Residential Decarbonization Industry Paper Series

Bay Area Residential Decarbonization Industry and Workforce Overview

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Sarah Thomason, Chelsey Bryant, Sharon Jan, and Kelly Haines

Prepared by Movement Economics and Ponder Analytics for the High Road Training Partnership: Bay Area Residential Building Decarbonization facilitated by Rising Sun Center for Opportunity in partnership with Construction Trades Workforce Initiative

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Residential Decarbonization Industry Paper Series

This paper is the first in a series produced by the High Road Training Partnership: Bay Area Residential Building Decarbonization, facilitated by Rising Sun Center for Opportunity in partnership with Construction Trades Workforce Initiative (CTWI), to support the Vision of the Partnership:

> A residential building decarbonization industry that supports quality jobs, has accessible entry points and pathways to build a qualified workforce, and provides stable career pathways for disadvantaged workers while simultaneously reducing greenhouse gas emissions, creating healthier and more affordable housing benefits for residents, and building more resilient and empowered communities.

Funders

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Executive Summary

As California strives to reduce the impacts of climate change, decarbonizing the state's building stock is a priority. Residential decarbonization involves converting gas appliances and HVAC systems to all-electric versions and weatherizing homes to improve energy efficiency by upgrading insulation, weather sealing, windows, and doors. While this work is still in its early stages, with only a small portion of homes fully retrofitted, new funding sources from the state and federal levels have increased the scale of public investment in recent years, spurring demand and momentum. Increasing demand for residential decarbonization projects will likely create more employment opportunities in this industry. However, little is currently known about the characteristics of the current workforce and how its needs may change as the industry develops.

The High Road Training Partnership: Bay Area Residential Building Decarbonization was formed to bring together local government agencies, community-based organizations, unions, and contractors to consider the impacts of new public investment and improve job quality across the industry. To support this process, the Partnership commissioned a study of the current landscape of workers and employers, including projections of what demand will look like between 2024 and 2029 based on currently allocated public investments. The following Industry Analysis provides an overview of the landscape of public investment, workers, and firms in the Bay Area (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties), based on the results of our industry study. We find that:

- Public investment in Bay Area residential decarbonization projects has increased rapidly over the past several years and is projected to reach a historic peak of $234 million in 2025.
    - Total public funding for Bay Area residential decarbonization projects in 2025 ($234 million) will be nearly four times greater than total funding in 2021 ($61 million).
    - The number of Bay Area residential decarbonization projects funded partially or fully through public programs will be approximately three times larger in 2025 (60,000) than in 2021 (22,000).
    - On average, public subsidies cover only 18.5 percent of the cost of residential decarbonization projects in the Bay Area and homeowners cover the remaining costs. Total spending by both homeowners and public programs on Bay Area residential decarbonization projects will be 12 times greater in 2025 ($1.2 billion) than in 2021 ($100 million). However, the expected total public plus private spending in 2025 ($1.2 billion) is still only a fraction of the estimated total cost of decarbonizing the residential building stock in Bay Area counties (between $85 and $119 billion based on a study by Inclusive Economics, n.d.).
- More than half (60 percent) of residential decarbonization funding for the Bay Area between 2024 and 2029 is expected to come from federal programs, primarily through the

Energy Efficient Home Improvement Tax Credit. Slightly more than one-third of funding will come from state programs, and just 4 percent of total funding will come from local programs.

- Most Bay Area residential decarbonization funding (65 percent) will be distributed through incentives such as rebates and tax credits. About one-third of funding will come from direct install programs (defined as programs that coordinate installation and hire contractors to do the work, compared to other programs where homeowners receive a subsidy and must hire a contractor themselves), and only two percent of funds will come from loan/financing programs.
- Nearly three-quarters of funding is expected to come from programs that provide subsidies for multiple installation measures and/or whole-building retrofits. About one-quarter of funds are specifically for weatherization, and just five percent of programs focus exclusively on heat pump water heaters, heat pump HVAC systems, and/or electric appliances.
- The median hourly wage of Bay Area residential decarbonization workers is $32.87 per hour, lower than the median wage for all residential and commercial construction workers ($34) and workers across all industries ($36) in the Bay Area. In contrast to other publicly funded construction projects requiring workers to be paid prevailing wages and benefits, most public programs that fund residential decarbonization projects do not include labor standards.
- There are currently between 6,000 and 10,000 workers in the Bay Area whose jobs include at least some work on residential decarbonization projects. We estimate that these workers, on average, spend half of their work hours on residential decarbonization projects and half of their work hours on other types of construction projects. Therefore, we estimate that there are between 3,000 and 5,000 full-time equivalent residential decarbonization jobs in the Bay Area.
- Based on our estimates of the increase in total public and private spending on residential decarbonization projects between 2024 and 2025, we project that between 200 and 1,000 new residential decarbonization jobs will be created in 2025.
- In interviews, contractors (primarily non-union) overwhelmingly described difficulties with recruitment and retention as the primary challenge they face when engaging in residential decarbonization work. If public investment continues to increase beyond 2025, higher wages and/or improved benefits may be needed to attract sufficient workers to meet demand.

Introduction

As California strives to reduce the impacts of climate change, decarbonizing the state's building stock is a priority. Residential buildings alone produced 10 percent of California's greenhouse gas (GHG) emissions in 2019 (California Air Resources Board 2022). Residential decarbonization involves converting gas appliances and Heating, Ventilation, and Air Conditioning (HVAC) systems to all-electric versions and weatherizing homes to improve energy efficiency by upgrading insulation, air sealing, windows, and doors.

The Bay Area is a leader in implementing residential decarbonization work, with many local governments offering incentives beyond those provided by the state and federal governments. This work is still in its early stages, and only a small portion of homes have been fully retrofitted to date. New funding sources from the state and federal levels have increased the scale of public investment in recent years, spurring demand and momentum. Increasing demand for residential decarbonization projects will likely create more employment opportunities in this industry. However, little is currently known about the characteristics of the current workforce and how its needs may change as the industry develops.

The High Road Training Partnership: Bay Area Residential Building Decarbonization (the Partnership) was formed to bring together local government agencies, community-based organizations, unions, and contractors to consider the impacts that new investment will have on this industry and to make recommendations on industry-specific labor standards to increase job quality and equitable career access for priority communities. To support this process, the Partnership commissioned a study of the current landscape of the industry and workforce, including projections of what demand will look like over the next few years based on committed public investments. The following Industry Analysis provides an overview of the landscape of public investment, workers, and firms in the Bay Area (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties) based on the findings from the industry study.

Data and Methods

Our analysis uses multiple data sources and methods to describe public investment levels and the characteristics of workers and firms. We define residential decarbonization projects as replacing gas appliances, water heaters, and HVAC systems with electric and improving the energy efficiency of single-family or small multi-family homes (4 units or less).[1]

[1] We exclude from our definition of residential decarbonization the installation of gas appliances, even if they are energy efficient.

To estimate public investment levels, we create an inventory of programs that have allocated funds for Bay Area residential decarbonization projects between 2021 and 2029. We use program data and public reports to estimate the proportion of each program's funding that will likely be used in Bay Area counties, the number of projects that will be funded, and total spending on projects by consumers and public agencies combined.

We use a variety of data sources to describe the characteristics of residential decarbonization workers, including data from the Census, Bureau of Labor Statistics, US Department of Energy USEER report, and a study of Bay Area residential decarbonization needs by Inclusive Economics. We also interviewed Bay Area contractors to understand the characteristics, challenges, and opportunities for residential decarbonization firms. Our Technical Appendix provides more detail on the methods and data used in each area of our analysis.

Public Investment

First, we describe the landscape of public investment for residential decarbonization projects in the Bay Area. After discussing why public investment is needed, we describe the programs that provide funding in the Bay Area and present our projections of funding amounts, number of projects, and total public and private spending in the Bay Area between 2024 and 2029.

Need for public investment

Fully decarbonizing the Bay Area's residential building stock will require public investment, as the cost of completely retrofitting a home is typically significant, exceeding $50,000 for the average single-family home (Walker, Casquero-Modrego, and Less 2023; Building Electrification Institute 2023). Table 1 shows estimates of the average cost of different residential decarbonization measures based on data from the Building Electrification Institute (2023) and an analysis of cost data from the TECH Working Data Set (2023). Decarbonizing residential buildings involves replacing all gas appliances, including stoves, dryers, water heaters, and HVAC systems, with electric systems, as well as increasing the energy efficiency of homes by upgrading windows, doors, air sealing, and insulation. The scope of work needed to fully retrofit a home varies greatly depending on the type of housing, current HVAC and water heater systems, and condition of different house components. In addition, many homes in the Bay Area need electrical upgrades or health and safety upgrades (such as ventilation improvements, roof repairs, or other structural work) before decarbonization retrofits can be completed (Building Electrification Institute 2023).

