationally. At the same time, a 2021 analysis of the job potential from full electrification and deep efficiency retrofits of Bay Area homes projected 13,490 – 20,740 full-time workers.[134] This estimated increase in jobs is greater than that projected for mobility hubs, however the need remains for training and career pathway entry points for workers under both types of activities.

There will be additional workforce demands for these same priority occupations for housing construction and other infrastructure projects beyond the scope of the measures. This will require increased coordination and planning across industries and the workforce ecosystem.

OPPORTUNITIES FOR CREATION OF HIGH-QUALITY JOBS

Growing demand for these occupations provide a significant opportunity overall to create and maintain high-quality jobs[135] throughout the Bay Area since they are associated with good wages,[136] benefits, and access to training pathways.

One key consideration within residential building electrification work is the greater likelihood of generating lower-quality opportunities with residential and small commercial construction firms (versus high-quality jobs more commonly found in large commercial and utility sectors.)[137][138] Given the building decarbonization measure focuses on residential and small multi-family homes, there is a risk of creating lower-quality jobs.

Strategies outlined in *Appendix E* aim to help new workers, existing workers, and workers in adjacent fields have access to high-quality jobs through activities to implement the measures. Meeting all requirements of the most ambitiously defined high-quality job may take time and there are many immediate and short-term steps that can boost the quality of local jobs. These range from establishing labor standards and wage requirements to monitoring and enforcing workplaces to ensure worker safety

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[134] "San Francisco Bay Area Residential Building Decarbonization Estimates" Inclusive Economics

[135] The Department of Labor defines "good jobs" through a set of principles that are summarized as: 1) Recruitment and Hiring – applicants are recruited from all communities, and evaluated free of discrimination, based on skill-based requirements, 2) Benefits – workers are provided and encouraged to use family-sustaining benefits such as health insurance, a retirement plan, and work-family benefits, 3) Diversity, Equity, Inclusion, and Accessibility – all workers have equal opportunity in a workplace that centers DEIA, 4) Empowerment and Representation - workers can form and join unions and have agency in the performance and direction of their work, 5) Job Security and Working Conditions – workers operate in a safe workplace, with job security and predictability, and proper classification of their status, 6) Organizational Culture – workers are valued and engage in respected work, 7) Pay – workers are fairly paid a living wage that increases with increased skills and experience, and 8) Skills and Career Advancement – workers have equitable opportunities to advance and access to training and education. These principles are mirrored in the categories that the California High Road Training Partnership (CA HRTP) proposes as comprising job quality. They include: 1) Family-sustaining wages and benefits that include health care, pension, paid sick leave, 2) Career pathways that are clearly defined and include access to education, training and support services, 3) Stable and predictable schedules that are reliable and consistent, 4) Worker voice and agency that includes respecting and valuing the worker and the right to organize and join unions, and 5) Healthy work environment with adequate training and protection, that incorporates racial equity practices.

[136] The median hourly wage for all but one of these occupations (construction laborers) offers a living wage for single adults with no dependents as well as family-sustaining wages for households with two working parents. The 25th percentile wage for electricians, HVAC/R mechanics and installers, plumbers, pipefitters, and steamfitters, and carpenters is a living wage for single adults with no dependent and family-sustaining wages for households with two working parents and one child.

[137] "CALIFORNIA BUILDING DECARBONIZATION WORKFORCE NEEDS AND RECOMMENDATIONS." 2019 UCLA and Inclusive Economics

[138] Current market dynamics within residential building decarbonization often favor lowest-bid contracting, which can make it challenging for high-road contractors to operate within the existing market.

and health and establishing clear career development opportunities. Roundtable members who participated in the development of the PCAP measures identified the establishment of workforce standards as an implementation priority (for a description of the Roundtable see *Section 4*).

Several stakeholders during the Working Sessions mentioned the potential tension between maximizing residential building decarbonization efforts while ensuring job quality and equity in accessing opportunities. Specifically, should cost efficiencies not sufficiently offset additional project costs from high-quality labor standards, the uptake of residential building decarbonization may occur at a slower rate—or may require greater public investment to subsidize. Conversely, stronger workforce standards may produce barriers to participation in the market by minority, women, and disadvantaged business enterprises that may lack the administrative capacity or profit margin to meet such standards. These challenges should be considered in implementation of the PCAP measures.

EXPANDING ECONOMIC OPPORTUNITY TO FRONTLINE COMMUNITIES AND HISTORICALLY EXCLUDED WORKERS

Just under a third of the region's working age population lives within frontline communities. These communities faced higher unemployment rates in 2022 (6.5% compared to 4.8% in non-frontline areas) and lower median household incomes (non-frontline communities' household income was 78% higher than in their frontline counterparts).[139] Other populations of historically excluded workers include formerly incarcerated people and people with other barriers to employment. Some job seekers from within these communities may require additional resources and supports—such as transportation, housing, childcare, and other assistance—during any unpaid training to help prevent life circumstances from precluding these job seekers from completing their training and entering a new career.

The PCAP measures support projects within frontline communities and benefit from the inclusion of CBOs, which can increase career awareness and accessibility to employment opportunities. By partnering with and augmenting local workforce training programs that target historically excluded workers (including potential partners listed in *Appendix E*), implementation of the PCAP measures aims to support these workers' entry into residential decarbonization and transportation careers, while workforce standards can help ensure these jobs offer living and family-sustaining wages.

WORKFORCE DEVELOPMENT ACTIVITIES

There are already several initiatives in the Bay Area listed in *Appendix E* that are aiming to provide current workers with the training they need and increase the number of on-ramps for new workers (through pre-apprenticeship and apprenticeship programs, and vocational and technical schools). Additional funding and collaboration are needed to scale these efforts to meet the anticipated regional need for high-quality building decarbonization jobs. An array of partners — including utility providers and state, regional, and local governments — are already harnessing federal, state, and local funds to propel workforce development initiatives and projects related to residential building decarbonization and mobility hubs.

As for the measures themselves, the Residential Building Decarbonization measure's inclusion of workforce standards, CBO engagement, and contractor support increases the likelihood that jobs created through implementation of the measure will be high-quality, that communities will participate in identifying core issues and developing solutions, and that existing workers and job seekers from frontline

[139] Community unemployment rate and labor participation rate are calculated as weighted averages using population. Data from US Census Bureau. 2022 Estimates

communities and other historically excluded groups will find greater access to economic opportunity. Partnering with and augmenting local workforce training programs for electricians, HVAC/R mechanics and installers, and plumbers and pipefitters will help close skilled labor gaps.

Research shows that the activities outlined in the Mobility Hub measure are likely to support high job quality[140] that is common throughout the transportation infrastructure construction industry, particularly on large infrastructure projects. Training and career pathway entry points for these occupations will continue to be important to support implementation of the Mobility Hub measure.

[140] "Evaluating Benefits from Transportation Investments Aligned with the Climate Action Plan for Transportation Infrastructure (CAPTI)" 2023 San Jose State University and Mineta Transportation Institute. This is often via prevailing wage contracts with labor signatory contractors or Project Labor Agreements for large construction projects.

6. Coordination and Outreach

Throughout development of the PCAP, the Air District conducted extensive coordination and outreach with other government agencies and engaged a range of stakeholders across the Bay Area region. This section describes the framework the Air District used to support robust and meaningful engagement strategies to ensure strong stakeholder representation and reduce potential barriers to engagement.

IDENTIFICATION OF STAKEHOLDERS

The Air District, with input from AWG members, identified stakeholders who either might participate in or be impacted by implementation of the measures in this PCAP or who are representative of the entities, groups, and individuals with relevant subject matter expertise. Stakeholders included, without limitation:

- Regional agencies, including BARC, ABAG/BayREN, and MTC
- Local government staff (city and county)
- Transportation authorities and transit agencies
- Public health agencies
- Community Choice Aggregators and utilities
- Community-based organizations
- Community-serving organizations
- Climate equity organizations and EJ advocates
- Environmental advocacy organizations
- Non-profit organizations (including subject matter experts)
- Non-profit housing developers
- Non-profit organizations that conduct building retrofits
- Bike and active transportation advocacy organizations
- Workforce training organizations
- Organized labor representatives

In addition, residents from the region and representatives of the following types of organizations participated in Air District outreach efforts:

- Higher education institutions
- Ports
- Real estate developers
- Waste reduction agency

The list of stakeholders who participated in the development of the PCAP is included in *Appendix B*. The Air District will update this list of stakeholders as needed. The complete outreach plan is available in *Appendix B*, including a log of participants in interagency and intergovernmental coordination and stakeholder and public engagement efforts associated with development of this PCAP. Meeting and outreach materials and resources are available at https://www.baaqmd.gov/plans-and-climate/climate-protection/bay-area-regional-climate-action-planning-initiative. For a summary of the engagement of frontline communities, see *Section 4*.

The Air District took the following steps to address potential barriers to participation:

- **Stipends:** The Air District offered stipends to support participation of CBOs in the Working Sessions to develop the PCAP measures, which are described in *Section 4*
- **Virtual meetings**: The Air District and its partners held most engagement and outreach events virtually to accommodate participation from across the Bay Area region. In addition, the public

workshop was held virtually and in the early evening to facilitate participation by stakeholders whose jobs prevented participation during the day

- **Online resources:** The Air District developed a webpage on its agency website to share information about the planning effort and post recordings and materials from public meetings, like the background webinar and public workshop, which are described below. There is also an email listserv that interested stakeholders can subscribe to for updates on the planning effort
- **Direct email:** The Air District provided an email account (climate@baaqmd.gov) as another avenue for the public to send comments and suggestions on the PCAP

INTERAGENCY AND INTERGOVERNMENTAL COORDINATION

ADVISORY WORK GROUP (AWG)

The Air District established the AWG composed of representatives from regional agencies (Air District, ABAG/BayREN, BARC, and MTC), the cities named in the federally-designated MSA (City of Berkeley, City of Oakland, and City and County of San Francisco) and the counties comprising the MSA (Alameda County, Contra Costa County, Marin County, Napa County, San Mateo County, and the portions of Solano County and Sonoma County that are within the Air District's jurisdiction). The Air District coordinated with Santa Clara County, who is leading the San Jose-Sunnyvale-Santa Clara MSA's CPRG planning process.

The AWG met monthly (for a total of 5 meetings) to discuss and make decisions on key aspects of the PCAP including coordination and engagement with other agencies, organizations, and LIDACs, measure selection, and development of deliverables, as well as provision of information and data and advising on technical analyses. Development of the PCAP leveraged ongoing stakeholder engagement efforts by AWG members, with some support from AWG members for targeted engagement as needed. The Air District co-developed the PCAP workplan and a shared communications approach with AWG members to ensure common messaging to local agencies and organizations, frontline communities, and other stakeholders. Members also participated in the measure design Working Sessions, described below.

The members of the Advisory Work Group are:

- Aleka Seville (ABAG/BayREN)
- Allison Brooks (BARC)
- Avana Andrade (San Mateo County)
- Cyndy Comerford (City and County of San Francisco)
- Dana Armanino (Marin County)
- Jamesine Rogers Gibson (Air District)
- Jody London (Contra Costa County)
- Katie van Dyke (City of Berkeley)
- Kim Springer (San Mateo County)
- Miya Kitahara (Alameda County)
- Shayna Hirschfield-Gold (City of Oakland)
- Therese Trivedi (MTC)

Ex-officio members[141] of the Advisory Work Group are:

- Narcisa Untal (Solano County)

[141] Representatives from Solano County, Napa County, and Sonoma County served as ex-officio members to the AWG to encourage coordination of aligned efforts across the region, since these counties were not officially approved by the USEPA for inclusion in the Bay Area region for the PCAP until January 2024.

- Ryan Melendez (Napa County)
- Tanya Nareth (Sonoma County)

LOCAL GOVERNMENTS

The Air District conducted extensive outreach to local governments in the Bay Area region to understand their priorities and implementation-ready projects for the PCAP, to request the results of recent community engagement efforts (as described in *Section 4*), and to further develop the PCAP measures during a series of Working Sessions. In total, over 50 cities, towns, and counties (or nearly 60 percent total regionwide) participated in at least one outreach effort. ABAG has served as a key partner and sub-awardee, primarily through its BayREN program. Specifically, ABAG/BayREN has supported the Air District in co-leading local government outreach and the measure design Working Sessions.

Surveys

The Air District conducted three surveys of local governments between April and July 2023. The first two focused on gathering initial input and interest from local governments about their priority sectors and implementation-ready projects for reducing GHG emissions. The third asked local governments with frontline communities to share findings from recent or ongoing engagement efforts.

County-Led Meetings and Individual Meetings

AWG members invited Air District staff to attend regularly occurring meetings of local governments convened from June – July 2023, including the Contra Costa County Energy Efficiency Collaborative, the Marin Clean Energy Partnership, Regional Climate Action Planning Suite Program (RICAPS) in San Mateo County, and StopWaste Technical Advisory Group in Alameda County. Air District staff presented on the CPRG effort and PCAP development and sought input from attendees.

Air District staff also met with several city and county staff individually during Summer and Fall 2023 to discuss their priorities, potential efforts that they would recommend scaling up and/or replicating regionally, and any input from their recently completed engagement of frontline communities.

Community Choice Aggregators and Utilities

In addition to robust outreach to local governments, the Air District engaged in targeted outreach and engagement with CCAs and the local investor-owned utility, PG&E. Air District staff held numerous one-on-one meetings with different CCAs in the Bay Area and included CCAs in the Working Sessions. Staff presented on BARCAP and the PCAP development process to the following CCA convenings of CBOs in their service territories:

- MCE Community Power Coalition, June 22
- Peninsula Clean Energy Community Partners Meeting, September 14

WORKING SESSIONS

The Air District designed and facilitated four Working Sessions to develop the PCAP measures during October–December 2023, with support from ABAG/BayREN. Invitations were extended to all local governments in the Bay Area region, with AWG members recommending specific non-governmental entities to invite as well. Staff from thirty cities and counties participated alongside other attendees which included AWG members, Roundtable members, CCAs and a utility, CBOs, transportation agencies, subject matter expert organizations for transportation and building decarbonization, multiple representatives from organized labor and workforce training, non-profit housing, non-profit retrofit

organizations, bike, environment, and other stakeholder organizations. In total over 90 stakeholders participated across all four sessions. The list of organizations represented can be found in *Appendix B*.

Sessions met virtually, with one hybrid meeting, and covered the following topics:

- **Working Session 1:** Establish a common understanding of existing programs, gaps and opportunities, and key agencies. Discuss a common vision for the necessary changes so that frontline communities have clean and healthy homes and convenient and safe mobility options. Obtain feedback on draft design principles to guide measure development.
- **Working Session 2:** Agree upon key elements of each measure, including a topic focus and geographic location. Begin to define potential coalitions.
- **Working Session 3:** Share finalized design principles (incorporating feedback from Roundtable). Review and refine initial measure descriptions and geographic locations. Continue to discuss coalitions.
- **Working Session 4:** Discuss final measure details and answer outstanding questions on measure language. Share feedback from the Roundtable. Discuss key implementation questions and share the process moving forward to develop funding proposals. Celebrate work together.

Ahead of the sessions, the Air District convened a background webinar in October 2023 to share information on the CPRG grant, the BARCAP process, and the Notice of Funding Opportunity, how the measure focus areas were selected, and the intent and structure of the Working Sessions. Attendees included AWG members, local government staff, CCAs and utilities, CBOs, community-serving organizations, subject matter expert non-profit organizations, and environmental advocacy groups. Slides and a recording of the webinar are available on the Air District's BARCAP website.[142] Staff also offered to meet with CBOs ahead of the Working Sessions to provide additional background and answer questions.

ADDITIONAL OUTREACH EFFORTS

The Air District held a public workshop in November 2023 for attendees to learn about the BARCAP effort and provide input on draft PCAP measure concepts in an interactive format. The workshop occurred virtually in the early evening. Attendees included local government staff, housing developers, building energy and transportation experts and NGOs, environmental advocacy organizations, the Port of Oakland, and interested individuals. Feedback from the public workshop was incorporated into the Working Sessions described above. The agenda, slides, and recording of the workshop is available here: https://www.baaqmd.gov/plans-and-climate/climate-protection/bay-area-regional-climate-action-planning-initiative

Air District staff also presented on the BARCAP at a public meeting of its Board of Directors' Stationary Source and Climate Impacts Committee on September 13, 2023. There is an additional presentation, to the Board's Policy, Grants, and Technology Committee scheduled for March 20, 2024.

[142] https://www.baaqmd.gov/plans-and-climate/climate-protection/bay-area-regional-climate-action-planning-initiative

7. Next Steps

This PCAP is the first deliverable under the USEPA CPRG planning grant awarded to the Air District. The next deliverable due to USEPA in 2025 is a regional comprehensive climate action plan (CCAP) to reduce GHG emissions across all sectors of the economy. In late spring 2024, the Air District will begin engagement for the CCAP, building upon the foundation of the PCAP through meaningful community engagement. Work with technical and facilitation consultants is already underway in preparation for the CCAP.

The CCAP will lay out the critical regional actions needed to support an equitable transition to a clean energy economy that enhances the quality of life for those living in the northern and central Bay Area. It will continue the work begun during the PCAP to identify areas where regional collaboration and action can accelerate our ability to meet ambitious near- and long-term climate goals. The CCAP will include near- and long-term GHG emissions targets and a suite of emission reduction measures, along with a robust analysis of measure benefits, plans to leverage federal funding, and a workforce planning analysis. It will also continue to elevate and center the priorities of frontline communities in the planning process and build on the extensive work that cities and counties in the region have been doing for years.

In 2027, the Air District will publish a status report that details implementation progress for measures included in the PCAP and CCAP, any relevant updates to PCAP and CCAP analyses, and next steps and future budget and staffing needs to continue implementation of CCAP measures.

If you have questions about this PCAP or suggestions for the upcoming CCAP and status report, contact Abby Young (ayoung@baaqmd.gov) or Jamesine Rogers Gibson (jrogersgibson@baaqmd.gov).

Appendix A: Emissions Inventory Supporting Documentation

The Bay Area Air Quality Management District (Air District) has prepared this Priority Climate Action Plan (Plan) for the San Francisco-Oakland-Berkeley Metropolitan Statistical Area (MSA). An important element of this Plan is an updated regional greenhouse gas (GHG) emissions inventory that will serve as the foundation for the development and implementation of reduction measures to reduce emissions of GHGs throughout the region, and especially in the frontline communities. This section provides a deeper understanding of:

- the scope of the regional GHG inventory,
- the inventory development methodology,
- the quality assurance process that is being applied to maintain data quality, and
- insights into emissions data and trends.

Scope

This section provides details about the scope of the GHG emissions inventory, both in terms of minimum requirements instituted by U.S. Environmental Protection Agency (EPA) as part of the Climate Pollution Reduction Program (CPRG) program, as well as specifics on how the emissions inventory is further classified into economic activity-based sectors and sub-sectors.

Geographical

The Bay Area region's GHG emissions inventory includes emissions for eight counties in the San Francisco-Oakland-Berkeley Metropolitan Statistical Area (MSA) that are represented in the PCAP. These include Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, and parts of Solano and Sonoma counties. The Air District's complete GHG inventory includes a ninth county - Santa Clara, which is within the jurisdiction of the Air District, but it is part of the San Jose-Sunnyvale-Santa Clara MSA's CPRG planning process.

Pollutants

The PCAP GHG inventory includes emissions of the following GHG pollutants:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur Hexafluoride (SF_6)
- Nitrogen Trifluoride (NF_3)

For the purposes of classification of chemically similar pollutants and ease of visualization, emissions of HFCs and PFCs are reported as one family of pollutants in this PCAP report.

Timespan

The year 2022 has been chosen as the base year for this inventory as it is the latest year for which complete, published, and verified datasets are available for most source categories within all sectors and sub-sectors. Additionally, the year 2022 is treated as representative of "business-as-usual" as it is considered a post-pandemic year. The Comprehensive Climate Action Plan (CCAP) will include a regional GHG inventory that accounts for emissions over a multi-decadal time frame. For the CCAP, further work will be done to refine the year 2022 emissions and to estimate emissions for future years, up through year 2050.

Sectors

For the Bay Area region's GHG emissions inventory, six major sectors have been identified based on an economic classification. These sectors include:

- Transportation,
- Industrial,
- Commercial and Residential,
- Electricity Generation,
- Waste Management, and
- Agriculture.

The sectors are further divided into sub-sectors (see *Figure 1* and *Table 1*). The definition and source composition of the economic sectors generally align with the USEPA's classification of GHG emissions sources[1] with some exceptions and deviations to account for differences at the regional level. Definitions for each sector are provided below:

Transportation

The emissions in this sector are comprised of direct and indirect combustion, non-combustion, and process emissions, occurring from complex machines including cars, trucks, aircrafts, railroads, ships, off-road equipment etc., whose primary objective is to transport people and goods from one place to another. The emission sources in this sector include, but are not limited to, the following:

- Emission from passenger cars, light duty vehicles, medium duty vehicles, and heavy-duty vehicles,
- Emissions from aircraft, marine vessels, and locomotives,
- On-road and off-road emissions sources which act as a residence / home are also included in the transportation sector (e.g., motorhomes, houseboats, RVs),
- Emissions from the use of lubricants to perform maintenance on on-road and off-road mobile equipment, and
- Emissions of high-GWP gases resulting from the use of air conditioners in vehicles and refrigerated transport.

Emission sources not included in this sector are:

[1] Sources of Greenhouse Gas Emissions, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

- On-road and off-road emissions sources with wheels and/or ability to move if the primary objective is to provide a service, e.g., lawn mowing and garden equipment (included in Commercial & Residential sector) or tractors (included in Agriculture),
- Emissions from transportation of natural gas via pipelines and water through water distribution network (this is considered a service to the general population for commercial, residential, and industrial use and both combustion and non-combustion emissions are excluded from this sector),
- Emissions from off-road equipment that pertains to agricultural activities, and from construction, mining, and industrial activities (considered under Agriculture and Industrial sectors, respectively), and
- Fugitive emissions from all kinds of fueling activities of primary sources included in the Transportation sector as well as combustion emissions from support equipment for the fueling (and other support) infrastructure. These emissions are accounted for under Commercial and Residential sectors (e.g., gasoline dispensing facilities, aircraft ground support equipment, etc.).

Industrial

This sector consists of emissions related to the production of goods and raw materials. This sector includes:

- Direct GHG process emissions that originate at the facility, primarily from combustion processes,
- Emissions resulting from chemical reactions in metal, cement, and mineral production, and
- Leaks from industrial processes, equipment, natural gas, and petroleum systems, including that of high-GWP gases.

Exceptions not included in this sector are:

- Indirect emissions that occur off-site but are associated with the facility's use of electricity (these are included in Electricity Generation), and
- Emissions from food processing of agricultural products, for example, ethanol emissions from wineries and emissions from food processing industries, etc. (considered under Agriculture sector).

Commercial + Residential

This sector includes the following direct emissions from homes, commercial businesses, office spaces, places of business, worship, and congregation, entertainment venues, etc. (excluding those classified as agricultural and industrial activities:

- Direct emissions resulting from fossil fuel combustion for heating, cooling, and cooking needs, for transport and management of waste and wastewater, and leaks of refrigerants from equipment.
- Direct emissions from all maintenance and service equipment, e.g., lawn mowing equipment, leaf blowers, floor cleaning and polishing, etc.
- Direct emissions from use of personal products and consumer goods within commercial and residential facilities.

Emissions sources that are not reported in this sector include:

- Indirect emissions produced by burning fossil fuel at a power plant to generate electricity (that occurs offsite) which is meant for consumption in residential and commercial facilities, such as lighting and for appliances (these emissions are included in Electricity Generation),
- Landfill waste emissions (like CH_4) that are generated from organic waste that originated at commercial and residential facilities (these emissions are included in Waste Management),
- On-site wastewater treatment plant emissions of CH_4 and N_2O, or emissions from sewer network (these emissions are included in Waste Management),
- Energy required to produce and transport clean water consumed at commercial and residential facilities (these emissions are included in Electricity Generation),
- Anaerobic digestion and composting emissions of CH_4 at biogas facilities that supply energy/product to commercial and residential buildings and venues (these emissions are included in Waste Management),
- Emissions/sinks from production of construction materials, for example, upstream emissions from production of cement, emissions and sinks from land use changes, etc. (these emissions are included in Industrial), and
- Direct emissions from onsite energy combustion and electricity production for energy-intensive warehouses and factories are typically included in the Industrial sector.

Electricity Generation

This sector includes emissions from activities and processes involved in the generation, transmission, and distribution of electricity within the Bay Area region. These emissions are direct and involve combustion of fossil fuels, such as coal, oil, and natural gas, etc., in a centralized power generation plant to produce electricity, or fugitive/leak-related emissions. This inclusion is independent of whether the electricity is consumed within the Bay Area or imported. Other sources include:

- Emissions from cogeneration facilities producing both heat and power are included in this sector, even if this heat and power is being consumed within the Industrial sector,
- Emissions of sulfur hexafluoride (SF_6), which is an insulating chemical used in electricity transmission and distribution equipment, and
- Onsite emissions from non-fossil fuel source generation facilities, including nuclear, and renewable energy sources like hydroelectricity, biomass, and wind.

A source that is not included in this sector is:

- Direct emissions caused due to production of electricity outside of the Bay Area, but which is imported and used in the Bay Area. These emissions are not accounted for in the GHG emissions inventory.

Waste Management

This sector includes direct and fugitive emissions from centralized waste management activities that focus on solid waste, wastewater, industrial, and non-hazardous waste. These activities usually occur at municipal solid waste (MSW) landfills, industrial waste landfills, industrial wastewater treatment, publicly owned wastewater treatment plants (POTWs), composting operations, anaerobic digesters, biogas facilities, and can also include processes like manure spreading / application, waste incineration, etc. Other direct emissions included are as follows:

- Direct emissions from combustion activities occurring at waste management facilities to provide heat and power,
- Fugitive emissions from the urban collection network of sewers, waste pipes, manholes, etc., and,
- Emissions from standalone septic systems.

Sources not included in this sector are:

- Waste management emissions occurring outside of the Bay Area region from management of waste originating within the region,
- Direct emissions from on-site waste treatment at commercial and residential facilities (included in the Commercial and Residential sector),
- Direct emissions from manure management at animal and dairy farms (included in the Agriculture sector), and
- CO_2 emissions from the combustion of biomass since it is considered biogenic.

Agriculture

This sector includes direct emissions from all agricultural and farming activities related to crop and livestock production including land and soil management activities, such as application of synthetic and organic fertilizers, the growth of nitrogen-fixing crops, the drainage of organic soils, irrigation practices, livestock enteric fermentation, manure management and storage, liming and urea application, burning of crop residues, and rice cultivation. All on-site combustion-related activities supplying energy to agricultural equipment (like diesel generators and pumps), and for farm-related activities are included. All emissions sources with wheels and/or ability to move are included if the primary objective is to provide a service to the agricultural industry (e.g., airplane fertilizer application, mechanical cotton picker, etc.). Sources not included in this sector include:

- Accidental wildfires over natural lands and forests

Organization of sources of high GWP fluorinated gases

The group of emission sources termed fluorinated gases or high-GWP compounds is emitted almost entirely from human-related activities. Their primary sources include:

1. Use of substitutes for ozone-depleting substances (referred to as ODSS compounds) - Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are ODSS that are considered replacements for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) because they do not deplete the stratospheric ozone layer. ODSS are high-GWP gases and contribute to the greenhouse gas effect (CFCs and HCFCs are also high-GWP gases). Example applications include refrigerants, aerosol propellants, foam blowing agents, solvents, and fire retardants.
2. Industrial processes such as aluminum and semiconductor manufacturing - PFCs are produced as a byproduct of aluminum production and are used in the manufacturing of semiconductors. Sulfur hexafluoride (SF_6) is used in magnesium processing and semiconductor manufacturing. Nitrogen trifluoride (NF_3) is used in semiconductor manufacturing. HFC-23 is produced as a byproduct of HCFC-22 production and is used in semiconductor manufacturing.
3. Transmission and distribution of electricity - SF_6 is used as an insulating gas in electrical transmission equipment, including circuit breakers.

The GHG emissions from this group of sources and source categories are not considered as a separate sector, as has been done in the past in the Bay Area region's inventory and in the current statewide California GHG inventory. This is because the prevailing logic for sector-level classification of GHG emissions sources is an economic activity driven classification, rather than a chemical family / pollutant-type based classification. Thus, all source categories associated with this group of emissions are assigned to different sectors based on the following logic:

- ODSS are assigned to Commercial and Residential, Transportation, and Industrial sectors based on category hierarchy and end-use information.
- Emissions of PFCs, NF_3, SF_6 and any other F-gas that is used for product manufacturing or metal production are assigned to the Industrial sector.
- Emissions from SF_6 from electrical transmission equipment are assigned to the Electricity Generation sector.

Inventory Methodology

The Air District takes a 'production-based' approach to develop the regional GHG emissions inventory, which focuses on estimating emissions from sources that directly produce emissions in the region, as compared to attributing emissions produced elsewhere to Bay Area consumers (and end-users) of goods and services (consumption-based approach). The Air District inventory methodology involves a combination of –

- a bottom-up approach that combines activity data and/or throughputs (e.g., fuel used, vehicle miles traveled, etc.) with GHG emissions factors (e.g., kg of CO_2 produced per unit mass of fuel burned, grams of CO_2-equivalent released per vehicle mile traveled, etc.) and local/regional controls to generate emissions,
- a top-down approach where emissions are derived by scaling down from an existing (e.g., national and/or state) emissions inventory using a proxy or surrogate, and
- self-reported emissions verified and approved through the Air District's permitting program.

Bottom-up Approach

A bottom-up GHG emission inventory involves estimating emissions using (1) emission factors (mass of pollutant emitted per unit of activity); (2) local activity or throughput information of the emission processes (e.g., number of events, duration of activity, duty cycle, and quantity of gallons consumed); and (3) estimated emissions reduction or control efficiency if an abatement device is installed or a relevant regulation is implemented. For permitted sources, the Air District uses source-specific information submitted by the facility (and accepted/approved by the agency) to calculate emissions. Detailed activity data and emission factors are also available for some mobile source categories and non-permitted source categories, the statewide EMFAC inventory (for on-road and off-road mobile sources) being an example.

The following equation illustrates a general formula for estimating emissions following the bottom-up method:

$$E_i = A \cdot (1 - ER_i) \cdot EF_i$$

where

E_i = emissions of pollutant i

A = activity rate or throughput

ER_i = emission reduction efficiency of pollutant i

EF_i = emission factor of pollutant i

Emission factor (EF) is a value that reflects the quantity of pollutant emitted per activity or time/distance/unit increment (e.g., grams per hour, grams per gallon of fuel consumed). EFs can be general or source specific. General EFs from published literature represent averages of similar operations, while specific EFs are derived from source-specific emission testing, mass balance, or chemical analysis. Specific EFs are typically more representative and can be self-reported by the facility/operator or compiled by the regulating agency.

Activity rate or throughput (A) data refers to the frequency and amount of pollution activities based on the operation of the source or facility. General activity data may be used for categories where minimal information is available, such as some area sources; for point source categories, activity data are based on reported source-specific information provided by the permitted facility.

Emissions reduction efficiency or control factors (ER) indicate the percent reduction in pollutant emissions if an abatement device is installed or specific regulations are applicable for the source. For example, if a baghouse on a cement silo serves as an abatement device that could reduce particulate emissions by 95%, then a control factor of 0.95 can be used for emissions estimation.

Top-down Approach

The top-down emissions estimation approach is typically used for those sources or categories with limited source-specific information. A top-down emissions inventory can be developed from a larger-scale (e.g., state or county) emissions inventory using spatial surrogates, activity proxies, socioeconomic trend indicators, etc., to disaggregate total emissions and apportion to finer spatiotemporal scales. A top-down emissions inventory is developed for the Bay Area region's non-permitted stationary source categories, where equipment-level identification and information are not available, often using county-level emissions and activity data obtained from California's State Implementation Plan Inventory[2]. Also, frequently used for top-down estimation of the Bay Area region emissions are the statewide greenhouse gas inventory[3]. Surrogate activity data, such as fuel throughput, population growth, employment by job sector, and land use, etc., are used to scale available statewide data to derive source-category specific GHG emissions estimates for the region. For example, county-specific cattle head count data are used to assign California GHG emissions total for animal manure management across the Bay Area region.

