

Choose Your Own Adventure: Funding the Decarbonization of Low- and Moderate-Income Residential Buildings

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ABSTRACT

The decarbonization of existing buildings through electrification is crucial to meeting our climate goals, however it has a large price tag. Absent substantial incentive funding, decarbonization efforts have the potential to exacerbate housing affordability and ongoing gentrification and displacement in vulnerable communities. Many building owners will pass electrification costs on to their low- and moderate-income tenants, and low- and moderate-income homeowners may have to bear costs they cannot afford. Building on their cutting-edge climate policies, the City of Berkeley wanted to better understand how to fund the decarbonization of Berkeley's housing stock while also preserving and improving housing affordability. The City partnered with the Building Electrification Institute (BEI) and Firefly Energy Consulting on a building electrification funding gap analysis. This project analyzed the full costs of decarbonizing the city's residential buildings, identified the existing funding sources available, and quantified the remaining funding gap. The analysis found that low- and moderate-income households face gaps of \$22,000 to \$40,000 per housing unit, and that the total additional funding needed to support a transition for these low- and moderate-income homes in Berkeley is \$1.2 billion by 2045. Future federal, state, and regional funding may help cover some of these needs, but substantial gaps are likely to remain, threatening housing affordability in the region if building electrification policies move forward without increased funding. These findings are intended to help inform federal and state advocacy efforts and support city efforts to develop funding programs for equitable building decarbonization.

Introduction

The Challenge of Decarbonizing Low- and Moderate-Income Homes

Over the last decade, North American cities have expanded the scope and ambition of climate policies and programs to support their goals to reduce and eventually eliminate carbon emissions from the building sector through electrification. There are numerous benefits to building electrification, such as reducing emissions that are causing climate change, improved indoor air quality and better associated health outcomes, and decreased expenditures on energy. City policy and program efforts to encourage the decarbonization of existing buildings include: benchmarking and disclosure policies requiring buildings of a certain size to annually report their energy performance data; building energy performance policies that set mandatory limits on a building's energy intensity or carbon emissions; and other supportive programs such as technical assistance, financing support, and workforce development initiatives needed to enable the successful retrofitting of existing buildings.

However, owners of buildings serving low- and moderate-income households, including both regulated and naturally occurring affordable housing,¹ face challenges in covering the cost of basic replacements and repairs, let alone compliance with future building performance and electrification policies. This is also true for owners of other types of under-resourced buildings, including houses of worship, small commercial properties, and buildings owned by non-profits. Owners of these buildings often have few to no building management staff, with many competing demands on their time. They also may be less aware of or have difficulty accessing technical and financial resources that are available to them, and therefore require deeper outreach, education, and technical support. Additionally, access to third party financing is not a viable solution for most of these building owners. They often do not have the up-front capital nor the financing capability and flexibility to make the needed investments in their building. For example, a poor credit history or lack of required financial data to share with financing entities can make reasonably priced loans difficult to obtain. In addition, affordable housing (both regulated and naturally occurring) already faces a gap between the cost it takes to build, operate, and maintain and the income it generates. Much of regulated affordable housing is developed using complex tax equity structures that are difficult to unwind outside of refinancing cycles (that usually occur every 15 years).

Given these constraints, absent significant public funding and support, the costs of electrification upgrades almost certainly will be passed on to tenants, including low- and moderate-income tenants at risk of displacement due to rising housing costs and/or tenants living in unsafe, unhealthy, or overcrowded conditions. The costs will also likely be borne by low-income homeowners, who may already have deferred maintenance or health and safety needs in their homes and cannot afford to make the required upgrades, putting them at risk of losing their homes. At the same time, if they are not supported and prioritized, as electrification ramps up, low- and moderate-income residents may be left on a gas system that is facing a vicious cycle of decreasing numbers of customers for its fixed cost assets, resulting in extreme rising gas costs for remaining customers (Gridworks 2019).

Displacement risk is already high in the San Francisco Bay Area, where the City of Berkeley is located. From 2010 to 2019, rent in Berkeley increased 63% (Fozi and Roseborough, 2021). Communities of color face the highest risk of displacement, particularly in neighborhoods that have been historically redlined and under-invested in for decades. From 2000 to 2020, Berkeley saw a 30% decrease in the African American population. Figures 1 and 2 show the correlation between census tracts where redlining was imposed and where the highest risk of displacement is today.

¹ Regulated affordable housing refers to housing that receives an explicit government subsidy and has regulated rents, while naturally occurring affordable housing does not receive any subsidies or have any regulations governing its rentals levels yet is lower cost than other properties due to location and/or property characteristics or amenities.

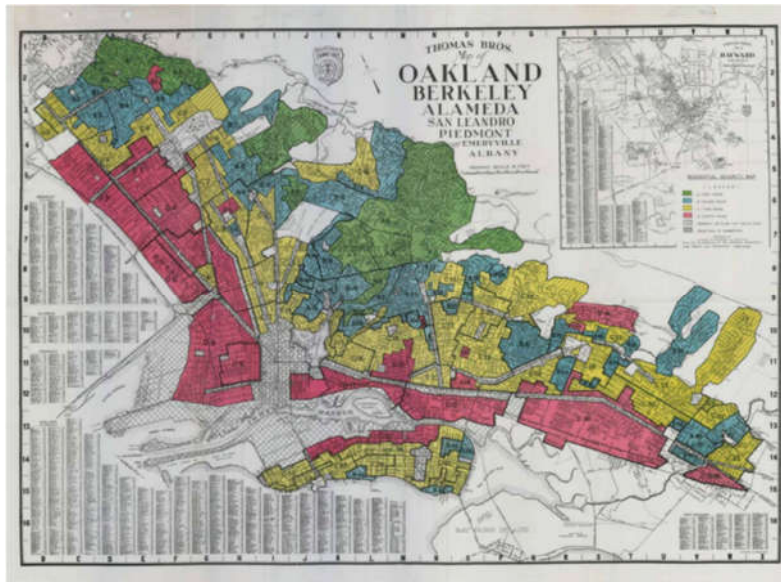


Figure 1. Redlining of Alameda County (Nelson, Winling and Marciano 2022)

These conditions indicate that the implementation of building decarbonization policies without proper supporting funding and programs may exacerbate ongoing challenges with housing affordability and displacement. Given both the significant benefits of electrification and these serious risks, cities are grappling with how to best support these buildings and building owners to ensure that they too can benefit from decarbonization while also ensuring that the costs of this transition are not inequitably distributed to low- and moderate-income residents.

