LOS ANGELES BUILDING DECARBONIZATION

COMMUNITY CONCERNS
EMPLOYMENT IMPACTS
OPPORTUNITIES

INCLUSIVE ECONOMICS

June 2021

Suggested Citation

Jones, Betony. June 15, 2021. "Los Angeles Building Decarbonization: Community Concerns, Employment Impacts, and Opportunities." Inclusive Economics, Oakland, CA

ACKNOWLEDGEMENTS

This research and report was commissioned by the Natural Resources Defense Council and Bloomberg Philanthropies under the American Cities Climate Challenge with support from the Los Angeles Alliance for a New Economy (LAANE).

Many thanks to LAANE staff and partners for contributing ideas to, critically reviewing, and providing feedback on this report and its recommendations. Thanks also to the research and editing contributions of Emma Tome and Maggie Jones. Errors and omissions are the responsibility of Inclusive Economics.

Table of Contents

Executive Summary 1

Introduction 4
- Background 5
- Principles for Building Decarbonization Policies and Programs 6
- Summary of Concerns and Potential Solutions 8

Employment Impacts of Building Decarbonization in Los Angeles 10
- Job Gain Methodology and Data 10
- Los Angeles Building Stock Summary 10
- Market Analysis, Including Gas Saturation 12
- Investment Costs and Distribution of Costs 13

Results 14
- Residential Sector Results 14
  - Affordable Housing Results 19
- Commercial Sector 21
  - Schools and Hospitals Results 24
- Summary of Employment Projections 25
- District Energy Approach 27
  - Jobs Potential 28

Job Loss Methodology and Data 29

Solutions, Strategies, and Recommendations 32
- Programmatic Efforts 33
- Policy Efforts 34
- Cross-Cutting Efforts 34

Appendix A. Gas Saturation by End Use 36

Appendix B. Cost Estimates 37

Appendix C. Number of Workers Employed in Natural Gas Distribution Industry in LA County, by Detailed Occupation 37

Appendix D. References for Gas Saturation Data in Inclusive Economics Decarbonization Jobs Model 38

Tables and Figures

Table 1. Job Calculations for Building Decarbonization by Sector 2

Table 2. Summary of Concerns and Potential Solutions 8

Table 3. Estimated Distribution of Los Angeles Residential Buildings 11

Table 4. Estimated Distribution of Los Angeles Commercial Buildings 11

Table 5. Estimated Upfront Investment Required 13

Table 6. Jobs and Careers Supported by Investments in Building Efficiency Retrofits 15

Table 7. Jobs and Careers Supported by Investments in Beneficial Electrification Retrofits 17

Table 8. Jobs and Careers Supported by Investments in Affordable Housing Building Efficiency Retrofits 20

Table 9. Jobs and Careers Supported by Investments in Affordable Housing Beneficial Electrification Retrofits 20

Table 10. Jobs and Careers Supported by Investments in Commercial Building Efficiency Retrofits 21

Table 11. Jobs and Careers Supported by Investments in Commercial Beneficial Electrification Retrofits 22

Table 12. Jobs and Careers Supported by Investments in School and Hospital Building Efficiency Retrofits 24

Table 13. Jobs and Careers Supported by Investments in School and Hospital Beneficial Electrification Retrofits 25

Table 14. Summary Building Decarbonization Careers (2021–2050) (Deep Efficiency + Electrification) 26

Table 15. Number of Workers Employed in Natural Gas Distribution Industry in LA County, by Occupation 31

Table 16. Job Calculations for Building Decarbonization by Sector 35

Figure 1. Distribution of Los Angeles Buildings by Square Footage 10

Figure 2. Distribution of Jobs by Trade, Residential Efficiency 15

Figure 3. Distribution of Jobs by Trade, Beneficial Electrification 18

Figure 4. Distribution of Jobs by Trade, Commercial Efficiency Retrofits 21

Figure 5. Distribution of Jobs by Trade, Beneficial Electrification, Commercial Sector 23

Figure 6. Distribution of Jobs by Trade, Deep Energy Efficiency and Beneficial Electrification, Existing Buildings in Los Angeles 26

Executive Summary

Electricity in California is getting rapidly cleaner. The proliferation of renewable energy has been the biggest driver of emission reductions in Los Angeles since 2008. LADWP procures 35 percent of its electricity from renewable sources, and by 2045, 100 percent of California electricity will be carbon free. Under the City of Los Angeles Existing Buildings Energy & Water Efficiency Ordinance, all private buildings of 20,000 square feet and above and municipal buildings of 7,500 square feet and above must measure and report their energy and water use. The associated data shows that there is a lot of room for cost savings and energy improvements in LA's buildings—particularly multifamily housing, office buildings, retail, and mixed-use buildings.[1] Investing in building upgrades requires local workers, thus stimulating job creation, and, if shaped thoughtfully, can yield not only climate, but also equity and economic benefits for the city.

Optimizing the jobs, equity, and other community benefits of building decarbonization, however, will not happen automatically. Policies that regulate emissions of privately-owned buildings can leave low-income residents and small businesses saddled with inefficient and unhealthy buildings and appliances. Thus, city building decarbonization policies need to be coupled with well-designed programmatic investments to ensure that renters, low-income neighborhoods, vulnerable businesses, and others are able to reap the benefits of building decarbonization. This paper suggests policy and program design features and examples to address some stakeholder concerns related to workforce and equity issues arising from building decarbonization.

The foundational principles behind this guidance are that (1) public funding should not subsidize the wealthy, (2) building investments must be coupled with anti-displacement measures, (3) building investments must be coupled with labor standards to support quality jobs, (4) comprehensive building investments are necessary support health and resilience, (5) policy and regulation without equitable programmatic investments will leave people behind in the clean energy transition, and (6) while both efficiency and fuel switching are necessary to achieve decarbonization goals, flexible pathways can mitigate job loss for gas workers.