Some homeowners may opt for installing electrical water heaters, HVAC systems, or appliances when their gas systems or appliances need to be replaced. However, installing electrical systems is currently more expensive on average than installing gas equipment. Nationally, the cost of installing an HVAC heat pump is 58 percent higher than installing a gas furnace, and the cost of installing a heat pump water heater is 43 percent higher than installing a gas water heater (Less et al. 2021). Decarbonizing a home can reduce monthly utility costs, potentially offsetting some or

all of the project cost in the long term. However, the potential for energy cost savings varies widely depending on the type of housing and retrofit work. In some cases, energy costs may increase due to the higher cost of electricity in California (Less et al. 2021). Public investment will be crucial for reducing the cost differential between gas and electrical replacement, incentivizing consumers with the means to afford upgrades to decarbonize their homes. Public investment will also be needed to completely cover the cost of retrofits for the many households that cannot afford any upgrades on their own and to ensure that the costs of retrofitting rental units are not passed on to low- and moderate-income tenants.

Table 1: Average costs for Bay Area residential decarbonization measures

Heat pump water heater installation	$7,793
Heat pump HVAC installation	$22,998
Weatherization (insulation and air sealing)	$5,170
Electric readiness (upgrades needed for full electrification)	$8,130
Health and safety upgrades	$10,125
Full electrification	$33,970
Full retrofit (full electrification + health & safety upgrades + electric readiness + weatherization)	$57,395

Source: Building Electrification Institute (2023) estimates for single-family homes and authors' analysis of the TECH Working Data Set for 2023 projects in Bay Area counties (see Technical Appendix for more detail)

Programs that fund residential decarbonization

Public investment for residential decarbonization work comes from a wide variety of programs funded at the local, state, and federal levels. Some programs provide rebates, tax credits, or other incentives for homeowners or contractors. In these cases, homeowners hire contractors directly. Other programs provide direct installation services, coordinating installation and hiring contractors to do the work. Some programs cover a portion of the project cost, and others cover the entire project cost (these programs typically focus on low and middle-income households). Most programs offer subsidies for a variety of retrofit measures, and the types of measures eligible for subsidies differ across each program, with some focusing exclusively on heat pumps or weatherization and others providing subsidies for many different types of decarbonization measures and whole-building retrofits.

Table 2 lists public programs that provide funding for residential decarbonization projects in the Bay Area, along with information about the funding source, funding mechanism, eligible project types, and our estimate of Bay Area funding for 2024-2029.

Table 2: Public programs funding Bay Area residential decarbonization projects

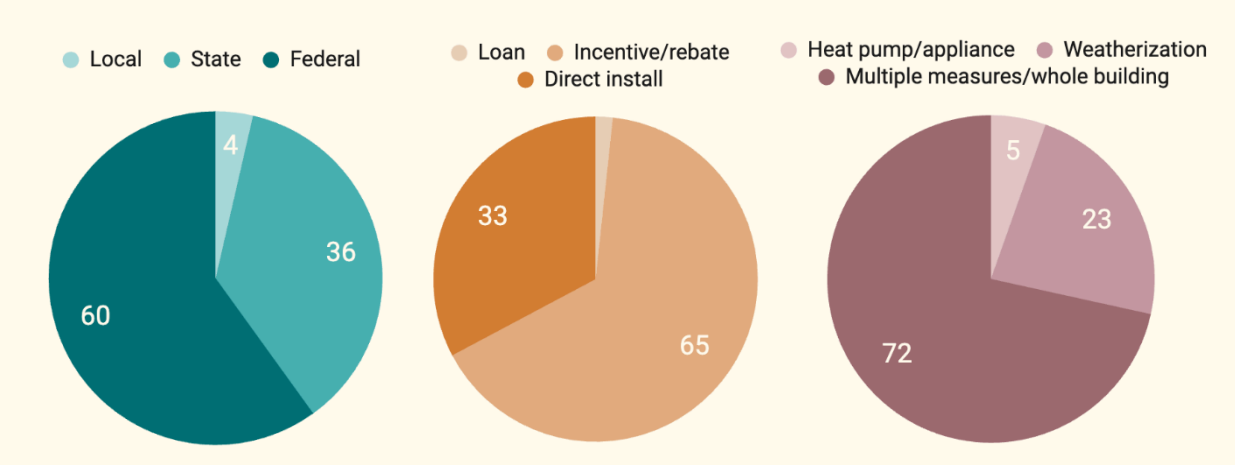
Program	Funding source	Funding mechanism	Project types	Projected Bay Area funding 2024-2029
Energy Efficient Home Improvement Tax Credit	Federal	incentive/ rebate	multiple measures/ whole building	$575,000,000
Energy Savings Assistance (ESA)	State	direct install	weatherization	$260,000,000
Equitable Building Decarbonization Direct Install	State	direct install	multiple measures/ whole building	$107,300,000
Homeowner Managing Energy Savings (HOMES)	Federal	incentive/ rebate	multiple measures/ whole building	$80,900,000
High-Efficiency Electric Home Rebate (HEEHRA) program	Federal	incentive/ rebate	multiple measures/ whole building	$37,100,000
BayREN Home+	State	incentive/ rebate	multiple measures/ whole building	$28,000,000
PCE HWPH and Panel Upgrade Incentive Program	Local	incentive/ rebate	heat pump/ appliance	$17,900,000
PCE Single-Family Home Electrification Turnkey and Direct Install Service	Local	direct install	heat pump/ appliance	$17,000,000
California Electric Homes Program (CalEHP)	State	incentive/ rebate	heat pump/ appliance	$16,200,000
Weatherization Assistance Program (WAP)	Federal	loan	weatherization	$10,700,000
GoGreen Home Energy Financing Program	State	loan	multiple measures/ whole building	$9,200,000
Silicon Valley Clean Energy FutureFit Program	Local	incentive/ rebate	heat pump/ appliance	$6,000,000
Technology and Equipment for Clean Heating (TECH) Initiative	State	incentive/ rebate	heat pump/ appliance	$5,600,000
California Energy-Smart Homes	State	incentive/ rebate	multiple measures/ whole building	$1,800,000
Sonoma Clean Power Energy HPWH Incentive Program	Local	incentive/ rebate	heat pump/ appliance	$700,000
Electrify Marin	Local	incentive/ rebate	multiple measures/ whole building	$440,000
Alameda Municipal Power Heat Pump Water Heater Rebates	Local	incentive/ rebate	heat pump/ appliance	$270,000
TOTAL				**$1,200,000,000**

Source: Authors' analysis of residential decarbonization program data. See the Technical Appendix for detail on methods and data sources.
Note: Total figure is rounded to the nearest $100 million.

Public investment by funding source, funding mechanism, and project types

Figure 1 below provides a breakdown of public funding for Bay Area residential decarbonization projects between 2024 and 2029 by funding source, funding mechanism, and eligible project types. The federal government has recently approved historic-level investments in residential decarbonization through the Inflation Reduction Act and Build Back Better Act. As a result, more than half (60 percent) of funding for the Bay Area will come from federal programs, primarily through the Energy Efficient Home Improvement Tax Credit. California has also made significant investments in residential decarbonization; slightly more than one-third of funding will come from state programs. The Bay Area is also a leader in residential decarbonization, with six different local government-funded programs. These programs make up four percent of total funding over this period, with some programs planning to phase out as new state and federal programs are implemented.

Figure 1: Public investment by funding source, funding mechanism, and project types, 2024-2029



Source: Authors' analysis of residential decarbonization program data. See the Technical Appendix for detail on methods and data sources.
Note: Data points refer to the percentage of total funding.

Most funding (65 percent) will be distributed through incentives such as rebates and tax credits. About one-third of funding will come from direct install programs and only two percent from loan/financing programs. Programs that provide rebates or financing typically have a maximum amount of funds allocated per year and cannot distribute additional subsidies once this maximum amount has been spent. In contrast, there is no limit on the number of homeowners that can claim federal tax credits. However, tax credits typically cover only a fraction of the total cost of residential decarbonization projects, presenting a significant barrier to participation among low-income homeowners and limiting the number of homeowners who can take advantage of tax credits. State and local programs that provide subsidies that can be layered on top of federal tax credits can reduce the overall cost to homeowners and increase the take up of the federal tax credits.

Nearly three-quarters of public investment dollars come from programs that provide subsidies for multiple installation measures that consumers can use individually or combine and/or whole-building retrofits.[2] About one-quarter of funds are specifically for weatherization, and just five percent of programs focus exclusively on heat pump water heaters, heat pump HVAC systems, and/or electric appliances.

Trends in public investment and total spending

New investments, particularly from the California state government and the federal government, have steadily increased the overall level of funding over the past few years. The green line in Figure 2 shows our estimates of total public investment in the Bay Area each year based on approved dollar amounts (this includes funding from all of the programs listed in Table 2). Total funding in 2025 ($234 million) will be nearly four times greater than in 2021 ($61 million). However, the total amount of committed funds steadily declines after 2025. This is primarily due to the budgeting cycles of some programs that only receive funding allocations on an annual basis. For these programs, it is impossible to predict whether funds will continue to be allocated or expanded in future years and at what level. However, a small number of local programs also plan to phase out their residential decarbonization programs over the next several years as new state and federal programs begin. We include an orange dotted line in Figure 2 that shows what funding levels would look like if every program continued at its highest annual committed funding level between 2024 and 2029.