Air District permit data

For most permitted stationary sources (including facilities, processes, equipment, etc.), GHG emissions are calculated from data that has been submitted by operators and owners, responsible and liable for

[2] California Emissions Projection Analysis Model (CEPAM 2018), https://ww2.arb.ca.gov/applications/cepam2019v103-standard-emission-tool

[3] California 2000-2021 GHG Inventory (2023 Edition), https://ww2.arb.ca.gov/ghg-inventory-data

those sources, as part of the annual Air District permit renewal process. These data submissions are verified for accuracy, consistency, change in permit and operating conditions, etc., by Air District staff before being approved for issuance of permit. These data are then utilized to generate emissions using the bottom-up approach (described above). For some select facilities and Bay Area region refineries, there are adopted regulations (e.g., Regulation 12 Rule 15) which impose a mandatory emissions reporting requirement on the facilities subject to these regulations. These regulations, thus, serve as a robust tool for the Air District to generate a GHG emissions inventory for some of the larger and more polluting sources in the region.

Quality Assurance Project Plan (QAPP)

The primary objectives for this PCAP are to develop reliable inventories for each of the GHG-emitting sectors in the Bay Area region, and to identify options for reducing emissions from those sectors. As per the USEPA's CPRG guidelines, the PCAP (and eventually the CCAP) require the development and implementation of a quality assurance program that promotes confidence in the developed emissions inventory and all subsequent policy initiatives and regulatory programs based on the inventory estimates.

Accordingly, all quality objectives and criteria are aligned with the overall PCAP objectives and laid out in a Quality Assurance Project Plan[4] (QAPP). The GHG emissions inventory is subject to a data review and quality control process that is described in the QAPP. All activities under this project will conform to the QAPP. The quality system used for this project is the joint responsibility of the Air District Project Manager (PM), Task Leaders (TLs), Technical Reviewers (TRs), and an organizationally independent Quality Assurance (QA) Manager.

A detailed quality assessment is applied to each of the six major sectors during the GHG inventory development process with a seven-step planned quality assessment and control activity (for each sector). This seven-step approach includes:

1. Determining quality of existing Air District inventory for the Bay Area region
2. Identifying, researching, and collecting other published data
3. Characterizing the data
4. Assessing data for accuracy and applicability
5. Deriving emissions estimates
6. Verification of quality
7. Quantification of reduction measure options

GHG Emissions Summary

Figure 1 presents a sunburst pie chart that shows the distribution of GHG emissions (in CO_2-equivalent terms) across sub-sectors within the major sectors. The sub-sectors are more specific classification of emissions sources within a sector and are often based on characteristics like emission-type (e.g., combustion), source type (e.g., ships), process (e.g., petroleum refining), pollutant class (e.g., high-GWP gases), etc. The inner ring in the sunburst chart is broken down into the six major GHG sectors, while the

[4] Quality Assurance Project Plan for The Bay Area Climate Action Planning Initiative, Grant No..: 98T73201; *submitted on*: 12-27-2023; *approved on*: 01-04-2024; available on request.

outer ring splits those major sector contributions further into several sub-sectors. For a detailed distribution of emissions across sub-sectors within the six major sectors, refer to *Table 1* in *Appendix A*.

Table 1 provides insight into the sub-sectors within major sectors and the relative share of the total GHG emissions between these sub-sectors. From the pie chart, it can be observed that passenger vehicles (~11% of total regional GHG emissions) within the Transportation sector has the largest share of GHG emissions, along with combustion of natural gas in industrial operations (~11%) and fuel combustion processes at refineries (~11%) within the Industrial sector. Other major GHG emissions sources include residential natural gas combustion (~7%) in Commercial and Residential sector, light-duty (~7%) and heavy-duty (~7%) trucks in the Transportation sector, cogeneration facilities (~7%) and power plants (~5%) in the Electricity Generation sector, and petroleum refining processes (~7%) in the Industrial sector. Emissions from landfills (~3% of total regional GHG emissions) constitute the largest share of GHG emissions within the Waste Management sector although recent measurement-based estimates in the Bay Area region indicate that CH_4 emissions from this sub-sector (along with those in the refinery sub-sector) are being underestimated and need revision[5].

Direct vs Indirect emissions from Electricity Generation

As has been stated in the *Scope* sub-chapter in *Chapter 2*, the Air District's GHG emissions inventory represents a production-based accounting approach with GHG pollutant emissions attributed to sources (categorized within sectors and sub-sectors) and accounted at point of origin (ascribed to county). This is also true for the Electricity Generation sector, where, in addition and in parallel, the Air District has also developed a regional emissions inventory for Electricity Use based on a consumption-style approach using independent data sources (see *GHG Emissions*).

A production based GHG emissions inventory for Electricity Generation sector is often broken down into two components:

Direct Emissions

These are GHG emissions emitted from power plants and cogeneration facilities, that are located within the Bay Area region, during the process of electricity production. These emissions are typically 'directly' emitted into the Bay Area's atmosphere with 'direct' local pollution and health impacts, independent of whether this generated electricity is consumed within the region or exported.

Indirect Emissions

These are GHG emissions emitted from power plants and cogeneration facilities that are located outside the Bay Area region, during the process of electricity production, where some of this generated electricity is being imported and used by consumers located within the Bay Area. In this case, the emissions can be referred to be 'indirectly' emitted within the Bay Area.

The Air District does not include 'indirect emissions' from electricity generation in the Bay Area regional emissions total for the following reasons:

[5] Assessment of Regional Methane Emission Inventories through Airborne Quantification in the San Francisco Bay Area, https://pubs.acs.org/doi/abs/10.1021/acs.est.0c01212

1) The Air District's 'direct' GHG emissions from the power plant sub-sector within the Electricity Generation sector are ~3 $MMTCO_2$-e for the Bay Area region, while the consumption-based emissions inventory from retail electricity usage is 2.1 $MMTCO_2$-e. This indicates that a large chunk of electricity produced in the Bay Area region is exported outside the region and not consumed by Bay Area users. Despite this consumption pattern, these emissions are accounted for and included as 'direct' emissions in the regional inventory. This is consistent with the Air District's production-based inventory accounting approach and independent of whether another MSA or regional entity is reporting and including these as 'indirect' emissions in their inventories. This ensures that the Bay Area region's emissions inventory accounting methods remain conservative and are all-encompassing, independent of another MSA's choice of scope of their inventory.

2) The Air District is unaware whether another MSA or region (where some of Bay Area's imported fossil-fuel based electricity may be produced) is including or excluding the Bay Area's 'indirect' emissions as part of their 'direct' emissions accounting. In the absence of this information, the Air District's practice helps avoid double-counting of GHG emissions at the state or federal level.

3) Availability of activity data for generated electricity going in and out of the Bay Area is not readily available as electricity trading is a continuous process and managed in a wholesale energy market[6], and this greatly hinders calculation of net emissions resulting from use and generation.

In this regard, the Air District encourages all PCAP participants and grantees to report the full scope of their 'direct' emissions without discounting any 'indirect' emissions of other regions.

[6] California Independent System Operator (ISO), https://www.caiso.com/Pages/default.aspx

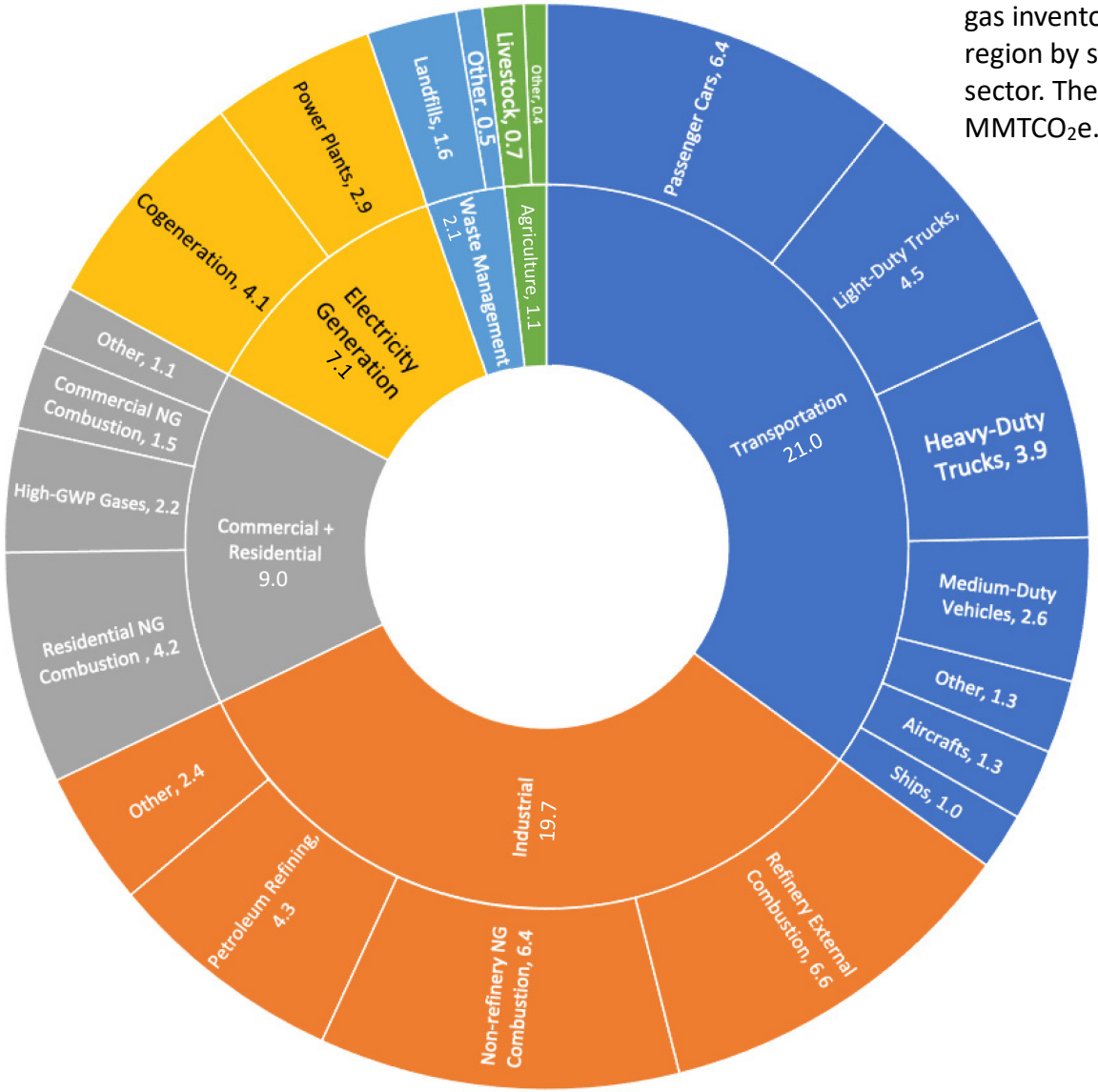

Figure 1. 2022 greenhouse gas inventory for the Bay Area region by sector and sub-sector. The total is 59.88 $MMTCO_2e$.

Table 1. 2022 Bay Area Region Greenhouse Gas Inventory by Sector and Sub-sector

Sector	Sub-sector	Emissions ($MMTCO_2e$)	Sector	Sub-sector	Emissions ($MMTCO_2e$)
Transportation	Passenger Cars	6.41	**Industrial**	Refineries External Combustion	6.64
	Light-Duty Trucks	4.46		NG Combustion	6.44
	Heavy-Duty Trucks	3.94		Petroleum Refining	4.27
	Medium-Duty Vehicles	2.57		Fuel Combustion	0.83
	Aircrafts	1.27		High-GWP Gases	0.59
	Ships	1.01		Off-Road Equipment	0.54
	High-GWP Gases	0.58		Manufacturing	0.19
	Buses	0.29		NG Leakage	0.15
	Other	0.12		Fugitive and Process Emissions	0.03
	Locomotives	0.09		Other	0.0004
	Heavy-Duty Vehicles	0.09		*Total*	*19.67*
	Motorcycles	0.07	**Electricity Generation**	Cogeneration	4.08
	Motor Homes	0.06		Power Plants	2.95
	Total	*20.95*		Transmission/Distribution	0.03
Commercial + Residential	Residential Combustion - Natural Gas Only	4.15		*Total*	*7.06*
	High-GWP Gases	2.21	**Waste Management**	Landfills	1.60
	NG Combustion	1.49		Domestic Wastewater Treatment	0.37
	Fuels Distribution	0.49		Industrial Wastewater Treatment	0.06
	Natural Gas Leakage	0.28		Other	0.03
	Residential Combustion - Other (non-Natural Gas)	0.15		Composting	0.01
	Lawn and Garden Equipment	0.09		*Total*	*39.06*
	Light Commercial Equipment	0.06	**Agriculture**	Livestock	0.73
	Commercial Cooking	0.05		Other	0.26
	Residential Wood Burning	0.01		Agricultural Equipment	0.15
	Off-Road Recreational Vehicles	0.002		Planned Fires	0.002
	Total	*8.98*		Food Processing	0.00004
				Total	*42.27*
Grand Total	**59.88**				

Table 2. 2022 Bay Area Region Greenhouse Gas Inventory by County and Sector

County	Sector	Emissions ($MMTCO_2e$)	Emissions (% in county)	County	Sector	Emissions ($MMTCO_2e$)	Emissions (% in county)
Alameda	Agriculture	0.11	0.95%	**San Francisco**	Agriculture	0.01	0.22%
	Commercial + Residential	2.39	21.05%		Commercial + Residential	1.64	36.45%
	Electricity Generation	0.55	4.81%		Electricity Generation	0.07	1.46%
	Industrial	0.97	8.55%		Industrial	0.79	17.60%
	Transportation	6.75	59.35%		Transportation	1.93	42.90%
	Waste Management	0.55	4.86%		Waste Management	0.06	1.37%
	Total	*11.32*			*Total*	*4.51*	
Contra Costa	Agriculture	0.21	0.79%	**San Mateo**	Agriculture	0.04	0.62%
	Commercial + Residential	1.79	6.71%		Commercial + Residential	1.39	24.20%
	Electricity Generation	6.14	23.02%		Electricity Generation	0.03	0.47%
	Industrial	14.11	52.91%		Industrial	0.47	8.12%
	Transportation	4.06	15.23%		Transportation	3.32	57.79%
	Waste Management	0.36	1.34%		Waste Management	0.51	8.80%
	Total	*26.67*			*Total*	*5.74*	
Marin	Agriculture	0.22	9.76%	**Solano**	Agriculture	0.15	2.78%
	Commercial + Residential	0.51	22.80%	(BAAQMD	Commercial + Residential	0.42	7.76%
	Electricity Generation	0.01	0.30%	portion only)	Electricity Generation	0.26	4.74%
	Industrial	0.07	3.15%		Industrial	2.98	54.64%
	Transportation	1.28	56.89%		Transportation	1.45	26.54%
	Waste Management	0.16	7.11%		Waste Management	0.19	3.54%
	Total	*2.25*			*Total*	*5.45*	
Napa	Agriculture	0.10	8.92%	**Sonoma**	Agriculture	0.30	10.76%
	Commercial + Residential	0.24	20.32%	(BAAQMD	Commercial + Residential	0.60	21.52%
	Electricity Generation	0.01	1.26%	portion only)	Electricity Generation	0.00	0.10%
	Industrial	0.11	9.57%		Industrial	0.17	6.05%
	Transportation	0.63	53.59%		Transportation	1.53	55.44%
	Waste Management	0.07	6.33%		Waste Management	0.17	6.12%
	Total	*1.17*			*Total*	*2.77*	
Grand Total	**59.88**						

Table 2 provides a detailed breakdown of the distribution of GHG emissions by county across the Bay Area region. As stated in *Chapter 2*, most of the region's refineries (Industrial sector) and power plants (Electricity Generation sector) are located in Contra Costa county. This leads to a large share of the Bay Area's regional GHG emissions being attributed to this county. In addition, this also makes Contra Costa county one of the only counties in the Bay Area region where the Transportation sector does not account for a bulk of the GHG emissions. This is also true for the southwestern portion of Solano county (in Air District's jurisdiction) which is sparsely populated (and thus has a relatively small vehicular population) and is the location of one of the region's five refineries.

Figure 2 presents an illustration of the information presented in *Table 2.1* in the form of a stacked bar chart that shows the relative distribution of GHG emissions across the six major source sectors by major climate pollutant type. This column chart shows that CO_2 is the predominant GHG pollutant emitted across three major sectors - Transportation, Electricity Generation, and Industrial (>95% relative share for each sector). HFCs and PFCs are important constituents of the Commercial & Residential sector (a combined 25% of sector emissions), although CO_2 (~67% of the sector emissions) remains the dominant pollutant for this sector. CH_4 is the predominant GHG pollutant emitted across the Waste Management and Agriculture sectors.

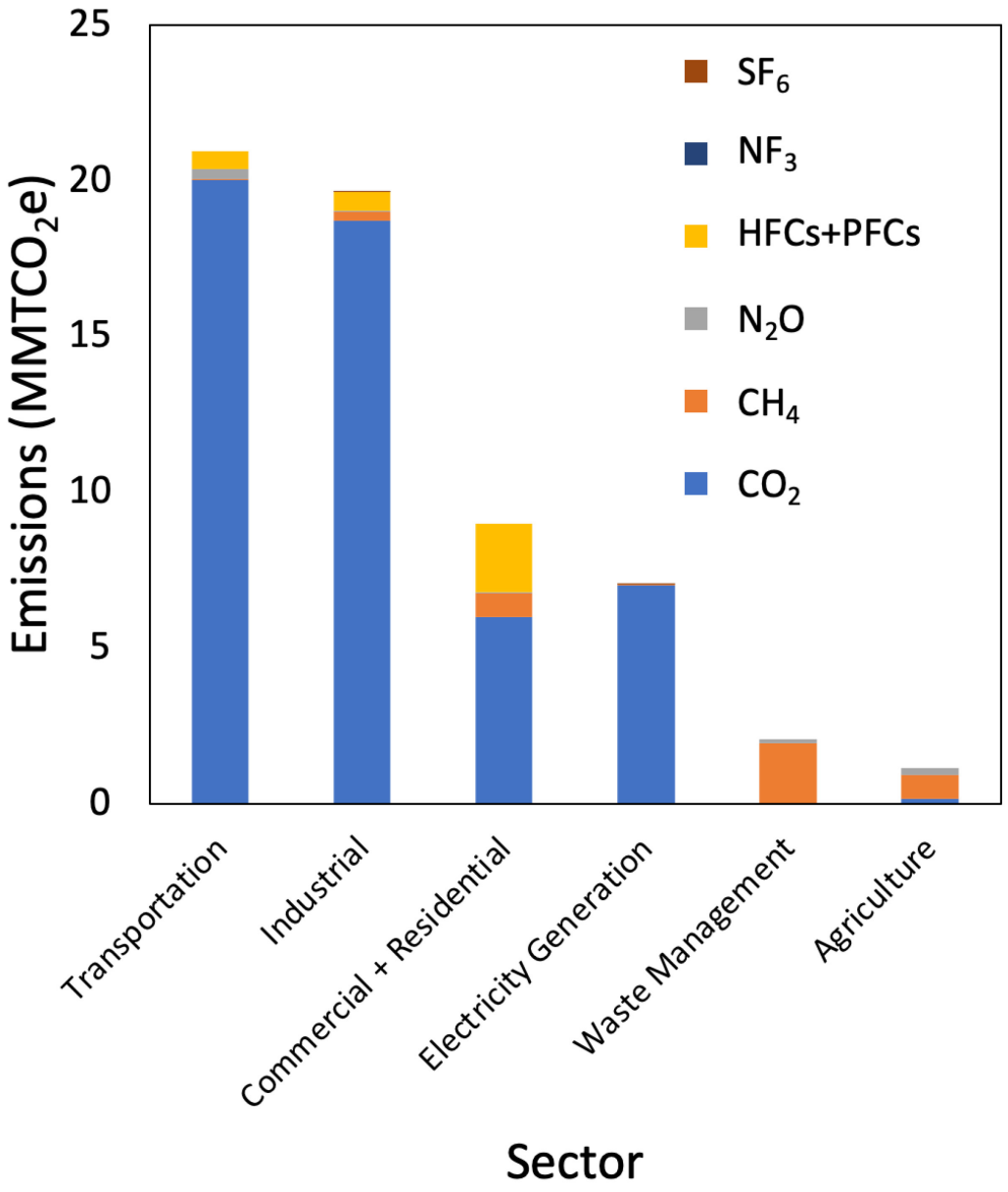

Figure 2. 2022 greenhouse gas inventory for the Bay Area region by sector and climate pollutant. The total is 59.88 $MMTCO_2e$.

Appendix B - Engagement of Stakeholders during the PCAP

Overview of Engagement Efforts

The Air District led a public and stakeholder engagement process for the PCAP, working closely with county partners, ABAG/BayREN, BARC, MTC/ABAG, CCAs, and community-serving organizations. The engagement process was designed to involve relevant stakeholders in the Bay Area region as broadly as possible in this planning effort, to ensure that a wide and diverse set of perspectives, experience and input is reflected in the PCAP. Engagement efforts relied largely upon established avenues for reaching local government staff, frontline communities, and other key stakeholders. The PCAP leveraged stakeholder engagement that is ongoing or was recently conducted within the Bay Area region for climate action plans and related efforts.

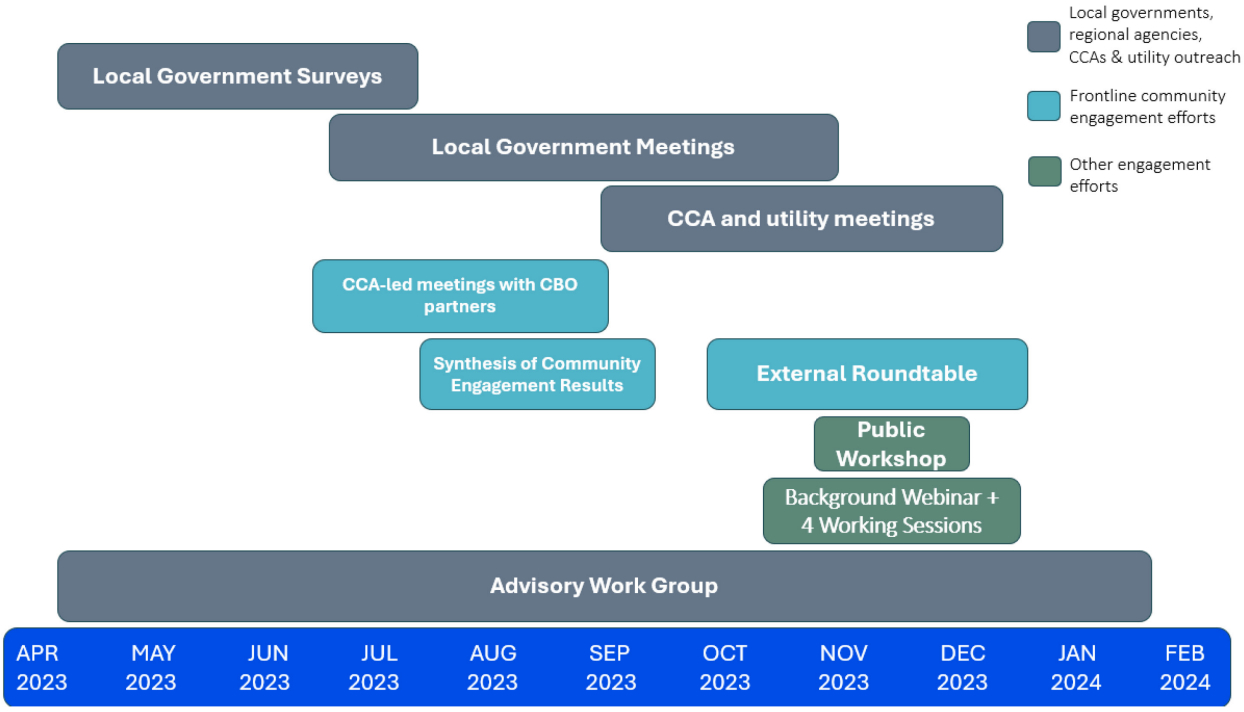

Figure 1. **Bay Area region's PCAP Engagement Plan**

Outreach and Coordination with Local Governments, Regional Agencies, Community Choice Aggregators and Utilities

Advisory Work Group

The District established an Advisory Work Group (AWG) composed of representatives from regional agencies (Air District, ABAG/BayREN, BARC, and MTC), the cities named in the federally-designated MSA (City of Berkeley, City of Oakland, and City and County of San Francisco) and the counties comprising the MSA (Alameda County, Contra Costa County, Marin County, Napa County, San Mateo County, and the

portions of Solano County and Sonoma County that are within the Air District's jurisdiction). The Air District coordinated with Santa Clara County, who is leading the San Jose-Sunnyvale-Santa Clara MSA's CPRG planning process.

The AWG met monthly (for a total of 5 meetings) to discuss and make decisions on key aspects of the PCAP including coordination and engagement with other agencies, organizations and LIDACs, measure selection, and development of deliverables, as well as provision of information and data and advising on technical analyses. Development of the PCAP leveraged ongoing stakeholder engagement efforts by AWG members, with some support from AWG members for targeted engagement as needed. The Air District co-developed the PCAP workplan and shared communications points with AWG members to ensure common messaging to local agencies and organizations, LIDACs, and other stakeholders. Members also participated in the measure design Working Sessions in October – December 2023, which are described later in this document.

Table 1. Members of the Advisory Work Group

Name	Role and Organization	Regional, County or City Representative
Aleka Seville	Regional Coordination Advisor, Association of Bay Area Governments/ Bay Area Regional Energy Network (ABAG/BayREN)	Regional
Allison Brooks	Executive Director, Bay Area Regional Collaborative (BARC)	Regional
Avana Andrade	Senior Sustainability Coordinator, Office of Sustainability, County of San Mateo	County
Cyndy Comerford	Climate Program Manager, SF Environment	City, County
Dana Armanino	Planning Manager, County of Marin	County
Jamesine Rogers Gibson	Senior Advanced Projects Advisor, Bay Area Air Quality Management District	Regional
Jody London	Sustainability Coordinator, Contra Costa County	County
Katie van Dyke	Climate Action Program Manager, City of Berkeley	City
Kim Springer	Transportation Systems Coordinator, City/County Association of Governments of San Mateo County	County
Miya Kitahara	Program Manager, Alameda County Waste Management Authority (StopWaste)	County
Narcisa Untal (ex-officio)	Senior Planner, Solano County	County
Ryan Melendez (ex-officio)	Sustainability Planner, Napa County	County
Shayna Hirschfield-Gold	Climate Program Manager, City of Oakland	City
Tanya Nareth (ex-officio)	Chief Deputy Executive Officer, Sonoma County Transportation Authority/Regional Climate Protection Authority	County

Therese Trivedi	Assistant Planning Director, Metropolitan Transportation Commission (MTC)	Regional

Representatives from Solano, Napa, and Sonoma counties served as ex-officio members to the Advisory Work Group to encourage coordination of aligned efforts across the region, since these counties were not officially approved by the EPA for inclusion in the Bay Area region for the PCAP until January 2024.

Table 2. Advisory Work Group Meetings

Advisory Work Group Meeting Date	Topics covered
June 15, 2023	• Develop Group Agreements • Agree upon frontline communities identification approach • Share and receive feedback on PCAP engagement approach and key messaging points • Request AWG members share results of frontline community engagement for relevant planning efforts and facilitate connections to existing engagement channels or efforts
July 27, 2023	• Discuss results of local government surveys and potential PCAP measure ideas • Review AWG charter and EPA workplan update
August 24, 2023	• Share preliminary findings from community engagement synthesis and survey • Discuss two high-level PCAP measure concepts – buildings and transportation, with more focused discussion on transportation
September 28, 2023	• Welcome new members • Provide overview of Notice of Funding Opportunity for the CPRG Implementation Grant Applications to inform measure development criteria • Identify existing barriers to successful implementation of PCAP measure concepts • Develop draft design principles for measures • Discuss and provide feedback on the Working Sessions approach • Request AWG members recommend who to invite to Working Sessions
December 6, 2023	• Review draft PCAP Measure Descriptions • Discuss implementation proposal ideas and potential roles and partners

AWG meetings and individual member contributions resulted in the following outputs:

- Input for EPA workplan
- Definition of frontline communities for BARCAP effort
- Input on priority sector selection and measure concepts
- Refinement of measure concepts

- Refinement of draft measure descriptions resulting from Working Sessions
- Initial input on design principles
- Meetings with local governments and other partners through AWG member facilitated meetings
- Findings from recent community engagement conducted by local governments and regional agencies
- Recommendations for invitees to Working Sessions
- List of existing efforts for PCAP and CCAP to build upon

Local Government Engagement

The Air District conducted extensive outreach to local governments in the Bay Area region to understand their priorities and implementation-ready projects for the PCAP, to request the results of recent community engagement efforts (as described in Section VI), and to further develop the PCAP measures during a series of Working Sessions. In total, over 50 cities, towns, and counties (or nearly 60 percent total regionwide) participated in at least one outreach effort. The Association of Bay Area Governments (ABAG) has served as a key partner and sub-awardee, primarily through its Bay Area Regional Energy Network (BayREN) program. Specifically, ABAG/BayREN has supported the Air District in designing the structure of the AWG, co-leading local government outreach and the measure design Working Sessions.

Table 3. Local governments who participated in at least one PCAP outreach effort

Alameda County	City of Alameda	City of Albany
City of Antioch	City of Atherton	City of Berkeley
City of Brisbane	City of Burlingame	City of Concord
Town of Corte Madera	Contra Costa County	City of Cotati
City of East Palo Alto	City of El Cerrito	City of Emeryville
Towns of Fairfax and San Anselmo	City of Foster City	City of Fremont
City of Half Moon Bay	City of Hayward	City of Healdsburg
City of Lafayette	City of Larkspur	Marin County
City of Martinez	City of Menlo Park	City of Mill Valley
City of Moraga	Napa County	City of Napa
City of Novato	City of Oakland	City of Oakley
City of Pacifica	City of Petaluma	City of Piedmont
City of Pinole	City of Pittsburg	City of Pleasant Hill
City of Pleasanton	City of Redwood City	City of Richmond
City of Rohnert Park	City and County of San Francisco	City of San Leandro
City of San Mateo	San Mateo County	City of San Pablo
City of San Rafael	City of Santa Rosa	Solano County
Sonoma County	City of South San Francisco	Town of Tiburon
City of Walnut Creek	Town of Windsor	

County-led meetings and individual meetings

AWG members invited Air District staff to attend regularly occurring meetings of local governments that they convened in June – July 2023, including the Contra Costa County Energy Efficiency Collaborative, the Marin Clean Energy Partnership, Regional Climate Action Planning Suite Program (RICAPS) in San Mateo County, and StopWaste's Technical Advisory Group in Alameda County. Air District staff presented on the BARCAP effort and PCAP development and sought input from attendees.

Air District staff also met with several city and county staff individually during summer and fall 2023 to discuss their priorities, potential efforts that they would recommend scaling up and/or replicating regionally, and any input from their recently completed engagement of frontline communities.

Table 4. Local Government Meetings

Meeting and date	Attendees	Type of meeting
6/20/23	StopWaste Technical Advisory Group (TAG)	Presentation
6/22/23	Contra Costa County Energy Efficiency Collaborative	Presentation
7/10/23	Marin Climate and Energy Partnership	Presentation
7/18/23	StopWaste TAG	Presentation
7/24/23	City of San Rafael	Individual meeting
7/25/23	San Mateo County RICAPs	Presentation
7/27/23	Bay Area County Transportation Agencies Executive Roundtable	Presentation
8/16/23	Alameda County Community Development Agency	Individual meeting
8/18/23	City of Berkeley	Individual meeting
8/18/23	City of San Leandro	Individual meeting
8/21/23	City of Hayward	Individual meeting
8/22/23	City of Fremont	Individual meeting
8/31/23	City of Berkeley	Individual meeting
9/11/23	Sonoma County RCPA	Individual meeting
9/12/23	Solano County	Individual meeting
9/13/23	Napa County	Individual meeting
9/25/23	San Mateo County, Caltrain, and SamTrans	Group meeting
9/27/23	Alameda County Public Works and Community Development Agency	Group meeting
9/29/23	City of Fremont	Individual meeting
10/3/23	City of East Palo Alto	Individual meeting
10/4/23	Marin Clean Energy	Presentation
10/5/23	City of Oakland (DOT)	Individual meeting
11/16/23	Port of Oakland	Individual meeting
11/21/23	Contra Costa County Dept of Health	Individual meeting

Surveys

The Air District conducted three surveys of local governments between April and July 2023. The first two focused on gathering initial input and interest from local governments about their priority sectors and implementation-ready projects for reducing GHG emissions. The third asked local governments with frontline communities to share findings from recent or ongoing engagement efforts.