In addition to policy guidance, this paper provides a quantitative assessment of LA's building stock, estimates the upfront investment required to decarbonize the city's buildings, and assesses the employment impacts of different policy and program scenarios, detailing the labor demand by trade and bookending potential job loss. Table 1. Job Calculations for Building Decarbonization by Sector summarizes the total potential job years[2] and investment, by building sector, along with an example mechanism for driving down emissions in that sector.

1 City of Los Angeles Department of Building and Safety (LADBS), "2016 Existing Buildings Energy & Water Efficiency Program (EBEWE) Annual Report," accessed May 5, 2021, https://www.ladbs.org/services/green-building-sustainability/existing-buildings-energy-water-efficiency-program/2016-ebewe-annual-report.

2 A job year is a full-time job for one person for one year. To convert job-years into full-time, 25-year careers, divide by 25.

Table 1. Job Calculations for Building Decarbonization by Sector

Sector (Existing Buildings)	Deep Efficiency + Electrification Job Years	Upfront Investment Required	Decarbonization Policy or Program Lever
Schools	2 - 3 thousand	$0.6 - 0.8B	Direct public investment and consolidate available funding (i.e., AB 841, DWP programs, local bond, federal funding, etc.)
Affordable Housing (Deed Restricted)	8 - 12 thousand	$2 - 7B	
Affordable Housing (Naturally Occurring)	38 - 62 thousand	$9 - 16B	Incentives with rent control requirements and eviction prevention
Universities & Hospitals	3 - 5 thousand	$1 - 1.2B	Direct public or utility investment in district energy systems
Large Commercial (>50,000 sq ft)	28 - 37 thousand	$8 - 10B	Mandate GHG reductions through BPS and other regulations, requiring apprenticeship and quality inspection standards
Large MF* Residential (>50,000 sq ft)	21 - 29 thousand	$5 - 8B	
Small & Medium Commercial (<50,000 sq ft)	42 - 54 thousand	$13 - 16B	Voluntary targets, neighborhood district energy pilots technical and financial assistance for low-income homeowners
Small MF* Residential	63 - 109 thousand	$14 - 25B	
Single Family Residential	177 - 251 thousand	$37 - 50B	

*MF: Multifamily

While it is clear from the above table that building decarbonization could support jobs for tens of thousands of LA residents, the public and private sector investment required to realize this potential is significant. The examples below illustrate the job impacts from smaller and more targeted investments and regulations. This list is not exhaustive but represents how the jobs analysis in this paper can inform the design of policies and programs.

- An $80M annual investment for 5 years could fully decarbonize and upgrade all of LA's public schools, supporting 400–500 full-time equivalent (FTE) union construction jobs per year, improving the quality and safety of school HVAC systems and redirecting energy spending to learning. Measure RR allocates $3 billion to retrofits and upgrades, providing a funding source to support this work.[3]
- A robust incentive fund for deep decarbonization of LA's affordable housing over 10 years, could create 4600–7400 FTE union construction jobs per year, securing affordable housing, improving indoor air quality, and reducing energy burdens for low-income renters, while ensuring that low-income residents will not be left behind as LA leads city efforts to address climate change.
- A Building Performance Standard requiring decarbonization of LA's largest buildings could catalyze $13–18B in private investment over the next 25 years, creating 2000–2600 FTE local jobs per year retrofitting buildings, requiring electricians, plumbers/pipefitters, sheet metal workers, insulators, carpenters, stationary engineers, and other skilled tradespeople, in addition to engineers and architects trained to design the city and buildings of a climate-safe future.

3 "The School Upgrade and Safety Measure" (Measure RR - Los Angeles Unified School District, November 3, 2020), https://achieve.lausd.net/cms/lib/CA01000043/Centricity/Domain/1265/Measure%20RR%20Overview%20Presentation%20FINAL%209.30.2020.pdf.

- Investments in decarbonized district energy could provide utility-scale solutions to decarbonize space and water heating, while supporting complementary climate measures like increased density and transit-oriented development. If district energy supported just 5–10 percent of LA's building heating and cooling needs, these systems would create 22,000–44,000 construction jobs and 1000–2600 annual operations and maintenance jobs.
- If LA were to invest in making existing large buildings "electric ready," which would involve electric panel and service upgrades and efficiency investments, the work would require 110–210 FTE licensed electricians annually over a 10-year period for the service upgrades and 1600–2400 jobs per year in efficiency, comprising jobs for electricians, plumbers/pipefitters, sheet metal workers, insulators, carpenters, laborers, building operators, and other trades. Deep efficiency investments could create more than twice that number.
- The City can target specific neighborhoods where there is a high incidence of methane leaks from the gas system and an aging building stock. By electrifying entire neighborhoods, it may be possible to "prune" the gas system, thus reducing the fixed costs associated with maintaining it. The workforce benefits of an aggregated neighborhood approach include the potential to adopt targeted hire standards and coordinate with apprenticeship and pre-apprenticeship programs to make the work opportunities accessible to city residents facing barriers to career-track jobs.

Of course, concerns of job loss and the quality of jobs created are not the only community concerns to address. Many stakeholder concerns about indoor air quality, energy cost burdens, quality of housing, and the preservation of affordable housing are highlighted in this paper, but the summaries and suggestions provided here do not supplant the need for meaningful engagement of the City's many community and labor stakeholders.

Introduction

Buildings account for more than a quarter of total greenhouse gas (GHG) emissions, and about 40 percent of building emissions are from the combustion of natural gas for heating, water heating, and cooking.[4] As cities seek to address climate change, they must figure out how to reduce emissions from new and existing buildings (i.e., decarbonize buildings). Cities in California can adopt requirements for new construction and influence upgrade and investment decisions in existing buildings. In exercising this power, cities must consider the needs of tenants, communities, workers, businesses, and other stakeholders. They must consider the costs and who bears them. They must consider energy affordability, health, and long-term resilience.

Cities must also weigh the pros and cons of different policy and programmatic interventions. Many cities looking to decarbonize buildings prefer regulations that require replacing gas with efficient electric appliances and all-electric new construction requirements because they are simple to communicate, implement, and enforce. However, looking beyond ease of deployment, there can be serious drawbacks to these approaches for communities and workers.