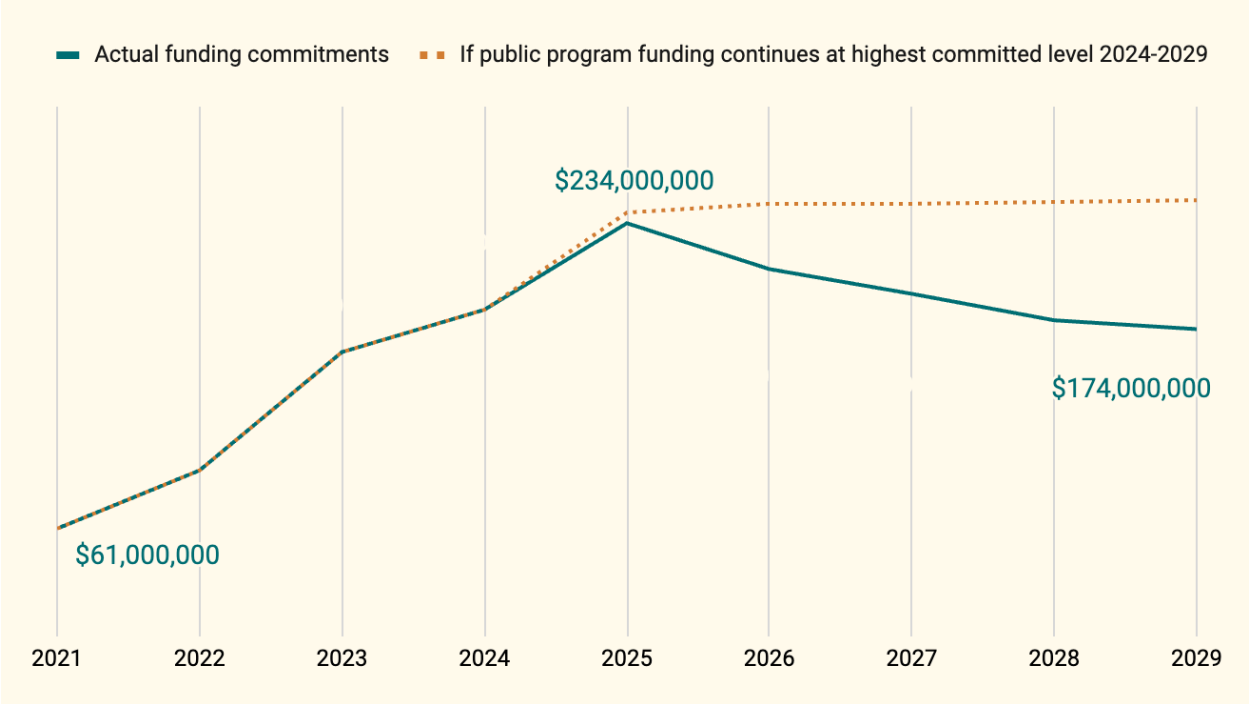
We estimate that in 2025, public investment will subsidize about three times as many projects (60,000) as in 2021 (22,000). Figure 3 shows our estimates of the number of residential decarbonization projects that will be partially or fully subsidized by public investment.

Most programs cover only a portion of the total cost of decarbonization projects and homeowners must cover the remaining project costs. We estimate that 2024 public investment covered only 18.5 percent of the total cost of residential decarbonization projects in the Bay Area. As a result, total aggregate spending on these projects is higher than public investment. Figure 4 shows our estimates of total spending on Bay Area residential decarbonization projects that are funded at least in part through public programs. Total public plus private induced spending on residential decarbonization projects has increased rapidly over the past few years, with total spending in 2025 projected to be about 12 times as much as total spending in 2021. Despite the significant growth, this level of public and induced private spending is only a fraction of the total estimated cost of retrofitting all residential buildings in the Bay Area. Based on committed

[2] Multiple programs provide funds for a menu of different measures that consumers can choose from and combine, including whole building retrofits. However, we were unable to identify the proportion of funds from each of these programs that go specifically to whole building retrofits. For this reason, we are not able to identify the proportion of overall funding going specifically to whole building retrofits.

public investment, we estimate that total spending on decarbonization work in the Bay Area will peak at $1.2 billion annually in 2025. In comparison, a study by Inclusive Economics finds that deep retrofits of the entire single-family and small multifamily housing stock in the Bay Area, including full electrification and other home upgrades that result in at least a 30 percent reduction in energy usage, would cost between $85 and $119 billion (Inclusive Economics 2020).

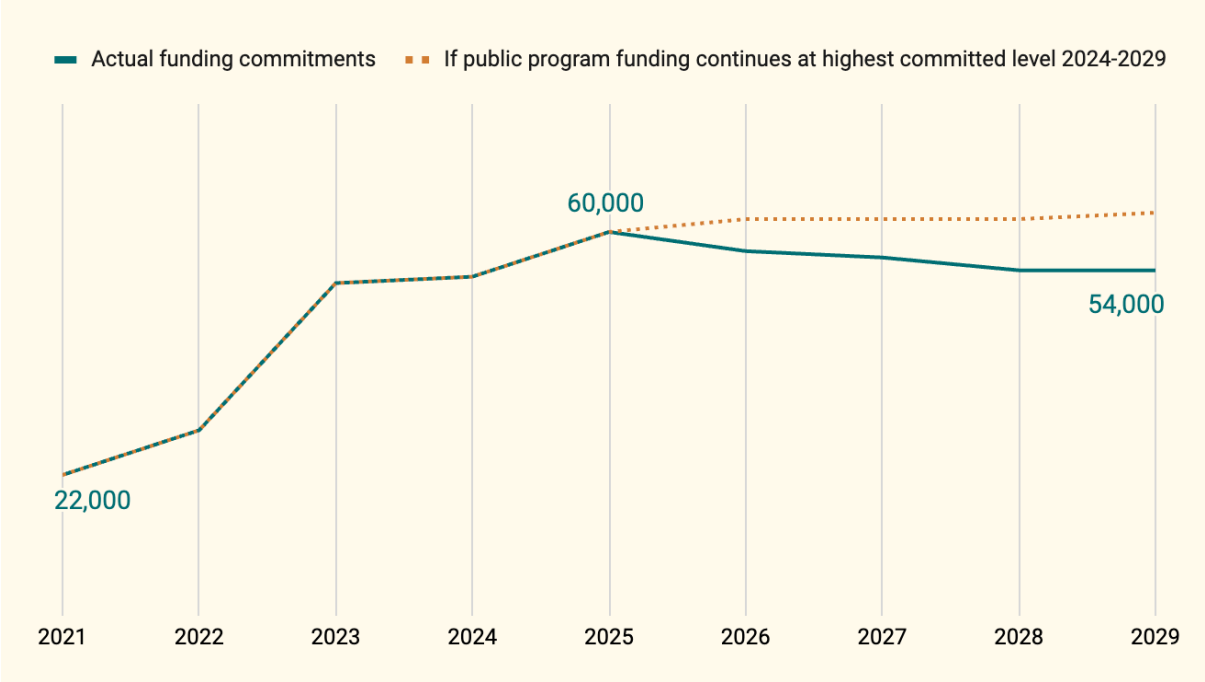
Figure 2: Public investment in residential decarbonization projects, Bay Area 2021-2029



Source: Authors' analysis of residential decarbonization program data. See the Technical Appendix for detail on methods and data sources.

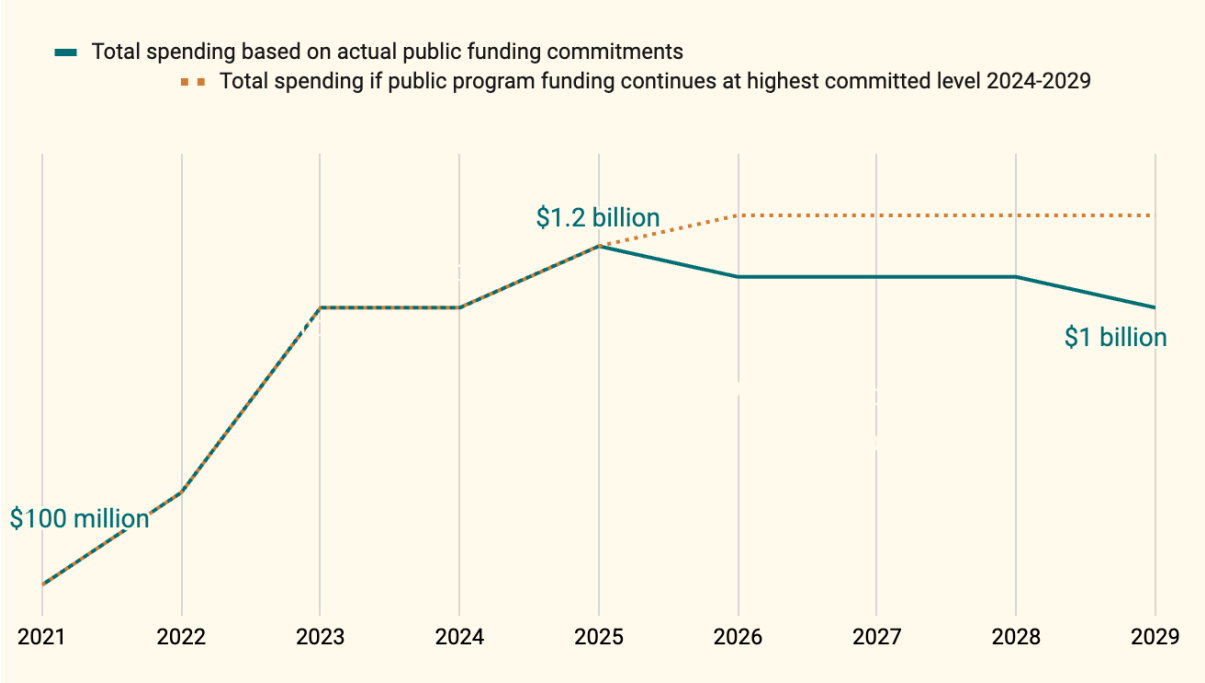
Our analysis does not include estimates of spending on residential decarbonization projects that are not subsidized by public programs and are instead paid for entirely by homeowners. We were unable to identify data that would allow us to estimate the number and proportion of residential decarbonization projects that are entirely paid for by private consumers; we therefore assume that all projects receive at least some amount of public subsidy. New regulations created by the Bay Area Air Quality Management District (BAAQMD) will prohibit the installation of gas water heaters in 2027 and gas furnaces in 2029. After those dates, all homeowners who replace their existing gas water heaters and furnaces must install electric versions. This will likely increase the overall number of projects completed and the number of projects paid for entirely by private homeowners.