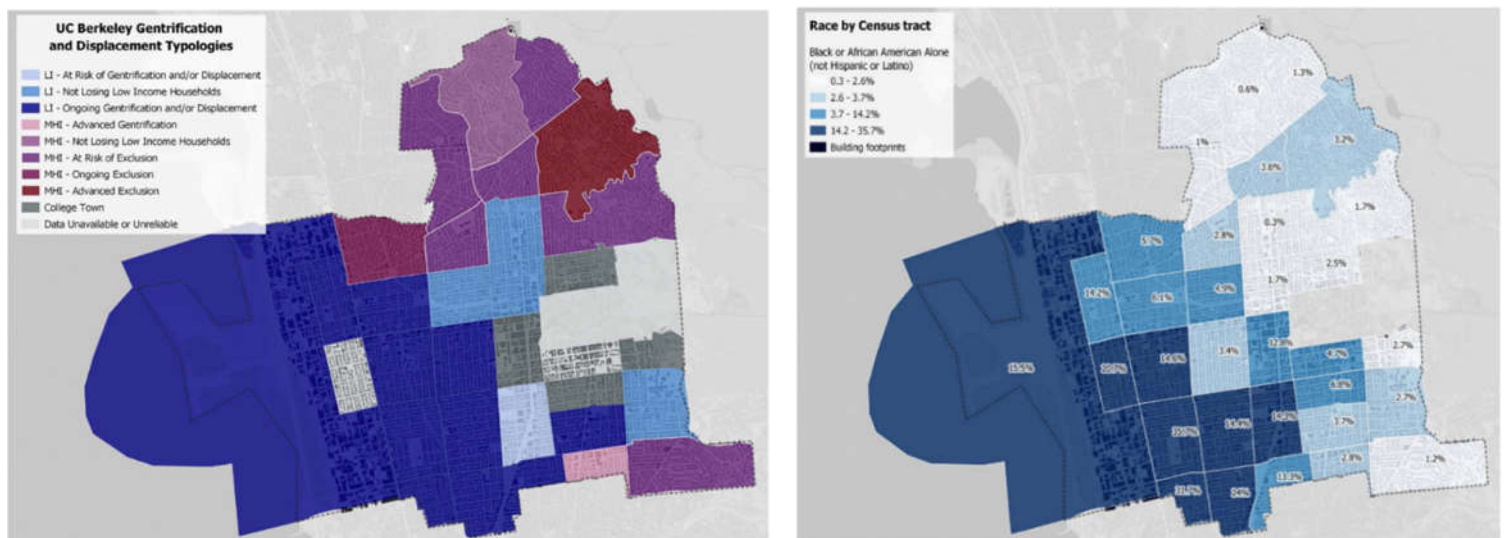


Figure 2. Gentrification Risk and Race by Census Tract in the city of Berkeley (BEI 2020; based on data from Urban Displacement Project and Census Bureau, American Community Survey 5-year estimate for 2017)

City of Berkeley's Goals

The City of Berkeley has been a long-time leader on environmental policies. In 2006, Berkeley voted to reduce its greenhouse gas emissions by 80% by 2050, and the City's first Climate Action Plan was adopted in 2009. In 2018, the Berkeley City Council declared a Climate Emergency and stated its goal of becoming a fossil fuel-free city as soon as possible.

To achieve these goals, Berkeley has implemented several key building-focused policies. In 2015, Berkeley passed its Building Emissions Savings Ordinance (BESO), which requires homeowners to complete an energy efficiency assessment and to submit that report prior to the sale of a house or building, as well as annual energy benchmarking and energy audits for large buildings.² In 2019, Berkeley became the first city in the country to prohibit natural gas in new construction.³ In 2021, Berkeley adopted its Existing Building Electrification Strategy (referred to here as "BEBES" or the "Strategy") as a roadmap to strategically, systematically, and equitably electrify existing buildings in the city.⁴ The Strategy was based on a detailed assessment of Berkeley's building stock and a building level energy model which assessed the likely scale of fuel switching and its associated costs. The Strategy was developed with extensive community outreach and engagement to ensure that it centered equity and prioritized efforts that would enable "outcomes that will benefit historically marginalized communities." The Strategy acknowledged that the health, safety, and resilience benefits of electrification must be accessible and affordable for all and identified the importance of ensuring that the City use this opportunity to train a local workforce for jobs that are inclusive, high quality, and family sustaining.

The Strategy identified numerous action items to make progress on building decarbonization and emphasizes that identifying public funding will be critical to enabling an equitable transition that does not exacerbate Berkeley's existing housing affordability and equity challenges. Building on this finding, the City of Berkeley worked with the Building Electrification Institute (BEI), a non-profit that supports cities in their efforts to equitably decarbonize their buildings, to conduct a detailed study on the total costs to decarbonize all of Berkeley's existing residential buildings and the current gap in funding.⁵ This study includes identifying all existing federal, state, regional and local sources of funding for residential building decarbonization, with a focus on low- and moderate-income residential buildings. This paper summarizes the findings of that analysis, which was conducted by Firefly Energy Consulting (Firefly) and the Association for Energy Affordability (AEA), with support from the City of Berkeley and BEI, referred to generally as "Project Team."