Other cities recognize that more flexible policies, such as building performance standards that establish emissions limits and energy improvement requirements, better address stakeholders' concerns. In either case, reducing emissions from existing buildings requires private sector participation and investment and influences living and working conditions for city residents. Hence, attention to stakeholder concerns is key.

Pertaining to building decarbonization, some of the workforce and community concerns include:

- High upfront investment costs of building retrofits could mean that low-income consumers will be left stranded with inefficient, unhealthy appliances and buildings.
- Building and energy improvements can trigger rent increases, regardless of the source of investment. Without renter protections, building decarbonization will lead to displacement.
- Reduced gas throughput resulting from economic and environmental electrification will increase gas rates, thus exacerbating energy burden for remaining gas customers.
- Pruning gas infrastructure and reduced gas sales can lead to a loss of good-paying union jobs associated with the gas system, particularly for utility workers and plumbers and pipefitters.
- In the private construction market, there are no assurances that the jobs created will be high-road, good quality jobs or accessible to workers and contractors historically excluded from economic opportunity.
- Investing in efficiency and beneficial electrification may not result in the anticipated energy savings and performance improvements.
- Community representatives are short on capacity, time, and resources to engage with and help shape building decarbonization pathways.
- Electrification of buildings and transportation will put new demands on the grid and the workers charged with maintaining grid reliability, a task made more complex by the shift to higher levels of intermittent wind and solar resources.

4 California Air Resources Board, "Existing Buildings," CA.gov, accessed May 5, 2021, https://ww2.arb.ca.gov/our-work/programs/building-decarbonization/existing-buildings#_ftn2.

These concerns are not insurmountable, but addressing them will require extensive stakeholder engagement, creativity, and commitment to equity. This paper provides policy and program ideas and recommendations to address these workforce and community concerns in the City of Los Angeles. It also provides data on investment costs, job creation, and job loss related to building decarbonization in the City of Los Angeles.

Background

Currently, fossil fuels—mainly fossil gas—are burned in buildings to provide space heating, water heating, cooking, and sometimes other services such as clothes drying and pool heating. When fossil gas is burned to provide these services, carbon dioxide is released into the atmosphere. But fossil gas is itself a potent greenhouse gas (methane), and when it leaks from pipes and appliances without being burned, it also exacerbates climate change. Continued use of fossil natural gas in buildings is incompatible with the aggressive action needed to stave off the worst effects of climate change.

As the electricity generation system in California migrates to renewable sources, electricity will, in many cases, be the cheapest low-carbon fuel to use in buildings.[5] In addition, reducing gas use in buildings confers health and safety benefits to building occupants. Energy improvements to buildings can also reduce operating costs and energy expenditures, and improved insulation and HVAC systems can protect residents during heat waves or from wildfire smoke. Thus building decarbonization has health, resiliency, and greenhouse gas mitigation benefits.

Improving the energy performance of buildings has the potential to create good local jobs. Even when improved energy performance is dependent on swapping out one type of equipment for another, significant work needs to be done in buildings to accommodate, install, and maintain new equipment, and because building work cannot be offshored, policies that stimulate such investments in buildings create jobs for local workers. The City of Los Angeles and Los Angeles Department of Water and Power can advance innovative strategies to address the climate crisis, generate good local jobs, improve the building stock, and reduce cost burdens for low-income customers. These entities can launch pilots, adopt new regulations, and provide financial support for building improvements.

This paper estimates the investment required to achieve these goals and models the associated job growth by building sector and by trade. These benefits will not be realized, however, without intentional policy and program design. The strategies and recommendations outlined in this report provide the City with guidance on how to approach building decarbonization in order to maximize the benefits while mitigating negative impacts. The content provided is based on independent research. It does not reflect consensus among the city's community and labor stakeholders, but it does reflect many of their concerns and provides a foundation upon which stakeholder engagement and eventual solutions might be built.

5 Amber Mahone et al., "Residential Building Electrification in California: Consumer Economics, Greenhouse Gases and Grid Impacts" (Energy and Environmental Economics, Inc., April 2019), https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf.

At the same time, this paper is based on the inherent assumption that doing nothing is not an option. The City of Los Angeles has set ambitious and necessary targets to address climate change. The Energy and Water Efficiency Ordinance requires private buildings of 20,000 square feet and above and city buildings of 7,500 square feet and above to disclose annual energy and water consumption.[6] Executive Directive No. 25 requires new and renovated municipal buildings to be carbon neutral by 2030.[7] The City aims to achieve 100 percent net zero energy consumption by 2050, with all new buildings net zero carbon by 2030, and 100 percent of buildings net zero carbon by 2050.[8]

At the state level, the California Air Resources Board has issued a resolution calling for electrification of appliances to reduce greenhouse gas emission associated with natural gas combustion and to improve indoor air quality.[9] This follows Senate Bill 32, which requires the state to reduce emissions 40 percent below 1990 levels by 2030; Assembly Bill 3232 requiring a 40 percent reduction in building-based emissions by 2030; and Executive Order B-55-18 establishing a goal of statewide carbon neutrality by 2045.

These commitments reflect a sense of urgency. The effects of climate change in the Los Angeles region are no longer just projections. Heat waves and drought, fires, and floods affect the daily lives of Los Angeles residents. Fall of 2020 saw record high temperatures and fires. Warmer temperatures in the Sierra Nevada threaten LA's water supply. Climate scientists warn that these trends will continue. Climate change is real; it is here; and it is disproportionately harming LA's poor and working families. The challenge before the City of Los Angeles is to develop the tools and strategies to reduce emissions, protect its most vulnerable residents from the current and future harms of climate change, secure accessible and affordable housing for its residents, and ensure that the solutions deployed do not levy disproportionate impacts on poor and working people.