Table 5. Local Government Surveys

Survey (date)	Description of Survey	Number of responses
Share Priorities for a Bay Area Regional GHG Reduction Plan (April 2023)	Requested local governments indicate how they would like to participate in the BARCAP, share their priority sectors for the PCAP (based on availability of implementation-ready projects), and share whether they have a climate action plan or GHG reduction plan	26
Participant Interest Form for BARCAP (June 2023)	Requested local governments indicate their interest in participating in the effort, share their ideas for consideration in the PCAP, and note if additional supporting information is available.	35
Community Engagement Findings Form by BARCAP Effort (July 2023)	Requested local governments with frontline communities to share their findings from recent or ongoing community engagement efforts.	13

In addition, the Air District invited local government staff from all cities and counties in the Bay Area region to the Working Sessions. All counties and 48 cities and towns participated in at least one session.

Engagement of local governments resulted in the following outputs:

- Identification of priority sectors, implementation-ready projects, and existing efforts to leverage, scale, and/or replicate
- Findings from recent or ongoing community engagement conducted by local governments
- Refinement of measure concepts into measure descriptions in Working Sessions

Community Engagement Efforts

Community Engagement Synthesis

When engaging communities in the Bay Area region, the Air District seeks to follow a meaningful and thoughtful process,[1] which is best practice in the Bay Area. The expedited PCAP timeline did not provide sufficient time to do that. Rather than launch a brand-new engagement effort, the Air District opted to learn from recent community engagement efforts conducted by local governments to inform their planning efforts (climate action plans, transportation plans, general plans, etc.). Air District staff synthesized the results of recently conducted, meaningful community engagement efforts described in documents provided by local governments in the Bay Area region. The purpose of the synthesis was to identify and summarize findings about common community priorities and concerns of the Bay Area region's frontline communities overall and with respect to the two identified sectors for the PCAP:

residential building electrification and transportation mode shift. The process benefited from community engagement that had already been conducted related to these topic areas.

This approach not only saved time, but it also protected the many crucial relationships between local governments and regional agencies and frontline communities from harmful impacts of a rushed and potentially ill-informed new engagement process. The approach prevented meeting fatigue and frustration stemming from frequent repetition of the same questions. It also allowed for strategically building upon thoughtful community-driven engagement while allowing room for deeper public engagement for the CCAP.

The Air District began this process in the summer by soliciting community engagement results from AWG members and local government staff through the July 2023 Community Engagement Findings Survey mentioned above. Regional agencies, cities, and counties shared documents related to a range of planning efforts across the region, including climate action plans, general plans, building electrification plans, transportation plans, community profiles, and housing plans. Once all relevant documents were collected, the Air District completed an initial screening, selecting the documents that contained findings from 2020 onward, and those that specifically engaged census tracts identified as frontline communities for the purposes of the PCAP.[1] The Air District then pulled out important information about community priorities and concerns from this pool of relevant documents. Extraction of information from the documents focused on who was engaged and how, frontline communities' priorities and concerns, and any feedback (positive or negative) that frontline communities provided on specific greenhouse gas reduction measures. Both qualitative and quantitative information was used as part of the analysis.

This work culminated with a draft Community Engagement Synthesis document (Synthesis) of findings about community priorities and concerns of the Bay Area region's frontline communities~~,~~ overall and with respect to the two identified sectors for the PCAP: residential building electrification and transportation mode shift. The Synthesis included executive summaries, exemplars from local planning process documents, benefits and dis-benefits of potential implementation measures, methodology, and a list of documents reviewed.

The Synthesis also informed the frontline community benefits/disbenefits analysis in the PCAP and will help shape measure development and the frontline communities benefits analysis for the CCAP. The needs and priorities of frontline communities identified through this process were critical to the development of the PCAP measures.

Roundtable

The draft Synthesis was then shared with a Roundtable of regional community-serving organizations to review, discuss, add to and otherwise improve and finalize the document. The Roundtable was tasked with ensuring that the Synthesis reflected the most important common needs and priorities of frontline communities. To maintain efficiency and focus, the Air District invited a select group of organizations for participation in the Roundtable. The Roundtable was composed of regional community-serving organizations (TransForm, PODER, Emerald Cities Collaborative, and Greenlining Institute), each having knowledge and expertise from their work with communities regionally in the two targeted sectors.

Criteria that went into the consideration and choosing of Roundtable members included:

[1] For the purpose of the PCAP, frontline communities are defined using: 1) EPA IRA Disadvantaged Communities, 2) AB 617 communities, and 3) MTC Equity Priority Communities, and visualized together in this map.

- Significant experience working on community-based issues
- In-depth understanding of Bay Area frontline communities
- Significant expertise in climate equity issues
- Expertise working with communities on transportation and clean building topics

Table 6. Community Engagement Roundtable Members

Name	Role and Organization
Aminah Luqman	Oakland Program Manager, Capacity Building, The Greenling Institute
Antonio Diaz	Coordinating Director, PODER
Megan Leary	Community Engagement and Policy Manager, Emerald Cities Bay Area Collaborative San Francisco Bay Area
Zack Deutsch-Gross	Policy Director, TransForm

The Air District contracted with the firm Christine Selig Associates to work with Air District staff to coordinate and facilitate a series of meetings with the Roundtable. Preliminary one-on-one meetings between Roundtable members and Air District staff and Christine Selig were conducted in early October 2023 to provide introductions, a briefing on the project's background, and an opportunity for Roundtable members to provide initial input. The Roundtable met together twice in October 2023 and a third time in individual meetings (due to scheduling challenges) in December 2023, with work on the synthesis document continuing in between meetings.

Table 7. Meetings of the Roundtable

Date of Meeting	Goal of Meeting
September 2023 (one-on-one introductory briefings)	• Meet and build rapport with contractor and Air District staff • Receive background on project • Provide input to engagement approach
Early October 2023	• Discussed participation during upcoming Working Sessions. • Introduction to design principles • Discussed workforce development as related to potential PCAP measures
Late October 2023	• Refine and finalize design principles • Review and discussed draft Synthesis
December 2023 (one-on-one meetings)	• Discuss and provide feedback on draft PCAP measures • Final review of draft Synthesis

In addition, three Roundtable members participated in a series of four Working Sessions with other critical stakeholders to design the PCAP measures during October – December 2023. In these Working Sessions, Roundtable members shared the priorities and issues based on their expertise and experience working with communities and those that had been arising through their work on the Synthesis

document. This input helped inform PCAP measure refinement and ensured the measures addressed frontline communities' priorities and concerns.

Roundtable meetings and individual member contributions resulted in the following outputs:

- Feedback on the design principles to guide PCAP measure development;
- Identified priorities for PCAP measures that reflect community needs and priorities;
- List of specific community benefits and disbenefits to inform the frontline communities benefits analysis; and
- Input for final Synthesis document reflecting implementation priorities to inform both the PCAP and CCAP.

Other CBO Engagement

The Air District presented on the BARCAP at two meetings hosted by community choice aggregators (CCAs) with their community partners. In June 2023, the Air District presented to the MCE Community Power Coalition[2] - a network of social, racial, and environmental justice organizations. In September 2023 Air District staff presented to a meeting of Peninsula Clean Energy and its community partners.

Other Stakeholder Engagement

In addition to the review and synthesis of recent community engagement documents and findings and the convening of the Roundtable, the Air District reached a broader universe of stakeholders through a four-part Working Session series and public workshop convened in Fall 2023.

Working Sessions

The Air District, with support from ABAG/BayREN, designed and facilitated four Working Sessions during October – December 2023 to develop the PCAP measures. Invitations were extended to all local governments in the Bay Area region. AWG members recommended specific non-governmental entities and individuals to invite as well. Criteria for inviting organizations and individuals to participate in the Working Sessions included:

- Local government staff and regional agencies, particularly those who work in agencies, offices or programs with plans or projects in either measure focus area
- Potential to participate in an implementation grant proposal as a coalition partner
- Program implementers with experience implementing relevant projects on the ground
- Expertise in the subject matter areas of sustainable transportation and building decarbonization
- Community-based organizations who work with the frontline communities likely to be impacted by measure implementation
- Background and expertise working on environmental, transportation, building, and/or climate issues at the community level
- Roundtable members
- Others as recommended

Thirty cities and counties participated in the Working Sessions alongside AWG members, and representatives from the following groups: non-profits with technical or subject matter expertise; non-

[2] https://www.mcecleanenergy.org/energy-equity/#communitypower

profit organizations that retrofit buildings, transportation agencies, workforce training and labor representatives, CCAs and utilities, non-profit housing developers, CBOs, and others. In total over 90 stakeholders participated across all four sessions.

Table 8. Working Session Participants

Organization (Number of participants)	Type of Stakeholder
AAPI Coalition of North Bay (1)	Community-based organization (CBO)
Association of Bay Area Governments/Bay Area Regional Energy Network (3)	Regional Agency
AEA (1)	Non-profit Organization that conducts building retrofits
City of Alameda (1)	Local Government
Alameda County (2)	Local Government
Alameda CTC (2)	Local Government, Transportation Agency
Alameda County Public Health Department (1)	Local Government, Public health
City of Albany (1)	Local Government
City of Antioch (1)	Local Government
City of Atherton (1)	Local Government
Ava Community Energy (3)	CCA
Bay Area Regional Collaborative (2)	Regional Agency
Bay Area Rapid Transit (1)	Transportation Agency
Building Electrification Institute (2)	Subject Matter Expert
City of Berkeley (2)	Local Government
City of Brisbane (1)	Local Government
City of Burlingame (1)	Local Government
Christine Selig Associates (1)	Consultant
Contra Costa County Health Department (1)	Local Government, Public Health
Contra Costa Transportation Authority (1)	Transportation Agency
Center for Human Development (1)	CBO
Contra Costa County (2)	Local Government
City of Cotati (1)	Local Government
Construction Trades Workforce Initiative (2)	Organized Labor Representatives
City of East Palo Alto (2)	Local Government
Emerald Cities Collaborative (2)	Roundtable Member
City of Fremont (1)	Local Government
Greenlining Institute (1)	Roundtable Member
City of Hayward (2)	Local Government
City of Healdsburg (1)	Local Government
Latino Service Providers (1)	CBO
Marin County (1)	Local government
Marin County Bicycle Coalition (1)	Bike/ped Advocacy Organization
MCE (1)	CCA

Marin Climate & Energy Partnership (1)	Local Government
Metropolitan Transportation Commission (3)	Transportation Agency
NAACP Sonoma (2)	CBO
City of Napa (1)	Local Government
Napa County (1)	Local Government
Northern California Land Trust (2)	Non-profit Affordable Housing Developer, CBO
City of Oakland (3)	Local Government
City of Oakley (1)	Local Government
Peninsula Clean Energy (1)	CCA
City of Petaluma (1)	Local Government
PG&E (1)	Utility
City of Piedmont (2)	Local Government
City of Pinole (1)	Local Government
City of Pittsburg (2)	Local Government
Rebuilding Together East Bay Network (1)	Non-profit Organization that conducts building retrofits
City of Redwood City (1)	Local Government
Richmond Community Foundation (1)	CBO
Rising Sun Center for Opportunity (1)	Workforce Training Organization, CBO
RMI (1)	Subject Matter Expert
City of Rohnert Park (1)	Local Government
San Mateo C/CAG (2)	Local Government
City of Santa Rosa (4)	Local Government
City and County of San Francisco (4)	Local Government
San Francisco Municipal Transportation Authority (1)	Transportation Agency
San Mateo County (1)	Local Government
Seamless Bay Area (1)	Non-profit Organization
Solano County (3)	Local Government
Sonoma County (1)	Local Government
Sonoma RCPA (2)	Local Government
StopWaste (3)	Local Government
Transportation Authority of Marin (1)	Transportation Agency
TransForm (1)	Roundtable Member
City of Walnut Creek (3)	Local Government
City of Windsor (1)	Local Government

Table 9. Working Sessions

Working Session (Date)	Topics covered
Background Webinar (October 17, 2023, virtual)	• Provide overview of the CPRG program and NOFO. • Establish background knowledge of BARCAP process to date. • Present process and timeline for developing PCAP measures.
Working Session 1 (October 27, 2023, virtual)	• Establish a common understanding of existing programs, gaps and opportunities, and key agencies. • Discuss common vision for necessary changes so that frontline communities have clean and healthy homes and convenient and safe mobility. • Obtain feedback on draft design principles to guide measure development.
Working Session 2 (November 8, 2023, virtual)	• Agree upon key elements of each measure and how to best focus it, including the geographic locations. • Begin to define potential coalitions.
Working Session 3 (November 30, 2023, hybrid)	• Share finalized design principles (incorporating feedback from Roundtable). • Review and refine initial measure descriptions and geographic locations. • Continue to discuss coalitions.
Working Session 4 (December 13, 2023, virtual)	• Discuss final measure details and answer outstanding questions on measure language. • Share feedback from the Roundtable. • Discuss key implementation questions and share the process moving forward to develop funding proposals. • Celebrate work together.

Agendas and slide presentations for each of the Working Sessions are located on the BARCAP web page (https://www.baaqmd.gov/plans-and-climate/climate-protection/bay-area-regional-climate-action-planning-initiative).

Outputs from the four Working Sessions included:

- Final Design Principles to guide PCAP measure development
- Detailed draft language for PCAP measures
- List of identified interested partners for implementation funding proposals
- Landscape analysis of existing relevant efforts in the region, including gaps and opportunities

Public Workshop

The Air District held a public workshop in November 2023 for attendees to learn about the BARCAP effort and provide input on draft PCAP measure concepts in an interactive format. The workshop occurred virtually in the early evening to facilitate participation by working stakeholders who could not attend during daytime hours. The agenda, slides, and recording of the workshop are available on the

BARCAP web page (https://www.baaqmd.gov/plans-and-climate/climate-protection/bay-area-regional-climate-action-planning-initiative).

Attendees included:

- local government staff
- housing developers
- building energy and transportation experts and NGOs
- environmental advocacy organizations
- the Port of Oakland
- interested individuals.

Feedback from the public workshop was incorporated into the Working Sessions described above.

Online Resources

The Air District developed a webpage[3] on its agency website to share information about the BARCAP planning effort and post recordings and materials from meetings, including the background webinar, public workshop and Working Sessions. An email listserv was created that interested stakeholders and members of the public can subscribe to for updated information on the BARCAP effort.

Direct Email

In addition to the email distribution list, the Air District provided an email account (climate@baaqmd.gov) as another avenue for the public to send comments and suggestions on the PCAP.

Design Principles

The Air District and AWG partners, with input from Roundtable and Working Session participants, developed a set of design principles to guide/influence development of the PCAP measures. They will continue to be used to identify and develop measures for the CCAP. The following text is the design principles document that was refined and finalized through the Working Sessions and shared below in its entirety.

Full Design Principles Text

This document outlines design principles that will guide measure development for the Priority Climate Action Plan through the Bay Area Regional Climate Action Planning (BARCAP) Initiative, funded through USEPA's Climate Pollution Reduction Grant program. They have been developed with input from the Advisory Work Group, Working Session participants, and the Roundtable.

What are Design Principles?

Design principles are a common set of guiding values to guide important decisions during measure development. They serve as guideposts to keep teams on the same path and identify values that unify collaborators around what is most important.[1]

Each design principle should focus on one value and articulate it clearly in short and easily

[3] https://www.baaqmd.gov/plans-and-climate/climate-protection/bay-area-regional-climate-action-planning-initiative

understandable language to avoid multiple interpretations. A list of design principles should be a manageable length, not containing too many, and avoid containing conflicting principles.[2] If potentially conflicting ones are both important in different contexts, then clarify the contexts in which one may be more important than the other.

How Will the Design Principles Be Used in Measure Development?

The EPA's primary goal for plans and implementation funding applications submitted to the Climate Pollution Reduction Grant program is reductions of greenhouse gases. However, there are many ways to achieve that goal within each of the measure focus areas (residential building electrification and transportation mode shift). The design principles helped guide measure development to ensure the final measures are consistent with the common values reflected in the relevant principles. The design principles will be referred to at key decision points and will help resolve conflicting perspectives.

List of EPA Criteria for the Implementation Grant Opportunity[3] (in order of potential points)

- ***Significant GHG reductions*:** Achieve substantial GHG reductions over the short-term (by 2030) as well as enable deep reductions long-term (by 2050) (60 pts in EPA's Notice of Funding Opportunity (NOFO) scoring criteria).
- ***Community benefits and community-based design:*** Implementation benefits low-income and disadvantaged communities, as defined by EPA, and contains a process for being informed by community (35 pts).[4]
- ***Replicable and innovative***: Can be pilots in specific geographies if regionally replicable and scalable (15 pts for transformative impact).
- ***Funding gap*:** Fills a need unmet by existing funding sources (10 pts).
- ***Jobs***: Creates lasting high-quality, family-sustaining jobs (5 pts).
- ***Regional***: Best at regional scale (vs. local or state) with participation from multiple jurisdictions.
- ***Implementable in short-term:*** Implementable within a 5-year timeframe (2024-2029) (e.g., funding expended by October 1, 2029).

Working List of Design Principles for Measure Development That Complement the EPA Criteria (in alphabetical order)

- ***Climate equity*:** Measures must provide direct, meaningful, desired, and assured benefits to frontline communities, with a particular focus on Black, Indigenous, and People of Color (BIPOC) communities. There is no one-size-fits-all solution, and what works for one community may not work for another community. No community's well-being is sacrificed for another community. Some initiatives include creating seedbed opportunities for communities that have been left out.
- ***Cooperative*:** Builds upon and integrates existing efforts to expand impact, rather than introduce duplication, including the California Energy Commission's Equitable Building Decarbonization Install Program.
- ***Coordinated*:** Building cooperation and peer working relationships among local government and community-based organizations that builds community capacity and empowers community leadership within and across counties.[5]

- ***Funding*****:** Increases access to critical financing and funding mechanisms for frontline communities and other key stakeholders.
- ***Genuine affordability and access*****:** Increases access to housing and transportation, especially for frontline communities. Reduces, or at least does not increase, housing/transportation/energy costs and considers options to expand access and affordability. Defines affordability as deeply affordable to low-income people. Improves affordability programs to increase eligibility and enrollment.
- ***Health & safety***: Improves living conditions (indoor and outdoor air quality, traffic safety, and pedestrian safety), especially in frontline communities.
- ***Housing and community stability*****:** Supports people, especially renters and low-income homeowners, be housed and remain in their homes by increasing healthy, resilient housing with affordable electricity and accessible transportation options.
- ***Jobs*****:** Creates lasting, high-quality, family-sustaining high-road jobs and other pathways to economic sovereignty in frontline communities. Implementing just transition must include tangible programs, including training to highroad jobs programs, not just a principle of creating jobs. Opening up sustainable jobs for minority, women, and people of color contractors and workers. Incorporating the needs of labor and the working class to build a transition that meets all people's basic needs. Ensure trackable economic benefits including lasting, high-quality, family-sustaining high-roads jobs; training and high-road job pathways; cost savings; contracting opportunities; and/or asset building opportunities for frontline communities. Support opportunities for community economic resilience building, when feasible and relevant (e.g., community land trusts; local, cooperatively owned businesses, etc.).
- ***Resilience*****:** Builds resilience, especially for frontline communities, through changing climate conditions in the near and long term.
- ***Strategic*****:** Uses one-time funding transformatively. Create programs that integrate transportation options with housing, schools, and communities. Considers both short- and long-term impact, and where possible implements short term impact that leads to long term transformation.

Commitment to Equity and GHG Reductions

Equitable decarbonization policies provide comprehensive investments and holistic upgrades to improve housing and transportation quality, health, and resilience and reduce climate emissions for populations facing the greatest disparities. These issues are central to climate justice, a movement that works to ensure everyone has affordable housing and access to affordable transportation that promotes health, well-being, stability and safety, by working to end historical and ongoing harms and disparities caused by structural racism and other systems of oppression.

We do not see a tension or conflict between reducing GHG emissions and addressing health equity and housing justice, but instead view advancing all together as an effective approach for working to end the climate crisis and its consequences. Thus, integrating equity in building and transportation decarbonization provides an opportunity to address long-standing inequities in the built environment born from racist and discriminatory policies, avoid perpetuating patterns of harm, improve the lives of those most impacted, and meet the climate emergency with the urgency and intensity it demands.

Bios of Roundtable Members

Aminah Luqman, Greenlining Institute
Aminah Luqman (she/her/hers) is the Oakland Program Manager for Capacity Building at the Greenlining Institute. In her role, she supports local stakeholders to advance community-driven, equitable climate solutions. Prior to joining The Greenlining Institute, Aminah worked at Shared Value Media as the Community Partnership Manager for the California COVID-19 Workplace Outreach Project (CWOP). As the Community Partnership Manager, she worked with community-based organizations in the Bay Area, Sacramento and Los Angeles regions to reach workers who were disproportionately affected by the COVID-19 pandemic about their rights in the workplace. She was also the Census 2020 Program Manager at United Way Bay Area, where she worked in coalition with 100+ community-based organizations to make the 2020 census more accessible and culturally relevant for "hard-to-count" communities in Alameda, Contra Costa, San Francisco, San Mateo, Santa Clara, Solano and Marin counties. Prior to moving back to Oakland to work at United Way Bay Area, Aminah lived and worked in Colombia for two years as a Fulbright grantee.

Antonio Diaz, PODER
Antonio Díaz is the Organizational Director for People Organizing to Demand Environmental and Economic Justice (PODER). He was raised along the Texas – México borderlands and has been engaged in the movement for environmental and economic justice since the early 1990's. Antonio moved to the Bay Area in 1995 and has been organizing with PODER since then. He is currently on the steering committees of San Francisco Rising and Bay Rising, and is the Chair of the Board of Directors of the California Environmental Justice Alliance. Recently, he served on San Francisco's Zero Emission Building Taskforce Executive Steering Committee to work with the City to develop a roadmap to transition away from fossil fuels in San Francisco buildings in a manner that is equitable. He also served on the San Francisco Climate Action Community Climate Council to support community engagement on the Climate Action Plan update and the Environmental Justice Working Group to develop an environmental justice framework to be incorporated into the City's General Plan, as required by SB 1000. He is currently on the Buildings Operations Task Force convened by San Francisco Environment to implement the building operations component of the Climate Action Plan.

Zack Deutsch-Gross, TransForm
Zack leads TransForm's policy and advocacy, applying a climate and equity framework to tackle housing, transportation, and land use issues in the Bay Area. Zack spent a decade in community organizing, centering BIPOC and low-income communities, winning intersectional campaigns for housing justice, transit funding, a just transition from fossil fuels, and healthy neighborhoods. At San Francisco Transit Riders, Zack built a coalition of labor, equity, disability, environmental and community groups to fight and win victories—preventing fare increases, saving vital transit lines from being cut, and securing new funding for transit, walking and biking. Expertise: community engagement, coalition-building, policy evaluation, politics, leadership development, cross-issue campaigns.

Megan Leary, Emerald Cities

Megan Leary is the Community Engagement and Policy Manager for Emerald Cities Collaborative, Northern California chapter where she facilitates community engagement efforts and equitable policy implementation initiatives. This includes participation in a variety of community-initiated tables and efforts to increase inclusive and equitable access for building electrification projects, collaboration with stakeholders across the nine San Francisco Bay Area counties on green building projects and community resilience-building efforts. She previously worked with the Alameda County Public Works Agency and Honolulu's Office of Climate Change, Sustainability and Resiliency in developing community-first climate policies and economically inclusive programming. She holds a B.A. in Environmental Studies from Oberlin College, and a Master of Science in Global Environment, Politics and Society from the University of Edinburgh.

Appendix C

GHG Reduction Quantification Supporting Documentation

The following summary was developed by ICF Incorporated for the Air District to inform PCAP measure development and outline the approaches used by ICF to quantify the anticipated greenhouse gas emission reductions resulting from the two priority measures in the PCAP.

The quantification of GHG emission reductions from PCAP measures is subject to a data review and quality control process that is described in the Quality Assurance Project Plan (QAPP). This quantification is based on assumptions made on how the measure might be implemented as well as variables identified from existing literature and real-world data. As such, these GHG emission reduction estimates may be subject to an update in the CCAP process based on further QA of assumptions, best and worst case scenarios, and future improvements to data.

Memorandum

To: Monte DiPalma

From: Emily Adkins, Mollie Carroll, Adam Agalloco, Sam Pournazeri, ICF Incorporated

Date: February 29, 2024

Re: PCAP Measure Modeling Methodology

Overview

The U.S. Environmental Protection Agency's (EPA) Climate Pollution Reduction Grant (CPRG) program is one of the most flexible, fastest paced programs the federal government needs to deploy per the Inflation Reduction Act (IRA) of 2022. To support the Air District in development of a Priority Climate Action Plan (PCAP) covering the greater Bay Area, ICF quantified greenhouse gas (GHG) emissions reductions from building and transportation measures. This analysis is one component in support of a comprehensive climate planning effort the Air District is overseeing. The intent of this memo is to briefly summarize the results of this modeling effort and describe the underlying assumptions and methodologies used.

Brief Results Overview

Residential Building Decarbonization Measure

Table 1. Annual Emissions Mitigated by Buildings Measure (MT CO_2e)

	2025	2030	2035	2040	2045	2050
Air-source heat pump replaced for:						
Gas Boiler	571	6,827	13,301	17,375	18,284	18,297
Gas Furnace	4,259	50,910	99,170	129,409	136,086	136,183
Propane Furnace	155	1,858	3,617	4,705	4,938	4,941

	2025	2030	2035	2040	2045	2050
Electric Central Heat Pump replacement of Gas Hot Water Heater	3,361	37,081	66,701	81,106	85,389	85,567
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	272	3,420	7,411	10,847	12,395	12,611
ENERGY STAR Electric Dryer replacement for a Gas Dryer	97	1,240	2,544	3,864	5,117	5,641
Efficiency Measures (Thermostats and Lighting)	411	5,037	11,862	16,436	14,165	11,554
Weatherization and Deep Envelope Measures	819	10,195	22,873	34,608	44,322	53,061
Total Annual Emission Reductions	**9,945**	**116,567**	**227,479**	**298,351**	**320,695**	**327,857**

Table 2. Cumulative Emissions Mitigated by Buildings Measure (MT CO_2e)

	2025-2030	2025-2050
Air-source heat pump replaced for:		
Gas Boiler	20,464	336,784
Gas Furnace	152,592	2,508,472
Propane Furnace	5,568	91,219
Electric Central Heat Pump replacement of Gas Hot Water Heater	114,894	1,627,388
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	10,047	209,754
ENERGY STAR Electric Dryer replacement for a Gas Dryer	3,628	81,318
Efficiency Measures (Thermostats and Lighting)	14,902	274,436
Weatherization and Deep Envelope Measures	30,034	720,152
Total Cumulative Emission Reductions	**352,129**	**5,849,523**

Transportation Decarbonization Measure

Table 3. Cumulative Emissions Mitigated by Transportation Measure (MT CO_2e)

	Assumed Project Lifetime	2025-2030	2025-2050
Bike Infrastructure			
Light Rail	2027 - 2042	922	3,206
Commuter Rail	2027 - 2042	24,910	86,670
BRT	2027 - 2042	28	96
Pedestrian Infrastructure			
Light Rail	2027 - 2042	306	1,065

	Assumed Project Lifetime	2025-2030	2025-2050
Commuter Rail	2027 - 2042	11,064	38,497
BRT	2027 - 2042	8	28
E-Bike Share	2027 - 2039	1,352	3,069
E-Bike Incentive	2027 - 2039	3,484	7,911
EV Car Share	2027 - 2039	52,054	145,234
Transit Subsidy	2027 - 2032	31	87
EV Charging	2027 - 2037	77,525	184,819
Total Cumulative Emissions Reduction		**171,648**	**470,682**

Residential Building Decarbonization Measure

Building Energy Use

Building energy use and building GHG emissions projections are based on energy consumption from electricity, natural gas, fuel oil, and propane in existing residential buildings (both single family and multifamily). The base year and projections for energy consumption in existing buildings are built from the 2022 Annual Energy Outlook (AEO), which represented projected energy use prior to the passage of the Inflation Reduction Act, from the U.S. Energy Information Administration (EIA)[1]. AEO data is scaled to the Bay Area counties by scaling AEO census level data with census level ResStock building summary information. The tool uses a ratio of county proportional ResStock data, to apportion energy use to the various counties. Energy use values have been integrated with emissions factors for primary fuels (electricity, gas, propane and fuel oil) to provide total emissions. Results are provided every five years from 2020 to 2050 and interpolated for years in between.

CO_2Sight[2] is a strategic planning platform for decarbonization developed and maintained by ICF. This platform leverage's ICF's experience developing energy and climate policies and programs into a unified scenario analysis that allows users to assess future scenarios. The platform allows for a high degree of customization based on individual project needs. The modeling methodology for existing buildings utilizes ICF's Distributed Energy Resources Planner (DER Planner) model. Together the CO_2Sight platform and DER Planner estimate energy and GHG emissions changes from a range of decarbonization strategies including electrification retrofits and energy efficiency as presented in these results. In modeling buildings, ResStock[3] building characteristics and energy use data serve as a representation of each county's building portfolio. The ResStock energy use data are calibrated to match the EIA's AEO dataset. ResStock data was compiled by the National Renewable Energy Laboratory (NREL) including large public and private data sources, statistical sampling, detailed subhourly building simulations, and high-performance computing. By synthesizing multiple sources into a single resource, these data allow for a granular understanding of the housing stock and the impacts of building technologies in different

[1] https://www.eia.gov/outlooks/aeo/
[2] https://www.icf.com/technology/energy-decarbonization-platform-cosight
[3] https://www.nrel.gov/buildings/resstock.html

communities. These data are comprehensive and widely used across similar analyses and modeling efforts, and thus allow for development of comparable results.

DER Planner, informed by stock CO_2Sight measures data, has the capabilities to model more than 80 residential and commercial energy efficiency, electrification, and building envelope measures, in selected building types. ICF's program experience and available national data sources inform these measures' impacts on energy use. The modeling analysis was applied to the Bay Area counties building datasets, which CO_2Sight aggregates to estimate the changes in energy use.

DER Planner takes into account implementation rates of energy measures whereby individual building systems will be replaced in kind, switched to a more efficient technology, or switched to a comparable efficient electric technology, either as elective retrofits or at the time of natural replacement. For this work, adoption curves were developed specifically to represent the maximum adoption potential of new incentive programs for electrification and energy efficiency technologies. ICF worked with Air District staff to determine the correct CO_2Sight Strategy packages (DER Planner modeling result) to apply that best represents the alternative case needs. Core assumptions are outlined below.

- Zero NO_x standard implementation dates (applies to appliances manufactured after the noted date):
  - **Jan. 1, 2027** – Water heaters less than 75,000 BTU/hr (typically residential tank water heaters)
  - **Jan. 1, 2029** – Residential and commercial furnaces
  - **Jan. 1, 2031** – Water heaters between 75,000 and 2 million BTU/hr (commercial and multifamily)

Figure 1: Zero NOx standards implementation dates

Finally, ICF worked to post process the outputs to account for the Air District's zero NOx-emitting appliance regulations.[4] Beginning in 2027, as restrictions on NOx limits availability to install certain emitting technologies, ICF reduced number of retrofits in alignment with the useful life of the equipment. As an example, in 2040, 11 years after the change in rules, the number of modeled retrofits for a furnace to air source heat pump, equipment with an estimate 18 year lifecycle, was reduced by 61% (11 years/18 year useful life), to account for the fact that only 39% of the existing stock would have been installed prior to the rule change. Additional details and specific assumptions on this post processing are found in the NOx regulation section below.

Electricity Grid

CO_2Sight uses ICF's Integrated Planning Model[5] (IPM) tool to generate a trajectory of grid emissions factors associated with the electricity grid. The IPM model is populated with inputs from sector-specific analyses and solves for a least-cost mix of clean energy resources that are able to satisfy the resulting energy demand. IPM provides long-term projections of behaviors for existing, new commercial, and renewable power plants to meet electric generation demand while complying with specific limitations

[4] https://www.baaqmd.gov/rules-and-compliance/rule-development/building-appliances
[5] https://www.icf.com/technology/ipm

including regulation, transmission constraints, and operating constraints. IPM is a logically consistent framework through which to examine compliance outcomes in wholesale power market operation.