Figure 3: Number of residential decarbonization projects funded through public programs, Bay Area 2021-2029



Source: Authors' analysis of residential decarbonization program data. See the Technical Appendix for detail on methods and data sources.

Figure 4: Total spending on residential decarbonization projects funded through public programs, Bay Area 2021-2029



Source: Authors' analysis of residential decarbonization program data, TECH Working Data Set, and Building Electrification Institute (2023). See the Technical Appendix for detail on methods and data sources.

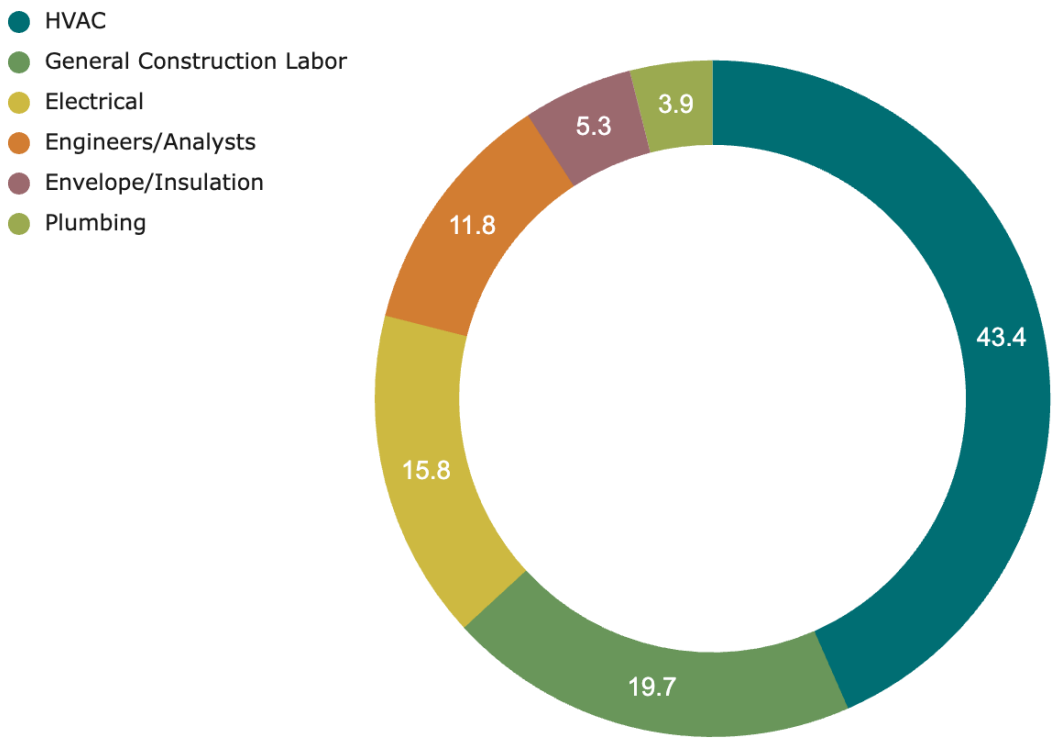
Workers

Next, we provide an overview of the residential decarbonization workforce in the Bay Area. We describe the characteristics of workers and jobs, present estimates of the current number of workers, project short-term job growth, and provide evidence that the industry may be on the verge of a worker shortage.

Worker and job characteristics

Residential decarbonization work requires a variety of skilled trades workers. Figure 5 describes residential decarbonization jobs by trade, based on an analysis by Inclusive Economics of the work hours required to decarbonize the residential building stock in the Bay Area (Inclusive Economics 2020). Most jobs are in HVAC, general construction labor, and electrical trades. A smaller portion of the jobs are engineers/analysts, envelope/insulation, and plumbing.

Figure 5: Bay Area residential decarbonization project work hours by trade



Source: San Francisco Bay Area Residential Building Decarbonization Jobs Estimates, Inclusive Economics, 2022

Census data sets that include data on worker demographics and earnings do not provide sufficient granularity in their industry categorization to allow for the identification of workers in the residential decarbonization industry specifically. To approximate workers in the residential decarbonization industry, we use IPUMS American Community Survey (ACS) data filtered to Bay Area workers in the construction industry who work in occupations found within the residential decarbonization industry. We use the data from Figure 5 on residential decarbonization work hours by trade to re-weight our ACS data so that the distribution of workers by occupation in our sample is the same as the distribution of workers by occupation within the residential decarbonization industry. Table 3 shows our resulting estimates of the demographics of residential decarbonization workers compared to all workers in the Bay Area. On average, residential decarbonization workers are more likely to be Latinx and less likely to be women than all workers.

Table 3: Characteristics of residential decarbonization workers compared to all workers, Bay Area 2018-2022

	Percentage of residential decarbonization workers	Percentage of all workers
Latinx	48	24
White	39	37
Black	3	6
Women	4	46
Immigrant	33	38

Source: Authors' analysis of 2018-2022 IPUMS American Community Survey and Inclusive Economics (2022)

Workers in the construction industry overall have higher rates of union representation (18 percent) than workers across all industries in California (9 percent) (Hirsch, Macpherson, and Even 2024). However, workers in residential construction are less likely to be represented by a union than workers in commercial or public infrastructure construction (less than 10 percent) (Tobias 2021). It is therefore likely that residential decarbonization workers also have lower rates of union representation. One reason for lower levels of union representation among these workers is that public programs that fund these projects, primarily through rebates and tax credits, typically don't attach labor standard requirements. This encourages a lowest-bid approach to competition in the market and discourages union firms from attempting to compete with non-union firms that provide lower compensation to workers. In contrast, most other publicly funded construction projects require prevailing wages and benefits for workers, which union firms already provide for their workers.

We estimate that the median Bay Area residential construction worker earns $32.87 per hour (see Technical Appendix for a detailed description of methods). This is lower than the median hourly wage for all residential and commercial construction workers ($34) and workers across all industries ($36) in the Bay Area.[3]

Undocumented workers in the residential decarbonization industry

In our interviews with residential decarbonization contractors in the Bay Area, none said that they knowingly employ undocumented workers. Still, several acknowledged that it was common to see undocumented workers on residential decarbonization job sites. An unknown number of undocumented workers are employed directly by residential construction contractors. Employers with federal and some state and local contracts must use the federal E-Verify system, which creates a barrier to hiring undocumented workers.

A number of studies have documented the day laborer model as a common practice for hiring undocumented workers within the residential construction industry. Day laborers are workers who are hired temporarily, typically from informal hiring sites such as Home Depot parking lots, and paid in cash under the table. Day laborers are generally paid low wages, do not have access to benefits, have high on-the-job injury rates, and are more likely to experience wage theft and other types of employer abuse due to a lack of institutional protections that are afforded to formal employees (Walter et al. 2002; Valenzuela Jr. and Theodore 2007). A 2004 study of California day laborers estimated that there were about 12,000 day laborers in the Bay Area and that 44 percent of day laborer employers were residential construction contractors (Valenzuela Jr. and Theodore 2007).

Residential construction contractors may hire day laborers as a lower-cost option for labor in general, to manage fluctuating labor needs from project to project, or as a temporary solution to fill immediate labor needs when they cannot recruit sufficient numbers of permanent employees. The growing demand for residential decarbonization work could create more opportunities for undocumented day laborers if contractors turn to this hiring model more frequently in response to difficulties recruiting workers at the current wages and benefits offered. Given the low pay, instability, and vulnerability to employer abuse typical in the day laborer model, this could lead the industry on a low-road path. The adoption of a wage and benefit standard for formal employees in the industry could drive even more contractors to rely on a low-road day laborer model if the labor standard design does not include policies and programs to prevent contractors from engaging in exploitative labor practices and provide high-quality job opportunities for undocumented workers.