² Note that BESO has been refined several times, most recently in 2020; See more information at: <https://www.cityofberkeley.info/BESO/>

³ See more information at: https://www.cityofberkeley.info/Clerk/City_Council/2019/07_Jul/Documents/2019-07-23_Item_C_Prohibiting_Natural_Gas_Infrastructure_pdf.aspx

⁴ See more information at: https://www.cityofberkeley.info/uploadedFiles/Planning_and_Development/Level_3_-_Energy_and_Sustainable_Development/BerkeleyExistingBuildingElectrificationCommunityMeeting_Reduced_2021-05-04.pdf

⁵ The extensive benefits of decarbonization are highlighted in Berkeley's Strategy and we do not cover that topic here.

Phase 1: Analysis of Gross Costs

Broad Scope of Analysis

The first phase of analysis entailed determining the gross (pre-incentive) costs for decarbonizing Berkeley's residential building stock. The Project Team analyzed each residential building type in Berkeley and assessed the costs for full electrification, energy efficiency upgrades, and additional costs to make a building ready for electrification (including addressing health and safety needs as well as electrical upgrades) (Figure 3).⁶ These four scenarios were chosen because it is common that health and safety issues or electrical repairs render a home ineligible for energy efficiency or electrification incentives. For example, knob and tube wiring, included in these cost estimates, is a pervasive, and potentially dangerous condition in older homes in Berkeley and must be addressed before any upgrades can be made. Additionally, electrical panels often need to be upgraded to handle a fully electric home. The percentage of households "deferred" from the federally funded weatherization and utility low-income efficiency programs due to outstanding health and safety repairs varies widely by state, program, and type of analysis, however programs commonly report deferrals over 20%, and occasionally as high as 60% (Benshoff 2022). The underlying principles of Berkeley's Existing Building Electrification Strategy means that the City must prioritize buildings that are at risk of being deferred.

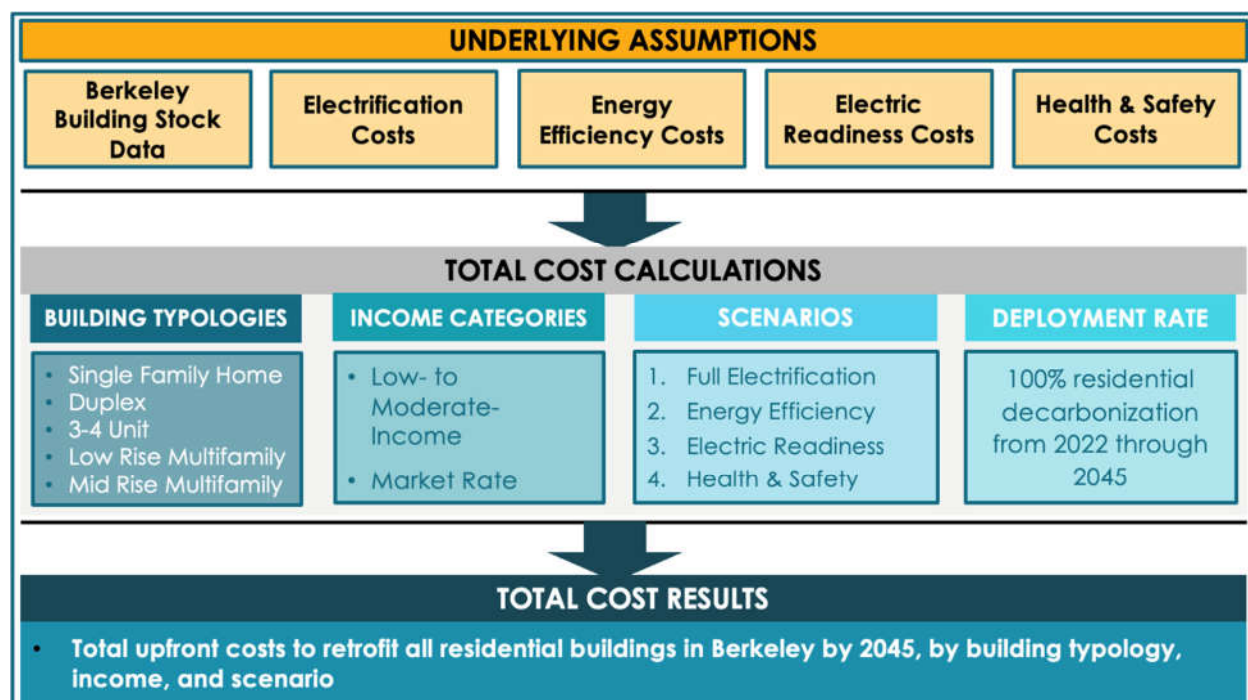


Figure 3. Overview to Total Cost Analysis

⁶ The Project Team initially intended to include an additional scenario looking at the costs of Solar PV, however, given ongoing regulatory changes being considered by the State of California that made these costs uncertain, we ultimately chose not to include this scenario.

Data Sources

The City of Berkeley, with BEI's support, had already conducted significant background research and analysis of its building stock and the costs to decarbonize its buildings. The City had a detailed Building and Housing Stock Analysis completed by BEI,⁷ and an extensive cost analysis by RMI as part of the BEBES to analyze the comparative economics of different possible “packages” of retrofit measures. This analysis was underpinned by the detailed analysis conducted by E3 for the California Energy Commission on the costs of electrifying different housing types across the state of California.⁸ The Project Team relied on the key findings of the E3 and RMI work, which most notably found that using a package of “mid-tier” appliances and integrating envelope measures offered the optimal combination of reduced emissions, bill savings, and needed up-front costs. Finally, AEA, an expert in multifamily energy efficiency with a high level of involvement in electrification projects in the Bay area, also reviewed and refined cost estimates for this analysis to reflect their ongoing on the ground experience.