Principles for Building Decarbonization Policies and Programs

1. Invest in comprehensive building retrofits to produce healthier, resilient buildings

Fuel switching in buildings from natural gas to electric appliances will, alone, achieve emission reductions because electricity generation is getting cleaner. However, coupling fuel switching with both energy efficiency measures and building envelope improvements can reduce energy cost burdens, reduce peak demand for electricity both seasonally and over the course of a day to mitigate grid impacts, and better protect inhabitants from extreme weather events like heat waves. To maximize benefits to occupants and return on investment, upgrades should produce healthy, high-quality indoor environments by using materials without hazardous chemicals and addressing issues like mold, moisture, and ventilation. Public financial support for comprehensive building improvements in the rental market can be coupled with anti-displacement measures that preserve and expand housing and energy affordability. Upgrading schools and colleges not only reduces operational expenditures but can improve ventilation and indoor air quality for students and teachers.

6 "City of Los Angeles Energy and Water Efficiency Ordinance," L.A. Energy and Water Efficiency Resource Center for Building Owners, accessed May 5, 2021, https://www.betterbuildingsla.com/.
7 Eric Garcetti, "Executive Directive 25: L.A.'s Green New Deal: Leading By Example" (Office of Los Angeles Mayor Eric Garcetti, February 10, 2020), https://www.lamayor.org/mayor_garcetti_s_executive_directives.
8 Eric Garcetti, "L.A.'s Green New Deal | Sustainable City pLAn 2019," 2019, 56, https://plan.lamayor.org/node.
9 California Air Resources Board, "California Indoor Air Quality Program Update: Resolution 20-32," November 19, 2020, https://ww3.arb.ca.gov/board/res/2020/res20-32.pdf.

2. Consider and pilot district-scale solutions

While building codes target solutions for individual buildings, a broader approach that considers neighboring buildings can bring new and sometimes better solutions to the fore. There are instances where building energy needs are complementary (i.e., when one building needs to cool while others need to heat), and the most efficient approach to energy performance is to treat the collection of buildings as a single system, networking them through infrastructure-scale district energy solutions. The district approach to building decarbonization can be not only more cost effective, but dramatically more efficient by using waste heat as a resource. Current gas utilities and their workers could shift from servicing a network of pressurized pipes that supply buildings with gas to installing and servicing a network of pressurized pipes that provide heating and cooling services to buildings. By tapping into other energy sources, such as geothermal or waste heat, district-scale solutions also relieve pressure on the grid caused by increasing electrification.

3. Couple energy and water performance in new construction requirements

Building regulations should consider how buildings can use both energy and water more efficiently. Climate change will require much more efficient use of water, and one of the ways to do this is to construct buildings so that reclaimed water can be used for certain purposes. Dual piping requirements would allow the city to supply both potable and reclaimed water to a home or business, using separate water piping systems to prevent mixing of the two water supplies. This approach to new construction could make up for the work lost by not installing gas lines, while ensuring that buildings will remain functional in a more water-constrained future.

4. Ensure high quality jobs and improved access to economic opportunities

Thinking upfront about who will perform the work to improve building performance is also important. Engaging a skilled and trained workforce is fundamental in ensuring that the expected energy savings and emission reductions are actually achieved. Proper installation, calibration, and maintenance of equipment is essential, particularly as buildings become more integrated with and responsive to the grid. In addition to the energy benefits, conditioning permits and financial incentives on the use of a skilled and trained workforce can ensure that the work created supports city workers and their families. Apprenticeship standards ensure that new work will provide career-track training opportunities for new workers. Targeted hire standards on publicly funded projects and coordination with the City's many MC3 apprenticeship readiness programs can ensure job access for priority populations underrepresented in high-road construction jobs. Support, training, and capacity building of women and minority-owned business enterprises (WMBEs) can ensure diversity, equity, and inclusion on the contracting side.

5. Commit to equitable implementation that centers the priorities and concerns of those who stand to be most impacted (i.e., low-income tenants, communities, and workers).

Concerns around indoor air quality associated with gas appliances, the quality of rental housing, energy costs, and displacement caused by building improvements described at the beginning of this paper cannot be ignored. These are complex issues, and the best solutions will emerge from the community through a stakeholder engagement process.

Table 2. Summary of Concerns and Potential Solutions

Concern	Mitigation
High upfront investment costs of building retrofits could mean that low-income consumers will be left stranded with inefficient, unhealthy appliances and buildings.	Provide public financing to accelerate decarbonization of affordable housing. Leverage funding streams like Measures HHH, JJJ, and M in addition to state programs like CAMR, LIWP,[10] and SOMAH.
While reducing emissions from buildings is important, improving the health and safety and general quality of housing is also important, and sometimes more urgent than climate change goals.	Create a "one-stop-shop" for whole home upgrades that address health and safety repairs and rehabilitation, efficiency and weatherization, electrification, grid-interconnectivity, and resilience.
Landlords who make investments in building and energy improvements will seek to recoup such investments with high rents, triggering displacement.	Tie public financing, subsidies, and incentives to restrictions on rent increases and property sales and eviction protections for a specified period of time,[11,12,13] and undertake other proactive measures to preserve and expand affordable housing.[14,15,16]
Reduced gas throughput resulting from economic and environmental electrification will increase gas rates, thus exacerbating energy burden for remaining gas customers.	Rate design and increased bill support for energy-burdened customers, while avoiding using public resources to subsidize wealthy property owners.
Displacement of good-paying union jobs associated with gas infrastructure and delivery, particularly for utility workers and plumbers and pipefitters.	Protect jobs through dual piping code, VRF systems, district energy, or other solutions.
In the private construction market, there are no assurances that the jobs created will be high-road jobs.	Adopt skilled and trained workforce, apprenticeship standards, and other high road labor standards.
Investing in efficiency and beneficial electrification may not result in the anticipated energy savings and performance improvements.	Adopt rigorous performance and inspection standards to track, evaluate, and ensure high quality workmanship.