IPM includes a characterization of existing and potential incremental capacity. EPA assumptions are used to represent on and offshore wind generation. IPM includes solar (PV and thermal) resource potential varying in costs, generation profile, and contribution to reserve margin, which is modeled consistent with market operations for capacity requirements.

For this model, ICF used stock and available IPM modeling runs based on "on the books" policies to account for reductions in GHG emissions from grid-sourced electricity that are expected to occur regardless of whether any additional policy action is taken to encourage them (i.e., policies that are already on the books). These policies excluded the IRA, IIJA or CHIPS and Sciences Act. The "on the books" reductions through IPM were used to develop CALISO emissions factors which were then used to calibrate projections of electricity emissions factors for the Bay Areas based on a consumption emissions factor provided by the Air District.

Greenhouse Gas Emissions

Energy results were combined with emissions factors and scaling of frontline community households (discussed in further detail in this memo) to determine GHG emissions reductions. Equation 1, outlines the general approach.

Equation 1

GHG Emissions Reductions	=	Change in energy use per measure	x	Fuel and electricity emissions factors	x	Scaling to frontline community household prevalence

Emissions and Energy Modeling Assumptions

ICF used a range of assumptions regarding existing building stock and equipment efficiency. These were based in part on equipment available in the marketplace and certified as energy efficient through EPA's ENERGY STAR[6] program and partially through previous program experience and published program result information. Together, ICF modeled 10 measures with retrofit curves. ICF worked with Air District staff and BAYREN to review assumptions on the efficiency levels for air-source heat pumps, gas furnace, gas boiler, electric central heat pumps and other equipment outlined below.

[6] https://www.energystar.gov/products

Table 4. Energy Change Assumptions by Measure

Efficient Measure	Baseline Measure	Fuel Type	Fuel Switch	Assumptions
Electric Central Heat Pump replacement of Gas Hot Water Heater	Gas Central hot water heater	Electricity & natural gas	Yes	Replace a Gas Hot Water Heater with 80% efficiency to a Heat Pump Water Heater with an energy factor (EF) of 2.
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	Gas Oven/stovetop	Electricity & natural gas	Yes	Replace a gas stovetop/oven with an induction stovetop/oven
ENERGY STAR Electric Dryer replacement for a Gas Dryer	Gas Dryer	Electricity & natural gas	Yes	Replace a gas dryer with an ENERGY STAR electric dryer.
Air-source Heat Pump (ASHP) replacement	Gas Furnace	Electricity & natural gas	Yes	Replace furnace with 80% efficiency with an ASHP that has a coefficient of performance (COP) of 2.8, also increased efficiency of AC from 2.5 COP
Air-source Heat Pump replacement	Propane Furnace	Electricity & propane	Yes	Replace furnace with 90% efficiency with an ASHP that has a 2.8 COP, also increased efficiency of AC from 2.5 COP
Air-source Heat Pump replacement	Gas Boiler	Electricity & natural gas	Yes	Replace boiler with 80% efficiency with an ASHP that has a COP of 2.8, also increased efficiency of AC from 2.5 COP
Smart Thermostat	Existing Thermostat	Electricity & natural Gas	No	8% reduction in gas, 10% reduction in electricity use from space heating and cooling
Building Envelope Sealing and Weatherization	Existing Building Envelope	Electricity & natural Gas	No	15% reduction in gas, 15% reduction in electricity use from space heating and cooling
Deep Building Envelope Sealing and Weatherization	Existing Building Envelope	Electricity & natural Gas	No	30% reduction in gas, 30% reduction in electricity use from space heating and cooling
Lighting Retrofit	Existing Lighting	Electricity	No	75% reduction in lighting energy use

Electricity Grid Emissions Factors

Grid emissions factors were developed using the methodology outlined above.

Table 5. Electricity Grid Emissions Factors (MT CO_2e/MWh)

2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050
0.051	0.050	0.052	0.054	0.056	0.058	0.060	0.053	0.022	0.001	0.000

Natural Gas and Propane Emissions Factors

Values from EPA's Center for Corporate Climate Leadership GHG Emission Factors Hub were used.[7]

Table 6. Fuel Emission Factors (kg CO_2e/MMBTU)

Fuel	Emission Factors
Natural Gas	53.06
Propane	62.39

Scaling Results by Frontline Communities

To derive the portion of DER Planner results attributed to frontline communities, ICF scaled output results (which include energy change and participation) from single family and multifamily households at the County level. Total housing units in frontline communities by County were provided by the Air District,[8] while total housing units were taken from the U.S. Census.[9] Scaling of results combined the building typology (e.g., single family or multi-family) and measure specific County results with the proportional households from frontline communities. As an example: The Alameda County results from updating single family homes from a gas hot water heater to an electric central heat pump were scaled to match the proportion of single-family homes that are in frontline communities. Using this approach, the frontline community participation, GHG emissions, and energy savings for each measure is scaled proportionally to both the measure penetration[10] within the Counties, the household types in the Counties, and the proportion of frontline community housing units within each County. Using this approach, the model assumes that frontline community housing units have the same general characteristics (equipment types) as those within other parts of the counties and thus a retrofit program has the same results on a household basis.

[7] https://www.epa.gov/climateleadership/ghg-emission-factors-hub

[8] Based on EPA IRA Disadvantaged Communities, AB 617 communities, and Metropolitan Transportation Commission's Equity Priority Communities.

[9] https://www.census.gov/data/datasets/time-series/demo/popest/2020s-total-housing-units.html

[10] Measure penetration is a value used to determine the percentage of users or available stock that adopts something; in this case it refers to the percentage of measures adopted in eligible households. Measure penetration will vary based on the unique equipment and building characteristics of a given area.

Table 7. Percentage of Housing types by County that are in Frontline Communities

County	Units in 2-4 Unit Buildings	Units in 5+ Unit Buildings	Units in Single-Family, Townhome, Etc.
Alameda County	5.2%	13.1%	18.6%
Contra Costa County	3.2%	7.8%	20.3%
Marin County	1.0%	6.4%	3.8%
Napa County	2.2%	4.6%	14.3%
San Francisco County	7.4%	28.0%	15.4%
San Mateo County	3.4%	10.2%	13.6%
Santa Clara County	0.0%	0.0%	0.1%
Solano County	3.3%	5.2%	16.2%
Sonoma County	2.8%	6.5%	13.7%
Average Frontline Community Housing Type Within the Region (Regional Weighted Average)	**3.4%**	**9.8%**	**12.5%**

Participation Rates

To model participation rates, an S-curve is assumed for adoption to match the rate and shape of technology curves from NREL's Electrification Futures Study.[11] The maximum program participation rate was set separately for each retrofit program based on participation rates in similar programs.[12] In the current modeling, retrofit programs for air source heat pumps to provide both space and water heating were set at a maximum adoption rate of 2.5%. Programs for appliances (both gas-to-electric dryers and gas ovens/cooktops-to-electric and energy efficiency) achieved a maximum of a 1.6% program adoption rate. In both cases, programs would scale rapidly to the maximum adoption rate to reflect a program that scales quickly and assumes existing barriers that can slow participation have been addressed.

Scaled Results

Table 8. Annual Installations

	2025	2030	2035	2040	2045	2050
Air-source heat pump replaced for:						
Gas Boiler	457	1,233	860	455	128	-
Gas Furnace	3,195	8,618	6,015	3,182	897	-
Propane Furnace	91	246	172	91	26	-
Electric Central Heat Pump replacement of Gas Hot Water Heater	4,885	11,378	6,156	771	-	-
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	2,019	5,918	6,111	5,746	5,664	5,703
ENERGY STAR Electric Dryer replacement for a Gas Dryer	1,022	2,995	3,093	2,908	2,866	2,886
Efficiency Measures (Thermostats and Lighting)	5,678	16,640	17,182	16,085	15,520	15,216
Weatherization and Deep Envelope Measures	4,324	12,673	13,085	12,234	11,724	11,394
Total Annual Installations	**21,671**	**59,701**	**52,674**	**41,471**	**36,825**	**35,199**

[11] https://www.nrel.gov/analysis/electrification-futures.html
[12] https://eta-publications.lbl.gov/sites/default/files/ee_program_participation.pdf

Table 9. Cumulative Installations

	2025-2030	2025-2050
Air-source heat pump replaced for:		
Gas Boiler	5,554	15,113
Gas Furnace	38,833	105,670
Propane Furnace	1,109	3,018
Electric Central Heat Pump replacement of Gas Hot Water Heater	55,257	113,230
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	25,204	142,280
ENERGY STAR Electric Dryer replacement for a Gas Dryer	12,755	72,002
Efficiency Measures (Thermostats and Lighting)	70,868	395,354
Weatherization and Deep Envelope Measures	53,975	299,991
Total Cumulative Installations	**263,555**	**1,146,658**

Table 10. GHG emissions reductions and energy change per Installation in 2025 by measure

	MT CO_2e reduced per install	Change in kWh per install	Change in therms per install
Air-source heat pump replaced for:			
Gas Boiler	1.25	2146.7	-255.9
Gas Furnace	1.33	2242.0	-272.4
Propane Furnace	1.69	2679.4	-294.3
Electric Central Heat Pump replacement of Gas Hot Water Heater	0.68	1708.8	-145.8
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	0.14	318.2	-28.6
ENERGY STAR Electric Dryer replacement for a Gas Dryer	0.10	742.5	-25.3

	MT CO_2e reduced per install	Change in kWh per install	Change in therms per install
Thermostat	0.08	-132.4	-13.8
Lights	0.04	-828.3	0.0
Weatherization	0.14	-126.7	-25.9
Deep Energy	0.29	-253.5	-51.8

Zero NOx-Emitting Appliance Regulations

Given that the focus of this measure is on retrofit programs and not a replacement on burnout for equipment, model results were post processed to account for the Air District's zero NOx-emitting appliance regulations. The rules focus on replacement upon burnout and thereby decrease total participation levels in retrofit programs in later years when a smaller population of retrofit opportunities exist due to stock turnover. ICF used a set of assumptions to post process modeling results to account for a decreasing population of retrofittable stock for four of the retrofit types per the appliance regulation (Gas Boiler to ASHP, Gas Furnace to ASHP, Propane Furnace to ASHP and Gas Hot Water Heater to Electric Central Heat Pump). Useful life for each equipment is based on data provided to ICF by the Air District in alignment with NOx regulation modeling assumptions.[13]

Table 11. Assumptions used for zero NOx-emitting appliance regulations post processing of results

Equipment	Assumptions
Small Gas Hot Water Heaters (smaller than 75,000 BTU/hr)	• Available stock for small water heaters begins declining in 2027, using a 13 year useful life. • Small gas hot water heaters are assumed for all single family housing units, all multifamily housing units with less than 4 units, and half of all multifamily units with 5 or more units
Large Gas Water Heater (between 75,000 and 2 million BTU/hr)	• Available stock for large water heaters begins declining in 2031, using a 13 year useful life. • Large gas hot water heaters are assumed for half of all multifamily units with 5 or more units
Residential furnaces	• Available stock for residential furnaces begins declining in 2029, using an 18 year useful life.

While the useful life of equipment above were used in modeling, the actual implementation of this regulation may vary. There will be significant upfront cost to replace aging equipment, property owners may work to extend the life of their aging equipment (in lieu of replacing it), providing for a longer retrofit program effectiveness than shown in modeling.

[13] Equipment lifetimes are from data supporting the National Energy Modeling System (NEMS) and *Residential Building Electrification in California* (2019) by Energy and Environmental Economics. https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

Additional Results Data

Table 12. Annual MMBTU Reduction by Measure

	2025	2030	2035	2040	2045	2050
Air-source heat pump replaced for:						
Gas Boiler	11,695	142,146	273,830	339,421	345,102	344,844
Gas Furnace	87,040	1,057,958	2,038,052	2,526,231	2,568,515	2,566,592
Propane Furnace	2,686	32,644	62,885	77,948	79,253	79,194
Electric Central Heat Pump replacement of Gas Hot Water Heater	71,227	805,645	1,425,471	1,607,710	1,612,655	1,612,655
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	5,770	72,025	159,805	230,266	245,061	238,152
ENERGY STAR Electric Dryer replacement for a Gas Dryer	2,589	32,322	71,715	103,336	109,976	106,875
Efficiency Measures (Thermostats and Lighting)	5,231	65,299	144,881	208,763	222,176	215,912
Weatherization and Deep Envelope Measures	14,713	183,652	408,480	621,610	818,501	999,147
Total Annual MMBTU Reduced	**200,952**	**2,391,691**	**4,585,119**	**5,715,285**	**6,001,239**	**6,163,370**

Table 13. Cumulative MMBTU Reduction by Measure

	2025-2030	2025-2050
Air-source heat pump replaced for:		
Gas Boiler	424,034	6,597,480
Gas Furnace	3,155,989	49,103,509
Propane Furnace	97,380	1,515,121

	2025-2030	2025-2050
Electric Central Heat Pump replacement of Gas Hot Water Heater	2,478,261	32,497,748
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	212,030	4,282,956
ENERGY STAR Electric Dryer replacement for a Gas Dryer	95,152	1,922,052
Efficiency Measures (Thermostats and Lighting)	192,229	3,882,984
Weatherization and Deep Envelope Measures	540,644	13,169,735
Total Cumulative MMBTU Reductions	**7,195,719**	**112,971,584**

Table 14. Annual MWh Reduction by Measure

	2025	2030	2035	2040	2045	2050
Air-source heat pump replaced for:						
Gas Boiler	(981)	(11,923)	(22,968)	(28,469)	(28,946)	(28,924)
Gas Furnace	(7,163)	(87,063)	(167,718)	(207,892)	(211,372)	(211,213)
Propane Furnace	(244)	(2,972)	(5,725)	(7,096)	(7,215)	(7,209)
Electric Central Heat Pump replacement of Gas Hot Water Heater	(8,348)	(94,422)	(167,065)	188,424)	(189,003)	(189,003)
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	(642)	(8,019)	(17,793)	(25,638)	(27,285)	(26,516)
ENERGY STAR Electric Dryer replacement for a Gas Dryer	(759)	(104,951)	(228,083)	(321,155)	(332,259)	(317,497)
Efficiency Measures (Thermostats and Lighting)	2,511	9,249	20,537	30,130	34,625	36,970
Weatherization and Deep Envelope Measures	720	8,982	19,978	30,401	40,031	48,865
Total Annual MWh Reductions	**(14,906)**	**(291,119)**	**(568,837)**	**(718,142)**	**(721,424)**	**(694,527)**

Table 15. Cumulative MWh Reduction by Measure

	2025-2030	2025-2050
Air-source heat pump replaced for:		
Gas Boiler	(35,566)	(553,366)
Gas Furnace	(259,717)	(4,040,889)
Propane Furnace	(8,865)	(137,927)
Electric Central Heat Pump replacement of Gas Hot Water Heater	(290,452)	(3,808,736)
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	(23,607)	(476,864)
ENERGY STAR Electric Dryer replacement for a Gas Dryer	(302,633)	(5,925,903)
Efficiency Measures (Thermostats and Lighting)	28,997	588,400
Weatherization and Deep Envelope Measures	26,441	644,093
Total Cumulative MWh Reductions	**(865,402)**	**(13,711,192)**

Costs Estimates

Results

ICF estimated costs for implementation of the residential buildings measure using a bottom-up methodology; multiplying the number of units retrofitted (found in Table 8. Annual Installations) by costs and incentives developed on a per retrofit basis. Costs and incentives were both provided by the Air District and gathered from a range of different sources as outlined in Table 16 below. All cost estimates are shown in 2022 dollars.

Several costs are estimated:

- ***Total cost of installation*****,** which is the average total cost of the appliance or equipment plus construction/installation costs and enabling upgrades.
- ***Total cost to customer,*** which is the potential cost of installation minus regional[14] and state, and with and without federal incentives to show the range of price a customer might pay.
- ***Total program costs,*** which is inclusive of the cost of regional incentives, program administration, and marketing associated with a retrofit program.
- ***Potential remaining funding need after state and federal incentives are applied,*** was estimated as total cost of installation minus federal and state incentives. Regional incentives are considered separately as reducing customer cost, but increasing the program cost for the regional agencies and community choice aggregators (CCAs) who administer them.

Summaries of outputs from this analysis can be found below in Table 16, Table 17, Table 18, Table 19, Table 20, Table 21, and Table 22 below.

[14] Regional incentives refer to BayREN incentives. Local incentives and CCA incentives are not included in this estimate.

Table 16. Cost Summary for each equipment installation or retrofit

Equipment/ Retrofit	Cost of Installed Equipment[15]	Program Cost per Install[16]	Total State and Federal Incentives [17]	Total Cost to Customer per Install with Regional and State Incentives [18]	Total Cost to Customer per Install with Regional, State, and Federal Incentives	Total Remaining Funding Need Per Install after State and Federal Incentives (excludes Regional incentives))[19]
Air Source Heat Pump	$18,465	$787	$8,000	$17,852	$9,852	$10,465
Hot Water Heat Pump	$8,042	$735	$2,650	$6,568	$4,818	$5,392
Electric Oven and Induction Stovetop	$2,481	$471	$840	$2,112	$1,272	$1,641
Electric Dryer	$992	$304	$0	$755	$755	$992
Smart Thermostat	$222	$96	$75	$72	$72	$147
Household LED Lighting Retrofit	$251	$128	$0	$151	$151	$251
Household Weatherization	$7,322	$388	$1,600	$7,021	$5,421	$5,722
Household Deep Energy Retrofit	$23,051	$1,251	$8,000	$22,076	$14,076	$15,051

[15] The average cost of appliance or equipment plus construction/installation costs and enabling upgrades.
[16] Program cost per install equals average program administration cost plus average regional rebates (which are administered by BayREN). This does not include local incentives and incentives from CCAs. (see Table 28).
[17] State incentives included are Golden State Rebates (TECH Clean CA and CEC Equitable Building Decarbonization are not included) Federal incentives included are: HEEHRA and HOMES programs (WAP and LIHEAP are not included).
[18] Total cost to customer without federal incentives equals cost of installed equipment minus state incentives and regional rebates (see Table 25 and Table 26).
[19] Total remaining funding need per install after state and federal incentives equals cost of installed equipment (including construction costs) minus federal and state incentives.

Table 17: Total Installation Costs *(without incentives)*	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Air-source heat pump replaced for:						
Gas Boiler	$8,437,383	$22,760,192	$15,885,287	$8,402,572	$2,370,123	$0
Gas Furnace	$58,993,223	$159,136,674	$111,068,120	$58,749,828	$16,571,627	$0
Propane Furnace	$1,684,856	$4,544,969	$3,172,123	$1,677,904	$473,288	$0
Electric Central Heat Pump replacement of Gas Hot Water Heater	$39,284,947	$91,496,264	$49,504,566	$6,196,647	$0	$0
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	$5,008,801	$14,679,676	$15,159,517	$14,253,784	$14,049,109	$14,146,837
ENERGY STAR Electric Dryer replacement for a Gas Dryer	$1,013,900	$2,971,514	$3,068,645	$2,885,303	$2,843,872	$2,863,655
Efficiency Measures (Thermostats and Lighting)	$1,314,468	$3,852,413	$3,977,815	$3,722,581	$3,585,418	$3,507,119
Weatherization and Deep Envelope Measures	$69,909,657	$204,889,568	$211,571,613	$198,417,565	$193,123,109	$191,450,686
Total Annual Costs	$185,647,236	$504,331,269	$413,407,686	$294,306,185	$233,016,546	$211,968,297

Table 18: Cumulative Installation Costs (without incentives)

	2025-2030	2025-2050
Air-source heat pump replaced for:		
Gas Boiler	$102,555,066	$279,067,427
Gas Furnace	$717,053,365	$1,951,207,727
Propane Furnace	$20,479,158	$55,726,803
Electric Central Heat Pump replacement of Gas Hot Water Heater	$444,348,406	$910,540,764
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	$62,520,386	$352,932,438
ENERGY STAR Electric Dryer replacement for a Gas Dryer	$12,655,606	$71,441,880
Efficiency Measures (Thermostats and Lighting)	$16,407,332	$91,441,711
Weatherization and Deep Envelope Measures	$872,619,722	$4,891,566,745
Total Cumulative Costs	**$2,248,639,043**	**$8,603,925,496**

Table 19. Annual Program Implementation Costs

	2025	2030
Air-source heat pump replaced for:		
Gas Boiler	$359,492	$969,745
Gas Furnace	$2,513,528	$6,780,347
Propane Furnace	$71,787	$193,648
Electric Central Heat Pump replacement of Gas Hot Water Heater	$3,592,356	$8,366,746
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	$951,032	$2,787,262
ENERGY STAR Electric Dryer replacement for a Gas Dryer	$310,639	$910,414
Efficiency Measures (Thermostats and Lighting)	$607,615	$1,780,783
Weatherization and Deep Envelope Measures	$3,776,854	$11,069,114
Total Annual Costs	**$12,183,303**	**$32,858,058**

Table 20. Cumulative Program Implementation Costs

	2025-2030
Air-source heat pump replaced for:	
Gas Boiler	$4,369,570
Gas Furnace	$30,551,539
Propane Furnace	$872,557
Electric Central Heat Pump replacement of Gas Hot Water Heater	$40,632,809
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	$11,870,882
ENERGY STAR Electric Dryer replacement for a Gas Dryer	$3,877,430
Efficiency Measures (Thermostats and Lighting)	$7,584,311
Weatherization and Deep Envelope Measures	$47,143,088
Total Cumulative Costs	**$146,902,187**

Table 21. Annual Potential Funding Need After State and Federal Incentives Applied

	2025	2030
Air-source heat pump replaced for:		
Gas Boiler	$4,781,878	$12,899,315
Gas Furnace	$33,434,348	$90,190,545
Propane Furnace	$954,890	$2,575,856
Electric Central Heat Pump replacement of Gas Hot Water Heater	$26,339,019	$61,344,661
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	$3,312,652	$9,708,641
ENERGY STAR Electric Dryer replacement for a Gas Dryer	$1,013,900	$2,971,514
Efficiency Measures (Thermostats and Lighting)	$1,030,589	$3,020,425
Weatherization and Deep Envelope Measures	$47,428,190	$139,001,418
Total Annual Funding Need	**$118,295,466**	**$321,712,376**

Table 22. Cumulative Potential Funding Need After State and Federal Incentives Applied

	2025-2030
Air-source heat pump replaced for:	
Gas Boiler	$58,122,978
Gas Furnace	$406,389,254
Propane Furnace	$11,606,542
Electric Central Heat Pump replacement of Gas Hot Water Heater	$297,918,203
Electric Oven and Induction Stovetop replacement of a Gas Oven and Range	$41,348,869
ENERGY STAR Electric Dryer replacement for a Gas Dryer	$12,655,606
Efficiency Measures (Thermostats and Lighting)	$12,863,915
Weatherization and Deep Envelope Measures	$592,003,682
Total Cumulative Funding Need	**$1,432,909,050**

Costs Modeling Assumptions

Methodology

Where possible, ICF sourced the cost of installed equipment from data provided by the Air District including data from an analysis by Rincon based on data provided by BayREN, Bay Area community choice aggregators, and TECH Clean CA. Where gaps remained, ICF primarily sourced data from NREL's Residential Efficiency Measures Database,[20] which lists a range of national average costs data inclusive of equipment, installation, and a range of other factors. When the NREL's Residential Efficiency Measures Database was used, ICF increased costs for specific retrofits in line with the RSMean's City Cost Index.[21] ICF used an average of San Francisco, San Jose, and Oakland's cost index to develop a regional cost increase for items from NREL's Residential Efficiency Measures Database. For the housing lighting retrofit, weatherization, and deep energy retrofit measures, ICF layered on industry assumptions to develop costs outlining what type of retrofit would be completed.

Table 23. Energy Efficiency Retrofit Cost Assumptions

Retrofit	Assumptions
Lighting	Assumed costs of a full LED changeout of lighting from incandescent.
Weatherization	Assumed costs associated with Air Sealing from 15 ACH to 1 ACH for 1,790 square foot single family home (a typical household size in California) Assumed 1/3 of that cost for each multifamily housing unit.
Deep Energy Retrofit	Assumed Costs associated with Air Sealing from 15 ACH to 1 ACH for 1,790 square foot single family home (a typical household size in California), Roof and wall insulation for a 30x30 two floor housing with 288 sqft of windows for single family housing units and assumed 1/3 of that cost for each multifamily housing unit.

Table 24. Assumed Cost of Installed Equipment/Retrofit

	Cost	Source
Air Source Heat Pump	$18,465	BAAQMD Rincon cost data weighted between single family and multifamily
Hot Water Heat Pump	$8,042	BAAQMD Rincon cost data weighted between single family and multifamily
Electric Oven and Induction Stovetop	$2,481	NREL National Residential Efficiency Measures Database, with regional cost adder derived from RS Means
Electric Dryer	$992	NREL National Residential Efficiency Measures Database, with regional cost adder derived from RS Means

[20] https://remdb.nrel.gov/
[21] https://www.rsmeans.com/rsmeans-city-cost-index

	Cost	Source
Smart Thermostat	$222	NREL National Residential Efficiency Measures Database, with regional cost adder derived from RS Means
Household LED Lighting Retrofit	$251	ICF Assumptions on typical household, with regional cost adder derived from RS Means
Household Weatherization[22]	$7,322	Derived from NREL's National Residential Efficiency Measures Database, with regional cost adder derived from RS Means
Household Deep Energy Retrofit[23]	$23,051	Derived from NREL's National Residential Efficiency Measures Database and ICF Assumptions, with regional cost adder derived from RS Means

ICF used online rebate calculators to determine available State and Federal rebates for installed equipment.[24, 25] ICF identified state rebates available to homeowners and renters in single and multi-family buildings from the Golden State Rebate.[26] ICF assumed that all participants would be eligible to receive the low-income qualifying rebate value for all installation types where available from the federal government (rebates include the High-Efficiency Electric Home Rebate Act (HEEHRA) and HOMES Program).[27] ICF did not assume any tax credits, as they can be difficult to monetize for low-income households, and did not include assumptions related to the Weatherization Assistance Program (WAP) or Low-Income Home Energy Assistance Program (LIHEAP).

Table 25. Assumed State and Federal Incentives for Equipment/Retrofit

	State Incentive	Federal Incentive	Total	Details
Air Source Heat Pump	$0	$8,000	$8,000	HEEHRA's rebate
Hot Water Heat Pump	$900	$1,750	$2,650	Golden State Rebate and HEEHRA's rebate

[22] Weatherization varies from home to home, but typically includes a diagnostic assessment of air leakage and targeted air sealing throughout the building envelope to reduce air leakage throughout a home. This can include caulk around windows, weather stripping and other repairs aimed at lowering energy costs and increasing energy efficiency.
[23] Deep Energy retrofits vary from household to household and are developed based on a diagnostic assessment. Cost information was assumed to include improved roof insulation, foam insulation on all exterior walls, and upgraded windows. Window upgrades are the largest cost improvement within deep energy retrofits.
[24] Federal rebates identified using: https://www.rewiringamerica.org/app/ira-calculator
[25] State rebates identified using: https://goldenstaterebates.com/
[26] TECH Clean CA incentives are not including as it is difficult to predict the fraction of installations modeled that would be able to successfully place a reservation for a Single Family Equity or Multifamily Equity Unitary Hot Water Heat Pumps or other equipment based on available remaining or future funding. Excluding this rebate for now is a more conservative estimate. https://switchison.org/contractors/incentive-resources/
[27] Readers can find out more about HEEHRA and HOMES online at: https://building-performance.org/ira/

	State Incentive	Federal Incentive	Total	Details
Electric Oven and Induction Stovetop	$0	$840	$840	HEEHRA's rebate
Electric Dryer	$0	$0	$0	
Smart Thermostat	$75	$0	$75	Golden State Rebate
Household LED Lighting Retrofit	$0	$0	$0	
Household Weatherization	$0	$1,600	$1,600	HEEHRA's rebate
Household Deep Energy Retrofit	$0	$8,000	$8,000	HOMES rebate

ICF assumed a rebate program run by an area implementer and sought to match rebate costs to existing programs including BAYREN's Home+ and BAMBE programs where available.[28] ICF assumed a rebate of program rebate of $200 for electric dryers, $75 for smart thermostats (to match the state rebate) and $100 for lighting retrofits.

Table 26. Assumed Program Rebates by Installed Equipment/Retrofit per Unit

	Single Family	Multifamily	Weight Average Rebate	Sources
Air Source Heat Pump	$400	$1,000	$613	BAYREN Homes+ and BAMBE rebates
Hot Water Heat Pump	$400	$1,000	$574	BAYREN Homes+ and BAMBE rebates
Electric Oven and Induction Stovetop	$250	$750	$369	BAYREN Homes+ and BAMBE rebates
Electric Dryer	$200	$375	$237	BAYREN BAMBE rebates and ICF assumption
Smart Thermostat	$75	$75	$75	ICF Assumption
Household LED Lighting Retrofit	$100	$100	$100	ICF Assumption
Household Weatherization	$150	$500	$302	BAYREN Homes+ and BAMBE rebates
Household Deep Energy Retrofit	$1,000	$1,500	$974	BAYREN Homes+ and BAMBE rebates

[28] https://www.bayren.org/rebates-financing

Finally, ICF estimated program implementation costs building from BAYREN's existing costs for Home+ and BAMBE.[29] Costs include administration and marketing and were derived by reviewing the total incentive and direct install program costs as a ratio of the total marketing and administration costs for each program.

Table 27. Assumed Program Implementation Costs by Source

Program	Total Program Admin Costs	Total Incentive and Direct Install Costs	Cost Ratio (Admin Costs/ Incentive Costs)
Home+	$2,014,916	$8,119,122	.25
BAMBE	$701,769	$2,250,120	.31

ICF weighted each measure based on the single family/multi-family housing need and applied the cost ratio derived from BAYREN actual costs for Home+ and BAMBE programs to derive the Total Program Costs by equipment/retrofit per unit.

Table 28. Assumed Program Implementer Costs by Installed Equipment/Retrofit per Unit

	Weighted average rebate	Weighted Average Program Administration Cost	Total Program Costs per install
Air Source Heat Pump	$613	$174	$787
Hot Water Heat Pump	$574	$174	$735
Electric Oven and Induction Stovetop	$369	$174	$471
Electric Dryer	$237	$161	$304
Smart Thermostat	$75	$102	$96
Household LED Lighting Retrofit	$100	$67	$128
Household Weatherization	$302	$21	$388
Household Deep Energy Retrofit	$974	$28	$1,251

[29] https://www.bayren.org/sites/default/files/2023-05/BayREN%20AR%2011x17.pdf

Transportation Sector Measures

Measure Specific Methodologies

Bike Facility within 3 miles of a Mobility Hub

Description

The addition of bicycle facilities in the vicinity of mobility hubs is a critical step towards enhancing the overall experience of bicycling. The most significant impact of this initiative is the displacement of vehicle travel, as it promotes bicycling as a preferable alternative to driving. This shift not only advances healthier commuting options but also plays a crucial role in reducing carbon emissions. Moreover, improving accessibility to transit hubs through these facilities leads to an increase in transit ridership, further contributing to the reduction of Vehicle Miles Traveled (VMT) and associated emissions. The range of bicycle facilities includes off-road bicycle paths or shared use paths, on-road bicycle lanes like side paths or designated bicycling lanes, and protected bicycle lanes or cycle tracks, which offer a safer and more segregated space from vehicular traffic.

Quantification Methodology

The calculation of GHG emission reduction attributed to a new bike facility takes into account two key factors: the decrease in GHG emissions from reduced single-occupancy vehicle (SOV) trips to the transit hub and the further GHG emission reductions brought about by increased transit ridership.