Detailed Assumptions

The Project Team analyzed Berkeley's buildings by building type, aggregating the costs entailed to reflect a comprehensive building retrofit. Rationales for key assumptions are provided below.

Building Typologies: The Project Team conducted analysis on each of the main categories of residential building stock found in Berkeley (Figure 4). This included single family homes, duplexes, three-to-four-unit homes, low rise multifamily buildings, and mid-rise multifamily buildings. Berkeley's building stock analysis showed that most of these were built before 1978 (Figure 5).

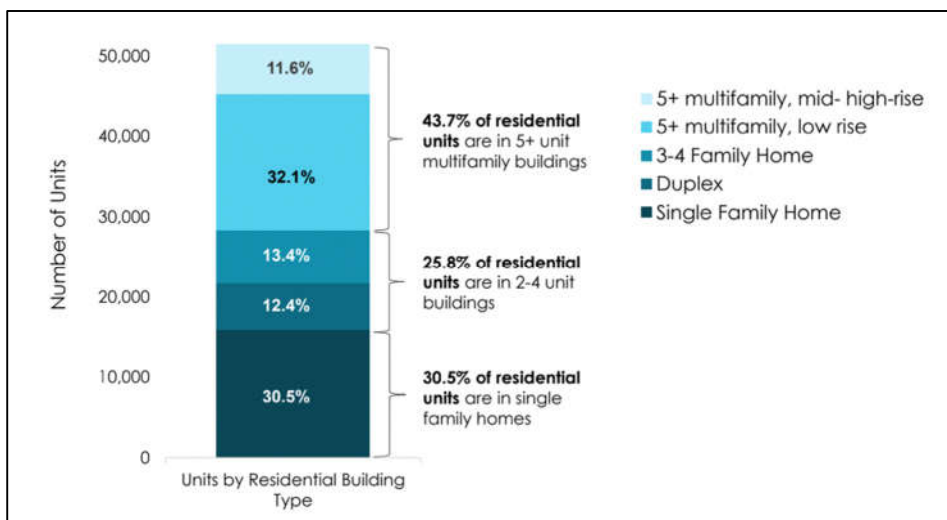


Figure 4. Housing Units in Residential Building Types, Building and Housing Stock Analysis (BEI 2020)

⁷ See www.beicities.org/city-resources for downloads.

⁸ This analysis is available at: https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

Electrification Costs: The Project Team used the assumed costs for electrification for the two relevant building types that E3 and RMI analyzed – pre-1978 single family homes and pre-1978 low-rise multifamily buildings. The Project Team then developed proxy cost estimates for Berkeley’s other building types by scaling single family and low-rise multifamily costs based on the average square footage of the different building types. AEA reviewed these estimates, and based on their recent project experience in the Bay area, recommended adding a 25% premium to the E3 and RMI cost estimates to better reflect unforeseen costs such as duct work, minor electrical repairs, plaster work, and other contingencies to better reflect the “on the ground” average cost.

The Project Team also incorporated an assumed capital cost reduction for electrification technologies given that this analysis extended through 2045. The Project Team relied on National Renewable Energy Laboratory (NREL) research on the likely evolution of electrified building technology costs (NREL 2018). The Project Team purposefully chose to use NREL’s “slow” case, which represents a more conservative technology adoption path and a less steep cost decrease. Given Berkeley’s goals of implementing a “high road” workforce strategy that would likely increase labor costs associated with these building retrofits, this approach was selected as a proxy to ensure that the impact of labor costs on total installed costs was not underestimated.

Energy Efficiency Retrofit Costs: RMI’s analysis for BEBES included basic envelope sealing and improvements to attic and wall insulation. The Project Team used RMI’s cost assumptions with minor updates based on AEA’s recent experience in the Bay Area.

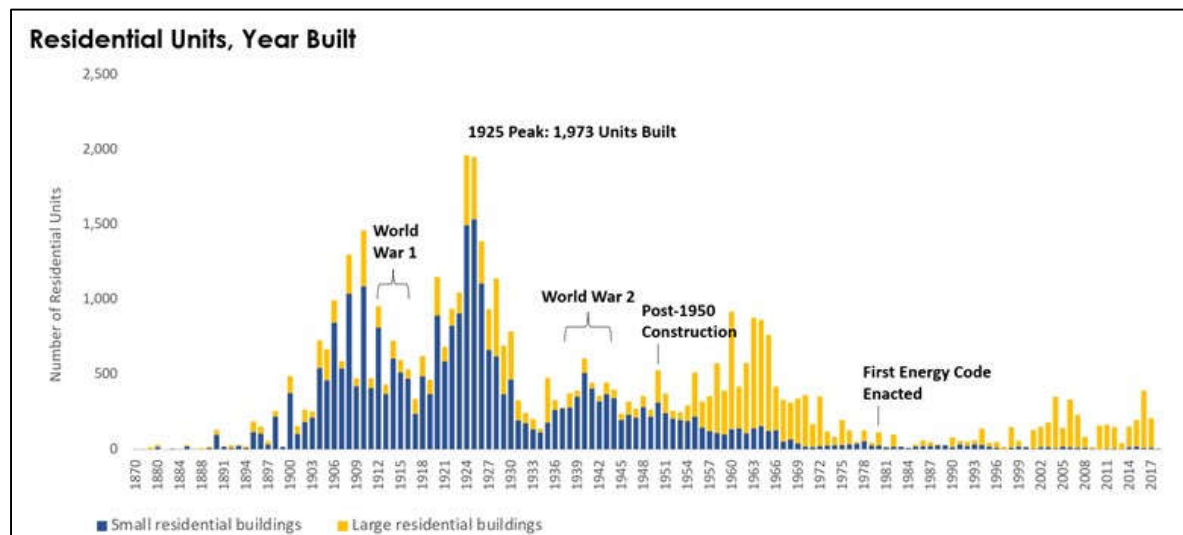


Figure 5. Vintage of Berkeley's Residential Buildings, Building and Housing Stock Analysis (BEI 2020)