10 LIWP-Multifamily (California Climate Investments), "California Low Income Weatherization Program for Multifamily Properties," accessed June 1, 2021, https://camultifamilyenergyefficiency.org/about/propertyowners/.
11 See Section 4(C) of "An Act Providing for Building Justice with Jobs," Massachusetts Senate Bill No. 2226 (2021), https://malegislature.gov/Bills/192/SD2102.
12 See Section 2(C) of "Affordable Housing: Weatherization.," California Assembly Bill No. 1232 (2019), https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB1232.
13 Kaitlyn Quackenbush and Alexander Ferrer, "The Los Angeles Housing Crisis in the Wake of the COVID-19 Global Pandemic," The Just Recovery Series (Strategic Actions for a Just Economy [SAJE], November 19, 2020), p.24, https://www.saje.net/the-just-recovery-series/.
14 David Luberoff, "How Do We Proactively Preserve Unsubsidized Affordable Housing? | Joint Center for Housing Studies," *Joint Center for Housing Studies of Harvard University* (blog), May 23, 2018, https://www.jchs.harvard.edu/blog/how-do-we-proactively-preserve-unsubsidized-affordable-housing.
15 Family Housing Fund, "The Space Between: Realities and Possibilities in Preserving Unsubsidized Affordable Rental Housing," June 2013, https://www.fhfund.org/report/the-space-between-preserving-affordable-housing/.
16 It is important to note that two-thirds of LA's rental housing is owned by speculative investment vehicles. Limited funding should not go to corporate landlords who can absorb the cost of upgrades without subsidies. See: Alexander Ferrer, "Beyond Wall Street Landlords," The Just Recovery Series (Strategic Actions for a Just Economy (SAJE), February 24, 2021), https://www.saje.net/beyond-wall-street-landlords/."collection-title":"The Just Recovery Series","language":"en-US","publisher":"Strategic Actions for a Just Economy (SAJE

Jobs and business opportunities created to respond to growing demand for building rehabilitation and retrofits may not be accessible to disadvantaged workers or small women and minority-owned businesses.	Include in any publicly funded program both targeted hire and supplier diversity metrics. Support high-road construction pre-apprenticeship programs for targeted populations and capacity building for WMBEs.
Community stakeholders do not have the time, resources, or capacity to meaningfully engage on building decarbonization issues, but without their engagement, policies and programs will not be responsive to their needs.	Ensure broad, inclusive community engagement, education, and capacity-building especially in frontline communities through the CEMO and in partnership with community-based organizations.
Electrification of buildings and transportation puts new demands on the grid and the workers charged with maintaining grid reliability while accelerating the development of carbon-free electricity.	Promote smart appliances, grid-responsive buildings, and pursue district energy solutions to tap into alternative energy sources like geothermal and waste heat.

LOCAL EFFORT

The Apprenticeship Readiness Fund of the LAOC Building Trades Council works to expand the Multi-Craft Core Curriculum (MC3) training programs throughout Los Angeles and Orange Counties. They have partnered with over 25 high-schools and training organizations that prepare workers facing barriers to employment for apprenticeship training. By working with over 25 high-schools and organization like the Anti-Recidivism Coalition, Women in Non-Traditional Employment Roles (WINTER), the Flintridge Center, and YouthBuild this effort is designed to improve diversity, equity, and inclusion in the construction trades while providing people with second chances and pathways to the middle class. (http://laocbuildingtrades.org/apprenticeship-building-trades/pre-apprenticeship/)

LOCAL EFFORT

To engage small and minority contractors in energy efficiency work, the County of Los Angeles partnered with Emerald Cities Collaborative to offer the E-Contractor Academy, a seven-week program designed to prepare small and minority contractors to compete and perform energy efficiency retrofit projects for and within the County of Los Angeles. The County awards projects using a procurement strategy that promotes local, small contractor participation and an integrated workforce development strategy rooted in a direct pipeline to union apprenticeship. (https://e-contractoracademy.com/los-angeles)

LOCAL EFFORT

The RePower LA coalition, anchored by LAANE and SCOPE, works with LADWP and IBEW Local 18 to administer the Utility Pre-Craft Training Program. Participants in this program learn various electrical and water utility skills while earning $19/hour with healthcare benefits working on energy efficiency and solar projects in low-income communities. Participants remain in the program while studying for the civil service exams and interviewing for permanent positions at LADWP or other City Departments. (https://laane.org/blog/campaigns/energy-and-water/)

Employment Impacts of Building Decarbonization in Los Angeles

Job Gain Methodology and Data

Inclusive Economics built a building decarbonization jobs model to estimate the employment impacts of building decarbonization policies. The model is based on the following inputs and sources. Total costs are translated into jobs using IMPLAN multipliers, customized by type of work and sector.

1. Los Angeles Building Stock Summary

Los Angeles building stock data was obtained from the LA County Assessor's database, which was cleaned and compiled by researchers at the National Renewable Energy Laboratory for the Los Angeles 100% Renewable Energy Study (LA100). Additional building analysis was obtained from City Energy, a joint project of Natural Resources Defense Council and the Institute for Market Transformation, which used 2013 CoStar data, and the Building Electrification Initiative which used 2017 LA County Assessor's data coupled with GIS analysis. The resulting building stock data used in the jobs model for this analysis is shown in Figure 1. Distribution of Los Angeles Buildings by Square Footage with details in Table 3. Estimated Distribution of Los Angeles Residential Buildings and Table 4.