Equation 2

$$GHG = GHG_{SOV} + GHG_{MS}$$

Table 29. Variables Included in Equation 2

ID	Variable	Value	Notes
GHG	Cumulative GHG emissions reductions	N/A	Calculated in Metric Tons
GHG_{SOV}	GHG emissions reductions due to a reduction in SOV trips to the transit hub	N/A	Calculated in Metric Tons
GHG_{MS}	GHG emissions reductions due to mode shift	N/A	Calculated in Metric Tons

Reduced SOV trips to the Transit Hub

The first part of the GHG emission reduction from a new bicycle facility near a transit hub is estimated by calculating the reduction in SOV trips to the transit hub:

Equation 3

$$\mathrm{GHG_{SOV}} = \mathrm{R} \times \mathrm{Frac_3} \times \mathrm{Frac_{bike}} \times \mathrm{Dist_{bike}} \times \mathrm{EF_{LDV}}$$

Table 30. Variables Included in Equation 3

ID	Variable	Value	Notes
GHG_{SOV}	GHG emissions reductions due to a reduction in SOV trips to the transit hub (metric tons)	N/A	Calculated in Metric Tons
R	Average annual ridership per station	Varies by transit mode	From Clipper Boarding Data[30]
$Frac_3$	Fraction of transit riders within 3 miles of the transit hub	65%	Based on trip data ending in transit from Replica[31]
$Frac_{bike}$	Fraction of transit riders within 3 miles of the transit hub who will transition to biking	50%	In the absence of project-specific information, the project team made an engineering judgment and assume a conservative shift from SOV to biking. This assumption is also supported by a survey data from WMATA. [32]
$Dist_{bike}$	Average biking distance to the transit hub	1.5 miles	Given that the bike facility will be developed within 3 miles, the project team is assuming an average trip length of 1.5 miles (half of the radius to transit hub)
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)

Increased Transit Ridership (i.e., Mode Shift)

The second part of the GHG emission reduction from a new bicycle facility is estimated by calculating the estimated increased transit ridership:

Equation 4

$$\mathrm{GHG_{MS}} = \mathrm{R} \times \mathrm{Frac_{R}} \times \mathrm{Dist_{trip}} \times \mathrm{D_{transit}} \times \mathrm{EF_{LDV}}$$

[30] https://mtc.ca.gov/operations/traveler-services/clipper

[31] https://replicahq.com/

[32] In 2010, Washington Metropolitan Area Transit Authority (WMATA) conducted a survey of individuals who currently drive to Metrorail Stations. The survey results revealed that over half would contemplate alternative modes of transportation if certain conditions were met. Specifically, 55% expressed willingness to walk to the stations, while 67% considered biking to the stations a viable option. Regarding the return journey, 60% were open to walking from the stations, and 50% would consider biking from them. This indicates a significant potential for increased walking and biking to and from Metrorail Stations if appropriate biking and walking facilities are being built near transit hubs. Available at: https://planitmetro.com/wp-content/uploads/2010/12/Metrorail-Bicycle-Pedestrian-Access-Improvements-Study-_Final.pdf

Table 31. Variables Included in Equation 4

ID	Variable	Value	Notes
GHG_{MS}	GHG emissions reductions due to mode shift	N/A	Calculated in Metric Tons
R	Average annual ridership per station	Varies by transit mode	From Clipper Boarding Data[33]
$Frac_R$	Increased ridership	10%	In the absence of project-specific information, the project team made an engineering judgment and assumed 10% increase in ridership
$Dist_{trip}$	Average transit trip distance	Varies by transit mode	Based on CARB's AHSC Benefits Calculator Tool (California Air Resource Board, 2021)
$D_{transit}$	Transit dependency (i.e., vehicle ownership)	Varies by transit mode	Based on CARB's AHSC Benefits Calculator Tool (California Air Resource Board, 2021)
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)

Example Project Quantification

For Bus Rapid Transit with an average transit trip distance of 4.61 miles per trip and transit dependency of 0.54, and a project starting in 2025 with a lifetime of 15 years, the calculations are:

Reduced SOV Trips to the Transit Hub

$$\frac{6{,}757\ trip}{year} \times 0.65\ x\ 0.5 \times \frac{1.5\ mile}{trip} \times \frac{3{,}954\ gCO_2.year}{mile} \times \frac{1\ MT\ CO_2}{1000000\ g\ CO_2} = \mathbf{13.0\ MTCO_2}$$

Increased Transit Ridership (i.e., Mode Shift)

$$\frac{6{,}757\ trip}{year} \times 0.1 \times \frac{4.61\ mile}{trip} \times 0.54 \times \frac{3{,}954\ gCO_2.year}{mile} \times \frac{1\ MT\ CO_2}{1000000\ g\ CO_2} = \mathbf{6.7\ MTCO_2}$$

Total GHG Reductions

$$13.0\ MTCO_2 + 6.7\ MTCO_2 = \mathbf{19.7\ MTCO_2}$$

[33] https://mtc.ca.gov/operations/traveler-services/clipper

Pedestrian Facility within 1 mile of a Mobility Hub

Description

The introduction of pedestrian facilities near mobility hubs significantly enhances the walkability of an area, which in turn plays a pivotal role in reducing vehicle travel by encouraging modal shifts towards walking. This shift from vehicular to pedestrian modes of travel is instrumental in lowering overall transportation-related carbon emissions. Furthermore, by improving accessibility to transit hubs, these pedestrian facilities indirectly boost transit ridership, leading to a further reduction in VMT and associated GHG emissions. The spectrum of pedestrian infrastructure is broad and includes elements like sidewalks and curb ramps, which provide safe and accessible walking routes; shared use paths that cater to both pedestrians and cyclists; crosswalks that ensure safe crossing over streets; and various street crossing treatments such as signals and signs that enhance pedestrian safety and visibility.

Quantification Methodology

The process of calculating the GHG emission reduction resulting from a new pedestrian facility involves the summation of two distinct components. Firstly, it accounts for the decrease in GHG emissions that results from a reduction in SOV trips to the transit hub. This reduction is primarily attributed to more people choosing to walk instead of driving, thereby decreasing the number of car trips. Secondly, the calculation includes the GHG emissions savings due to increased transit ridership, a ripple effect of enhanced accessibility to transit hubs. This increase in the use of public transit contributes to further GHG emission reductions.

Equation 5

$$\mathrm{GHG} = \mathrm{GHG}_{\mathrm{SOV}} + \mathrm{GHG}_{\mathrm{MS}}$$

Table 32. Variables Included in Equation 5

ID	Variable	Value	Notes
GHG	Annual GHG emissions reductions	N/A	Calculated in Metric Tons
GHG_{SOV}	GHG emissions reductions due to a reduction in SOV trips to the transit hub (metric tons)	N/A	Calculated in Metric Tons
GHG_{MS}	GHG emissions reductions due to mode shift (metric tons)	N/A	Calculated in Metric Tons

Reduced SOV Trips to the Transit Hub

The first part of the GHG emission reduction from a new pedestrian facility is estimated by calculating the reduction in SOV trips to the transit hub:

Equation 6

$$\mathrm{GHG}_{\mathrm{SOV}} = \mathrm{R} \times \mathrm{Frac}_{1} \times \mathrm{Frac}_{\mathrm{walk}} \times \mathrm{Dist}_{\mathrm{walk}} \times \mathrm{EF}_{\mathrm{LDV}}$$

Table 33. Variables Included in Equation 6

ID	Variable	Value	Notes
GHG_{SOV}	GHG emissions reductions due to a reduction in SOV trips to the transit hub	N/A	Calculated in Metric Tons
R	Average annual ridership per station	Varies by transit mode	From Clipper Boarding Data[34]
$Frac_1$	Fraction of transit riders within 1 mile of the transit hub	37%	Based on trip data ending in transit from Replica[35]
$Frac_{walk}$	Fraction of transit riders within 1 mile of the transit hub who will transition to walking	50%	In the absence of project-specific information, the project team assumed this value. This assumption is also supported by a survey data from WMATA. [36]
$Dist_{walk}$	Average walking distance to the transit hub	0.5 miles	Given that the pedestrian facility will be developed within 1 miles, the project team is assuming an average trip length of 0.5 miles (half of the radius to transit hub)
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)

Increased Transit Ridership (i.e., Mode Shift)

The second part of the GHG emission reduction from a new bicycle facility is estimated by calculating the estimated increased transit ridership:

Equation 7

$$\mathrm{GHG_{MS}} = \mathrm{R} \times \mathrm{Frac_R} \times \mathrm{Dist_{trip}} \times \mathrm{D_{transit}} \times \mathrm{EF_{LDV}}$$

[34] https://mtc.ca.gov/operations/traveler-services/clipper
[35] https://replicahq.com/
[36] In 2010, Washington Metropolitan Area Transit Authority (WMATA) conducted a survey of individuals who currently drive to Metrorail Stations. The survey results revealed that over half would contemplate alternative modes of transportation if certain conditions were met. Specifically, 55% expressed willingness to walk to the stations, while 67% considered biking to the stations a viable option. Regarding the return journey, 60% were open to walking from the stations, and 50% would consider biking from them. This indicates a significant potential for increased walking and biking to and from Metrorail Stations if appropriate biking and walking facilities are being built near transit hubs. Available at: https://planitmetro.com/wp-content/uploads/2010/12/Metrorail-Bicycle-Pedestrian-Access-Improvements-Study-_Final.pdf

Table 34. Variables Included in Equation 7

ID	Variable	Value	Notes
GHG_{MS}	GHG emissions reductions due to mode shift	N/A	Calculated in Metric Tons
R	Average annual ridership per station	Varies by transit mode	From Clipper Boarding Data
$Frac_R$	Increased ridership	5%	In the absence of project-specific information, the project team assumed this value.
$Dist_{trip}$	Average transit trip distance	Varies by transit mode	Based on CARB's AHSC Benefits Calculator Tool (California Air Resource Board, 2021)
$D_{transit}$	Transit dependency (i.e., vehicle ownership)	Varies by transit mode	Based on CARB's AHSC Benefits Calculator Tool (California Air Resource Board, 2021)
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)

Example Project Quantification

For Bus Rapid Transit with an average transit trip distance of 4.61 miles per trip, transit dependency of 0.54, and a project starting in 2025 with a lifetime of 15 years, the calculations are:

Reduced SOV Trips to the Transit Hub

$$\frac{6{,}757\ trip}{year} \times 0.37 \times 0.5 \times \frac{0.5\ mile}{trip} \times \frac{3{,}954\ gCO_2.year}{mile} \times \frac{1\ MT\ CO_2}{1000000\ g\ CO_2} = \mathbf{2.5\ MTCO_2}$$

Increased Transit Ridership (i.e., Mode Shift)

$$\frac{6{,}757\ trip}{year} \times 0.05 \times \frac{4.61\ mile}{trip} \times 0.54 \times \frac{3{,}954\ gCO_2.year}{mile} \times \frac{1\ MT\ CO_2}{1000000\ g\ CO_2} = \mathbf{3.3\ MTCO_2}$$

Total GHG Reductions

$$2.5\ \frac{MT\ CO_2}{year} + 3.3\ \frac{MT\ CO_2}{year} = \mathbf{5.8\ MTCO_2}$$

E-Bike Share

Description

E-Bike share represents a micromobility initiative that operates with minimal to no emissions, playing a crucial role in reducing carbon emissions through modal shift. By offering a zero-emission alternative to traditional transportation methods, e-bike sharing encourages individuals to switch from high-emission vehicles to electric bikes for their travel needs. E-Bike share serves as a complementary option for the

first and last miles of a journey, thereby making transit systems more convenient, reliable, and efficient for users. In assessing the GHG emission reduction potential of establishing or expanding e-bike share programs, the primary focus is on the displacement of SOV VMT. However, it is important to note that this methodology does not take into account any potential impacts on existing transit activities.

Quantification Methodology

The GHG emission reduction from E-Bike share is estimated by calculating the GHG emission reductions from displaced VMT:

Equation 8

$$GHG = n_{ebike} \, x \, n_{trips} \, x \, VMT_d \, x \, EF_{LDV}$$

Table 35. Variables Included in Equation 8

ID	Variable	Value	Notes
GHG	GHG emissions reductions	N/A	Calculated in Metric Tons
n_{ebike}	Number of e-Bikes in bike share	1200 e-Bikes	In the absence of project-specific information, the project team assumed this value.[37]
n_{trips}	Number of trips per bike per day	621 trips per bike per day	(National Association of City Transportation Officials, 2019)
VMT_d	VMT displaced per e-Bike trip	1.30 miles	Based on (Rzepecki, 2019) applying the adjustment factor from (Volker, Handy, Kendall, & Barbour, 2020)
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)

Example Project Quantification

For a project starting in 2025 with a lifetime of 12 years, the calculations are:

$$1{,}200 \; bikes \; x \; \frac{621 \; trips}{bike * day} \; x \; \frac{365 \; day}{year} \; x \frac{1.3 \; miles}{trip} \; x \; \frac{3{,}224 \; gCO_2.year}{mile} \; x \; \frac{1 \; MT \; CO_2}{1{,}000{,}000 \; g \; CO_2} = \mathbf{3{,}120 \; MTCO_2}$$

[37] From July 2022 to July 2023, San Francisco recorded an average of 6,200 daily bike trips. Based on the National Association of City Transportation Officials' 2017 data (https://nacto.org/bike-share-statistics-2017/), which suggests that each bike is typically used for 1.7 trips per day, it can be estimated that approximately 3,700 bikes are in operation in the area. This data supports the hypothesis that a bike-share program with an initial fleet of 500 bikes could be a reasonable starting point. Bike Share Systemwide Activity available at: https://transtat-public.sfmta.com/t/public/views/FordGoBike/BikeShareSystemwideActivity?%3Aembed=y#2

E-Bike Incentive

Description

E-bikes, with their electric assistance, are more accessible to a wider range of users, including those who may find physical exertion challenging. This feature makes longer distances or hilly terrains more manageable, thus appealing to a broader demographic who might otherwise rely on cars for such trips. The implementation of incentives for e-bikes is a strategic approach that can lead to substantial emissions reduction by encouraging modal shifts. Furthermore, e-bikes are adept at facilitating smoother integration with existing transit systems. They provide efficient solutions for covering the first and last miles of trips, effectively bridging the gap between public transit stops and the final destination. This enhancement not only makes transit systems more convenient and reliable but also potentially increases their use, thereby contributing to further GHG emission reductions, however the GHG emission reductions that could result from an increase in transit use due to the e-bike incentive is not calculated in this methodology. While the primary benefit of e-bike incentives is the direct reduction in SOV trips, leading to lower VMT, it is also worth noting that the broader impacts on overall travel patterns and public transit usage contribute significantly to a more sustainable transportation ecosystem. The GHG emissions reduction from e-bike incentives is estimated by calculating the emission reductions from displaced VMT:

Equation 9

$$GHG = n_{ebike} x\, VMT_d\, x\, EF_{LDV}$$

Table 36. Variables Included in Equation 9

ID	Variable	Value	Notes
GHG	GHG emissions reductions	N/A	Calculated in Metric Tons
n_{ebike}	Number of e-Bikes incentivized	2,500	In the absence of project-specific information, the project team assumed this value.[38]
VMT_d	Daily VMT displaced per e-Bike	2.73 miles	Based on (Johnson, Fitch-Polse, & Handy, 2023)
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)

Example Project Quantification

For a project starting in 2025 with a lifetime of 12 years, the calculations are:

[38] Assuming a rebate of approximately $2,000 per bike, the maximum offered by the California Air Resources Board's (CARB) statewide e-bike incentive program, the total incentives for this program would amount to around $2 million. This represents about one-sixth of the total funds allocated to the statewide e-bike program.

$$5{,}000\ ebikes\ x\ \frac{2.73\ miles}{day}\ x\ \frac{365\ day}{year}\ x\ \frac{3{,}224\ gCO_2.year}{mile}\ x\ \frac{1\ MT\ CO_2}{1{,}000{,}000\ g\ CO_2} = \mathbf{16{,}091}\boldsymbol{MTCO_2}$$

EV Car Share

Description

Electric vehicle (EV) car-sharing programs represent a transformative approach in urban mobility, with the potential to promote shared ridership and reduce reliance on gasoline vehicles. By providing convenient access to EV for short-term use, these programs make it easier for individuals to choose EVs over traditional gasoline-powered cars for their transportation needs. This accessibility is particularly impactful in urban areas where car ownership may be less practical or desirable. There are different models of car sharing, including traditional services like Zipcar, which require returning the vehicle to a specific location, and one-way services like Gig, which offer more flexibility. These services, often membership-based, cover costs like fuel, maintenance, parking, and insurance. Partnerships with transit agencies, like Gig's with BART, enhance multimodal travel. The shift to EV car-sharing helps in multiple ways: it not only reduces the number of gasoline vehicles on the road, thereby directly cutting down on emissions from conventional fuel sources, but also decreases driving frequency. Moreover, EV car-sharing can complement public transit systems by providing a flexible, zero emission option for trips that are not easily covered by existing transit routes.

Quantification Methodology

The GHG emission reduction resulting from EV car share programs is calculated by combining the reductions in emissions from decreased SOV trips with those achieved by shifting to EVs.

Equation 10

$$\mathrm{GHG} = \mathrm{GHG}_{\mathrm{SOV}} + \mathrm{GHG}_{\mathrm{MS}}$$

Table 37. Variables Included in Equation 10

ID	Variable	Notes
GHG	Cumulative GHG emissions reductions	Calculated in Metric Tons
GHG_{SOV}	GHG emissions reductions due to a reduction in SOV VMT	Calculated in Metric Tons
GHG_{MS}	GHG emissions reductions due to mode shift	Calculated in Metric Tons

Reduced SOV VMT

The first part of the GHG emission reduction from EV car share is estimated by calculating the reduction in single occupancy vehicle trips:

Equation 11

$$\mathrm{GHG}_{\mathrm{SOV}} = \mathrm{EF}_{\mathrm{LDV}} \times \mathrm{n}_{cars} \times \mathrm{m}_{car}\ \left(\left(\mathrm{Frac}_{tcs} \times \mathrm{VMT}_{r,tcs}\right) + \left(\mathrm{Frac}_{owcs} \times \mathrm{VMT}_{r,owcs}\right)\right) \times d_{travel}$$

Table 38. Variables Included in Equation 11

ID	Variable	Value	Notes
GHG_{SOV}	GHG emissions reductions due to a reduction in SOV VMT	N/A	Calculated in Metric Tons
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)
n_{cars}	Number of EV cars to be funded	650 cars	In the absence of project-specific information, the project team assumed this value.[39]
m_{car}	Average number of members per car	19 people	(San Francisco Municipal Transportation Agency, 2017)
$Frac_{tcs}$	Fraction of traditional car share members	81%	(Metropolitan Transportation Commission, 2018)
$VMT_{r,tcs}$	VMT reduction for traditional car share program	7 miles	(Martin, Stocker, Nichols, & Shaheen, 2021)
$Frac_{owcs}$	Fraction of one-way car share members	19%	(Metropolitan Transportation Commission, 2018)
$VMT_{r,owcs}$	VMT reduction for one-way car sharing	1.07 miles	(Martin, Elliot, & Shaheen, 2016)
d_{travel}	Number of travel days per year	347	Standard state assumption

VMT Shift to EVs

The second part of the GHG emission reduction from EV car share is estimated by calculating the shift in gasoline vehicle VMT to EV VMT:

Equation 12

$$\mathrm{GHG_{MS}} = \mathrm{EF_{LDV}} \times \mathrm{n}_{cars} \times \mathrm{m}_{car} \ ((\mathrm{Frac}_{tcs} \times \mathrm{VMT}_{tcs}) + (\mathrm{Frac}_{owcs} \times \mathrm{VMT}_{owcs})) \times d_{travel}$$

[39] Based on the information in the On-Street Car Sharing Pilot Program evaluation report, in 2016, Getaround maintained a fleet of 700 vehicles while Zipcar operated 800 vehicles. Therefore, it seems reasonable to estimate a fleet size of approximately 400 vehicles for a car share program. Link to SFTMA On-Street Car Sharing Pilot Program evaluation report: https://www.sfmta.com/sites/default/files/projects/2017/Carshare_eval_final.pdf

Table 39. Variables Included in Equation 12

ID	Variable	Value	Notes
GHG_{MS}	GHG emissions reductions due to mode shift	N/A	Calculated in Metric Tons
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)
n_{cars}	Number of EV cars to be funded	650 cars	In the absence of project-specific information, the project team assumed this value.
m_{car}	Average number of members per car	19 people	(San Francisco Municipal Transportation Agency, 2017)
$Frac_{tcs}$	Fraction of traditional car share members	80.6%	(Metropolitan Transportation Commission, 2018)
VMT_{tcs}	Average daily VMT in traditional car share vehicles by members	3.46 miles	(Martin, Elliot, and Susan Shaheen, 2016)
$Frac_{owcs}$	Fraction of one-way car share members	19.4%	(Metropolitan Transportation Commission, 2018)
VMT_{owcs}	Average daily VMT in one-way car share vehicles by members	0.3 miles	(Martin, Elliot, and Susan Shaheen, 2016)
d_{travel}	Number of travel days per year	347	Standard state assumption

Example Project Quantification

For a project starting in 2025 with a lifetime of 15 years, the calculations are:

Reduced SOV VMT

$$\frac{3{,}896.4\ gCO_2.year}{mile} \times \frac{1\ MT\ CO_2}{1000000\ g\ CO_2} \times 650\ cars \times \frac{19\ members}{car} \times$$
$$\times \left(\left(80.6\% \times \frac{7\ miles}{member.day} \right) + \left(19.4\% \times \frac{1.07\ miles}{member.day} \right) \right) \times \frac{347\ days}{year} = \mathbf{97{,}706\ MTCO_2}$$

VMT Shift to EVs

$$\frac{3{,}896.4\ gCO_2.year}{mile} \times \frac{1\ MT\ CO_2}{1000000\ g\ CO_2} \times 650\ cars \times \frac{19\ members}{car} \times$$
$$\times \left(\left(80.6\% \times \frac{3.46\ miles}{member.day} \right) + \left(19.4\% \times \frac{0.3\ miles}{member.day} \right) \right) \times \frac{347\ days}{year} = \mathbf{47{,}528\ MTCO_2}$$

Total GHG Reductions

$$97,706\ MTCO_2 + 47,528\ MTCO_2 = 145,234\ MTCO_2$$

Transit Subsidy

Description

Transit subsidies represent a strategic approach to promote public transportation use, resulting in significant modal shifts and fostering both equity and GHG emission benefits. By reducing the cost barrier associated with transit use, subsidies make it more accessible and financially viable for a broader segment of the population. This increased affordability can lead to an increase in transit ridership, as more individuals opt for buses, trains, or other public transportation modes over private vehicles. Furthermore, transit subsidies have a pronounced impact on promoting social equity. They provide lower-income communities, who often rely more on public transportation, with greater mobility and access to essential services and opportunities.

Quantification Methodology

The GHG emission reduction from a transit subsidy is estimated by calculating the mode shift from light-duty vehicles (LDV) to increased transit ridership and reduction in LDV VMT:

Equation 13

$$GHG_{MS} = R_{total} \times Frac_{eligible} \times Frac_{fare} \times e_{rf} \times Dist_{trip} \times D_{transit} \times EF_{LDV}$$

Table 40. Variables Included in Equation 13

ID	Variable	Value	Notes
GHG_{MS}	GHG emissions reductions due to mode shift	N/A	Calculated in Metric Tons
R_{total}	Total annual transit ridership across the region	Varies by transit mode	From Clipper Boarding Data[40]
$Frac_{eligible}$	Percent of people eligible for transit subsidy	18%	From (Metropolitan Transportation Commission, 2021)
$Frac_{fare}$	Percent change in transit fare	-50%	Based on Clipper START program.[41]
e_{rf}	Elasticity between total ridership and transit fare	-43%	From (Handy, Lovejoy, Boarnet, & Spears, 2013)
$Dist_{trip}$	Average transit trip distance	Varies by transit mode	Based on CARB's AHSC Benefits Calculator Tool (California Air Resource Board, 2021)

[40] https://mtc.ca.gov/operations/traveler-services/clipper

[41] Clipper START is a pilot program offering a 50% discount on single rides for eligible participants across various services including AC Transit, Marin Transit, SolTrans, BART, Muni, and others.

ID	Variable	Value	Notes
$D_{transit}$	Transit dependency (i.e., vehicle ownership)	Varies by transit mode	Based on CARB's AHSC Benefits Calculator Tool (California Air Resource Board, 2021)
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)

Example Project Quantification

For BRT, which has a transit dependency of 0.54, and with a project start year in 2025 and a project lifetime of 15 years, the calculation is:

$$\frac{229{,}752\ trips}{year} \times 0.18 \times (-0.5) \times (-0.43) \times \frac{4.61\ mile}{trip} \times 0.54\ x\ \frac{3954.9\ gCO_2.year}{mile} \times \frac{1\ MT\ CO_2}{10^6\ gCO_2}$$
$$= \mathbf{87.5\ MTCO_2}$$

Public EV Charging Infrastructure

Description

The deployment of public EV charging stations (EVCS) is a critical factor in accelerating the adoption and usage of EVs, subsequently leading to reduction in emissions. By ensuring that drivers have reliable and convenient places to charge their vehicles, especially in urban and high-traffic areas, the attractiveness of owning an EV increases. This enhanced infrastructure not only encourages more consumers to transition from traditional gasoline vehicles to EVs, but it also supports existing EV owners in using their vehicles more frequently and for longer trips, further contributing to a decrease in carbon emissions from transportation. Additionally, the equitable expansion of the EV charging network is essential in ensuring that all communities, including underserved and lower-income areas, have equal access to EV technology. This inclusive approach to infrastructure development is crucial in avoiding a transportation divide and ensures that the environmental and economic benefits of EV adoption are shared widely.

Quantification Methodology

The GHG emission reduction is calculated by estimating the total displaced VMT from gasoline LDVs to EVs, using total electricity or energy consumed by EVCS.

Equation 14

$$GHG = \sum N_i P_i U_i H_i \div \eta_{EV,LDV} \times EF_{LDV}$$

Table 41. Variables Included in Equation 14

ID	Variable	Value	Notes
GHG	GHG emissions reductions	N/A	Calculated in Metric Tons
N_i	Number of chargers of a certain power level	250	In the absence of available data, we assumed 50 Level 2 and 50 DCFC chargers
P_i	Charger power level	L2: 19.2 kW; DCFC: 150 kW.	19.2 and 150 kW are typical power level for public Level 2 and DCFC
U_i	Average charger utilization rate	L2: 10% DCFC: 5%	Estimated using current national average (Bauer, Hsu, Nicholas, & Lutsey, 2021) (Fitzgerald & Nelder, 2019); can be replaced with project-specific input using total time a charger is actively used divided by the evaluation period[42].
H_i	Total annual hours in use	8,760 hour/year	Assuming charger in use 24/7.
$\eta_{EV,LDV}$	Average EV energy efficiency	0.294 kWh/mile	Average EV efficiency published by the Argonne National Laboratory in 2022 (David, Yan, Xinyi, & Calista, 2022); to be updated with future EV model characteristics.
EF_{LDV}	Cumulative light duty vehicle emission factor	Sum of grams per mile emission rates over the project lifetime. The longer the project lifetime, the higher the emission rate.	Based on CARB'S EMFAC2021 model (California Air Resource Board, 2021)

Example Project Quantification

For a public EVCS site with fifty 19.2 kW and fifty 150 kW DCFC stations lasting over 10 years (typical lifetime of chargers) the cumulative carbon reduction would be:

$$\frac{[(250 \times 19.2\ kW \times 10\% + 250 \times 150\ kW \times 5\%]}{\frac{0.294\ kWh}{mile}} \times 2{,}727 \frac{gCO2.year}{mile} \times \frac{8760\ hour}{year} \times \frac{1\ MT\ CO_2}{10^6\ gCO_2}$$
$$= 191{,}352\ \boldsymbol{MTCO_2}$$

Transportation References

Bauer, G., Hsu, C.-W., Nicholas, M., & Lutsey, N. (2021, 7). *Charging up America: Assessing the growing need for U.S. charging infrastructure through 2030.* Retrieved from https://theicct.org/sites/default/files/publications/charging-up-america-jul2021.pdf

California Air Resource Board. (2021). *AHSC Benefits Calculator Tool.* Retrieved from https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/sgc_ahsc_guide_022521.pdf

California Air Resource Board. (2021). *EMFAC2021*.

[42] For example, if a charger is actively used 2 hours in a day, the daily utilization rate would be $2\ \mathrm{h}/24\ \mathrm{h} = 8.3\%$.

David, G., Yan, Z., Xinyi, W., & Calista, C. (2022, 11 1). *Assessment of Light-Duty Plug-in Electric Vehicles in the United States, 2010 – 2021.* Retrieved from https://www.osti.gov/biblio/1898424

Fitzgerald, G., & Nelder, C. (2019). *DCFC Rate Design Study For The Colorado Energy Office.* Retrieved from https://rmi.org/insight/dcfc-rate-design-study/

Handy, S., Lovejoy, K., Boarnet, M., & Spears, S. (2013). *Impacts of Transit Service Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions.* California Air Resources Board.

Johnson, N., Fitch-Polse, D. T., & Handy, S. L. (2023). Impacts of e-bike ownership on travel behavior: Evidence from three northern California rebate programs. *Transport Policy*, 163-174.

Martin, E., Stocker, A., Nichols, A., & Shaheen, S. (2021). Roundtrip Carsharing in New York City: An Evaluation of a Pilot Program and System Impacts.

Martin, Elliot, & Shaheen, S. (2016). Impacts of Car2Go on Vehicle Ownership, Modal Shift, Vehicle Miles Traveled, and Greenhouse Gas Emissions.

Metropolitan Transportation Commission. (2018). *Bay Area Carsharing Implementation Strategy.*

Metropolitan Transportation Commission. (2021). *Poverty*. Retrieved from Vital Signs: https://vitalsigns.mtc.ca.gov/indicators/poverty

MnDOT. (n.d.). *Roadway Data*. Retrieved July 2023, from http://www.dot.state.mn.us/roadway/data/data-products.html#VMT

MPCA. (n.d.). *Greenhouse gas emissions data*. Retrieved July 2023, from https://public.tableau.com/app/profile/mpca.data.services/viz/GHGemissioninventory/GHGsummarystory

National Association of City Transportation Officials. (2019). *Bike Share in the U.S.: 2017*. Retrieved from https://nacto.org/bike-share-statistics-2017/

Rzepecki, R. (2019). *Celebrating One Year in San Francisco*. Retrieved from https://medium.com/@jumpbikes/celebrating-one-year-in-san-francisco-28469d5dccaa

San Francisco Municipal Transportation Agency. (2017). *On-Street Car Sharing Pilot Program.*

Volker, J., Handy, S., Kendall, A., & Barbour, E. (2020, May 29). Revisiting Average Trip Length Defaults and Adjustment Factors for Quantifying VMT. *California Air Resource Board*. Retrieved from https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/sharedmobility_technical_052920.pdf

Appendix D

LIDAC Benefits Analysis Documentation

The following summary was developed by Cascadia Consulting Group for the Air District to inform the LIDAC/Frontline Communities benefits analysis discussion in the PCAP.

Frontline Communities' Benefits Analysis for Priority Climate Action Plan Greenhouse Gas Reduction Measures

Bay Area Air Quality Management District | Bay Area Regional Climate Action Planning Initiative

Prepared by Cascadia Consulting Group, Inc.

CASCADIA CONSULTING GROUP

Table of Contents

1 Overview

1.1 Project Overview

The Bay Area Air District Management District (BAAQMD or the Air District) is leading a regional climate action planning process, funded by the U.S. Environmental Protection Agency's **Climate Pollution Reduction Grant (CPRG) program**. The regional climate planning initiative will identify implementation-ready climate measures that reduce the Bay Area's greenhouse gas (GHG) emissions and provide benefits for frontline communities. The planning process will culminate in a Priority Climate Action Plan (PCAP) and Comprehensive Climate Action Plan (CCAP), which will include the identified climate measures, a GHG inventory, and supporting analyses, including this frontline communities' benefits analysis.

1.2 Purpose of Analysis

As part of this process, the Air District conducted an analysis of the potential benefits and disbenefits on frontline communities from implementation of PCAP measures. The objective of this analysis is to identify how PCAP measures can support frontline communities while also identifying how potential disbenefits and unintended consequences of these measures can be mitigated.

2 Approach

The approach used for this analysis was adapted from the U.S. Environmental Protection Agency's (EPA) guidance document, *Benefits Analyses: Low-Income and Disadvantaged Communities* (U.S. EPA), which was developed to support regional and local government agencies to assess equity benefits and disbenefits under EPA's CPRG program.

This analysis assessed benefits and disbenefits for seven primary categories: housing quality and security; public and community health; jobs and workforce development; community engagement, awareness, and capacity; transportation access and costs; climate resilience co-benefits; and energy costs and burden (Table 1). These categories aligned with:

- Priorities identified through a review of recently completed community engagement.

- Priorities voiced by a Roundtable of community-serving organizations with deep familiarity with frontline communities in the eight counties.
- EPA's guidance document.

For each category in this assessment, we provide:

- A general summary of benefits and disbenefits.[1]
- A more detailed assessment of potential benefits and disbenefits to support overarching conclusions using peer-reviewed research, public data sources, and public reports and documents. As part of this process, we also note areas where research is still emerging and where there is a lack of consensus on directional impacts.
- Equitable implementation considerations to mitigate disbenefits. Some of these considerations are already explicitly called out in the Air District's PCAP measures and are noted as such.