Electric Make-Ready Upgrades: Given the relatively old vintage of Berkeley’s residential buildings (Figure 5), many buildings still have some level of knob and tube wiring, which is a fire hazard and should be removed and replaced anytime there are updates to the home or building. The Project Team conducted interviews with Berkeley-based electricians to develop average costs of these upgrades and developed estimates informed by the City of Berkeley’s Rental Housing Safety Program and Building Inspectors about what percentage of buildings (by

residential building type) required what amount of knob and tube replacement. As will be discussed in the results section below, these are significant costs and will be important for Berkeley to address in future policy and programmatic efforts.

In addition, driven also by the age of Berkeley's residential buildings and the higher electrical capacity required by a fully electrified home, the Project Team assumed that 80% of homes and building units would require new electric panels to be able to manage the higher electric load required by all electric appliances. The Project Team used E3's assumption about the cost of those panels.

Health and Safety Upgrades: Many homes must first address health and safety repairs before broader energy efficiency and electrification retrofits can be implemented. It is common, in particular for low- and moderate-income buildings, to need substantial repairs, and without these upgrades, buildings are often ineligible to receive incentives. As such, the Project Team developed two potential sets of assumptions for health and safety upgrades.

The first set of assumptions was around which homes would require basic health and safety upgrades, estimated at \$3,500 for a single-family home and ranging up to \$70,000 for a mid-rise multifamily building. Examples of the kinds of retrofits involved in the basic health and safety upgrade included: smoke detectors, ventilation improvements, pest infestations, minor asthma triggers, minor electrical and plumbing repairs, and slip and fall hazards.

The second set of assumptions was around which homes would require deep, structural health and safety interventions, estimated at \$30,000 for a single-family home and ranging up to \$350,000 for a mid-rise multifamily building. The kinds of repairs included in this structural intervention include the items from the first path as well as mold remediation, repairing unsafe electrical, plumbing or mechanical equipment; roof repairs; and addressing other structural defects in the home.⁹

The Project Team then developed a set of assumptions with the City of Berkeley's Building and Safety Division and AEA about what percentage of each building type might need each type of health and safety intervention.

Deployment Rate: The baseline deployment rate assumed that 100% of Berkeley's residential buildings would be decarbonized by 2045. The Project Team included a slower ramp-up in the early years, starting in 2023 to account for the fact that installers and building owners are just starting to get familiar with these technologies. The deployment rate was increased to 6% of the building stock in 2029 to achieve the city's goal of a 25% retrofit rate by 2030, and slowly decreased over time thereafter to achieve 100% of the building stock refurbishment by 2045.

Note that the Project Team also examined two alternative scenarios – an aggressive growth deployment rate that tested the impact of achieving 50% retrofits completed by 2030, and a slow deployment rate that assumed a slower growth trajectory, achieving only 90% of buildings electrified by 2045. The results of this funding gap analysis were based on the baseline deployment rate, however these two alternative scenarios will provide the City with helpful context as staff considers different policy routes.

⁹ Note that neither health and safety assumptions explicitly included the cost of seismic retrofits.

Total Costs Analysis Results

The analysis of total costs (costs before any financial incentives or subsidies are reflected) to decarbonize all of Berkeley's residential buildings, including electrical upgrades and health and safety repairs required to make buildings ready for electrification, totals \$2 to \$2.5 billion in 2022 dollars (not adjusted for inflation), as shown in Figure 6. In Berkeley, single family homes represent the largest portion of these costs at 35% of the total, or almost \$800 million, while low rise multifamily buildings (MFB) represent the second largest costs at 28% (note that this breakdown will vary from city to city depending on building stock composition).

The costs of electrification are the largest category by far, representing 59% of the total (Figure 7), or \$1.3 billion (Figure 6), even after incorporating anticipated modest decreases in capital costs for electrification technologies (discussed above). Electric readiness represents the second largest category of costs at 20%, or \$445 million. Health and safety costs were also significant at 12% or \$280 million.

Scenario	Single Family Homes	Duplexes	3-4 Unit Buildings	Low Rise MFB	Mid Rise MFB	Total
Electrification	\$ 510	\$ 185	\$ 185	\$ 360	\$ 90	\$ 1,330
Energy Efficiency	\$ 85	\$ 35	\$ 30	\$ 50	\$ 15	\$ 215
Electric Readiness	\$ 120	\$ 70	\$ 85	\$ 135	\$ 35	\$ 445
Health & Safety	\$ 80	\$ 45	\$ 50	\$ 85	\$ 20	\$ 280
Total	\$ 795	\$ 335	\$ 350	\$ 630	\$ 160	\$ 2,270

Figure 6. Total Costs (Millions, Rounded) under Baseline Scenario and by Residential Building Type