Figure 1. Distribution of Los Angeles Buildings by Square Footage

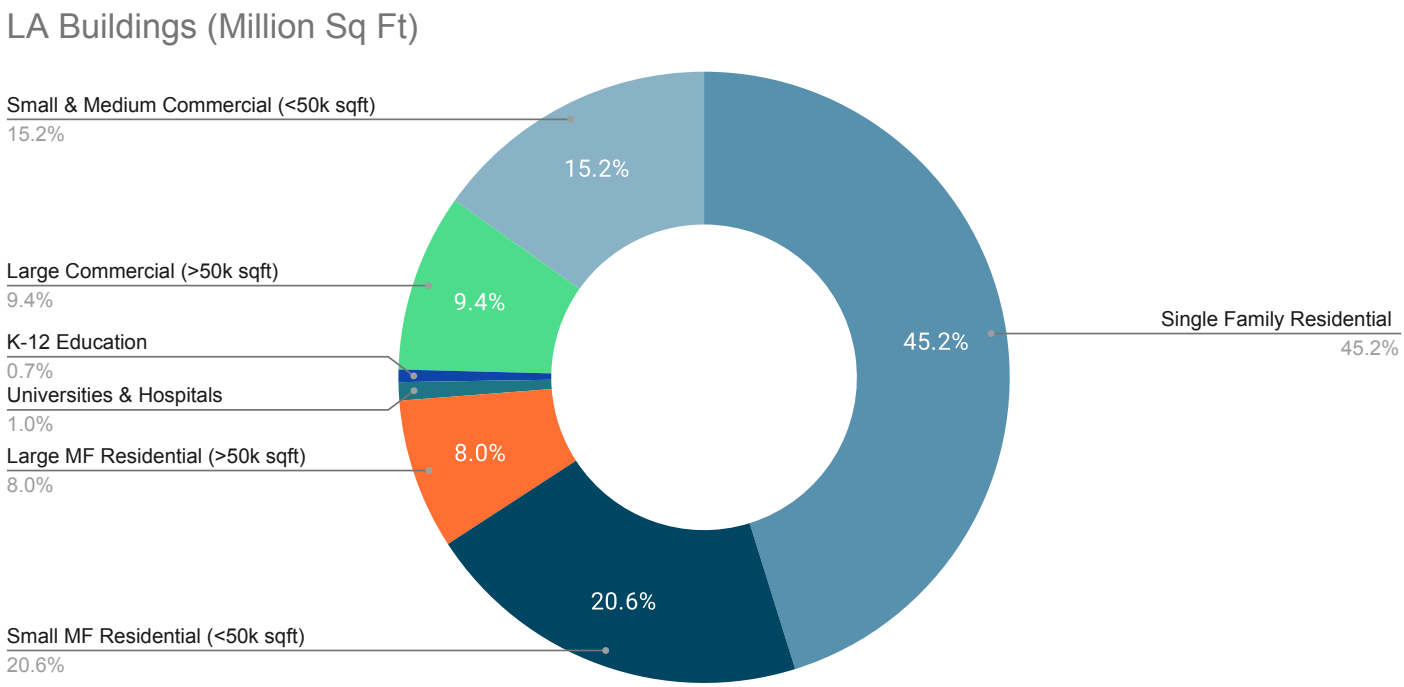


Table 3. Estimated Distribution of Los Angeles Residential Buildings

Residential Building Type	Floor Space (million square feet)	Number of Units	Number of Buildings	Percent of Total
Single Family and Duplex	1027.0	848,000	758,200	62%
Small Multifamily (<50k sq ft)	468.6	524,000	108,700	28%
*Affordable Small**		*277,000*	*57,500*	
Large Multifamily (>50k sq ft)	181.3	200,000	4100	10%
*Affordable Large**		*132,000*	2700	

*These figures are subsets of the total. They were estimated from the affordable housing analysis in a 2019 study conducted by Energy Efficiency for All (EEFA), which provides detail on deed restricted versus naturally occurring affordable housing, a distinction that is important for program design.[17]

Table 4. Estimated Distribution of Los Angeles Commercial Buildings

Commercial Building Type	Type of Building	Floor Space (million square feet)	Number of Buildings
K-12	Education - Primary School	2.8	519
	Education - Secondary School	12.5	968
	K-12 Total	**15.3**	**1487**
Higher Ed	Education - Community College	1.8	23
	Education - University	7.3	73
	Higher Ed Total	**9.1**	**96**
Hospitals	**Health/Medical - Hospital**	**12.9**	**219**
Commercial Small	Health/Medical - Nursing Home	9.8	391
	Lodging - Motel	7.2	606
	Office - Small	28.4	5,614
	Restaurant - Fast-Food	0.9	253
	Restaurant - Sit-Down	6.5	1698
	Retail - Small	118.3	14326
	Retail - Single-Story Large	4.3	62
	Grocery	5.6	251
	Assembly - Small	21.8	2163
	Manufacturing Light Industrial	85.7	6311
	Storage - Conditioned	60.5	2393
	Storage - Unconditioned	15.7	217
	Small Total	**344.6**	**34,006**
Commercial Large	Office - Large	154.1	627
	Retail - Multistory Large	17.3	202
	Assembly - Large	3.1	8
	Lodging - Hotel	19.4	167
	Large Total	**213.8**	**1,283**
TOTAL		**2.27 billion sq ft**	**37,100**

17 Energy Efficiency for All, "Affordable Homes First: Advancing a Green New Deal for Los Angeles Renters" (Energy Efficiency for All, May 2019), https://www.energyefficiencyforall.org/resources/advancing-a-green-new-deal-for-los-angeles-renters/.

2. Market Analysis, Including Gas Saturation

Present-day appliance gas and electric saturation data for end uses was obtained from the Residential Appliance Saturation Survey (RASS) conducted by DNV-GL and Commercial End Use Survey (CEUS) conducted by Itron, both led by the California Energy Commission.[18,19] Results from the 2019 RASS and 2020 CEUS are still forthcoming from the CEC. Gas saturation by end use is summarized in Appendix A.

In addition to building gas consumption by end use, we assumed 95 percent of buildings could use energy efficiency upgrades and 35 percent will require panel and service upgrades to fully electrify. The panel upgrade estimate is based on building vintage and renovation rates of 0.5 to 1 percent.

3. Investment Costs and Distribution of Costs

Efficiency and electrification costs were obtained from a wide range of sources including published literature, case studies, construction cost estimators, and interviews with industry professionals. In addition to total upfront costs, we gathered information on the marginal costs of replacing gas with electric appliances. We looked at how costs were distributed, not only between equipment, labor, and overhead, but also to account for different types of work, corresponding to different trades. These cost estimates are provided in Appendix B.