Table 1. Benefit and disbenefit categories and details used in the analysis.

Benefit / Disbenefit Category	Definition and Details
Housing Quality and Security	• Housing burden and costs, particularly for renters • Housing security and public safety • Gentrification and/or displacement impacts
Public and Community Health	• Exposure to environmental hazards and/or pollution • Physical and mental health impacts from amenity access (e.g., transit hubs, green spaces) • Public safety considerations • Quality of life and comfort • Access to care and public services
Jobs and Workforce Development	• Educational and training opportunities • Employment opportunities and access to jobs • High-road jobs, with fair pay and benefits • Job security • Post training employment • Potential unemployment impacts

[1] When a measure does not directly affect a category, we noted that the benefits/disbenefits did not apply.

Benefit / Disbenefit Category	Definition and Details
Community Engagement, Awareness, and Capacity	• Community awareness of solutions and projects • Community capacity building • Trust between communities and the government
Transportation Access and Costs	• Transportation access, including access to non-vehicular mobility alternatives • Transportation costs and burden • Reliability and access of transit options • Safe transit options
Climate Resilience Co-benefits	• Ability to adapt or cope with climate-related impacts and hazards
Energy Cost Burden and Security	• Increased or decreased energy cost burden • Increased or decreased energy security

3 Results of Benefits and Disbenefits Analysis

This section describes benefits and disbenefits for the two PCAP measures, which are:

- Safe, accessible, clean, and equitable multi-modal transportation
- Holistic building decarbonization for clean, healthy, and secure housing

3.1 Safe, Accessible, Clean, and Equitable Multi-modal Transportation

Public and Community Health

SUMMARY

The connectivity of mobility hubs is anticipated to bring various benefits, such as reduced traffic congestion, improved air quality, enhanced accessibility, and increased sustainable and active commuting habits. Additionally, safety improvements in the measure can help prevent fatalities and severe injuries, particularly in high-fatality and

high-injury sections of bicycle and pedestrian infrastructure as use of this infrastructure increases. Additionally, there is potential for physical health benefits for communities surrounding mobility hubs that prioritize active transportation alternatives. However, there may be short-term increases in air pollution burden for mobility hub-adjacent communities until public fleets transition away from gas and diesel-powered vehicles. Additionally, there is potential for physical health benefits for surrounding communities of mobility hubs that prioritize active transportation alternatives.

SUPPORTING RATIONALE

- **Investments in active transportation infrastructure improve safety and access for walking, biking, and rolling activities, while facilitating better connectivity to public transportation.** These initiatives reduce air pollution that typically pose a higher risk for vulnerable groups like children, pregnant women, seniors, and those with pre-existing health considerations, particularly in frontline communities (Bay Area Air Quality Management District, 2018).
- **Investing in active transportation infrastructure mitigates obesity**, lowering the risk of expensive chronic conditions like diabetes and cardiovascular disease (Wolch et al., 2014;Department of Transportation, 2015).
- **Investing in active transportation infrastructure reduces the space needed for transportation, freeing up land and decreasing noise and pollution**. This active approach ultimately improves the quality of life, particularly in disadvantaged communities (U.S. Department of Energy, 2023).
- **Despite potential benefits, low-income communities of color, who already engage in higher rates of active transport, may face health issues if strategies promoting active travel are poorly executed** (Wolch et al., 2014). For example, introducing bike lanes with inadequate safety measures for pedestrians and cyclists could heighten the risks of accidents and injuries. This disproportionately impacts low-income individuals who may depend heavily on active transportation (Wolch et al., 2014).
- **The California Air Resources Board has established a statewide objective to transition to an all-electric public bus fleet by the year 2040.** This initiative seeks to mitigate tailpipe pollution, particularly in low-income communities, contributing to cleaner air. The shift to a zero-emissions public fleet will bring multiple advantages for transit-dependent riders. In areas where the public fleet has not fully transitioned to zero emissions, transit hubs, especially in disadvantaged communities, may experience short-term increases in air pollution burden despite the long-term benefits of improvements in public health, energy consumption, and cost savings (Alameda Contra Costa Transit District, 2022;California Air Resources Board, 2018).

EQUITY CONSIDERATIONS

To mitigate potential barriers or challenges, implementation of the measure should consider the following:

- **Conduct spatial planning and design analysis to assess environmental justice impacts**, including air quality, noise, place, landscape, and flood/wildfire risks (OCTA, 2022).
- **When identifying potential locations for mobility hubs, evaluate proximity to essential services** (healthcare facilities, greenspace, recreational areas, grocery stores, affordable housing) (OCTA, 2022).

Transportation Access and Costs

SUMMARY

There is a risk that some costs associated with transit infrastructure and operational improvements may be passed onto users. However, if investments in transit access are coupled with discounted fare integration programs and other multi-modal incentive programs, there is strong potential for short- and long-term transit cost savings, particularly for low-income residents. Enhancing access to a variety of mobility options can also play a crucial role in lowering barriers to reaching employment, educational opportunities, health care, and other essential services (Stacy et al., 2022).

SUPPORTING RATIONALE

- **Increased access to diverse mobility options can help reduce barriers to accessing employment, educational opportunities, health care, and other key services and amenities** (Stacy et al., 2022)
- **The Sacramento Metropolitan Air Quality Management District initiated a project offering subsidized transportation to participating residents, which yielded benefits such as enhanced clean mobility access and improved air quality through reductions in greenhouse gas and toxic emissions**. The program incorporated clean technology car sharing, electric bike sharing, and pre-paid vouchers for ride-hailing services and public transportation. The project has yielded benefits such as enhanced clean mobility access and improved air quality through reductions in greenhouse gas and toxic emissions. Through these alternatives, residents can transition from traditional, more energy-intensive modes of transportation to cleaner options, contributing to overall energy savings and aligning with regional and statewide goals for transportation electrification (Sacramento Metropolitan Air Quality Management District., 2017).
- **Multiple studies in California highlight the potential risks of increased cost burden for communities surrounding transit hubs** (Zhou & Zolnik, 2013;Rodier et al., 2015). **However, the same studies also highlight that**

transit hubs can lead to reductions in transportation and housing expenditures, primarily because relying on public transportation is often more cost effective than owning and maintaining a personal vehicle (Zhou & Zolnik, 2013;Rodier et al., 2015).

- Placing mobility hubs exclusively in areas with high population or employment density is likely more cost effective because it maximizes utilization of services (e.g., leads to increased ridership). This, in turn, could generate more revenue (Hachette & L'Hostis, 2024).
- **Integrating a solution offering enhanced first/last mile connectivity and off-peak trip options is crucial for individuals who commute during off-peak hours or engage in trip chaining throughout the day**. Providing options that alleviate transportation cost burdens has the potential to significantly enhance the overall quality of life for this group (OCTA, 2022). For instance, numerous property owners serving as major employers in Orange County could achieve financial savings by consolidating current private transit services and managing commute reduction programs. This consolidation effort has the potential to significantly reduce the need for expensive employee parking spaces (OCTA, 2022).
- **Adapting to new services or route changes may prompt transit agencies to make operational adjustments, often necessitating periodic small fare increases** (San Francisco Bay Area Rapid Transit District, 2024).

EQUITY CONSIDERATIONS

To mitigate barriers and challenges, the measure includes an incentive element to:

- Integrate discounted fare programs and discounted bike share passes for low-income and underserved populations and offer e-bike incentives.

In addition, mobility hubs should be subjected to a comprehensive performance and cost audit to ensure that transit costs remain affordable, cost effective, and equitable to low-income communities (Frost, 2022).

Jobs and Workforce Development

SUMMARY

Mobility hubs have the potential to reduce vehicle miles traveled (VMT), produce and sustain high-road jobs, and increase use of alternative modes of transport to improve access to employment opportunities.

SUPPORTING RATIONALE

- **Communities of color often experience lower vehicle ownership rates**, **resulting in negative impacts on their corresponding employment rates**

(Ong, 2002). Mobility hubs have the potential to reduce VMT and present a more accessible and cost-effective option than vehicle ownership for low-income households to rely on for employment, community, and traveling.

- **Construction of mobility hubs can generate critical, living-wage jobs for local communities.** While not synonymous, synergy between mobility hubs and Transit-Oriented Development (TOD) is an important aspect to consider, as it is essential for creating sustainable, accessible, and thriving urban environments that can result in more efficient transportation, greater employment opportunities, and improved quality of life for residents. For example, BART's TOD program at existing levels could generate 85,000 direct and indirect jobs in California between 2020-2030. 62% of these jobs are "middle-skill" jobs - requiring on-the-job training rather than a college degree while still offering a living wage (San Francisco Bay Area Rapid Transit District, 2023).
- **Areas adjacent to transit stops can experience enhanced commercial activity and job opportunities**, with the introduction of shops, restaurants, and other businesses that attract commuters and non-commuters alike (Cash et al., 2020).

EQUITY CONSIDERATIONS

To maximize equitable distribution of benefits, the measure should consider:

- Preference to hire local contractors and residents for capital projects.

Climate Resilience Co-benefits

SUMMARY

Mobility hubs can lead to some climate resilience co-benefits, primarily air quality benefits. Additionally, urban greening along pedestrian, bicycle, and transit infrastructure can help shade surfaces, reduce travelers' discomfort and risk of heat illness during periods of extreme heat, and reduce the risk to infrastructure from flooding during heavy rains (National Association of City Transportation Officials, 2017).

SUPPORTING RATIONALE

- **Efficient street shading and reduction of distances to transit stations, like walking and cycling infrastructure in proximity to mobility hubs, can promote use of sustainable transportation modes** (Elmarakby & Elkadi, 2024).
- **Transit infrastructure related to traditional roads and car-based infrastructure has been correlated with the urban heat island (UHI) effect**, influenced by factors such as population density, land use, and building characteristics. Measures such as urban greening can mitigate UHI impacts (Elmarakby & Elkadi, 2024).

- **Enhancing clean and efficient transportation options and optimizing vehicle efficiency can effectively mitigate the adverse impacts of climate change and air pollution**. This approach promotes a more equitable, accessible, and affordable transportation system, thereby improving all users' overall quality of life. Additionally, it helps diminish reliance on fossil fuels and enhances energy security (U.S. Department of Energy, 2023).

EQUITY CONSIDERATIONS

To maximize the equitable distribution of benefits, the measure includes connectivity and green infrastructure elements that can also improve resilience outcomes, such as:

- Urban greening along pedestrian, bicycle, and transit infrastructure.
- Bicycle and pedestrian facility improvements, incorporating complete streets and vision zero[2] in design (Vision Zero Network, 2024).
- Micro-mobility, bikeshare/e-bike share.
- Electric vehicle (EV) carshare/EV charging (on-site and in adjacent ½ mile area).

In addition, reducing heat emissions from building systems (e.g., HVAC systems) within commercial and entertainment activities can reduce the UHI effect (Elmarakby & Elkadi, 2024).

Community Engagement, Awareness, and Capacity

SUMMARY

Utilizing community-centered engagement strategies, focusing on youth and community-based organizations (CBOs), is anticipated to increase community buy-in, awareness, and capacity for utilizing individual mobility options like bicycles, electric scooters, and walking.

SUPPORTING RATIONALE

- **To prevent displacement and champion community interests, it is crucial to involve residents in the design process**, consider affordability implications, and advocate for the needs of long-time, lower-income residents to developers and stakeholders (Holland, 2022).
- **Social capital is associated with livable, walkable neighborhoods, suggesting that areas with greater walkability may have higher social**

[2] *Vision Zero is a multidisciplinary approach to road safety with the belief that every traffic-related death or serious injury is preventable, and the ultimate goal is to achieve zero fatalities or severe injuries on roadways. This approach emphasizes a holistic perspective, focusing on safe system design, technological innovations, public awareness, and the adoption of policies that prioritize human life over mobility convenience. Vision Zero has gained international recognition and has been adopted by numerous cities and countries worldwide as a guiding principle to reshape transportation systems and enhance overall road safety.*

capital and cohesion. In such communities, residents are more likely to know their neighbors and engage with other community members (Ribeiro et al., 2015).

EQUITY CONSIDERATIONS

To maximize equitable distribution of benefits, the measure includes a community engagement element that will:

- Prioritize community outreach and education, specifically targeting youth, and actively involve Community-Based Organizations (CBOs) to promote the increased utilization of single-occupancy mobility options.
- Actively engage CBOs and employ a participatory community process to identify various components addressing the community's needs.

In addition, mobility hub governance that is inclusive of stakeholder groups such as landowners, public transit operators, regional policy and funding agencies, major utility providers, and local community-based organizations, can foster greater buy-in and help mitigate potential disbenefits (OCTA, 2022).

Housing Quality and Security

SUMMARY

Generally, mobility hubs can benefit low-income communities by increasing access to job opportunities, which can benefit housing security. However, there is not a clear consensus about whether mobility hubs lead to increased housing costs or contribute to subsequent displacement. Some studies show an association between mobility hubs and gentrification, which can lead to displacement of low-income residents, especially residents who are most likely to benefit economically from transit access. Disbenefits can be mitigated with a strong affordable housing policy, which can maintain and increase housing security in light of new transportation amenities.

SUPPORTING RATIONALE

- **Mobility hubs have the potential to maintain and increase housing security if they are integrated near affordable housing**. These mobility hubs can create opportunities for residents to live near various transit options, thus reducing commuting costs and promoting housing affordability (Patel et al., 2022). Constructing and maintaining affordable housing near mobility hubs promotes economic accessibility and reduces disparities in housing security (OCTA, 2022).
- **Transit infrastructure and its attendant development have the potential to spur gentrification in racially diverse and/or low-income areas**. Transit development can be one driving factor in increasing housing costs, resulting in low-and moderate-income residents – particularly renters – being displaced. However, when executed with an intentional focus on enhancing regional equity,

transit-oriented development has enormous potential as an overall benefit for low- and moderate-income (LMI) communities (Carlisle, 2020). This inclusivity promotes economic accessibility and reduces disparities in housing security (OCTA, 2022).

- **Proximity to active transportation infrastructure, such as bike lanes, is sometimes associated with positive or neutral benefits to LMI communities but is sometimes associated with increased property values and gentrification.** Discrepancies in investment patterns have transformed bike infrastructure into a contentious topic within gentrification debates. While numerous studies demonstrate positive or neutral impacts, it is important to acknowledge the existence of studies that indicate negative associations with property values. Notably, there is a notable disagreement in the directional change, with some studies suggesting a positive shift, for instance, asserting that the presence of bike lanes correlates with higher property values (Cash et al., 2020).
- **Urban greening strategies - like parks, greenspace, urban forests, and community agriculture - all tend to increase surrounding property values** and may contribute to gentrification and displacement; therefore, ensuring equitable implementation necessitates designing accessible and inclusive green spaces, engaging the community in decision-making, mitigating gentrification risks through measures like affordable housing and job creation, and preserving cultural identity to foster fair and inclusive distribution of benefits among diverse populations (Wolch et al., 2014;Cash et al., 2020).

EQUITY CONSIDERATIONS

To mitigate potential barriers or challenges, the measure includes a housing security element that will:

- Produce, preserve, and protect affordable housing and stabilize businesses to prevent displacement, similar to the goals outlined in the MTC-Transit Oriented Community (TOC) Policy.

In addition, using anti-displacement policy tools through CASA Compact and anti-displacement strategies such as the All-In Cities Policy Toolkit developed by Policy Link (2022) can identify policy levers that can mitigate disbenefits. Some strategies these tools include are:

- Zoning near transit
- Inclusionary zoning
- Unlock public land at hubs for affordable housing
- Just cause eviction ordinances

Energy Cost Burden and Security

SUMMARY

Incorporating on-site electric vehicle (EV) car sharing and charging, coupled with suitable discount fare programs, is expected to alleviate energy cost burdens among those who use EVs. This integrated approach ensures affordability for low-income residents, particularly in frontline communities.

SUPPORTING RATIONALE

- **Beyond the cost barrier associated with acquiring electric vehicles, accessibility of charging stations is recognized as a challenge for EV adoption and usage**. Ensuring a fair deployment of charging infrastructure requires deliberate measures to prioritize underserved communities and align with the expanded provision of EV incentives to various population segments (Jackson, 2021).This shift can reduce the overall energy burden associated with EV usage in these communities.

EQUITY CONSIDERATIONS

Additional considerations include prioritizing frontline communities for installing charging stations and aligning with the expanded provision of EV incentives to various population segments, as outlined in the framework by U.S Department of Transportation (2022).

3.2 Holistic Building Decarbonization for Clean, Healthy, and Secure Housing

Public and Community Health

SUMMARY

Building electrification and energy efficiency measures are expected to produce regional and local indoor and outdoor air quality benefits. The measure can also improve residential health and safety concerns by addressing exposure to hazards such as lead, mold, and asbestos. Possible disbenefits of building electrification and energy efficiency measures include: increased PM2.5 from fossil fuel electric generating units (electricity-producing power plants) to meet increased electricity demand; increased indoor air pollution if efficiency measures are implemented without effective ventilation or electrification; and health hardships during power outages (see the *Energy Cost Burden and Security* category).

SUPPORTING RATIONALE

- **Building electrification has the potential to achieve equitable health outcomes such as reducing exposure to indoor and outdoor air pollutants** (Kime et al., 2023; Zhu et al., 2020;Holstius & Martien, 2022; Tanrikulu et al., 2022). Communities of color in the U.S. are exposed to disproportionately high levels of ambient fine particulate air pollution (PM2.5); residential gas combustion and commercial cooking are among the largest sources of relative disparities for Black, Hispanic, and Asian groups (Tessum et al., 2021). A recent analysis by the Air District found that nitrous oxides (NOx) and PM2.5 emissions from home and water heating disproportionately impact communities of color (Tanrikulu et al., 2022).
- **Public health benefits from electrification and envelope improvements accrue from reductions in exposures to natural gas combustion co-products, such as PM2.5**, due to a shift toward electric appliances and away from natural gas appliances (Moe & Gibbs, 2023;Fournier et al., 2022).
- **Electrification can improve overall regional air quality.** The Bay Area Air Quality Management District found that installing zero NOX-emitting appliances could prevent up to 85 premature deaths per year, lowering PM2.5 exposure, and avoiding up to $890 million per year in health impacts due to air pollution exposure (Tanrikulu et al., 2022). These appliances reduce pollutants that are vented outdoors, including those from natural gas appliances.
- **Additional studies have estimated decreases in illness and death (and associated economic benefits) resulting from building electrification**:
    - A Bay Area study found the following:
        - Reductions in secondary PM2.5 from BAAQMD's Rules 9-4 and 9-6 would reduce premature mortality within the Air District's jurisdiction by 23 to 52 cases per year. Reductions in total PM2.5 concentrations would reduce premature mortality by 37 to 85 cases per year. The valuations assigned to premature death cases range from 230 to 530 million U.S. dollars for secondary PM2.5 and from 380 to 870 million U.S. dollars for total PM2.5 (Tanrikulu et al., 2022).
        - For a 2020 population, 2.6 to 24 non-fatal heart attacks would be prevented with the modeled reductions in secondary PM2.5 and 4.2 to 39 non-fatal heart attacks would be prevented with the modeled reductions in total PM2.5. The associated valuations are estimated to be 0.23 to 2.1 million U.S. dollars and 0.38 to 3.5 million U.S. dollars, respectively (Tanrikulu et al., 2022).
    - A CA statewide study found the following:
        - Under a 2018 scenario where all residential gas appliances in CA were transitioned to electric, the reduction of secondary nitrate PM2.5 (from NO_X) and primary PM2.5 would result in 354 fewer

deaths, and 596 and 304 fewer cases of acute and chronic bronchitis, respectively. The reduction in associated negative health effects is equivalent to approximately $3.5 billion in monetized health benefits for just one year (Zhu et al., 2020).
    - A study estimated that building electrification in the Bay Area can lead to regional economic benefits that exceed $1.2 billion annually due to decreased mortality associated with PM2.5 and fewer pre-mature deaths associated with chronic and acute bronchitis (Zhu et al., 2020).
- **Concentrations of CO and NO_2 while cooking with natural gas can exceed national and California-based ambient air quality standards**, especially in smaller residences/apartments, which can result in greater impacts on renters and low-income residents (Zhu et al., 2020).
- **Tighter building envelope measures can result in health benefits due to better protection from outdoor air pollution** (PM2.5 exposure) (Zuraimi & Tan, 2015). See the *Climate Resilience Co-benefits* category for some additional notes on the benefit of improved air quality.
- **Addressing deferred maintenance and health and safety concerns can also result in public health benefits**, as lead, asbestos, and mold have negative health impacts (U.S. EPA, 2023).
- **Poorly or incompletely installed envelope measures could result in increased indoor pollutants**, especially if natural gas appliances are still present in the home (Moe & Gibbs, 2023). The health effects of indoor air pollution on building occupants pose additional risks to groups that have previously received poorer healthcare services and have lived in historically redlined neighborhoods (Chu, 2023).
- **Net increases in electricity demand associated with electrification can result in increased PM2.5 in areas near electric generating units (EGUs) that use fossil fuels**. When modeling electrification measures in Los Angeles County, significant health impacts from increased emissions of PM-2.5 by fossil EGUs are likely to be experienced in other areas across the state, up to and including those within the Bay Area (Fournier et al., 2022).

EQUITY CONSIDERATIONS

The measure will implement electrification of gas appliances in addition to efficiency measures for building envelopes and heating distribution systems, thus mitigating the potential disbenefits of increased indoor air pollution due to envelope measures without proper HVAC or electrification.

This is supported by studies in CA that suggest that weatherization and building efficiency measures should be coupled with residential and other building electrification measures to support multiple health, air quality, and climate co-benefits by mitigating

hazardous air pollutants and methane emissions while appliances are both off and on (Lebel et al., 2022).

The measure also includes health and safety upgrades to address health issues from lead, asbestos, and mold.

Though the Bay Area already has generally clean electricity, potential disbenefits of increased emissions by electric generating units (power plants) can be mitigated by further investing in and lobbying for clean energy sources from electric utilities.

Housing Quality and Security

SUMMARY

The risk of displacement of current residents due to residential building electrification is complex, with competing increased and decreased costs. For example, there is a risk that some landlords may pass on costs to tenants or displace tenants during housing construction and retrofit phases. However, electrification can ease housing and energy burden in the long-term, which reduces the risk of utility shut-offs and evictions.

SUPPORTING RATIONALE

- **The impact of electrification and energy efficiency projects on displacement is complex**. For example, property values generally increase with energy efficiency measures, and these increased housing values can lead to the displacement of low-income residents. Additionally, while improved energy efficiency can make housing more expensive and less affordable, it also serves to lower utility bills and burdens for renters and homeowners, thereby reducing the risk of utility shut-offs and evictions (Cash et al., 2020).
- **Studies have found correlations between energy improvements and increased cost burdens** (Kime et al., 2023). Some examples include:
    - Decarbonization could cost up to $20,000 per rental unit, and if landlords pass this cost on to tenants, this will erode affordability, resulting in larger rent burdens for low-income renters, or worse, the inability to pay rent (Kirk, 2023).
    - Landlords may use construction projects (noise, dust, and hazards that make tenants feel pressured to leave voluntarily) to displace tenants to see a quicker return on investment or capitalize on the value-add to their properties (Kirk, 2023).
    - Some statewide policy interventions, such as AB 1482, include an exception that allows landlords to evict tenants if they plan to remodel the unit for more than 30 days and it is unsafe for the tenant to stay. Building decarbonization retrofits, which may take months to complete, could lead to evictions under this loophole (Kirk, 2023).

EQUITY CONSIDERATIONS

Studies have shown that designing electrification measures with equity and justice in mind can reduce the consequences and disbenefits for low-income households and other frontline community groups (Nadel, 2019; Barker, 2021). To mitigate potential barriers or challenges and to strengthen the program, the measure includes a housing security element that will:

- Identify and implement housing security and anti-displacement best practices for retrofits and health and safety upgrades, with policy support from regional agencies, and best practices to engage and encourage rental property owners' participation in retrofits.
- Provide policy support to local governments and CBOs to address implementation barriers as they emerge.

These implementation considerations are supported by Hens & Lamon (2021), who assert that programs should provide protection against rent increases, similar to LIWP, to protect against potential displacement impacts.

As mentioned above in the *Public and Community Health* category, the measure also includes health and safety upgrades to address health issues from lead, asbestos, and mold, which will improve housing quality.

Energy Cost Burden and Security

SUMMARY

Electrification upgrades can result in both benefits and disbenefits related to energy costs and burdens. Upgrades can be expensive, though they can result in reduced utility bill costs. Natural gas prices may increase for remaining gas customers as more utility customers shift to electricity. An increased reliance on electricity may result in greater energy insecurity and associated disbenefits; however, reduced demand can improve energy reliability and security.

SUPPORTING RATIONALE

- **There are immediate up-front costs for electrification upgrades, however, these upfront costs will result in long-term savings and return-on-investment.** Programs that support electrification upgrades for low-income households can reduce the upfront cost barriers to retrofit. In a study in Richmond, CA, building envelope and electrification upgrades resulted in reduced annual utility bill costs for modeled buildings that resulted in a 100%+ return on investment for upfront costs (Moe & Gibbs, 2023).
- **It's important to note that the high upfront cost of envelope and electrification measures may be a barrier to low and moderate-income**

owner households and small-scale landlords. Even when items are cost-effective over the lifetime of the measures, a 15–30-year payback may not be feasible for many households—especially low-income households and communities of color—who are more likely to be living paycheck to paycheck and with limited savings (Moe & Gibbs, 2023).

- **The upfront costs depend on the existing infrastructure in the home**. For retrofits of existing homes, heat pumps can be lower cost than replacing furnaces and air conditioners separately. For homes currently using natural gas heating and only needing to replace a gas furnace, it is usually more expensive to electrify than to stick with gas (Billimoria et al., 2018).
- **The energy transition has the potential to increase energy burden for low-income communities, if it is not done with strategic planning and financial investment for frontline communities** (Fenton, 2022). For example, a decline in gas sales (due to more electrification of buildings) could raise gas prices further for remaining customers; as more households in the region transition to electricity, fewer customers remain to cover the fixed costs of the natural gas system. This could also accelerate further shifts away from gas for consumers able to invest in alternatives (Jones et al., 2019).
- **Rebates and other cost-saving measures are available**:
    - BayREN rebates and other community choice aggregator, utility, state, and federal programs and rebates can help lower financial cost barriers to retrofit.
    - PG&E offers an Electric Home Rate Plan for homes with EVs, electric heat pumps, or battery storage; the plan can save customers money if they are large electricity users who can shift usage to lower-priced times of day (PG&E, 2024).
- **One study found that lower-income households, renters, and households living in multifamily buildings may likely see less savings as a result of envelope and electrification upgrades** (absolute dollars and percent savings) compared to higher-income households, owners, and those living in single-family buildings. This study modeled impacts from residential upgrades in Richmond, CA. This difference stems largely from higher-income households in Richmond being more likely to live in single-family homes, which tend to be older buildings and consume more energy overall compared to lower-income households. As a result, single-family homes also see a higher decrease in overall utility payments, and a higher decrease in terms of percent change. (These trends are the same for owners versus renters, since almost all owners in Richmond live in single-family homes.) The study found that in Richmond, renters were more likely to pay for electricity while rental property owners paid for natural gas. (Moe & Gibbs, 2023).
- **Energy security and reliability may be reduced due to electrification**. **However, when electrification is coupled with energy efficiency measures, the risk of energy disruptions is reduced.**

- An increased reliance on electricity may result in greater energy insecurity and associated disbenefits. Power outages strain chronic health conditions and can result in increased rates of hospitalization. The hardship of energy insecurity intersects with other hardships, such that each compounds the severity of the others and contributes to detrimental health consequences (Jessel et al., 2019).
- The potential for critical infrastructure failures during extreme weather events is rising. Major electrical grid failure or "blackout" events in the United States increased by more than 60% over the most recent 5-year reporting period. Study results find simulated compound heat wave and grid failure events of recent intensity and duration to expose between 68 and 100% of the urban population to an elevated risk of heat exhaustion and/or heat stroke (study modeled heat waves/blackout conditions for Atlanta, Georgia; Detroit, Michigan; and Phoenix, Arizona) (Stone et al., 2021).
- PG&E sometimes conducts power shut-offs (Public Safety Power Shutoff) to minimize risk of wildfires in certain conditions (PG&E, 2024b).
- Energy efficiency measures can reduce demand and strain on the energy system, improving energy reliability and security (Ribeiro et al., 2015).

EQUITY CONSIDERATIONS

The measure includes subcomponents to increase energy resilience, such as distributed solar and storage, where strategic and feasible; this can support energy security and reliability and reduce potential disbenefits.

Additional equitable implementation considerations include:

- **Industry destabilization (from increased gas prices) can, and should, be avoided with sound planning and the right set of policy tools** (Jones et al., 2019). The focus of this measure on helping frontline communities transition to electricity can help insulate these communities from anticipated gas price increases as more households in the region transition to electricity, leaving fewer customers to cover the fixed costs of the natural gas system.
- **Programs should reduce out-of-pocket costs for residents as much as possible to improve cost-effectiveness and avoid potential disbenefits. The** measure includes incentives, direct installations, financing, and rebates, which should reduce the upfront and out-of-pocket costs for residents in frontline communities.

Jobs and Workforce Development

SUMMARY

Building energy efficiency and electrification can sustain and produce high-road jobs, especially if done with intentional workforce development, training, and support.

SUPPORTING RATIONALE

- **Models suggest that all low-carbon energy technologies create more jobs per unit of energy than their coal and natural gas counterparts** (Kime et al., 2023).
    - A study modeled that pursuing residential envelope and higher-efficiency electrification upgrades in Richmond could support up to 7,500 direct and indirect jobs, with two-thirds of those more likely to be local jobs, and half of them likely to be new jobs. This would include occupations such as HVAC technicians, plumbers, electricians, and general residential construction and remodeling. The occupations more likely to be new/net jobs are the insulators and electricians, while HVAC technician and plumbing jobs are more likely to be existing jobs installing new technologies, rather than jobs that would not otherwise exist for Contra Costa County (Moe & Gibbs, 2023).
    - An analysis of potential employment impacts of California building electrification (assuming the state electrified all buildings by 2045) projected the following (Jones et al., 2019):
        - 59k-100k jobs from construction, supported annually over 2020-2045.
        - 3k-5k from manufacturing, supported annually over 2020-2045.
        - 10k-12k new jobs from electricity generation and distribution by 2045.
        - 7k-14k fewer jobs from gas distribution by 2045.
    - Three out of five jobs required to meet CA's building electrification goals would be in "high-road" sectors. The right set of policy interventions can reform the competitive dynamics in traditionally "low-road" industries like residential and small commercial construction to improve the quality of jobs and engage more highly skilled workers (Jones et al., 2019).
- **There is the potential for new jobs to be well-paid and benefitted, allowing for improved quality of life for some frontline communities; this requires intentional workforce standards.**
    - Regarding employment indicators, the 2023 Equitable Electrification Analysis for Existing Buildings in Richmond, CA showed that 75% of private industry construction workers nation-wide had access to employer-sponsored health care benefits, 81% had access to paid vacation benefits,

69% had access to paid sick leave, and 63% had access to retirement benefits plans (Moe & Gibbs, 2023).
    - Agencies can, with deliberate effort, support high-road workforce development in the building electrification field. By establishing (or failing to establish) workforce standards, agencies set the bar for the level of skill and training of workers in the labor market, particularly in emerging industries (Jones et al., 2019).

EQUITY CONSIDERATIONS

To mitigate potential barriers or challenges and to strengthen the program, the measure includes a workforce development and contractor support element that will:

- Partner with and augment local workforce training programs for electricians, plumbers, and other decarbonization-related roles, particularly those that target workers from frontline communities, formerly incarcerated people, and people with other barriers to employment.
- Seek to develop and implement regionally consistent workforce standards for retrofit projects to increase the number of family-supporting/high-road jobs.
- Provide streamlined contractor support (e.g., increase awareness of and access to incentives, improve communication tools with customers).

This aligns with Jones et al.'s recommendations to create conditions that attract skilled workers, pre-qualify contractors, support the up-skilling of workers through stackable credentials, and structure the work to create opportunities for disadvantaged workers (Jones et al., 2019).

Additionally, a Greenlining Institute report recommends including labor and workforce development agencies in program design, building workforce transition into program budgets, and ensuring that current low-income fossil fuel workers have access to and training for electrification job opportunities (Miller et al., 2019).