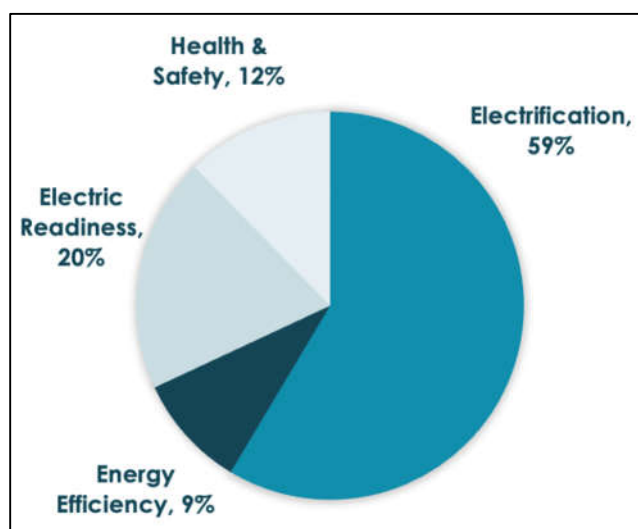


Figure 7. Breakdown of Total Gross Costs by Category of Costs (under baseline scenario)

Phase 2: Existing Funding Resources to Decarbonize Residential Buildings

To identify possible funding resources for the decarbonization of Berkeley's residential building stock, the Project Team cast a broad net both across different levels of government

(federal, state, regional, local) and across different possible needed areas of investment (energy efficiency, electrification, health, housing, etc.). The Project Team assessed a variety of factors for each funding stream:

- Whether the funding stream is currently being deployed (planned funding was not included, nor were programs where all funds were completely allocated)
- Guarantee of funding availability (i.e. formulaic or incentive funds as compared to competitive grants)
- Eligible activities relevant to capital investments needed
- Eligible applicants (focusing mainly on building owners, developers, program managers, and municipalities or community groups)

Landscape Assessment

The Project Team found that the landscape of funding is changing at both the federal and state level. The Biden administration is developing new programs and revamping existing ones in ways that may become more impactful, but many are still nascent. For example, the Weatherization Assistance Program (WAP)—a program administered by the Department of Energy (DOE) that offers energy efficiency and weatherization services to low-income households—not only received a significant amount of funding through the Infrastructure and Investments Jobs Act but also revised its eligibility requirements to better align with programs offered by the Department of Housing and Urban Development (HUD), though challenges with using such funding for multi-family buildings remain.

California, a leader in decarbonization, is a few steps ahead of many states in understanding the complexity of funding decarbonization and is trying to improve existing programs and expand funding for successful programs to better fund this work, especially in disadvantaged communities. The State is redesigning its Energy Savings Assistance (ESA) Program, a program run by utilities that offers weatherization services to eligible applicants, to better address the needs of multifamily properties and facilitate more extensive energy savings related retrofits within such properties. The governor’s 2022 budget also included funding for a new state-wide program geared at providing incentives to low- to moderate-income households for decarbonization. Similarly, regional programs are also in the process of being developed. For example, East Bay Community Energy, the local community choice aggregator (CCA) and electricity provider in Berkeley, is initiating a program with energy technology firm BlocPower to support low- to moderate-income families with decarbonization. This period of flux means that we have had to rely on current implementation of existing programs without relying on new programmatic funding that may emerge in the next year or two.

Key Findings

Our key findings in reviewing the available funding sources indicate that there are about a half dozen funding sources for energy efficiency and electrification, but much less so for any health and safety repairs that might be needed as a precursor to this work. Additionally,

despite the diverse array of funding sources to support energy efficiency and electrification activities, the extent to which they can address the needs of single-family and multifamily housing is often insufficient. There is minimal funding for electrical upgrades to address the old and faulty knob-and-tube wiring that is prevalent in Berkeley's older building stock, though California's TECH program is helping to fund the needed upgrades for electric panels.¹⁰

In addition, there are numerous competitive grants that are not factored into the gap calculations that may be useful for cities seeking to decarbonize aggressively. These grants could cover local electrification projects, ideally in conjunction with local community groups, or for more comprehensive zero carbon goals that could also include transport and smart planning. Examples of potentially relevant competitive grants include California-specific programs, such as the Affordable Housing and Sustainable Communities Program and the Transformative Climate Communities program, both of which now include incentives within their respective applications for respondents to engage in building electrification related scopes of work. Additionally, federal programs run by the Housing and Urban Development agency (HUD) such as the Choice Neighborhoods Planning and Implementation grants and the Lead-Based Paint Hazard Control and Lead Hazard Reduction Programs (in which applicants can access additional funding via the Healthy Homes Supplemental funding program) provide additional opportunities to fund health and safety measures.

Phase 3: Funding Gap Analysis

After completing the assessment of gross costs to decarbonize and identifying existing funding sources to cover those gross costs, the Project Team then moved to link specific costs and specific funding sources to estimate the gap in funding by residential building type and retrofit measure. The Project Team also created assumptions to differentiate between buildings that were owned or occupied by predominantly low-income and moderate-income households, aligning assumptions where possible with income-qualified program eligibility.

The investment costs needed by building type for electrification, energy efficiency, electric readiness, and health and safety were mapped to specific federal, state, and regional funding sources that could be used for each capital expenditure, detailing the maximum that could be used, any caps for the programs, and which funds could be "stacked" on top of one another. An example of this analysis for low-income, single family home electrification is shown in Figure 8 below.

This enabled the Project Team to calculate the gap in funding for each category of investment by building type.

¹⁰ After completing the analysis and as we were finalizing this report, TECH reported that it had expended most of its incentives in most regions of California including the Bay area.