4. Employment Multipliers

Off-the-shelf economic models do not work well for building decarbonization. While IMPLAN uses 542 different industries, there are only two industries that cover building retrofit work—one for commercial building repairs and one for residential building repairs. Building decarbonization activities are similar to building repairs but differ in important ways. For example, the distribution of costs for building electrification are more capital intensive than a typical building repair, and the wages of workers can vary significantly depending on the sector and type of work. For this reason, we used construction cost estimators and extensive literature review to determine the distribution of costs and customize jobs/$ million multipliers. The total investment figures are shown in Table 5. Estimated Upfront Investment Required.

18 Kema, Inc. et al., "2009 California Residential Appliance Saturation Study: Executive Summary" (California Energy Commission, October 2010), https://planning.lacity.org/eir/CrossroadsHwd/deir/files/references/C18.pdf.
19 Itron, Inc., "California Commercial End-Use Survey" (California Energy Commission, March 2006), https://planning.lacity.org/eir/CrossroadsHwd/deir/files/references/C19.pdf.

Table 5. Cost Estimates by End Use

TOTAL	RESIDENTIAL									COMMERCIAL					
	Single Family			Small Multifamily			Large Multifamily			Small & Medium			Large Commercial		
	Low	High	Per (Unit)	Low	High	Per (Unit)	Low	High	Per (Unit)	Low	High	Per (Unit)	Low	High	Per (Unit)
Benchmarking							$580	$750	*building*	$580.00	$750.00	*building*	$580.00	$750.00	*building*
Basic Efficiency 10–14%	$3,100	$5,400	*unit*	$2,600	$4,300	*unit*	$2,300	$3,800	*unit*	$2.60	$4.20	*sq ft*	$2.60	$4.20	*sq ft*
Efficiency 15–30%	$8,200	$12,200	*unit*	$7,200	$10,200	*unit*	$6,600	$9,200	*unit*	$8.60	$11.50	*sq ft*	$8.60	$11.50	*sq ft*
Deep Energy Retrofit 30%+	$20,600	$33,500	*unit*	$19,000	$30,200	*unit*	$18,100	$28,500	*unit*	$33.65	$40.36	*sq ft*	$33.65	$40.36	*sq ft*
Space Heating/ Cooling Electrification	$19,500	$20,500	*unit*	$9,000	$11,000	*unit*	$11,600	$12,200	*unit*	$4.00	$11.33	*sq ft*	$19.00	$28.00	*sq ft*
Water Heating Electrification	$3,000	$3,100	*unit*	$1,180	$2,740	*unit*	$890	$1,180	*unit*	$0.79	$0.88	*sq ft*	$0.44	$0.52	*sq ft*
Dryer Electrification	$1,000	$1,800	*unit*	$1,300	$2,600	*building*	$1,300	$2,600	*building*			*sq ft*			*sq ft*
Miscellaneous										$1.50	$2.00	*sq ft*	$1.50	$2.00	*sq ft*
Cooking Electrification	$1,400	$2,900	*unit*	$1,400	$2,900	*unit*	$1,400	$2,900	*unit*	$16.00	$20.00	*sq ft of kitchen space*	$16.00	$20.00	*sq ft of kitchen space*
Gas Disconnection	$400	$600	*unit*	$600	$800	*building*	$600	$800	*building*	$800.00	$1,000	*building*	$1,200	$1,600	*building*
Panel up-grades	$4,400	$4,500	*unit*	$11,540	$89,600	*building*	$179.2k	$281k	*building*	$20k	$40k	*building*	$68k	$128k	*building*

Results

The following tables provide the jobs, work hours, and upfront investment required to achieve building efficiency and electrification across a range of building sectors. These results are presented in modules with the most aggressive building decarbonization actions in the furthest right columns. Technologies will continue to evolve, and this analysis is based on currently available options and likely retrofit scenarios based on literature review and interviews with industry experts. Also, every building is unique and the specific technologies appropriate for a particular building may mean that total projects costs for particular projects could deviate from the cost ranges assumed.

The donut charts following the tables provide an estimated distribution of work hours by trade. For electrification, we have provided both the *total* jobs, which are the number of full-time equivalent (FTE) workers required to meet the decarbonization goal, and *incremental* jobs, indicating the marginal increase in work resulting from replacing a broken or old gas appliance with an efficient electric alternative.

Except when otherwise noted, "jobs" are "job years." A job year is an FTE job for one year, and can be converted to and from work hours. In this paper, one job-year is equivalent to 1800 work hours. This is based on 40-hour work weeks, 52 weeks a year, with 10 holidays, 10 sick days, and 3 weeks of vacation.

To convert job years into careers, we divide the job years by the number of years over which the investment will occur. For example, 1000 job years over 25 years will support 40 full-time, 25-year careers. With continuous investment "temporary" construction jobs can be strung together to support a worker over the course of their career.

Residential Sector Results

Residential customers consume 40 percent of the natural gas consumed in LA County and about 70 percent of the gas consumed in buildings.[20] Generally, single family homes use more gas than multifamily homes due to more common use of gas for space heating, water heating, and cooking as well as their larger unit size. As shown in Table 6 and Table 7, policies to encourage residential homeowners to invest in mid-level cost-effective efficiency upgrades and beneficial electrification could support 3,290–4,900 *new* long-term jobs for city residents.

One challenge, however, is that only about 80 percent of these jobs are in the single family and small multifamily markets, where poor job quality is a persistent challenge. Violations of labor laws and building codes in the small residential sector are common, and enforcement is necessary to support improved job quality. In addition, low cost is the primary driver of competition between firms serving the residential sector. Business models built on providing the lowest-cost service are often premised on low, sometimes illegal wages. Furthermore, when competition is driven by low cost, higher performing contractors will seek other labor markets where they can adequately compensate and retain their skilled workforce.
It will be difficult to change the residential construction market dynamics, but these concerns around job quality should be considered in the design of incentives and programs so that the use of public resources does not, inadvertently, further entrench these dynamics.