Climate Resilience Co-benefits

SUMMARY

Building electrification and efficiency retrofits can protect residents and workers from wildfire smoke, extreme heat, power outages from extreme events, and outdoor air pollution.

SUPPORTING RATIONALE

- **Energy efficiency retrofits can protect against outdoor wildfire smoke; electric heat pump installation can increase comfort and safety of homes during heat events** (Fenton, 2022). See the *Public and Community Health* category for additional discussion about protection from outdoor air pollution.

- **Improving building envelopes through better insulation and air sealing can maintain more livable conditions for occupants when electricity from the grid is unavailable or unreliable**. Buildings that allow residents to stay in their homes during power outages are of particular importance for housing-vulnerable populations that are more sensitive to temperature changes, including people with health conditions and the elderly (Ribeiro et al., 2015). See the *Energy Costs and Burden* category for additional discussion about energy security and reliability.

EQUITY CONSIDERATIONS

As discussed in the *Public and Community Health* category, the measure will implement electrification of gas appliances in addition to efficiency measures for building envelopes and heating distribution systems, thus mitigating the potential disbenefits of increased indoor air pollution due to envelope measures without proper HVAC or electrification.

As discussed in the *Energy Costs and Burden* category, the measure includes subcomponents to increase energy resilience, such as distributed solar and storage, where strategic and feasible; this can support energy security and reliability, reduce potential disbenefits, and provide climate resilience benefits.

Community Engagement, Awareness, and Capacity

SUMMARY

Equitable and inclusive governance and decision-making is critical for successful and equitable programs; the measure's Community Work Group will aim to support community engagement, awareness, and capacity.

SUPPORTING RATIONALE

- **Equitable participation in decision-making processes for all communities is crucial as society undergoes significant changes through energy transition planning** (Kime et al., 2023).
- **One energy equity indicator for access is decision representation**, or control and governance over energy systems and decision-making processes (Kime et al., 2023).
- **Pursuing inclusive and equitable climate governance can be a way to combat historic underinvestment and limited access to efficient, healthy, and affordable services and infrastructure in cities**. The emergence of local and community-led approaches—coupled with increasing collaboration among city, Tribal, state, and federal governments—indicates a movement toward more inclusive planning and implementation of climate actions (Chu et al., 2023).

EQUITY CONSIDERATIONS

To mitigate potential barriers or challenges and to strengthen the program, the measure will:

- Establish a Community Work Group that includes community-based organizations (CBOs), community members, and other partners to advise on and participate in implementation so that frontline community members' needs are prioritized.

Additionally, the measure's housing security and policy support element will:

- Provide policy support to local governments and CBOs to address implementation barriers as they emerge.

This is supported by SAJE's Decarbonizing CA Equitably report (Kirk, 2023), which recommends that policy makers:

- Seek out perspectives from tenant advocates, legal service providers, and low-income tenants.
- Solicit insights into the specific hardships encountered by tenants, particularly those involving landlord harassment, displacement due to construction, rent burden, and eviction.
- Prioritize active listening to hear how tenants are currently affected by the affordable housing crisis, and whether and how they believe decarbonization efforts will compound those effects.
- Acknowledge their contributions by providing appropriate compensation for their valuable time and input.
- Develop relationships with CBOs to leverage existing relationships and connect with community members.

Transportation Access and Costs

N/A

4 References

Alameda Contra Costa Transit District. (2022). *Zero Emission Bus Transition Plan*. https://www.actransit.org/sites/default/files/2022-06/0162-22%20ZEB%20Transition%20Plan_052022_FNL.pdf

Barker, E. (2021). *Building a Just Transition: Creating a Community Engagement Building a Just Transition: Creating a Community Engagement Strategy for Building Electrification Policy in the City of Riverside Strategy for Building*

Electrification Policy in the City of Riverside [Pitzer Senior Theses.]. https://scholarship.claremont.edu/cgi/viewcontent.cgi?article=1125&context=pitzer_theses

Bay Area Air Quality Management District. (2018, October 4). *Air Pollution and Community Health*. Bay Area Air Quality Management District . https://www.baaqmd.gov/community-health/air-pollution-and-community-health

California Air Resources Board. (2018). *California transitioning to all-electric public bus fleet by 2040*. California Air Resources Board. https://ww2.arb.ca.gov/news/california-transitioning-all-electric-public-bus-fleet-2040

Equitable TOD: A Sound Transit Case Study, (2020). https://www.academia.edu/43796093/Equitable_TOD_A_Sound_Transit_Case_Study

Cash, A., Chapple, K., Depsky, N., Elias, R. R., Krnjaic, M., Manji, S., & Montano, H. (2020). *Climate Change and Displacement in the U.S. – A Review of the Literature*.

Chu, E. K. , M. M. F. J. C. S.-M. C. C. C. M. C. D. M. H. D. H. V. L. J. J. M. K. A. K. T. A. M.-E. and N. T. O. J. (2023). *Chapter 12 : Built Environment, Urban Systems, and Cities. Fifth National Climate Assessment*. https://doi.org/10.7930/NCA5.2023.CH12

Elmarakby, E., & Elkadi, H. (2024). Impact of urban morphology on Urban Heat Island in Manchester's transit-oriented development. *Journal of Cleaner Production*, *434*, 140009. https://doi.org/10.1016/j.jclepro.2023.140009

Fenton, L. (2022). *Examining Equity in Building Decarbonization: Critical Issues and Opportunities*. University of California San Diego.

Fournier, E. D., Federico, F., Cudd, R., Pincetl, S., Ricklefs, A., Costa, M., Jerrett, M., & Garcia-Gonzales, D. (2022). Net GHG emissions and air quality outcomes from different residential building electrification pathways within a California disadvantaged community. *Sustainable Cities and Society*, *86*, 104128. https://doi.org/10.1016/j.scs.2022.104128

Frost, M. (2022, May 22). *In five years, Sound Transit has racked up an additional $50 billion for rail plan*. Washington Policy Center. https://www.washingtonpolicy.org/publications/detail/in-five-years-sound-transit-has-racked-up-an-additional-50-billion-for-rail-plan

Hachette, M., & L'Hostis, A. (2024). *Mobility Hubs, an Innovative Concept for Sustainable Urban Mobility?* (pp. 245–278). https://doi.org/10.1007/978-3-031-35664-3_14

Hens, I., & Lamon, E. (2021). *A Methodology for Geographically-Targeted Building Electrification for Environmental and Social Justice Communities in California*. University of California, Berkeley.

Holland, N. (2022, August 2). *How Transit-Oriented Housing Can Advance Access to Opportunity While Curbing Climate Change*. Urban Institute.

Holstius, D., & Martien, P. (2022). *Exposure and Equity Assessment of Natural Gas Appliances in the San Francisco Bay Area*. https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-6-nitrogen-oxides-emissions-from-natural-gasfired-water-heaters/2021-amendment/documents/20221220_sr_appf_rg09040906-pdf.pdf?rev=c7a8dc1225b243298e7bd9395a292844

Jackson, C. T. (2021). Expanding access to electric vehicles in California's low-income communities. *Journal of Science Policy & Governance*, *18*(01). https://doi.org/10.38126/JSPG180107

Jessel, S., Sawyer, S., & Hernández, D. (2019). Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature. *Frontiers in Public Health*, *7*. https://doi.org/10.3389/fpubh.2019.00357

Jones, B., Karpman, J., Chiebnikow, M., & Goggans, A. (2019). *California Building Decarbonization Workforce Needs and Recommendations*. https://innovation.luskin.ucla.edu/california-building-decarbonization/

Kime, S., Jacome, V., Pellow, D., & Deshmukh, R. (2023). Evaluating equity and justice in low-carbon energy transitions. *Environmental Research Letters*, *18*(12), 123003. https://doi.org/10.1088/1748-9326/ad08f8

Kirk, C. (2023). *Decarbonizing California Equitably: A Guide to Tenant Protections in Building Upgrades/Retrofits Throughout the State*. https://www.saje.net/wp-content/uploads/2023/09/Decarbonizing-California-Equitably-Report-1.pdf

Lebel, E. D., Michanowicz, D. R., Bilsback, K. R., Hill, L. A. L., Goldman, J. S. W., Domen, J. K., Jaeger, J. M., Ruiz, A., & Shonkoff, S. B. C. (2022). Composition, Emissions, and Air Quality Impacts of Hazardous Air Pollutants in Unburned Natural Gas from Residential Stoves in California. *Environmental Science & Technology*, *56*(22), 15828–15838. https://doi.org/10.1021/acs.est.2c02581

Miller, C., Chen, S., Hu, L., & Sevier, I. (2019). *Equitable Building Electrification A Framework for Powering Resilient Communities*. https://ecology.iww.org/PDF/misc/Greenlining_EquitableElectrification_Report_2019_WEB.pdf

Moe, A., & Gibbs, P. (2023). *Equitable Electrification Analysis for Existing Buildings in Richmond, CA*. https://doi.org/10.2172/1998661

Nadel, S. (2019). Electrification in the Transportation, Buildings, and Industrial Sectors: a Review of Opportunities, Barriers, and Policies. *Current Sustainable/Renewable Energy Reports*, *6*(4), 158–168. https://doi.org/10.1007/s40518-019-00138-z

National Association of City Transportation Officials. (2017). *Urban Street Stormwater Guide*. National Association of City Transportation Officials. https://nacto.org/publication/urban-street-stormwater-guide/streets-are-ecosystems/complete-streets-green-streets/

Ong, P. M. (2002). Car ownership and welfare-to-work. *Journal of Policy Analysis and Management*, *21*(2), 239–252. https://doi.org/10.1002/pam.10025

Orange County Transportation Authority. (2022). *Orange County Mobility Hubs Strategy*. https://octa.net/pdf/MobilityHubsStudyFinalReport.pdf

Pacific Gas & Electric (PG&E). (2024a). *Electric Home Rate Plan (E-ELEC)*. Pacific Gas & Electric (PG&E). https://www.pge.com/en/account/rate-plans/find-your-best-rate-plan/electric-home.html

Pacific Gas & Electric (PG&E). (2024b). *Public Safety Power Shutoffs*. Pacific Gas & Electric (PG&E). https://www.pge.com/en/outages-and-safety/safety/community-wildfire-safety-program/public-safety-power-shutoffs.html

Patel, R. K., Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J. M., & Foss, A. (2022). Mobility-on-demand (MOD) Projects: A study of the best practices adopted in United States. *Transportation Research Interdisciplinary Perspectives*, *14*, 100601. https://doi.org/10.1016/j.trip.2022.100601

PolicyLink. (2022). *All-In Cities Policy Toolkit*. PolicyLink. https://allincities.org/toolkit

Ribeiro, D., Mackres, E., Baatz, B., Cluett, R., Jarrett, M., Kelly, M., & Vaidyanathanmm Shruti. (2015). *Enhancing Community Resilience through Energy Efficiency* .

Rodier, C., Farzad, A., & Robert A, J. (2015). Exploring Unintended Environmental and Social-Equity Consequences of Transit Oriented Development. *UC Davis: National Center for Sustainable Transportation*. https://escholarship.org/uc/item/88d8236t#author

Sacramento Metropolitan Air Quality Management District. (2017). *Our Community CarShareSacramento Pilot Project ourcarshare.org* . https://ww2.arb.ca.gov/sites/default/files/movingca/pdfs/ourcommunity.pdf

San Francisco Bay Area Rapid Transit District. (2023). *BART's Transit-Oriented Development Program Work Plan*.

https://www.bart.gov/sites/default/files/docs/BART%20TOD_Workplan_FINAL_Spreads_200814%20Reduced.pdf

San Francisco Bay Area Rapid Transit District. (2024, January 1). On Jan. 1, BART fares to increase 5.5%, low-income fare discount to increase to 50%. *San Francisco Bay Area Rapid Transit District* . https://www.bart.gov/news/articles/2023/news20231211-0

Stacy, C., Blagg, K., Su, Y., Rainier, M., Noble, E., & Ezike, R. (2022). *Access to Opportunity through Equitable Transportation*. https://www.urban.org/sites/default/files/publication/102992/access-to-opportunity-through-equitable-transportation_0.pdf

Stone, B., Mallen, E., Rajput, M., Gronlund, C. J., Broadbent, A. M., Krayenhoff, E. S., Augenbroe, G., O'Neill, M. S., & Georgescu, M. (2021). Compound Climate and Infrastructure Events: How Electrical Grid Failure Alters Heat Wave Risk. *Environmental Science & Technology*, *55*(10), 6957–6964. https://doi.org/10.1021/acs.est.1c00024

Tanrikulu, S., Reid, S., Koo, B., Fang, Y., Baird, A., Jia, Y., Cordova, J., & Matsuoka, J. (2022). *Assessing Ambient Air Quality and Health Impacts from Natural Gas Building Appliances in the Bay Area: Supplmental Information for Proposed Amendments to Regulation 9, Rule 4 and Rule 6*. https://www.baaqmd.gov/~/media/dotgov/files/rules/reg-9-rule-6-nitrogen-oxides-emissions-from-natural-gasfired-water-heaters/2021-amendment/documents/20221220_sr_appe_rg09040906-pdf.pdf?rev=f05e1e6f12874600a0382b178b04ab0d

Tessum, C. W., Paolella, D. A., Chambliss, S. E., Apte, J. S., Hill, J. D., & Marshall, J. D. (2021). PM 2.5 polluters disproportionately and systemically affect people of color in the United States. *Science Advances*, *7*(18). https://doi.org/10.1126/sciadv.abf4491

United States Environmental Protection Agency Office of Air and Radiation. (2023). *Benefits Analyses: Low-Income and Disadvantaged Communities* . https://www.epa.gov/system/files/documents/2023-05/LIDAC%20Technical%20Guidance%20-%20Final_2.pdf

U.S. Department of Energy. (2023). *The U.S. National Blueprint for Transportation Decarbonization*. https://www.energy.gov/sites/default/files/2023-01/the-us-national-blueprint-for-transportation-decarbonization.pdf

U.S. Department of Transportation. (2015, August 24). *Active Transportation*. U.S. Department of Transportation. https://www.transportation.gov/mission/health/active-transportation

U.S. Department of Transportation. (2022). *A Toolkit For Planning and Funding Rural Electric Mobility Structure* .

U.S. Environmental Protection Agency. (2023, November). *Protecting Your Health*. U.S. Environmental Protection Agency . https://www.epa.gov/flooded-homes/protecting-your-health

Vision Zero Network. (2024). *What is Vision Zero?* Vision Zero Network . https://visionzeronetwork.org/about/what-is-vision-zero/

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough.' *Landscape and Urban Planning*, *125*, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017

Zhou, X., & Zolnik, E. J. (2013). Transit-Oriented Development and Household Transportation Costs. *Transportation Research Record: Journal of the Transportation Research Board*, *2357*(1), 86–94. https://doi.org/10.3141/2357-10

Zhu, Dr. Y., Connolly, R., Lin, Dr. Y., Mathews, T., & Wang, Z. (2020). *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California*.

Zuraimi, M. S., & Tan, Z. (2015). Impact of residential building regulations on reducing indoor exposures to outdoor PM 2.5 in Toronto. *Building and Environment*, *89*, 336–344. https://doi.org/10.1016/j.buildenv.2015.03.010

Appendix E

Workforce Planning Analysis Documentation

The following summary was developed by BW Research for the Air District to inform the Workforce Planning analysis discussion in the PCAP.

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MEMORANDUM

To: **Bay Area Air Quality Management District**

From: **BW Research Partnership**

Date: **February 12, 2024**

Re: **Workforce Assessment PCAP Submission**

INTRODUCTION

This memorandum summarizes the workforce planning assessment conducted by BW Research Partnership in support of the Bay Area Air Quality Management District's (BAAQMD's) Priority Climate Action Plan (PCAP). This memo:

- Forecasts workforce needs for Residential Building Decarbonization and Mobility Hub activities within the region;
- Identifies key occupations and skills;
- Surfaces opportunities for residents of frontline communities;
- Discusses job quality and high road approaches underway;
- Highlights relevant organizations and initiatives that are complementary to, and already engaged in, work that supports the activities outlined in the Measures.

The memo concludes with a discussion of the strengths, weaknesses, opportunities, and threats to the region's workforce as it seeks to support the Measures and related activities.

The building decarbonization and mobility hub measures being led by BAAQMD will create good jobs in growing clean energy sectors that can be filled by residents of the region. Meeting the demand for these jobs with a supply of qualified and trained workers, pulled from all areas within the region, will require a commitment to partnership and learning from many different stakeholders and a willingness to invest in equitable workforce development activities over the long run.

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MEMORANDUM

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MEMORANDUM

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MEMORANDUM

FORECAST OF LABOR DEMAND AND SKILLS IN NEED

Five Priority Occupations

A review of literature[1] [2] and interviews with building decarbonization and transportation experts surfaces five occupations that are crucial to the successful deployment of the proposed Residential Building Decarbonization and Mobility Hub Measures. Although these are not the only occupations that will be in-demand through these activities, they are at greatest risk of supply shortages driven by the Measures and similar initiatives in the region. These occupations also often require specialized skills or certifications, meaning that supply cannot be "ramped up" immediately. A sustained shortage of these workers would greatly hinder the success of the detailed Measures. For the remainder of this report, these five occupations are referred to as the "priority occupations". The five occupations are:

- **Electricians** install, maintain, and repair electrical wiring, equipment, and fixtures.

- **Heating, Air Conditioning, and Refrigeration (HVAC/R) Mechanics and Installers** install or repair heating, central air conditioning, HVAC, or refrigeration systems, including oil burners, hot-air furnaces, and heating stoves.

- **Plumbers and Pipefitters** assemble, install, alter, and repair pipelines or pipe systems that carry water, steam, air, or other liquids or gases.

- **Construction Laborers** perform tasks involving physical labor at construction sites.

- **Carpenters** construct, erect, install, or repair structures and fixtures made of wood and comparable materials, such as concrete forms; building frameworks, including partitions, joists, studding, and rafters; and wood stairways, window and door frames, and hardwood floors.

For the remainder of this memorandum, these five occupations are referred to as "priority occupations" that are likely to see the greatest increase in demand through the Residential Building Decarbonization and Mobility Hub measures identified. Based on the typical attributes of these jobs including wages, benefits, training needed, and access to training pathways, the increase in demand for these occupations provides a significant opportunity to create and maintain high road jobs throughout the Bay Area. By focusing workforce development on these occupations, BAAQMD and its partners can maximize the funding resources available and streamline engagement with critical stakeholders.

[1] "CALIFORNIA BUILDING DECARBONIZATION WORKFORCE NEEDS AND RECOMMENDATIONS." 2019 UCLA and Inclusive Economics. https://innovation.luskin.ucla.edu/california-building-decarbonization/

[2] "Evaluating Benefits from Transportation Investments Aligned with the Climate Action Plan for Transportation Infrastructure (CAPTI)" 2023 San Jose State University and Mineta Transportation Institute. https://transweb.sjsu.edu/research/2227-California-Climate-Action-Plan-Transportation-Infrastructure

Key Occupations by Measure – Residential Building Decarbonization

The occupations at greatest risk for supply shortage for residential building decarbonization activities are primarily 1) Electricians, 2) Heating, Air Conditioning, and Refrigeration (HVAC/R) Mechanics and Installers, and 3) Plumbers and Pipefitters.[3] Although there are thousands of workers currently working in these occupations across the Bay Area, their concentration in the region is lower than the national average (Location Quotient), meaning that these occupations make up a smaller share of the Bay Area workforce than they do for the broader country (Table 1). For example, the concentration of HVAC/R Mechanics and Installers is 14% lower in the Bay Area than the national average. Therefore, the additional occupational demand spurred by these building decarbonization measures will need to be met from a smaller-than-average pool of workers.

The median hourly wages for all priority occupations exceed the regional median wage of $36.10/hour for all priority occupations and offer living wages[4] for single adults with no dependents as well as family sustaining wages for households of four with two working parents.[5] It is important to note that the current residential building decarbonization market is largely comprised of low road contractors, which means that wages may be on the lower end of the distribution highlighted below in Table 1. While the 25th percentile of wages for each of these occupations still earn more than the living wage for a single adult in the Bay Area, introducing workforce standards—such as those highlighted in the Residential Building Decarbonization measure—can help ensure that workers receive higher wages and have higher rates of access to benefits.

Table 1. Top Occupations for Residential Building Decarbonization Measure 2023[6]

	Total Employment	Location Quotient	25th Percentile Wage	Median Hourly Wage
Electricians	13,417	0.93	$29.77	$41.60
Plumbers, Pipefitters, and Steamfitters	8,039	0.88	$30.19	$38.24
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	6,677	0.86	$27.46	$36.40

[3] "CALIFORNIA BUILDING DECARBONIZATION WORKFORCE NEEDS AND RECOMMENDATIONS." 2019 UCLA and Inclusive Economics
[4] Living wages—unlike the federal poverty line—include regionally-specific costs, such as housing, healthcare, and transportation, and therefore provide a more local perspective of economic well-being.
[5] MIT Living Wage Calculator. https://livingwage.mit.edu/metros/41860
[6] Data from JobsEQ. 2023Q4.

Key Occupations by Measure – Mobility Hubs

Similar to the Residential Building Decarbonization priority occupations, there are thousands of workers throughout the Bay Area economy who are already working in the priority occupations for Mobility Hubs. The occupations most needed for Mobility Hubs—primarily through the development of the infrastructure needed to support these hubs—are 1) Construction Laborers, 2) Carpenters, and 3) Electricians.[7] Electricians and Carpenters both offer median hourly wages that are higher than the regional median wage of $36.10/hour for all jobs (Table 2). Importantly, same as above, these jobs also offer living wages[8] for single adults with no dependents as well as family sustaining wages for households with two working parents (Construction Laborer median wages do not meet family sustaining wage criteria).[9] It is also important to note that the concentration of Construction Laborers, is the lowest of the five priority occupations, at about 20% lower in the Bay Area than the national average (Location Quotient).

Table 2. Top Occupations for Mobility Hubs Measure 2023[10]

	Total Employment	Location Quotient	25th Percentile Wage	Median Hourly Wage
Electricians	13,417	0.93	$29.77	$41.60
Carpenters	21,263	1.20	$30.32	$37.84
Construction Laborers	21,496	0.80	$23.99	$30.04

Projected Demand and Gap Analysis

Modeling the precise employment impacts of the proposed Measures would require detailed cost estimates or a detailed quantification of specific activities, neither of which were available at the time of writing this memorandum. The proposed Measures also align closely with existing regional goals for building decarbonization and transportation improvements, and the scale of these regional goals far exceed the workforce demands that would be imposed purely through the Measures. Given that neither

[7] "Evaluating Benefits from Transportation Investments Aligned with the Climate Action Plan for Transportation Infrastructure (CAPTI)" 2023 San Jose State University and Mineta Transportation Institute
[8] Living wages—unlike the federal poverty line—include regionally-specific costs, such as housing, healthcare, and transportation, and therefore provide a more local perspective of economic well-being.
[9] MIT Living Wage Calculator. https://livingwage.mit.edu/metros/41860
[10] Data from JobsEQ. 2023Q4.

workforce demands would occur in isolation, **the workforce estimates below forecast the total employment needed for the broader regional goals**, which provide an 'umbrella' of activities which include the activities outlined within the Measures. Accordingly, the below estimates should be understood as regional demand according to broader goals and policies beyond the Measures, but that include activities like those outlined in the Measures. This information can be useful in devising regional workforce strategies that identify industry-wide workforce needs beyond a specific Measure or initiative, hopefully allowing for coordination of workforce development efforts across programs and initiatives to support programmatic efficiency and effectiveness.

Residential Building Decarbonization

An economic impact analysis for the decarbonization of all relevant residential buildings in the Bay Area[11] conducted by Inclusive Economics[12] found that between 10,300 and 15,900 workers[13] working full-time on building decarbonization would be needed throughout the Bay Area for 25 years to fully electrify and decarbonize the entire residential building stock to meet net-zero GHG emissions by 2045.

This analysis concluded that the workers would be needed immediately to ensure that overall residential decarbonization goals were met on time, and that this work would be available over an entire 25-year career. This also means that, for every year that the residential building decarbonization workforce does not achieve its annual capacity goal, the more decarbonization activity will have to be squeezed into the remaining years.

Using Inclusive Economics' original trade-level research, an estimated 4,900 HVAC/R Mechanics and Installers will be needed for the remaining 21 years to 2045, representing a sizable 73% of the workers currently employed across the entire occupation.[14] Put another way, 4,900 HVAC/R Mechanics and Installers would have 21-year long careers working full-time on residential building decarbonization in the Bay Area. In contrast, the number of HVAC/R Mechanics and Installers in the Bay Area only increased by 11% between 2017 and 2023, suggesting training and education pipelines will need significant support to attract and train this number of workers. Electricians are also poised to see

[11] Throughout this report, the Bay Area is defined to include Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Solano, and Sonoma Counties. Santa Clara County is omitted from the workforce analyses.
[12] "CALIFORNIA BUILDING DECARBONIZATION WORKFORCE NEEDS AND RECOMMENDATIONS." 2019 UCLA and Inclusive Economics
[13] Original calculations were adjusted to remove Santa Clara County. For more information, please see the appendix section.
[14] These estimates are "total" workers needed, which is agnostic to the total number of HVAC/R Mechanics and Installers currently working on residential building decarbonization. Innovations in HVAC technologies and system designs (i.e. in-window systems) may put downward demand for HVAC/R Mechanics and Installers.

substantial demand increase through Residential Building Decarbonization—amounting to 12% of the current number employed today (Table 3).

Table 3. Occupation Projections for Residential Building Decarbonization

Occupation	Total Employment 2023Q3[15]	Historical Employment Growth (2017-2023) [16]	Workers Needed from 2024 Through 2045[17]	Share of full-time worker relative to 2023
Electricians	13,417	19.3%	1,650	12%
Plumbers, Pipefitters, and Steamfitters	8,039	-3.4%	450	6%
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	6,677	11.2%	4,900	65%

Improving Regional Transportation

A report on the economic impacts of California's Climate Action Plan for Transportation Infrastructure shows that Construction Laborers, Carpenters, and Electricians will be in highest demand through the types of activities outlined in the Metropolitan Transportation Commission's 2023 Transportation Improvement Plan (TIP). The 2023 TIP contains a range of transit and mobility activities, some of which include the activities outlined in the Mobility Hub Measure. An estimated additional 870 Construction Laborers, 630 Carpenters, and 540 Electricians are projected to be needed annually to support the TIP's activities throughout the Bay Area through 2030 (Table 4).[18] While this does not equate to a substantially higher growth rate in additional jobs, the context of historical job growth—particularly for Carpenters—highlights the need to reinforce training and career pathway entry points for these occupations.

[15] Data from JobsEQ. 2023Q4.
[16] Data from JobsEQ. 2023Q4.
[17] "San Francisco Bay Area Residential Building Decarbonization Jobs Estimates." Inclusive Economics
[18] CAPTI figures were proportioned to the Metropolitan Transportation Commission's 2023 Four-Year Transportation Improvement Program that includes local, state, and federally-funded transportation projects. For more information, please see the appendix section.

Table 4. Occupation Projections for Transportation Improvements

Occupation	Total Employment 2023Q3[19]	Historical Employment Growth (2017-2023) [20]	Additional Workers Needed from (2024 Through 2030)[21]	Growth Rate From 2023
Electricians	13,417	19.3%	540	4%
Carpenters	21,263	-4.2%	630	3%
Construction Laborers	21,496	8.9%	870	4%

One additional consideration is that neither Measure will be implemented within a vacuum. As California's housing crisis continues, the need to build more housing will continue to increase. Many occupations that support the two Measures are also key occupations within the new housing construction industry. Furthermore, other infrastructure projects and initiatives—ranging from climate resiliency projects to ports and clean energy generation and transmission—are already underway or will be during the time of implementation of these two Measures. These types of projects will also require many of the same occupations as housing construction and broader infrastructure.

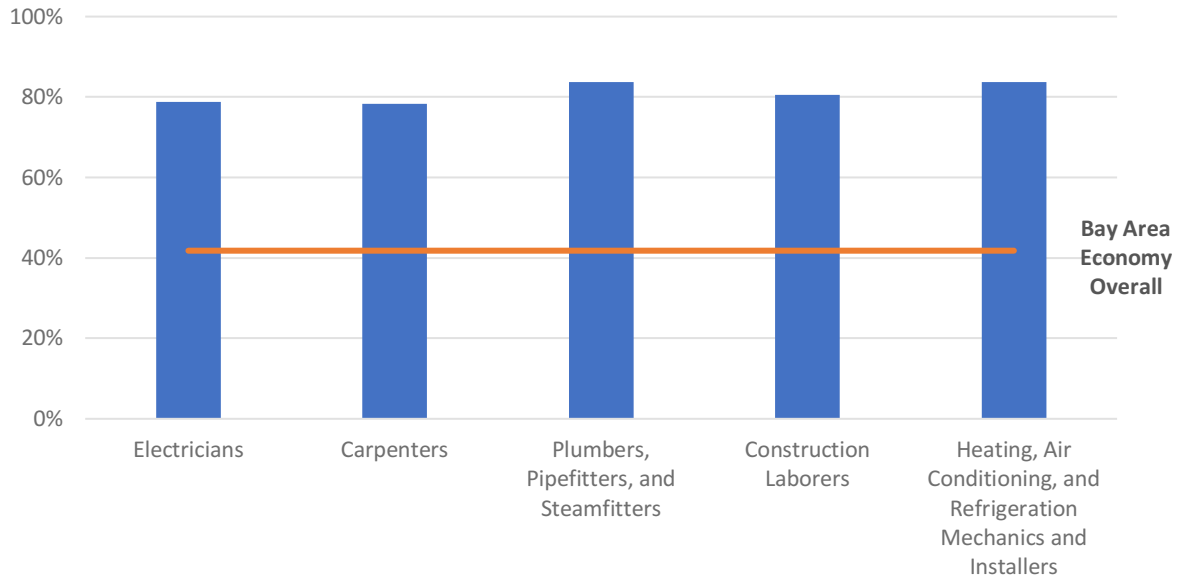
The additional workforce demands for the same priority occupations will place additional strain on the talent pipelines and support systems highlighted throughout this memo. This will require increased coordination and planning across industries and the workforce ecosystem, especially including employers and worker organizations such as unions. It also underlines the importance of moving quickly on the funding and other programmatic recommendations highlighted in this memo.

Key Skills and Education

The priority occupations for both Measures overwhelmingly do not require a four-year degree. Between 78% and 84% of workers currently in these occupations do not have a four-year degree. This is in stark contrast to the Bay Area average for all workers, where 42% have at least a four-year degree. These data make it clear that the occupations created through these Measures create good-paying jobs (Table 1 & Table 2) without extensive educational requirements (Figure 1).

[19] Data from JobsEQ. 2023Q4.
[20] Data from JobsEQ. 2023Q4.
[21] "Evaluating Benefits from Transportation Investments Aligned with the Climate Action Plan for Transportation Infrastructure (CAPTI)" 2023 San Jose State University and Mineta Transportation Institute

Figure 1. Share of Workers With Less Than Four-Year Education By Occupation[22]



O*NET—a free online database supported by the US Department of Labor/Employment and Training Administration—lists the top Knowledge, Skills, and Attributes needed for specific occupations. Many of the top Knowledge, Skills, and Abilities are shared across the priority measure occupations. For instance, all five priority occupations have Building and Construction as a one of the most-needed knowledge attributes, and four out of five occupations have Problem Sensitivity and Near Vision as top abilities and Critical Thinking as a top skill (Table 5).

Table 5. Top Three Knowledge, Skills, and Abilities Across All Priority Measure Occupations[23]

Knowledge	Skills	Abilities
Building and Construction	Critical Thinking	Problem Sensitivity
Mechanical	Troubleshooting	Near Vision
Mathematics	Active Listening	Deductive Reasoning

Common Entrance Ramps for Priority Occupations

Pre-apprenticeships, vocational and technical schools, and apprenticeship programs can benefit job seekers by offering early experience and teaching foundation skills, including key areas like Mathematics

[22] Data from JobsEQ. 2023Q4.
[23] KSAs identified through O*NET

and Building and Construction (Table 5). Apprenticeship programs, in particular, offer "learn and earn" environments that can be more financially feasible for job seekers, particularly those from disadvantaged backgrounds. Furthermore, these programs allow students to "test drive" jobs before making a commitment to formal schooling or programs.

The most common pathways to entry in these priority occupations are summarized below, and highlight the breadth of entry points, the importance of experienced workers in training new workers, and the time required.