There are, however, models for including pathways for undocumented workers in the building trades and improving wages and worker protections. Some day laborers have established workers' centers and hiring halls to create more formalized systems for hiring workers. Research has shown that these models improve day laborers' wages and working conditions (Theodore

[3] Authors' analysis of 2018-2022 IPUMS American Community Survey data

2020; 2023; E. J. Meléndez et al. 2014; E. Meléndez et al. 2016). Workers centers in California have also developed training programs specifically for undocumented workers. For example, a collaboration between workers centers, the IUPAT, and the AFL-CIO created a painter apprenticeship program that allows undocumented workers to join the union upon completing the training program, even though employers do not hire them as W2 employees.

Any efforts to establish labor standards within the residential decarbonization industry should include undocumented workers in the planning and implementation process to ensure that the labor standard provides opportunities for undocumented workers that lead to high-quality careers and does not unintentionally encourage and reinforce existing employment models that exploit undocumented workers.

Size of workforce and projected job growth

Based on an analysis of data from the Department of Energy USEER report and the Quarterly Census of Employment and Wages, we estimate that there are currently between 6,000 and 10,000 workers doing residential decarbonization work in the Bay Area. However, many of these workers are employed at firms that do residential decarbonization projects and other residential construction work. Based on our interviews with contractors, we estimate that, on average, these contractors spend about half of their annual work hours on residential decarbonization projects. Therefore, we assume there are currently between 3,000 and 5,000 full-time equivalent residential decarbonization jobs in the Bay Area. This is significantly less than the number of jobs needed annually to decarbonize the Bay Area's single-family and small multi-family housing stock within the state's target timeline for meeting emission reduction goals. The Inclusive Economics study estimates that to meet state climate goals, between 11,000 and 18,000 full-time equivalent residential decarbonization workers would be needed in the Bay Area annually (2020). Significantly more public investment would likely be required to reach these job levels, given that public investment is currently the main driver of demand for residential decarbonization projects.

The Department of Energy USEER report projects that annual energy efficiency job growth will be about 6 percent in California between 2023 and 2024 (US Department of Energy 2023). Applying this annual job growth rate to our estimates of the number of full-time equivalent jobs in 2024 gives us an estimate of between 200 and 300 new full-time equivalent jobs created in 2025 (see Table 3). Our analysis of total public and private spending on residential decarbonization projects estimates an increase of 20 percent between 2024 and 2025. Assuming that the number of jobs increases at this same rate as total spending, we estimate that between 600 and 1,000 new full-time equivalent jobs will be created in 2025 (see Table 3).

These estimates are of the number of additional full-time equivalent jobs that will be needed. However, this does not necessarily mean that contractors will recruit and train this many new workers. Since it is common for contractors to work on residential decarbonization and other types of residential construction projects, this could mean that some workers who already spend a portion of their work hours on residential decarbonization projects will spend additional hours

on these projects. Alternatively, it could mean that contractors will recruit and train a greater number of workers to work on both residential decarbonization and other types of construction projects. Our estimates of jobs created also do not take into account a potential decrease in the number of jobs needed for installing gas appliances, as public programs incentivize homeowners to replace failing systems with electric versions instead of gas.

It is difficult to predict job growth and training needs beyond 2025 because demand is currently driven primarily by public investment, and funding decisions for most public programs are made on an annual basis during local, state, and federal budget processes. As we report in our earlier description of public investment, the aggregate amount of committed funding declines after 2025, but this is due in part to the nature of public budget cycles and many programs receiving funding allocations on an annual basis, thus making it difficult to know what aggregate funding will look like beyond the years for which funding has been allocated. Public investment currently drives demand for residential decarbonization projects, and therefore, the amount of future public investment will also impact future job growth in the industry. However, in 2027 and 2029 the BAAQMD regulations described in the section above will start to go into effect, requiring all new water heater and furnace installations to be electric. This will likely have a large impact on the need for residential decarbonization workers. Since gas water heaters and furnaces won't be installed after the regulations go into effect, there may be a need for retraining workers who currently only install gas water heaters and HVAC systems to install electric versions.

Table 3: Projections of the number of full-time equivalent jobs created through increased public investment, Bay Area 2025

	Projected number of new full-time equivalent residential decarbonization jobs, Bay Area 2025
Based on DOE USEER projected annual job growth (6 percent)	200 - 300
Based on authors' projected increase in public investment 2024 - 2025 (20 percent)	600 - 1,000

Source: Authors' analysis of Department of Energy USEER data, Quarterly Census of Employment and Wages data, and program documentation for residential decarbonization programs funding Bay Area projects. See the Technical Appendix for more detail on methods and data sources.

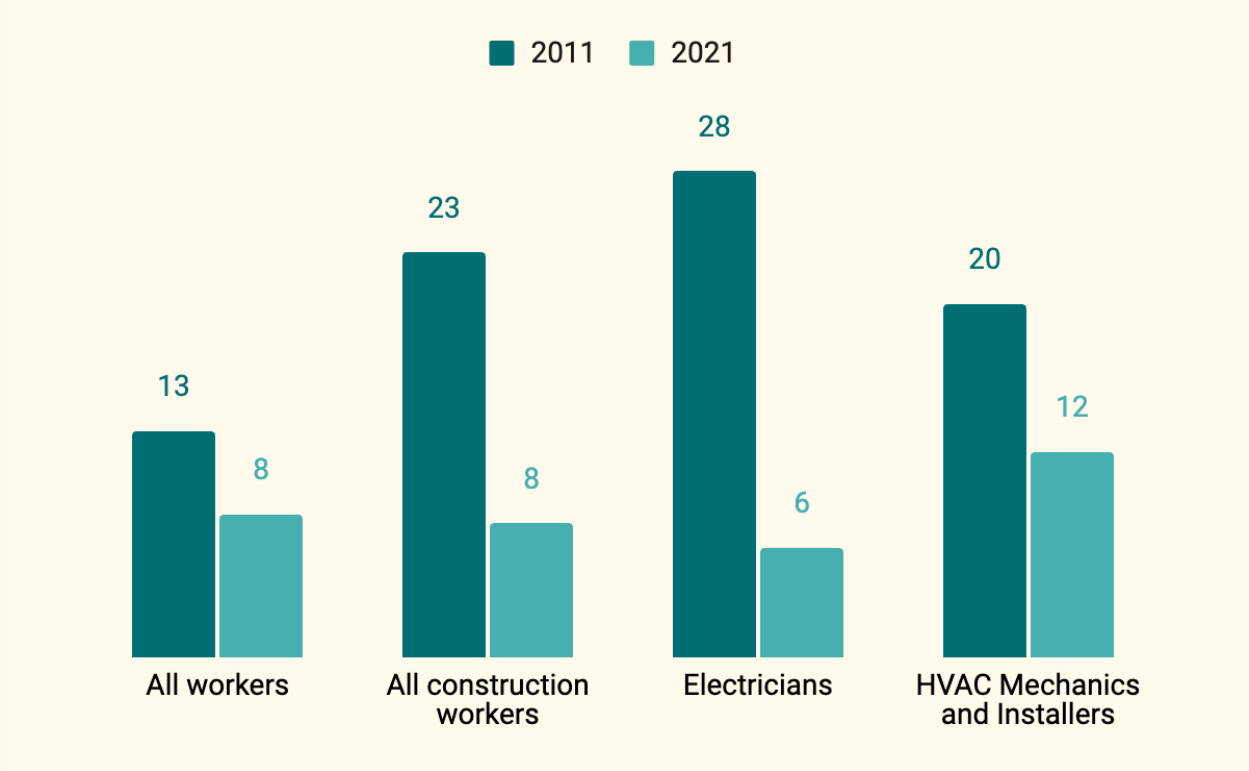
Potential for a future worker shortage

As public investments in residential decarbonization work have increased rapidly in recent years, employers have struggled to hire enough workers to meet the growing demand. Evidence that the labor market for residential decarbonization workers is relatively tight, where there are more job openings and fewer workers looking for jobs, could suggest that the industry is on the verge of a worker shortage. Historically, unemployment rates have been significantly higher for construction workers than other workers because the work is both more seasonal in nature, and the industry has historically experienced more extreme swings in employment levels during economic

downturns and recovery periods (Littlehale 2019). However, as of 2021, California construction unemployment had fallen to the same level as for all workers (6 percent), suggesting that the labor market for construction workers has become tighter than in previous years (see Figure 6). We see this same trend within occupations common in the residential decarbonization industry, such as HVAC installers and electrical workers (see Figure 6).