Gross Costs			Applicable Funding Sources					
			Low Income			Market Rate		
Electrification			MESP	TECH	BAMBE	MESP	TECH	BAMBE
HVAC	\$	251,830	\$14,000	\$56,000	\$28,000	\$14,000	\$56,000	\$28,000
Water Heating	\$	140,000	\$8,400	\$50,400	\$28,000	\$8,400	\$50,400	\$28,000
Cooktop	\$	72,240			\$9,800			\$9,800
Clothes Dryer	\$	72,240			\$7,000			\$7,000
Total Cost	\$	536,305	\$22,400	\$106,400	\$72,800	\$22,400	\$106,400	\$72,800
Remaining Gap			\$357,105			\$357,105		
Energy Efficiency			ESA		BAMBE	MESP		BAMBE
Roof Insulation	\$	39,920						
Air Sealing	\$	47,910						
Total Cost	\$	87,830		\$56,000	\$21,000	\$2,800	\$21,000	
Remaining Gap			\$31,830			\$66,830		
Electric Readiness			TECH			TECH		
Knob & Tube	\$	78,960						
Panel Upgrade	\$	119,170		\$39,200			\$39,200	
Total Cost	\$	198,130		\$39,200			\$39,200	
Remaining Gap			\$158,930			\$158,930		
Health + Safety			HOME / CDBG		PLHA	HOME / CDBG		PLHA
Basic Retrofit	\$	24,500		\$0	\$0		\$0	\$0
Deep Retrofit	\$	140,000		\$0	\$0		\$0	\$0
Total Cost	\$	164,500						
Remaining Gap			\$140,000			\$24,500		
TOTAL GAP FOR MID RISE MULTIFAMILY			\$687,860			\$607,359		

Figure 8. Example of Gap Analysis Cost Mapping for Mid-rise Multifamily (gold indicates optimal funding combination)

Results and Findings

The Project Team found that despite numerous possible incentives available to Berkeley households, there is still an average of a \$26,400 funding gap for electrification technologies and a \$14,300 gap for “make ready” investments related to health and safety and electrical upgrades for a low-income single-family home in Berkeley. The results of this analysis for all building types in Berkeley are shown in Figure 9 below. The gap was higher for low-income units (due to higher costs associated with health and safety needs) at \$27,800, while the gap for market rate units was \$23,900. The funding gap is the highest for single family homes, with a gap ranging from \$35,000 to \$40,000 per home.

	Single Family Homes		Duplex		3-4 Unit		Low-Rise Multifamily		Mid-Rise Multifamily	
	Low Income	Market	Low Income	Market	Low Income	Market	Low Income	Market	Low Income	Market
Electrification	\$ 26,400	\$ 26,400	\$ 25,000	\$ 25,000	\$ 38,400	\$ 38,400	\$ 112,000	\$ 112,000	\$ 357,100	\$ 357,100
Energy Efficiency	\$ -	\$ 2,700	\$ -	\$ 1,700	\$ -	\$ 1,900	\$ 3,800	\$ 13,800	\$ 31,800	\$ 66,800
Electric Readiness	\$ 5,300	\$ 5,300	\$ 10,100	\$ 10,100	\$ 19,400	\$ 19,400	\$ 50,400	\$ 50,400	\$ 158,900	\$ 159,000
Health & Safety	\$ 9,000	\$ 900	\$ 10,600	\$ 1,300	\$ 18,200	\$ 1,900	\$ 40,000	\$ 7,000	\$ 140,000	\$ 24,500
Total Gap per Building	\$ 40,700	\$ 35,300	\$ 45,700	\$ 38,100	\$ 76,000	\$ 61,600	\$ 206,200	\$ 183,200	\$ 687,800	\$ 607,400
Avg Gap per Unit	\$ 40,700	\$ 35,300	\$ 22,850	\$ 19,050	\$ 25,333	\$ 20,533	\$ 25,775	\$ 22,900	\$ 24,564	\$ 21,693

Figure 9. Summary of funding gap analysis (rounded, under baseline scenario). Color coding for average gap per unit is red for highest costs per unit and green for lowest costs.

This analysis also helped confirm our preliminary suppositions from funding research: there is little funding available for health and safety measures or for electrical upgrades such as knob and tube upgrades. (The new TECH program can offset the cost of new electric panels in

the near future, although the market rate incentives for this program ran out after our analysis had been completed.)

Health and safety funding is a particular challenge. While federal and state programs do exist, such as the federally funded HOME and Community Development Block Grant programs or California's Permanent Local Housing Allocation (PLHA) program, there is insufficient funding overall to develop and maintain affordable housing and support homeless populations, so these funds are generally in high demand for multiple different housing programs and inaccessible to support decarbonization programs. There are also competitive grant programs, such as the federal Housing and Urban Development Agency's Lead-Based Paint Hazard Control Program and the Lead Hazard Reduction Program, which then open access to further health and safety measures via the Healthy Homes Supplemental funding. Similarly, California's Low Income Weatherization Program (LIWP) also allows for some health and safety investment. However, LIWP is targeted at Disadvantaged Communities (based on a statewide definition) and only a small number of Berkeley census tracts fall into that categorization.

Another key finding is that there is still a very large gap in funding for low-income households. These households will face higher costs to decarbonize given the other likely investment needs in their homes and buildings before decarbonization retrofits can be made, and programs are not offering the level of funding needed to make these investments accessible and to avoid the exacerbation of housing affordability concerns and the likely risk of displacement.

Estimate of funding needed to support low- to moderate-income households in Berkeley

Berkeley's goal for this project was to quantify the total gap in funding that would be needed to support low- to moderate-income residential buildings in their efforts to decarbonize. To that end, our analysis included a broad interpretation of low- to moderate-income, assuming that any household under 80% of the Area Median Income (referred to as "low- to moderate-income" or LMI in this report) may require financial assistance to electrify their homes, given the soaring cost of living in the Bay Area. For Berkeley, this interpretation reflects an annual income of less than \$109,600 for a family of four.

However, federal, state, and utility programs tend to use a much narrower definition of low-income to include only those households that are under 200% of the federal poverty line (FPL) (referred to in this report as "low-income" or LI). For a family of four, being under the 200% of the FPL translates to less than \$53,000 in annual income. As a result, moderate-income households (making \$53,000-\$109,600 for a family of four) in Berkeley do not have access to most of these funding sources, and were assessed separately from LI households in this phase of the analysis.