	Common pathways?	**Typical time requirements?**	**Licensing?**
Electricians	California State-approved school as a trainee. The list of approved schools includes union JATCs (Joint Apprentice and Training Committee), community colleges, and adult schools.	8,000 hours for general electricians and 4,800 for residential electricians; can take 2.5-4 years	After approved hours, trainees take the California State Certification Exam to be a licensed Electrician
Heating, Air Conditioning, and Refrigeration (HVAC/R) Mechanics and Installers	Typically entails enrollment in an apprenticeship or secondary educational program	2-4 years	No formal license is required by technicians so long as they are supervised by a licensed contractor; an exception is an EPA Section 608 Certification specific to the handling of refrigerants.
Plumbers	Ibid	ibid	No formal license is required by technicians so long as they are supervised by a licensed contractor.
Carpenters	Ibid	ibid	Ibid

Construction Laborers	Of the priority occupations, Construction Laborers have the least formal requirements or pathways. But hiring is often based on prior job site experience, so vocational or technical schools, pre-apprenticeships, apprenticeships, and potentially even some secondary education can be useful in helping candidates distinguish themselves in the hiring process.	ibid	Ibid

Certifications for New Workers

The core occupation and trade-specific training that job seekers looking to enter priority occupations will pursue will likely include the necessary skills and certifications for entry-level workers. Ensuring accessibility to these training opportunities and relevant credentials can ensure that all job seekers are prepared to succeed once on the job site. Some relevant certifications—that are often incorporated into new workers trainings—in Residential Building Decarbonization[24] include:

- OSHA 10
- CPR/First Aid
- Multi-Craft Core Curriculum (MC3)
- Urban Green Council GPRO Fundamentals of Building Green Training Program
- BPI's Building Science Principles, Infiltration and Duct Leakage, and Air Leakage Control Installer Certificates
- HVAC Excellence Employment Ready Certifications
- NATE Ready-to-Work Certification

The OSHA 10, CPR/First Aid, and Multi-Craft Core Curriculum (MC3) also support a broad base of skills and knowledge for entry-level Mobility Hub workers. Electricians may also benefit from having an Electric Vehicle Infrastructure Training Program (EVITP) certification, which is required for at least one worker on a project team for all state-funded charging infrastructure projects in California.

[24] This list is largely drawn from the list developed by the Bay Area High Road Training Partnership Contractor Training RFI Response.

The cost of these programs depends largely on the training institution. Union apprenticeships offer experience-adjusted prevailing wages throughout the apprenticeship, while programs at community colleges or private colleges could cost thousands of dollars in tuition if students are unable to secure California College Promise Grants or other tuition waivers.

Certifications for Incumbent Workers

There are a number of certifications that can help incumbent workers upskill and demonstrate proficiency or excellence. Below are some certifications specific to Residential Building Decarbonization:

- BPI Air Conditioning & Heat Pump Professional, Building Analyst Technician or Professional,
- Heating Professional, and Retrofit Installer Technician Certifications
- HVAC Excellence
- NATE HVAC Support Technician and Professional Certifications
- NADCA Credentials

For Mobility Hub Electricians, the EVITP certification is a particularly useful certification to hold as it ensures they are eligible for a greater number of federal and state projects.

Certifications for Contractors

The certification process to become a licensed contractor depends on the occupation, but it can present a challenge for some individuals. For example, to get an HVAC contractor's license in California one must pass the trade exam, pass the California Law and Business exam, pass an asbestos exam, provide a contractor bond, meet the insurance requirements, and importantly—pass a background check. This process can present a substantial barrier to potential contractors and may even limit the number of individuals who seek contractor licenses—resulting in fewer employers in the industry. Making it easier for well-trained individuals to overcome certain barriers like insurance requirements can help increase the accessibility of licensure and entrepreneurialism.

Economic Opportunity for Low-Income and Disadvantaged (Frontline) Communities

With enforceable standards and policies, additional resources, and active stakeholder engagement, employment demand created through Mobility Hubs and Residential Building Decarbonization Measures can also offer substantial opportunities for Low-Income and Disadvantaged Communities (LIDAC) or frontline communities.[25] Nearly 1.8 million residents that are 16 years or older—accounting

[25] LIDACs are generally defined at the census tract level and include communities that meet EPA IRA DAC (defined at the census block group level), MTC Equity Priority Communities, or AB617 CERP definitions.

for just under a third of the region's working age population—live within frontline communities. Although the labor force participation rates are identical between frontline and non-frontline areas, the unemployment rates are notably different.

The unemployment rate in 2022 in non-frontline regions was 4.8%, compared to 6.5% in frontline areas—meaning that unemployment in frontline communities was roughly a third higher. It is important to note that a higher unemployment rate in frontline communities means that there may be more job seekers within those communities. However, job seekers from these communities may need additional resources and supports to overcome challenges of poverty and systemic disinvestment. Household incomes are also substantially lower within frontline communities, with the median household in non-frontline communities 78% higher than their frontline counterparts (Table 1).

Table 6. Employment, Unemployment, and Labor Force Participation Rate by Community, 2022[26] [27]

	Population	Employment	Unemployment Rate	Labor Force Participation Rate	Median Family Income
Non-LIDAC	4,040,368	2,116,653	4.81%	66.58%	$168,620
LIDAC	1,739,666	889,397	6.49%	66.52%	$94,700

There are several ways that the Measures may directly and indirectly present economic opportunity for residents within LIDACs. Both Measures will:

- Prioritize frontline communities and incorporate policies that protect existing affordable housing and prevent displacement.
- Prioritize projects within communities. Doing so may help increase awareness of programs, accessibility for local workers, and improve the transportation and housing of members of those communities.
- Engage with CBOs to ensure community interests and needs are being addressed.

The Residential Building Decarbonization measure will also address health and safety concerns in homes, so that they are best suited to serve residents and provide maximal efficiency benefits and cost savings. Importantly, the Measure includes support of workforce development programs to support entry into decarbonization careers, as well as development of workforce standards for retrofits projects to increase the number of family-sustaining and high-quality jobs.

[26] Community unemployment rate and labor participation rate are calculated as weighted averages using population.
[27] Data from US Census Bureau. 2022 Estimates

The activities outlined in the Mobility Hubs and Residential Building Decarbonization Measures can help drive investment and economic opportunity for residents in these communities while also supporting improvements to housing stock and mobility options.

JOB QUALITY AND THE HIGH ROAD APPROACH

Definitions of High-Quality Jobs

Creating jobs through these Measures that are "high-quality jobs"[28] will bring benefits to the businesses involved with these Measures, the workers carrying out the Measures, and to the communities where those workers reside. The criteria considered in determining job quality varies considerably. Job quality definitions increasingly integrate more holistic criteria that capture the totality of the working experience and worker well-being. For example, the Department of Labor defines "good jobs" through a set of principles[29] that include (descriptions of each principle modified from original):

1) **Recruitment and Hiring** – applicants are recruited from all communities, and evaluated free of discrimination, based on skill-based requirements
2) **Benefits** – workers are provided and encouraged to use family-sustaining benefits such as health insurance, a retirement plan, and work-family benefits
3) **Diversity, Equity, Inclusion, and Accessibility** – all workers have equal opportunity in a workplace that centers DEIA
4) **Empowerment and Representation** – workers can form and join unions and have agency in the performance and direction of their work
5) **Job Security and Working Conditions** – workers operate in a safe workplace, with job security and predictability, and proper classification of their status
6) **Organizational Culture** – workers are valued and engage in respected work
7) **Pay** – workers are fairly paid a living wage that increases with increased skills and experience.
8) **Skills and Career Advancement** – workers have equitable opportunities to advance and access to training and education

[28] The terms 'high-quality' jobs, 'high road' jobs and 'good' jobs tend to be used interchangeably by academics, advocates and workforce professionals. For example the Department of Labor uses all three in its brief "Good Jobs in Federal Investments: a Toolkit for Employers, Workers and Government." Distinctions and differences in definition revolve around what to consider in defining a job as "good/high-quality/high-road" beyond economic factors, such as broader worker well-being, social good, justice, environmental sustainability, and unionization opportunities.

[2929] https://www.dol.gov/general/good-jobs/principles#:~:text=Diversity%2C%20Equity%2C%20Inclusion%2C%20and,systemic%20barriers%20in%20the%20workplace.

These principles are mirrored in the categories that the California High Road Training Partnership (CA HRTP) proposes as comprising job quality. They include:

- **Family-sustaining wages and benefits** that include health care, pension, paid sick leave
- **Career pathways** that are clearly defined and include access to education, training, and support services
- **Stable and predictable schedules** that are reliable and consistent
- **Worker voice and agency** that includes respecting and valuing the worker and **the right to organize and join unions**
- **Healthy work environment** with adequate training and protection, that incorporates racial equity practices

This definitional alignment can further be demonstrated through a blog post by the Secretary of Labor Julie Chu that highlights the California High Road Training Partnership as being a model effort for the DOL Good Jobs Initiative.[30] BAAQMD is actively partnering with several organizations that comprise the CA HRTP in developing these measures.

Connecting Priority Occupations to High-Quality Jobs

As the Aspen Institute highlights in a recent report: "jobs don't fall on a "good jobs/bad jobs" binary; rather, they fall somewhere along a continuum."[31] Depending upon labor standards, procurement approaches, use of project labor and community workforce agreements, apprenticeship, and wage requirements—among other elements—any job within these five priority occupations has the opportunity to become a high-quality/high-road job as defined by the HRTP and DOL Good Jobs Principles.

The sectors where these occupations will be located can have a significant impact on job quality. As highlighted in the California Building Decarbonization report, workers employed in building electrification work that takes place in large commercial and utility sectors tend to be "high road" sectors, while residential and small commercial construction are more at risk of generating "low road" opportunities.[32] This report highlights the findings of other reports regarding lower pay and more limited benefits for workers in these low road sectors.

[30] https://blog.dol.gov/2023/07/13/the-high-road-to-the-middle-class
[31] "Lessons and Takeaways from Supporting Small Businesses To Improve Job Quality: Seven Tips for Workforce Organizations", The Aspen Institute, April 2022
[32] "CALIFORNIA BUILDING DECARBONIZATION WORKFORCE NEEDS AND RECOMMENDATIONS." 2019 UCLA and Inclusive Economics

Given that the building decarbonization measure is focused on residential and small multi-family homes, there is a greater risk of creating lower quality jobs than through a focus on other building sectors. However, there are a number of strategies that can provide new workers, existing workers, and workers in adjacent fields with access to high quality jobs and help existing contractors engage in high-road approaches through Residential Building Decarbonization and Mobility Hub activities. While meeting all requirements of the most ambitiously defined high-quality or high-road job may not be immediately possible, there are many steps that can boost the quality of a job. They can range from establishing labor standards and wage requirements to monitoring and enforcing workplaces to ensure worker safety and health, to establishing clear career development opportunities that let workers move along a career pathway, among many other approaches.

The following sections outline some of the challenges that new workers, existing workers, and workers in adjacent fields may face in accessing and maintaining high quality jobs in the five priority occupations as well as targeted opportunities that BAAQMD and its partners can explore to address and overcome those challenges.

New Workers

Challenge: There are a number of challenges for new entrants seeking entry into priority occupations. These priority occupations generally require specific skills and experience gained through education, training, apprenticeships, and work experience. Individuals currently in, or recently completing training, education, and/or apprenticeships may have difficulties finding and connecting with employers who seek to provide high-road job opportunities. The small contract size of individual homes also means that few union signatory contractors[33] may be interested or able to work in the residential market. A final challenge—which is particularly true for Residential Building Decarbonization rather than Mobility Hubs—is that job quality in specific occupations is at risk of being lower, especially with many types of building retrofits and simple energy efficiency measures. According to one report by Smart Cities Prevail,[34] residential construction workers make 33% less than their non-residential construction counterparts, and benefit rates are substantially lower.

These challenges are intertwined, and solutions must both stimulate demand for high-quality jobs while also supporting the pathways into, and supply of, high-quality workers. The need to support both the supply and demand for high-quality jobs can be difficult to balance.

[33] A union signatory is a company that has agreed to meet a union's guidelines and has a subsequent legally binding agreement with a union.
[34] Littlehale, S. (2019). Rebuilding California: The Golden State's Housing Workforce Reckoning. Smart Cities Prevail. https://www.smartcitiesprevail.org/wp-content/uploads/2019/02/SCP-Rebuilding-CA-Press-Release-02.20.19.pdf

Opportunity: The Bay Area is already working to address the challenges outlined above that may impact implementation of the Residential Building Decarbonization and Mobility Hub Measures. On the building decarbonization side, programs that aggregate residential projects such as one in the City of Berkeley, are already under way throughout the Bay Area and will make these projects more accessible to labor signatory contractors and capitalize on economies of scale. The Residential Building Decarbonization Measure's addition of workforce standards, Community Based Organization engagement, and contractor supports aims to ensure that the jobs created through the measure will generate high-quality jobs, work with communities to find solutions, and increase the accessibility of the economic opportunity to workers and job seekers from frontline communities and other historically excluded groups. Fortunately, research shows that the activities outlined in the Mobility Hub Measure are likely to support high job quality[35] that is common throughout the transportation infrastructure construction industry, often via prevailing wage contracts with labor signatory contractors or Project Labor Agreements. The scale of contracts is one driver of this, and several counties and cities within the Bay Area have prevailing wage requirements for contracts above a certain amount.[36]

On the supply side, new entrants to the five priority occupations have an increasing number of on-ramps to begin careers in building decarbonization or supporting mobility hubs. Pre-apprenticeship programs offer an opportunity to combine career awareness and hands-on learning experimentation. Pre-apprenticeships that offer wraparound support services and pay participants are particularly impactful in increasing the accessibility of pre-apprenticeship programs for disadvantaged and historically excluded job seekers including women, BIPOC, and other historically disadvantaged job seekers. The Bay Area High Road Training Partnership recommends at least one year of case management for those in training programs to ensure that life events have minimal impact on participants' ability to learn and advance their careers. Many pre-apprenticeships adopt Multicraft Core Curriculum (MC3) that provides a foundational set of experience and skills that allow program completers to matriculate into a range of trade-specific training programs.

Workforce intermediaries and workforce development boards can also be helpful in establishing relationships between employers and job seekers, providing career navigation support and support services to workers, and developing multi-partner collaboratives, among other efforts. State and local workforce development boards implement a range of different workforce programming, leveraging federal funding and other sources, while workforce intermediaries—which can intersect with workforce boards—convene participants in a workforce ecosystem to design and implement workforce interventions.

[35] "Evaluating Benefits from Transportation Investments Aligned with the Climate Action Plan for Transportation Infrastructure (CAPTI)" 2023 San Jose State University and Mineta Transportation Institute

[36] http://www.opencompca.com/issues/project-labor-agreements/california-government-project-labor-agreement-list/

High school Career Technical Education (CTE), adult schools, and community colleges also offer job seekers the chance to gain experience and education. High school CTE programs are particularly important in providing younger students with an understanding of the types of roles available within the clean energy space and the opportunity to practice some of the daily skills and activities required for those jobs. These programs can then help connect interested high school students to pre-apprenticeship, apprenticeship, or other training opportunities.

Existing Workers

Challenge: Continued learning and advancement opportunities are crucial to ensure that workers are prepared for new technologies and can advance in their careers. Training in the five priority occupations typically occurs continually on the job, and workers in those fields can specialize or advance via trade or scope-specific certifications. While there are increasing options, there can be a "chicken-egg" dynamic where a lack of market entry by specific technologies can leave existing workers unfamiliar with the technologies and unable to gain the training needed.

Opportunity: There are already several initiatives throughout the Bay Area that are helping current workers get the training they need. For example, BayREN's Energy Expert program helps contractors and their employees receive training about financial incentives and provides contractors with marketing and outreach, and adds them to an exclusive contractor database. Joint Apprenticeship Training Centers (JATCs) are another high-road training institution for current workers (as well as new workers). Union programs operated through JATCs offer prevailing wages and apprenticeships that allow workers to continue to get paid while they learn. Another solution can be to promote more informal training such as manufacturer-specific information on new heat pump features taught by wholesalers and distributors for HVAC/R Installers and Repairers, or formal certifications like the Electric Vehicle Infrastructure Training Program (EVITP) that ensures journeymen Electricians have the EV-infrastructure specific knowledge to install and maintain charging infrastructure.

Contractors

Licensed contractors have the foundational technical knowledge and skills needed to conduct day-to-day activities. Additional education and certifications can help increase awareness of the most up-to-date technology, rebate and incentive programs, and help them navigate the bidding or administrative process. There are a number of partners and organizations involved in supporting contractors—including minority, women, and disadvantaged business enterprises (MWDBEs). These organizations are highlighted in the following section.

The challenges and opportunities discussed below primarily focus on residential building decarbonization contractors. Contractors/employers that will be operating within the Mobility Hub space are already likely to be high-road contractors that pay prevailing wages, offer frequent training for current workers, and are often union labor signatories.

Challenge: There is a shortage of high-road residential contractors within the Bay Area, largely as a consequence of market structure. In the residential market, lowest-cost contractors often win bids with price sensitive consumers that are already wary of unplanned (replacement is often catalyzed by sudden system failure) and relatively high-cost expenses. Workforce standards—including certification and licensing—can be hard to secure, monitor, and enforce in the residential, lowest-bid market. Addressing this challenge will not only require incentivizing demand for high-road contractors to enter the residential market, but also supporting existing contractors as they seek to become high-road employers.

Opportunity: As with addressing the challenges for new and existing workers, the Bay Area is already thinking about and working to address challenges related to supporting high road contractors. The Bay Area High Road Training Partnership has made and continues to make considerable headway in thinking about and navigating these issues.[37] Their recommendations are wide ranging but include:

1. Set floor wage and minimum job quality requirements.
2. Provide resources and supports for contractors to meet those requirements.
3. Offer incentives to those who go beyond wage and job quality requirements.
4. Funding support to assist in trainings and certifications for contractors and their employees.
5. Streamlined rebate and incentive processes and sources of information. Paid training to gain familiarity with rebates and incentives is also important.
6. Funded efforts to engage with and build trust within communities. This includes information and "meet and greet" sessions and partnerships with CBOs to build cultural competencies and language skills to better work within BIPOC and immigrant communities.
7. Supporting the creation of MWBDE contractors and support to meet high road standards and public procurement requirements.

A number of the partnerships highlighted below have already begun efforts that seek to address many of these recommendations, but additional funding and collaborations are needed to scale these efforts to meet the needs for high-road building decarbonization.

[37] "Bay Area High Road Training Partnership Contractor Training RFI Comments on Inflation Reduction Act Residential Energy Rebate Programs" https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=23-DECARB-01

KEY PARTNERSHIPS AND OTHER INITIATIVES TO COORDINATE WITH

Organizations and Initiatives Within the Bay Area with Workforce Component

- **Bay Area High Road Training Partnership:** is a California Workforce Development Board initiative that built a regional coalition around job quality and job access for local residents within residential building decarbonization.
- **BayREN:** BayREN has a number of Education and Training Initiatives, including the Climate Careers program, which is an earn-and-learn program that helps introduce local young adults to enter decarbonization careers.
- **City of Berkeley's Just Transition Residential Electrification Pilot:** Seeks to decarbonize affordable housing low-to-moderate income households, while also introducing workforce standards.
- **California Energy Commission Equitable Building Decarbonization Program:** This program includes a Direct Install Program and an Incentive Program for residential decarbonization.
- **California Energy Commission (CEC) Training for Residential Energy Contractors (TREC) workforce program:** The CEC is administrating the state's TREC program funded by the IRA. As the name suggests, this grant seeks to support the training and diversification of residential contractors. The CEC in the late fall of 2023 sent out a survey to stakeholders to supplement public comment and enhance program delivery.
- **Construction Trades Workforce Initiative:** a nonprofit partner of the East Bay Building Trades that seeks to connect union construction labor with key stakeholders—including job seekers, training providers, public agencies, communities, and developers.

Education and Training

New Entrants

Pre-Apprenticeship

Below is a non-exhaustive list of the pre-apprenticeship programs throughout the Bay Area that offer MC3 training, which would be relevant to workers for both Measures:

- **Rising Sun Center for Opportunity, Opportunity Build program**
- **Cypress Mandela**
- **City College Apprenticeship Programs**
- **Richmond Build**
- **SF City Build**
- **North Bay Trades Introduction Program**

- **Plumbing, Heating & Cooling Contractors Association (PHCC)**

Adult Schools, Community Colleges, and Career and Technical Education

- **IDEAL ZEV:** California Air Resources Board (CARB) and the California Energy Commission (CEC) have partnered on the Inclusive, Diverse, Equitable, Accessible, and Local (IDEAL) Zero-emission Vehicle (ZEV) Workforce Pilot. This initiative, funded at $6.5 million, will offer investments to large and small educational institutions and community organizations to support pathways for clean transportation jobs, including electric vehicle charging.[38]
    - Simultaneously, CARB has allocated $1.5 million for the existing Adult Education & Vocational School Zero-Emission Vehicle Technology Training Project,[39] which aims to provide investments to non-traditional workforce partners with deep connections to disadvantaged communities.
- **Diablo Valley College**
- **Foothill College**
- **Laney College**
- **Santa Rose Junior College**
- **Skyline College**

Organized Labor

- **Joint Apprenticeship Training Centers (JATCs)**

Incumbent Workers

- **Joint Apprenticeship Training Centers (JATCs)**
    - **IBEW EVITP Certified Electric Vehicles Technician** (CEVT) program
- **International Certification Board**
- **Testing, Adjustment, and Balancing Bureau**

Contractors

- **Manufacturer- and distributor-led trainings** are among the most common methods for contractors and their employees to learn new technologies or methods. Most contractors

[38] https://ww2.arb.ca.gov/our-work/programs/accessible-clean-transportation-options-sb-350/expand-workforce-training-and
[39] https://ww2.arb.ca.gov/sites/default/files/2023-08/fy21-22adultandvocational_solicitation.pdf

regularly stay in frequent contact with manufacturers and distributors through purchasing and warranties, so leveraging these strong existing relationships with contractors is essential.

- **Buildings and Construction Trades Contractors Associations** offer contractor training and support for labor signatory contractors.
- **Emerald Cities Collaborative E-Contractor Academy** is a free resource that offers guidance to small and disadvantaged contractors to scale their business into decarbonization and clean energy industries.
- **BayREN:** Home+ is a resource available to contractors (and with some mandatory trainings for contracts that are part of BayREN's Contractor list) to cover the basics of building science, heat pump technology, and compliance for certain certifications. BayREN is also a reliable resource for contractors looking for information on rebates and certifications.
- **Community Choice Aggregate Contractor Support Programs**
    - **MCE Community Choice Energy** is a community choice aggregator that provides stipends to contractors within their service region for contractors and crews to attend heat pump manufacturer training.
    - **Silicon Valley Clean Energy FutureFit Fundamentals Contractor Training program** incentivizes training for contractors as well as compensation for each electric device installed within a customer's home.
- **National Association of Minority Contractors** offers training and other resources for contractors within their networks. Trainings include opportunities for upskilling as well as resources and work with pre-apprenticeship and apprenticeship programs.
- **TECH Clean California Training Hub** offers low or no-cost trainings to contractors and their employees. Several initiatives offer trainings under the TECH umbrella, including the Energy Star Manufacturers Action Council, The Association for Energy Affordability, and the National Comfort Institute.
- **PG&E** offers a range of trainings for contractors and workers.

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STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS FOR THE BAY AREA'S HIGH-ROAD WORKFORCE IN RESIDENTIAL BUILDING DECARBONIZATION AND MOBILITY HUBS

Strengths

1. **Many key stakeholders in the Bay Area have accepted the high road as a goal and a variety of coalitions and conversations are already underway.** Organizations and employers throughout the Bay Area have embraced the high road as a goal to work towards. Coalitions—such as the Bay Area High Road Training Partnership for Residential Building Decarbonization—have already made significant progress in furthering conversations within residential building decarbonization. Job quality within the construction industry for transportation infrastructure in California is already reputably strong.

2. **Emerging coordination and relationships with unions.** Unions are deeply involved in the discussions and coalitions occurring throughout the Bay Area. The Construction Trades Workforce Initiative (CTWI) has been working as part of the Bay Area High Road Training Partnership for Residential Building Decarbonization to support union's role within residential electrification. Construction of transportation infrastructure in California also has a long history of union involvement.

3. **There is a strong network of high road training and education providers throughout the Bay Area.** The Bay Area's union training centers and a large number of pre-apprenticeships and vocational trainings—often offered at no cost—with support services provide a number of accessible on-ramps for jobs seekers of all backgrounds.

4. **The state of California and local jurisdictions have already developed climate action plans that complement the Measures.** The proposed Measures are not novel solutions or concepts to the state or the region. There are several state, regional, and local-level programs that support the exact types of activities proposed through the measures, meaning that workforce planning can—and should be—coordinated across initiatives.

5. **Access to a wide range of state and regional funding streams exist to support current programs.** An array of partners—including utility providers, state, regional, and local governments are already harnessing federal, state, and local funds to propel initiatives and projects related to workforce within Residential Building Electrification and Mobility Hubs.

Weaknesses

1. **There is a lack of current data on job quality within each of the existing sectors.** Stakeholder interviews and existing research provide a general understanding of market dynamics, but there is a scarcity of up-to-date, granular information about job quality within these specific markets, which makes it difficult to measure and monitor.

2. **A limited number of high-road contractors are focusing on the residential building decarbonization market.** Market dynamics within residential building decarbonization often favor lowest-bid contracting, which makes it difficult for high-road contractors to operate within the existing market, leaving low-road contractors with less commitment to create high quality jobs.

3. **There are few MWDBE contractors, and those that exist can struggle to access publicly funded projects.** MWDBEs tend to lack the resources and administrative capacity that might enable them to pursue publicly funded projects that require substantial training requirements, include job quality standards, or require the tracking of detailed metrics. Without services to support MWDBEs in these positions, they will likely struggle to participate in publicly funded projects and support high road approaches.

4. **Contractors operating in the residential building decarbonization sector must navigate tensions and tradeoffs when deciding between programs that incentivize whole home retrofits (with stronger climate and workforce options) or single appliance replacement.** Whole home retrofits can be more cost effective by reducing crew transportation and improving home efficiency and cost savings in the long run, but cost and construction-wary customers may often favor single appliance replacement.

5. **Awareness of careers and entry points, particularly for job seekers from frontline communities, is lacking, but is essential to ensure that a sufficient number of workers is available to implement the Measure activities.** Recruiting and retaining a large number of additional workers will be difficult in the current tight labor market with low unemployment, meaning that establishing larger, more sustainable worker pipelines for these occupations is a crucial objective.

Opportunities

1. **The Measures are designed intentionally to support workers and projects in frontline communities.** The Measures propose favoring projects within frontline communities, which can support career awareness, increase accessibility to employment opportunities, and improve

those communities. Planned coordination with CBOs can also increase engagement of frontline communities and hard-to-reach populations throughout the planning and construction process.

2. **Innovative methods are being tested to increase value propositions for residential building decarbonization that can boost opportunities for high-quality jobs**. Project aggregation is a key innovation that aims to make these projects more appealing to high-road contractors while also driving efficiencies of economies of scale. Novel business models, such as no-money-down retrofits, may also remove some of the industry's existing barriers to adoption.

3. **The existing network of organizations within residential building decarbonization means that there are more informational touchpoints for contractors.** Improving information sharing and access to resources can bolster the positive impacts of this network.

4. **The use of qualified contractor lists for state and regionally-funded projects can help drive demand for high-road contractors and employment opportunities.** Supporting contractors to achieve contractor list standards will be an important component of this strategy.

5. **There is a great opportunity to leverage significant state and federal funding for increasing demand and workforce needs.** Adding workforce standards will increase opportunities to leverage the power of public funds to support high road employment.

Threats

1. **Maximizing residential building decarbonization efforts while ensuring job quality and equity in accessing opportunities may introduce contradictory tensions.** If cost efficiencies cannot offset additional project costs from high-road labor standards, project costs may increase and uptake of residential building decarbonization may occur at a slower rate—or may require greater public funds to subsidize. Conversely, high workforce standards may produce barriers to participation in the market by MWDBEs, which may lack the administrative capacity or profit margin to meet such standards.

2. **The scale of additional workers needed for Measure-related and unrelated decarbonization efforts throughout the Bay Area may leave positions unfilled for extended periods, particularly at a time of near record-low unemployment.** The significant demand for these priority occupations across decarbonization activities as well as housing construction and other infrastructure projects means that a coordinated strategy across industries is needed. Previously mentioned career awareness and talent attraction strategies are one core component of this broader need for action.

3. **Growing the number of high-road contractors and building out qualified contractor lists will be a challenge for the region.** A limited number of contractors will restrict the number of available apprenticeships or other learning roles under supervision. If the number of contractors is restricted enough, it could ultimately end up hampering the capacity of publicly funded projects.

4. **The number of interested parties throughout the Bay Area means that coordinating and establishing delineating leadership responsibilities is of great importance.** Representative leadership and regular coalition meetings can help facilitate the range of stakeholders operating in unity.

Conclusions

The various Residential Building Decarbonization- and Mobility Hub-related initiatives, pilot programs, and array of stakeholders mean that the Bay Area is at the national forefront of the most pressing workforce issues related to Residential Building Decarbonization and Mobility Hubs. The tasks of decarbonizing the region's residences and changing how residents travel and commute are monumental tasks. The Measures as drafted provide a roadmap for how these types of projects can succeed in reducing greenhouse gas emissions while supporting high road employment. With a successful template in hand, the region can then leverage the breadth of other federal, state, and local funding to meaningfully affect change at scale throughout the region. Implementation of these Measures is the next step forward, and learning from and building on that implementation will help the Bay Area continue to advance the national understanding of impactful climate actions that improve the economic opportunities of all residents.

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MEASURING OUTCOMES

Using metrics to track the progress and accomplishment for outlined goals is an imperative step in understanding a program or initiative's success. Below is a list of metrics that could help quantify and track the success of high road employment outcomes for communities within the Bay Area.

- Demographics of the workforce (gender, race, ethnicity, educational attainment)
- Geographic distribution of workers
- Share of workers from within frontline or low-income and disadvantaged communities
- Median and average wages and benefits rates for workers
- Number of certified or licensed workers
- Number of contractors that meet workforce standards
- Number of contractors that apply to support the measure-funded activities
- Number of women and minority-owned businesses that apply to support measure-funded activities
- Number of women and minority-owned businesses engaged in measure-funded activities
- Use of community benefit plans or community benefit agreements

APPENDIX A: METHODOLOGY

Forecasting Residential Building Decarbonization Workers

Estimates for the Residential Building Decarbonization measure workforce were developed largely from existing work conducted by Betony Jones and Inclusive Economics. A presentation developed by these authors titled "San Francisco Bay Area Residential Building Decarbonization Jobs Estimates"[40] provides employment estimates for decarbonization efforts across the nine county Bay Area on a 25-year basis. For this project, the "Deep Efficiency and Electrification" job totals were highlighted because these entail comprehensive building decarbonization activities in line with the measure outlined for this PCAP. Because the research area for the PCAP excludes Santa Clara County, which was originally included by Inclusive Economics, BW Research proportioned total employment by the share of inhabited residential units in the desired eight counties. The numbers presented in this memo represent the total number of workers needed that would be working on residential decarbonization full-time for 21 years in order to decarbonize all residential buildings in the eight county Bay Area region.

Forecasting Demand for Mobility Hub Workers

The research team heavily leveraged research developed by Serena Alexander, Shams Tanvir, and T. William Lester at San Jose State University and Mineta Transportation Institute titled "Evaluating Benefits from Transportation Investments Aligned with the Climate Action Plan for Transportation Infrastructure (CAPTI)." This report quantifies the economic and workforce impacts of the statewide Climate Action Plan for Transportation Infrastructure (CAPTI). The CAPTI activities—which include investments in public transportation, walking and biking infrastructure, electrification of transportation fleets, and reducing vehicle miles traveled—are similar to the mobility hub measure. Because this report looked at statewide spending on transit, the BW Research proportioned the jobs created via the post-CAPTI spending to the Metropolitan Transportation Commission Draft 2023 TIP amount of approximately $2.725 billion annually.[41] It should be noted that additional transportation-related jobs may be created and supported by activities that occur outside of Bay Area counties (high speed rail, for example) but use workers from within the region. Funding for private or other consumer-accessible charging infrastructure may not be included as well.

[40] "San Francisco Bay Area Residential Building Decarbonization Jobs Estimates." Inclusive Economics.
[41] https://mtc.ca.gov/funding/transportation-improvement-program/draft-2023-tip