Employers are also expressing difficulties in recruiting workers. The DOE USEER report finds that 51 percent of California clean energy employers experience difficulty in hiring sufficient numbers of workers (2023). In our interviews, non-union residential decarbonization contractors in the Bay Area also described challenges in recruiting and retaining workers. With these contractors already struggling to hire enough workers, employers may need to offer higher wages and more generous benefits to attract enough workers to fill the new positions we project will be created in 2025 (see Table 3). At least one contractor we interviewed had already increased wages offered to new hires in an attempt to improve their applicant pool and employee retention. The employers we interviewed were primarily non-union, as are most residential decarbonization contractors currently. Union contractors that on average provide higher compensation levels may not face these same challenges with recruitment and retention.

Figure 6: Unemployment rates for construction and all workers, Bay Area 2011 and 2021



Source: Authors' analysis of 2011 and 2021 IPUMS American Community Survey data

Firms

Finally, we provide an overview of firms engaged in residential decarbonization work in the Bay Area based on interviews conducted by our research team with primarily non-union contractors (see Technical Appendix for a description of our interview methods).

Types of firms

Several different kinds of firms do residential decarbonization work, including home performance contractors, HVAC installers, energy auditors, and general construction firms (Less et al. 2021). While some firms specialize in residential decarbonization projects, this work represents just a subset of projects for many businesses. For example, HVAC contractors may install both gas furnaces and HVAC heat pump systems. On average, contractors that we interviewed spend about half of their annual work hours on residential decarbonization work. This work is primarily carried out by small firms; most of the contractors we interviewed were small businesses with fewer than five employees.

Worker recruitment and retention

In our interviews, finding and retaining skilled labor, such as installers and technicians with appropriate industry qualifications, was the primary challenge reported by non-union residential decarbonization firms. These firms prefer to employ workers who already have the skills and experience to do the work with little additional training necessary. However, the construction employment landscape is highly competitive, and wages for non-union residential decarbonization work are lower on average than those for other construction positions. This has hindered contractors' ability to add skilled and experienced staff in response to increasing demand for residential retrofits in the Bay Area.

Unable to attract more experienced workers, multiple non-union firms said that they typically hire entry-level workers with little to no basic skills or vocational training in the construction industry and do not provide classroom training components or participate in available state apprenticeship or pre-apprenticeship programs, instead relying on on-the-job-training. However, employers report difficulties retaining these entry-level workers. As one firm explained, "For every three new hires, only one makes it through the [required] four years to become a journeyman." Churning through many unskilled workers is costly to employers, as firms spend additional resources to recruit, hire, onboard, and train new, inexperienced workers. In addition, if workers do not stay on, employers cannot capitalize on potential productivity gains associated with longer tenure with an employer and experience in a trade.

In contrast, union contractors participate more directly in apprenticeship programs that may more readily provide them with a ready pool of trained workers. These union contractors universally pay for classroom training and continuous education for their workers as a requirement of their

master labor agreement. Union contractors also have a greater ability to attract more experienced workers by offering higher wages and better benefits.

A series of interviews conducted with Bay Area contractors by the Construction Trades Workforce Initiative (2022) found that although union contractors experience similar struggles with recruiting and retaining workers, apprenticeship programs alleviate these challenges to some extent by providing union contractors with a pipeline of qualified and vetted workers. Nearly all union contractors interviewed by the Construction Trades Workforce Initiative expected that apprenticeship programs would help them meet their projected hiring needs for the coming year.

Increasing wage compensation and providing more robust and generous benefits have been shown to significantly reduce turnover and increase worker productivity as workers gain more skills and experience as they continue in their career pathway for a more extended period of time (Zipperer 2022). Given the labor market tightness described by residential decarbonization employers, higher wages and improved benefits may be necessary to attract and retain enough workers to fill the new jobs we project will be created in 2025 (see Table 3).

Minority and women-owned firms

Minority contractors face a unique set of additional challenges. Minority firms continue to confront historical impediments, such as a lack of formal education and outreach resources to inform homeowners in their communities of available rebates and incentives to decarbonize their homes. These contractors also face difficulties securing long-term contracts, even as subcontractors. A lack of stable and consistent revenue limits their ability to expand or adapt within this rapidly developing industry. When one interviewee was asked to describe current challenges, they observed that larger contracting firms had the resources to capitalize on growing project demand. In comparison, smaller minority firms lack the cash flow and reserves needed to recruit more workers and take advantage of new project opportunities. Businesses owned by minorities and women are disproportionately affected by systemic racism and sexism, which impede their progress and long-term viability.

Conclusion

Public investment in Bay Area residential decarbonization work has increased rapidly over the past few years. It will reach a historic peak of $234 million in 2025, inducing $1.2 billion in spending on residential decarbonization projects. This recent growth has led to an increase in the number of jobs. Still, residential decarbonization wages remain lower than wages in other types of construction work and in other industries, and formalized training approaches are less common and less utilized by contractors compared to contractors in the commercial, industrial, and new construction industries. Offering noncompetitive wages and opting to refrain from participating in more formalized training approaches for new workers, employers have struggled to recruit and retain enough workers to take advantage of growing demand. In interviews, employers cited

challenges with recruitment and turnover as the main roadblock to scaling their residential decarbonization work further. The need for workers is expected to grow between 2024 and 2025, and potentially beyond, as local regulations prohibiting the installation of gas water heaters and furnaces begin to take effect. Although public investment is currently at an all-time high, even more would likely be needed to stay on track to reach the state's emission reduction goals, given that public investment is currently the main driver of demand for residential decarbonization projects. Allocated funds decline for years beyond 2025, meaning additional funding will be needed to maintain 2025 funding levels. If demand does continue to grow beyond 2025, employers and the industry at large may need to consider improving job quality by providing higher-quality training, higher wages, and better benefits to attract and retain workers.

Technical Appendix

The following technical appendix describes the data and methods used to produce the estimates described in this Industry Analysis and conduct interviews with residential decarbonization firms.

Average cost of residential decarbonization projects

To estimate the average cost of heat pump water heater and heat pump HVAC system installations, we analyze data from the TECH Working Data Set. This data set provides cost information for individual projects funded in part through TECH incentives across California. We take the average cost for these projects for the nine Bay Area counties in 2023.

All other project cost estimates in Table 1 come from the Building Electrification Institute's gap analysis for the City of Berkeley (2023).

Estimates of public investment dollar amounts

We first identify programs funding residential decarbonization projects for existing single-family and small multi-family homes. We start with an inventory of residential decarbonization programs compiled by the Residential Decarbonization HRTP members. We conducted Internet searches to add to this initial inventory. We exclude programs that do not primarily fund residential decarbonization projects, that mainly fund projects for large multi-family housing, or that primarily fund projects for new construction.

To estimate annual funding levels for each program, we conducted Internet searches for program documentation and, in some cases, contacted staff at administering agencies directly. When state and federal program documentation did not provide funding amounts for specific counties, we estimated the proportion of state or federal funds that would ultimately go to Bay Area counties by either dividing by the proportion of state residents living in the Bay Area, the proportion of state low-income residents living in the Bay Area, or the proportion of state funds for similar programs that have gone to the Bay Area in the past. Table A1 shows our annual estimates of funding from each public program. Next, we describe our methods and data sources for estimating each program's funding.

Energy Efficient Home Improvement Tax Credit

We start with estimates of projected tax expenditures for this tax credit produced by the Joint Committee on Taxation (2018). Next, we multiply this estimate of national tax expenditures by an estimate of the proportion of these tax credits claimed by California residents from the Internal Revenue Service (2024). Finally, we apply an estimate of the proportion of California residents that live in Bay Area counties (19.2 percent). At the time of our analysis, tax expenditure projections were only available through 2027. We estimate the average annual growth rate between 2024-2027 and assume that expenditures will increase at this rate in later years.

Energy Savings Assistance (ESA)

To produce estimates for 2021, 2022, and 2023, we multiply the statewide authorized budget amounts for each of those years (Pacific Gas and Electric Company 2022; 2023a; 2023b) by an estimate of the proportion of participating households in California that are in Bay Area counties from Table 4A-E of the May 2023 ESA tables (Pacific Gas and Electric Company 2023c). We assume that funding will continue at 2023 levels in later years.

Equitable Building Decarbonization Direct Install

We start with the annual amount of program funding for the northern region of California and multiply by the proportion of Bay Area counties that make up the northern region of the state (67.6 percent) (California Energy Commission 2023). We multiply this amount by the ratio of statewide direct install program funds to total funds to remove spending on other programs and program administration from our estimate.

Homeowner Managing Energy Savings (HOMES)

We multiply estimated statewide funding (California Energy Commission 2024) by the proportion of TECH funding that has gone to Bay Area counties (authors' analysis of TECH program data (TECH Clean California 2023)) since the TECH program similarly is available to households regardless of income level (although the rebate amount varies by income level) and we assume that take-up rates by region will be similar. Although funding is available for ten years through 2031, we assume that funding will likely be expended within six years, based on the historical usage rates of TECH program funds.

High-Efficiency Electric Home Rebate (HEEHRA) program

We multiply estimated statewide funding by the proportion of statewide DAC-SASH funding that goes to Bay Area counties (authors' analysis of Solar on Multifamily Affordable Housing (SOMAH) program data (California Distributed Generation Statistics 2024)) since DAC-SASH programs are also targeted to low- and middle-income homeowners and we assume that the take-up rates by region will be similar. Although funding is available for ten years through 2031, we assume that funding will likely be expended within six years, based on the historical usage rates of TECH program funds.