In addition to this distinction, it is also important to note that the best available data on income is by census tract, and therefore this analysis had to rely on tract-level assumptions to pull out both low-income and low- to moderate-income household estimates.¹¹ Figure 10 summarizes the results of this analysis, showing the percentage of residential buildings that are considered low-income, the percentage considered moderate-income which don't have access to low-income programs, and the total percentage of total low- to- moderate income households. There are many more buildings in Berkeley that fall into this moderate-income category than those that are considered true low-income, using a 200% of Federal Poverty Line standard.

Building Type	# of Buildings	Low Income	Moderate Income	TOTAL: Low to Moderate Income
Single Family Homes	16,156	8%	36%	44%
Duplexes	5,013	18%	51%	69%
3-4 family homes	3,246	23%	60%	83%
Low Rise Multi-Family	2,476	33%	51%	84%
Mid Rise Multi-Family	182	60%	25%	85%
Total	27,073			

Figure 10. Estimate of Low-Income and Moderate-Income Households in Berkeley by Building Type; Note that for single family homes we used number of units, not buildings, to avoid double counting accessory dwelling units.

The Project Team then used these LMI and LI breakdowns to calculate the total funding gap faced by these buildings. The Project Team found that moderate-income households (those that fall below 80% of Area Median Income and above 200% of the Federal Poverty Line) face a higher funding gap (on average almost \$30,000 per unit) than low-income or market rate buildings given that they have the same costs as low-income buildings, but don't have access to low-income incentives.

Scaling this up citywide, the total funding needed for low-income buildings is \$390 million, as shown in Figure 11, while the total gap for moderate income buildings (above the 200% federal poverty line) is \$848 million. This results in a total funding need to support low to moderate income residential buildings in Berkeley of \$1.2 billion by 2045.

Building Type	Low Income Buildings	Moderate Income Buildings	Total
Single Family homes	\$ 50.0	\$ 261.8	\$ 311.8
Duplexes	\$ 40.8	\$ 127.5	\$ 168.3
3-4 family homes	\$ 57.6	\$ 151.1	\$ 208.7
Low Rise Multi-Family	\$ 166.2	\$ 275.4	\$ 441.6
Mid Rise Multi-Family	\$ 75.7	\$ 32.3	\$ 108.0
Total	\$ 390.3	\$ 848.2	\$ 1,238.4

Figure 11. Total Additional Funding Needed to Support LMI Residential Buildings in Berkeley (\$ millions)

¹¹ Low-income (LI) households were identified using 2017 5-year ACS estimates from Berkeley's Building & Housing Stock Analysis. Tracts with 76-100% percentile of households that earn 200% below the federal poverty line were assumed to be "low-income", and these assumptions were applied to residential buildings in those census tracts by typology.

While new programs may defray some of these costs, a large gap remains given the scale of investment needed. For example, Governor Newsom announced \$922 million in this year's budget for low to moderate income building decarbonization. While this is a significant sum, we estimate that Berkeley may expect to receive roughly \$1 million if it receives a proportional population-based allocation, given California's large size and number of low to moderate income buildings. Similarly, the East Bay Community Energy (EBCE) program is considering a proposal by BlocPower to help support the decarbonization effort in the region, which would include \$400,000 in incentives. However, given Berkeley's population compared to the geographic area covered by EBCE, we estimate that only roughly \$40,000 in incentive dollars could flow to Berkeley's buildings from this program if it receives a proportional population-based allocation.

Finally, there are programs offering financing that may also be useful for market rate buildings. For example, the California Advanced Energy and Advanced Transportation Authority has created multiple pilots to test the best way to offer reasonably priced loans for homes and businesses through its Go Green platform. However, it is unclear whether low-to moderate-income households will want to or be able to finance electrification upgrades. Financing would require low- to moderate-income families to pay interest rates on top of the building decarbonization costs, and most households in this category are unlikely to be able to do so, given their economic circumstances.

Key Findings and Implications for Other Cities

Berkeley's funding gap analysis highlights the challenges of equitably decarbonizing the residential building stock. The results of this analysis will help enable city officials to be more strategic about federal and state grant applications and to consider new programs and policies to advance its decarbonization goals. This information will also be helpful in advocacy efforts with the California Public Utility Commission, the California Energy Commission, the California legislature, and others who are developing new programs and funding streams for building decarbonization. In addition, it will help cities like Berkeley consider whether they should stand up their own programs to support low- and moderate-income buildings in this transition, funded by city budgets or a specific tax. A number of cities have already started moving forward on these options, such as Denver's Climate Protection Fund and Portland's Clean Energy Fund.

Additional findings for cities and states seeking to decarbonize their residential buildings include:

- Cities should not pursue building electrification requirements without simultaneously ensuring significant public funding and supportive programs are in place to avoid displacing vulnerable residents and worsening the affordable housing crisis.
- Even in a state and city that is prioritizing equitable decarbonization, there are major gaps in the availability of funding to adequately support low- to moderate-income buildings. This demonstrates that more work is needed to design, target, and expand funding programs to ensure that the most vulnerable populations are supported in the decarbonization effort.
- The specific types of funding gaps identified in this analysis are likely to be the same in other jurisdictions. Notably, flexible funds are needed to make health and safety repairs in buildings (including electrical upgrades) so that they are ready to receive decarbonization retrofits.

- While this Berkeley-focused analysis will help provide a roadmap for other jurisdictions to conduct similar analyses, cities will still need to analyze their own building stock; the cost to retrofit buildings in their region; and local, regional, and state-specific incentives are available to help defray the costs.
- The findings from this analysis can help guide federal and state advocacy, and can be used with stakeholders to consider pursuing local funding mechanisms (as seen for example in Portland, Seattle, Denver, Minneapolis), which provide local flexibility to cities in funding this work.

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