BayREN Home+

Our 2023 and earlier estimates are based on total 2022 incentives. For 2024-2029, we start with the amount of approved funding for 2024-2031 as reported in the BayREN Application for Approval ($72,642,901) (Association of Bay Area Governments 2022). We then divide this amount by the number of years over which the funding is distributed (seven). We finally multiply this amount by 0.45, an estimate of the percentage of program funding that will be used for incentives. We arrived at this number by taking the average percentage of annual expenditures spent on incentives between 2019 and 2022 (BayREN 2022).

PCE HWPH and Panel Upgrade Incentive Program

Our annual funding estimates are based on data provided by program staff over email.

PCE Single-Family Home Electrification Turnkey and Direct Install Service

Our annual funding estimates are based on data provided by program staff over email.

California Electric Homes Program (CalEHP)

We divide the minimum funding that must go to incentives between 2025 and 2029 and divide by the number of years (five). While funding can be used through 2032, we assume that funding will be exhausted within five years based on historical usage rates of TECH program funds. We anticipate that funding will begin in 2025 because the program was still in development as of late 2023. To estimate the proportion of funding that will go to the Bay Area, we multiply the statewide funding amounts each year's state funding amount by 0.279, based on the proportion of TECH incentive dollars that have gone to the Bay Area (authors' analysis of TECH program data (TECH Clean California 2023)).

Weatherization Assistance Program (WAP)

We estimate annual program funding based on both regular WAP funding and the Bipartisan Infrastructure WAP funding (Department of Community Services and Development, State of California 2023). For both, we sum the total amount contracted to three organizations covering Bay Area counties and assume 10 percent administrative costs. The regular WAP funding is for July to July; we put estimates in the later year (for example, our 2025 estimates include WAP funding allocated for July 2024-July 2025). For the Bipartisan Infrastructure WAP, we divide funding evenly across the years of allocation, 2022-2027. We may overestimate the amount of funds that will be used, as California has historically used less WAP funding than applied for.

GoGreen Home Energy Financing Program

We multiply total funding ($75.2M from 2022-2027) by the proportion of loans that were estimated to go to the Bay Area in 2023 to estimate the total funding going to the Bay Area (California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) 2023). We assume that the 2023 level of funding will remain constant in later years. Based on the current funding usage rate, we assume funds will only last through 2026.

Silicon Valley Clean Energy FutureFit Program

Our annual funding estimates are based on data provided by program staff over email.

Technology and Equipment for Clean Heating (TECH) Initiative

Funding estimates for 2021 and 2022 are based on our analysis of TECH program data (TECH Clean California 2023). Estimates for later years are based on TECH budget data (TECH Clean California 2024).

California Energy-Smart Homes

We multiply the current budget for direct implementation incentives and rebates (California Energy-Smart Homes 2024)by the proportion of TECH funding that has gone to Bay Area counties (authors' analysis of TECH program data ("TECH Working Data Set" 2023)) since the TECH program similarly is available to households regardless of income level and we assume that take up rates by region will be similar.

Sonoma Clean Power Energy HPWH Incentive Program

Our annual funding estimates are based on data provided by program staff over email.

Electrify Marin

Our annual funding estimates are based on data provided by program staff over email.

Alameda Municipal Power Heat Pump Water Heater Rebates

Our estimates are based on data from the City of Alameda's annual climate resiliency report (City of Alameda 2022) and data provided by program staff over email. We estimate that the amount of water heater rebates will increase to 30 by 2024 and hold constant through 2029 based on Alameda's goal of providing a total of 382 rebates by 2030.

Number of projects completed through public investment

To estimate the number of projects completed through public investment, we first estimate the number of projects that will be funded by each individual program. When available in program documentation or through data requests to program staff, we use the actual or estimated number of projects to be completed with program funds. For other programs, we were able to get data on the average subsidy amount per project and divided total funding by this amount to get an estimate of the number of projects. When neither of these data points is available for a program, we divide total funding by the maximum subsidy amount for the program. In this case, we likely underestimate the number of projects completed by a program.

Table A1: Annual estimates of public investment dollars by program, Bay Area 2021-2029

Program	2021	2022	2023	2024	2025	2026	2027	2028	2029
Energy Efficient Home Improvement Tax Credit	0	28,000,000	92,000,000	92,000,000	92,000,000	97,000,000	97,000,000	98,000,000	99,000,000
Energy Savings Assistance (ESA)	45,000,000	42,000,000	43,000,000	43,000,000	43,000,000	43,000,000	43,000,000	43,000,000	43,000,000
Equitable Building Decarbonization Direct Install	0	0	0	7,200,000	50,300,000	24,800,000	19,200,000	5,800,000	0
Homeowner Managing Energy Savings (HOMES)	0	0	0	13,500,000	13,500,000	13,500,000	13,500,000	13,500,000	13,500,000
High-Efficiency Electric Home Rebate (HEEHRA) program	0	0	0	6,200,000	6,200,000	6,200,000	6,200,000	6,200,000	6,200,000
BayREN Home+	3,900,000	5,000,000	5,000,000	4,700,000	4,700,000	4,700,000	4,700,000	4,700,000	4,700,000
PCE HWPH and Panel Upgrade Incentive Program	34,000	300,000	2,800,000	2,900,000	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000
PCE Single-Family Home Electrification Turnkey and Direct Install Service	0	0	0	0	8,500,000	8,500,000	0	0	0
California Electric Homes Program (CalEHP)	0	0	0	0	3,200,000	3,200,000	3,200,000	3,200,000	3,200,000
Weatherization Assistance Program (WAP)	0	800,000	4,400,000	2,700,000	2,700,000	2,700,000	2,700,000	0	0
GoGreen Home Energy Financing Program	2,100,000	3,700,000	4,500,000	4,500,000	4,500,000	200,000	0	0	0
Silicon Valley Clean Energy FutureFit Program	300,000	1,200,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000

Technology and Equipment for Clean Heating (TECH) Initiative	7,300,000	10,800,000	5,600,000	5,600,000	0	0	0	0	0
California Energy-Smart Homes	0	600,000	600,000	600,000	600,000	600,000	0	0	0
Sonoma Clean Power Energy HPWH Incentive Program	300,000	300,000	300,000	300,000	300,000	0	0	0	0
Electrify Marin	250,000	250,000	250,000	440,000	0	0	0	0	0
Alameda Municipal Power Heat Pump Water Heater Rebates	23,000	30,000	38,000	45,000	45,000	45,000	45,000	45,000	45,000

Source: Authors' analysis of residential decarbonization program data. See the Technical Appendix for detail on methods and data sources

Many projects are eligible for multiple subsidies and some programs assist homeowners in applying for multiple incentives to cover a larger proportion of project cost, suggesting that it is common for homeowners to layer more than one incentive program. Federal tax credits are the largest source of public funds for residential decarbonization projects. We assume that projects that receive funding from other programs also receive federal tax credits unless the program is a direct install program that covers 100 percent of the project cost or is a program targeted at primarily low-income households. We assume that there is no overlap between direct install programs that cover 100 percent of project costs and other programs. We assume that projects funded by programs that serve primarily low-income households will not receive federal tax credits. Low-income households typically receive tax refunds as a result of the earned income tax credit and/or child tax credit, and would therefore be unlikely to claim the nonrefundable federal energy efficiency tax credits, as it would not have an impact on their refund amount (Congressional Research Service 2020). Based on our analysis of data from TECH and the BayREN HOMES+ program, we assume that 26 percent of TECH funded projects also receive subsidies from BayREN programs.

Total cost of projects subsidized through public investment

Most public programs do not cover the entire cost of residential decarbonization projects. To estimate the total cost of projects for public agencies and consumers combined, we multiply our estimates of the number of projects funded through public investment by estimates of the average cost of residential decarbonization projects. Table A2 shows the assumptions we use for the average cost of projects by the types of projects the program funds.

Table A2: Average cost assumptions for estimating total spending on residential decarbonization projects

Measures funded by program	Data source for cost assumption	Average cost assumption
Heat pump/appliance	Average cost of HVAC and water heater heat pump projects funded by TECH in Bay Area counties (73.2 percent of TECH projects were HVAC heat pumps and 26.8 percent were heat pump water heaters)	$18,923
Whole building/multiple projects	Building Electrification Institute (2023) cost estimates for HVAC, insulation, and air sealing for a single family home in Berkeley	$28,060
Weatherization	Building Electrification Institute (2023) cost estimates for energy efficiency projects for single family homes in Berkeley	$5,170

Identifying residential decarbonization workers in ACS data

We use IPUMS American Community Survey data to estimate wages and demographic characteristics of residential decarbonization workers. Because Census or Bureau of Labor Statistics datasets do not allow for identification of residential decarbonization workers specifically, we instead assign individuals as residential decarbonization workers in our ACS microsimulation model if they work in the construction industry and in a residential decarbonization occupation as defined by an O-NET list of energy efficiency occupations ("Green Economy Sector: Green Construction - Occupational Listings" 2023).

Since ACS data only allow us to see workers in the construction industry as a whole, and not in the residential decarbonization industry specifically, the proportion of workers in our ACS data in each occupation reflects their proportions in the overall construction industry. To make our ACS sample better reflect the actual distribution of workers across occupations in the residential decarbonization industry, we reweight workers in our sample according to an estimate from Inclusive Economics of the distribution of residential decarbonization project work hours across trades in the Bay Area (Inclusive Economics 2020).

Estimate of median hourly wage

We use our reweighted 2018-2022 ACS sample described above to estimate the median hourly wage of residential decarbonization workers.

Adjusting for inflation

We inflate ACS annual earned income to 2023 dollars using the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) for San Francisco - Oakland - Hayward (California Department of Industrial Relations 2023).

Constructing an hourly wage variable

The ACS provides data on annual earned income for individual workers. To construct an hourly wage variable, we divide annual earned income by weeks worked per year and usual hours worked per week. As the ACS weeks worked variable is only available as a categorical variable for years 2008-2018, we use the midpoint of each response category for the weeks worked in our calculation of hourly wages.

Next, we randomly add a dollar amount between $-0.25 and $0.25 to each individual's estimated hourly wage, which smoothes out some of the bunching in the wage estimates and creates a more realistic wage distribution curve.

Finally, we used the same method used by the Economic Policy Institute in their annual State of Working America reports to trim outliers (Economic Policy Institute 2019). This approach involves dropping observations with an estimated hourly wage less than $0.50 or more than $100 in 1989 dollars.

Adjusting wages using National Compensation Survey data

We are not able to identify residential decarbonization workers specifically in the ACS dataset due to limitations on the granularity of the industry and occupation variables (see description in the section above). Instead, we include all Bay Area workers in the construction industry in trades that do residential decarbonization work. Therefore, our estimates of wages include other kinds of construction workers who likely earn more on average than residential decarbonization workers. For example, residential construction workers earn less than commercial construction workers, but our sample includes both types of workers. Because of this, estimating wages using ACS data alone would likely overestimate the current wages of residential decarbonization workers.

To account for this limitation, we adjust our ACS data using unpublished data from the 2019 National Compensation Survey provided by Scott Littlehale at the California Center for Construction Economics. This data allows us to calculate the ratio of residential construction wages to all construction wages nationally (84 percent). We apply this ratio to estimated wages for each individual worker in our microsimulation model to adjust for the difference between average residential and all construction wages.

The residential decarbonization industry is a subset of the residential construction industry and wages may differ from those across all residential construction. The best available data that we were able to identify on the wages of residential decarbonization workers in the Bay Area specifically is a survey of contractors by BayREN. The BayREN survey data has a number of limitations as a measure of average wages for workers in the industry. It only includes a small number of contractors (38) that meet all requirements of becoming BayREN affiliated contractors, including providing certification training for staff and meeting minimum insurance coverage requirements. These contractors therefore may not be representative of all residential decarbonization firms, potentially paying their workers more on average. In addition, this dataset only includes the range of wages each contractor pays their workers and does not include data about either the number of employees at each firm or the distribution of wages within each firm. For these reasons, we do not use data from the BayREN survey to adjust the data in our ACS microsimulation model. However, the ratio of the average of the lowest and highest wages paid by firms in the BayREN dataset to the median wage of construction workers in our ACS dataset (85 percent) is almost the same as the ratio of residential construction wages to all construction wages in the 2019 National Compensation Survey (84 percent) that we use to adjust wages in our microsimulation model.

Recoding low estimated hourly wages

Finally, we recode worker earnings to the California state minimum wage ($15.50) if their ACS estimated hourly wage is less than the California state minimum wage. Low estimates for hourly wages using ACS data often are the result of the imprecision of the constructed hourly wage variable, which relies on dividing annual earnings by usual weeks worked per week and the midpoint of a categorical variable of the number of weeks worked per year, and are unlikely to reflect the true proportion of workers earning less than minimum wage.

Size of residential decarbonization workforce

We use two different methods to estimate the current size of the residential decarbonization workforce, producing lower and upper bound range estimates. Both of our estimates are based on data from the Department of Energy's USEER reports (US Department of Energy 2023), the Quarterly Census of Wages and Employment (QCEW), the Inclusive Economics analysis of residential decarbonization work in the Bay Area (Inclusive Economics 2020), IPUMS American Community Survey, and our interviews with contractors.

The methods we use, as described below, estimate the number of frontline construction workers (those who are not in managerial positions) who are engaged in Bay Area residential decarbonization projects for single-family and small multi-family homes for at least a proportion of their work hours. We also describe our methods for converting these total worker count estimates to estimates of full-time equivalent jobs.

Lower bound worker count estimate

For the lower bound estimate, we start with estimates from the DOE USEER report of the number of energy-efficiency construction workers in California. Due to sample size limitations, state-level USEER estimates of the number of energy efficiency workers include all kinds of energy efficiency work, including the installation of appliances that are considered energy efficient but use fossil fuel energy sources such as natural gas. The national USEER report estimates that 54 percent of energy efficiency jobs are "net zero," meaning that they do not involve the installation of fossil fuel-burning equipment. We therefore apply this 54 percent national estimate to the USEER California estimate to arrive at an estimate of the number of workers involved in residential decarbonization projects specifically.

We then divide that number by the number of residential construction workers in the state of California using QCEW data. This gives us an estimate of the proportion of residential construction workers in California that work on residential decarbonization projects. We then apply this proportion to an estimate from QCEW of the total number of residential construction workers in Bay Area counties. Next, we apply an estimate from the Inclusive Economics Bay Area analysis of the proportion of residential decarbonization work hours used for single-family and small multi-family homes (86.0 percent). We use IPUMS American Community Survey data to estimate the proportion of Bay Area construction workers who are frontline workers, excluding managerial workers, and apply this percentage to our estimate (85.7 percent).

Upper bound worker count estimate

For the upper bound estimate, we start with estimates from the DOE USEER report of the number of energy efficiency workers in Bay Area counties. As with our lower bound estimate described above, we adjust this estimate using an estimate from the USEER national report of the proportion of energy efficiency workers that work on "net zero" projects (54 percent) to arrive at an estimate of the number of workers involved in residential decarbonization projects specifically.

The USEER estimate of the number of energy-efficiency workers in the Bay Area includes all industries. We use state-level USEER data to estimate the proportion of all residential decarbonization workers in California who are in the construction industry (52.2 percent) and apply this proportion to the USEER estimates of the number of residential decarbonization workers in all industries in the Bay Area to arrive at an estimate of the number of residential decarbonization workers in the Bay Area who are in the construction industry.

We adjust our estimates to exclude commercial construction workers by applying an estimate of the proportion of Bay Area construction workers that work in residential construction using QCEW data (45.8 percent). Next, we apply an estimate from the Inclusive Economics Bay Area analysis of the proportion of residential decarbonization work hours used for single-family and small multi-family homes (86.0 percent). We use IPUMS American Community Survey data to estimate the proportion of Bay Area construction workers who are frontline workers, excluding managerial workers, and apply this percentage to our estimate (85.7 percent).

Estimate of full-time equivalent jobs

Many residential decarbonization workers are employed by firms that carry out both residential decarbonization projects and other kinds of construction projects, such as the installation of gas furnaces or water heaters. Our estimates of the total number of workers therefore include workers for whom residential decarbonization work only makes up a portion of their work hours. In our interviews with contractors, we asked about the proportion of their work hours used for residential decarbonization work. On average, about half of the firms' work hours are used for residential decarbonization work. We apply this proportion to our estimates of the total number of workers to arrive at an estimate of the number of full-time equivalent jobs.

Interviews with residential decarbonization contractors

To gain additional insights for this report, we conducted a series of structured interviews with residential construction contractors to understand and solicit needs, experiences, insights, and feedback from contractors involved in residential decarbonization. The following sections summarize the interview approach, characteristics of participating contractors, and our interview questions.

The intended interviewees were Bay Area contractors focused on energy efficiency and electrification in the residential construction sector. The project team conducted a mapping exercise to identify stakeholders related to building electrification in the residential market by auditing online contractor directories, including Go Green Financing, Bay Area Regional Energy Network (BayRen), California Department of General Services Statewide Supplier Diversity program, Clean Energy Connection, and TECH Clean California. Since the directories entailed hundreds of verified contractors, we selected 20-40 Bay Area contractors to contact.

We interviewed twelve (12) contractors performing varying types of work: Home Energy Auditing, HVAC, Plumbing, Design & Build, Electrical, and Home Performance. Of those interviewed, three (3) were minority-owned contractors, eleven (11) non-union contractors, and one (1) union contractor. Despite our outreach attempts, we were unable to interview an even number of union and non-union contractors. This may be due to the fact that most residential decarbonization firms are non-union.

An interview guide was designed to pose questions about contractors' scope of work, perspectives on the future demand of residential decarbonization projects, employment practices to recruit and retain workers, and challenges related to the emerging residential decarbonization sector. The interviews were conducted remotely through Zoom and on average lasted one hour.

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