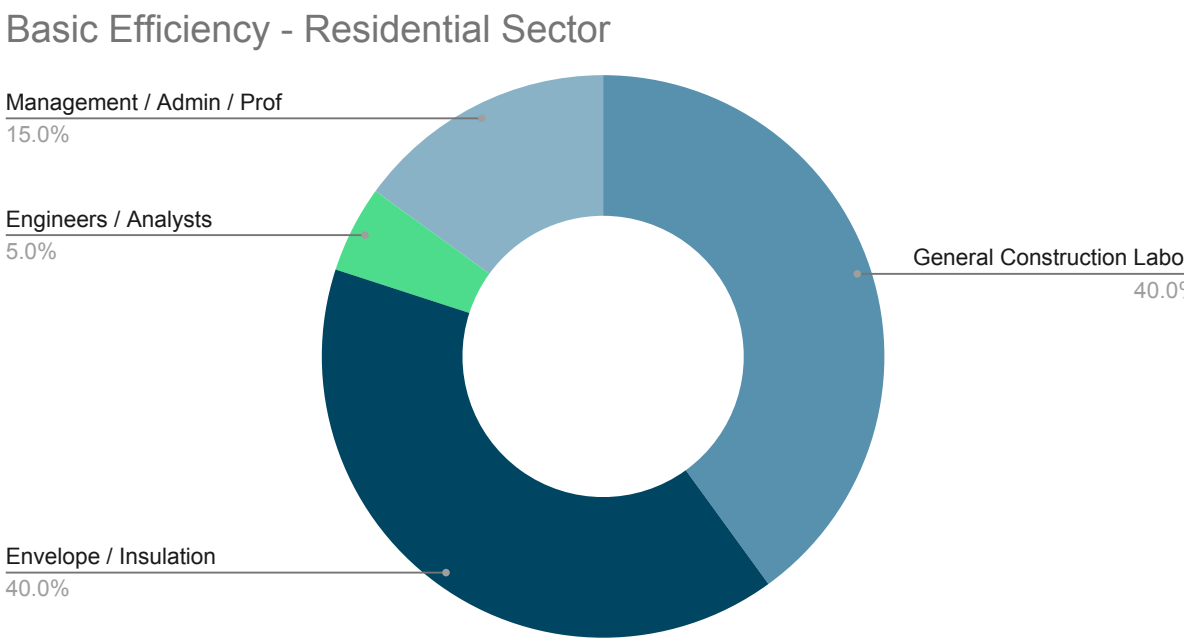
20 California Energy Commission, "Gas Consumption by County," CA.gov, accessed May 5, 2021, http://www.ecdms.energy.ca.gov/gasbycounty.aspx.

Table 6. Jobs and Careers Supported by Investments in Building Efficiency Retrofits

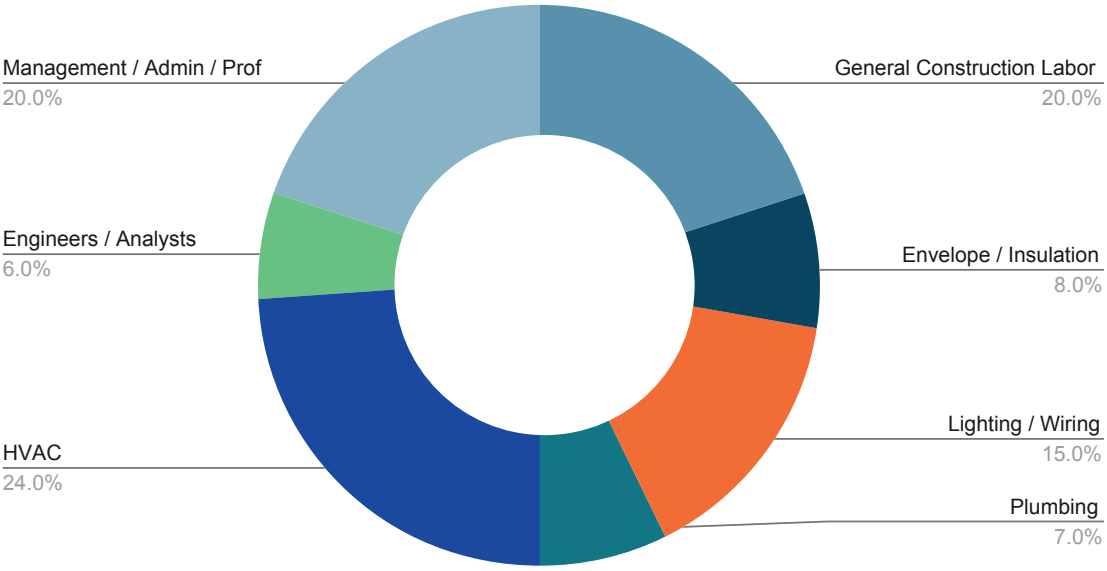
	Basic Efficiency 10–14%	Mid-Efficiency 15–30%	Deep Efficiency >30%
Single Family Jobs	22,000 - 38,000	30,000 - 44,000	106,000 - 172,000
Small MF Jobs	11,000 - 19,000	15,000 - 22,000	43,000 - 69,000
Large MF Jobs	4,000 - 6,000	7,000 - 10,000	11,000 - 18,000
Sum of Work Hours	67 - 114M	94 - 136M	288 - 464M
Total Investment Cost	$4.2 - 7.2B	$11.4 - 16.6B	$29.5 - 47.4B
25-Year Careers Supported	1,480 - 2,520	2,080 - 3,040	6,400 - 10,360

Deeper efficiency retrofits require higher levels of investment and support more jobs. In addition, the types of jobs are more variable than with lighter levels of efficiency, as shown in Figure 2. Distribution of Jobs by Trade, Residential Efficiency.

Figure 2. Distribution of Jobs by Trade, Residential Efficiency



Deep Efficiency - Residential Sector



Mid-Efficiency - Residential Sector

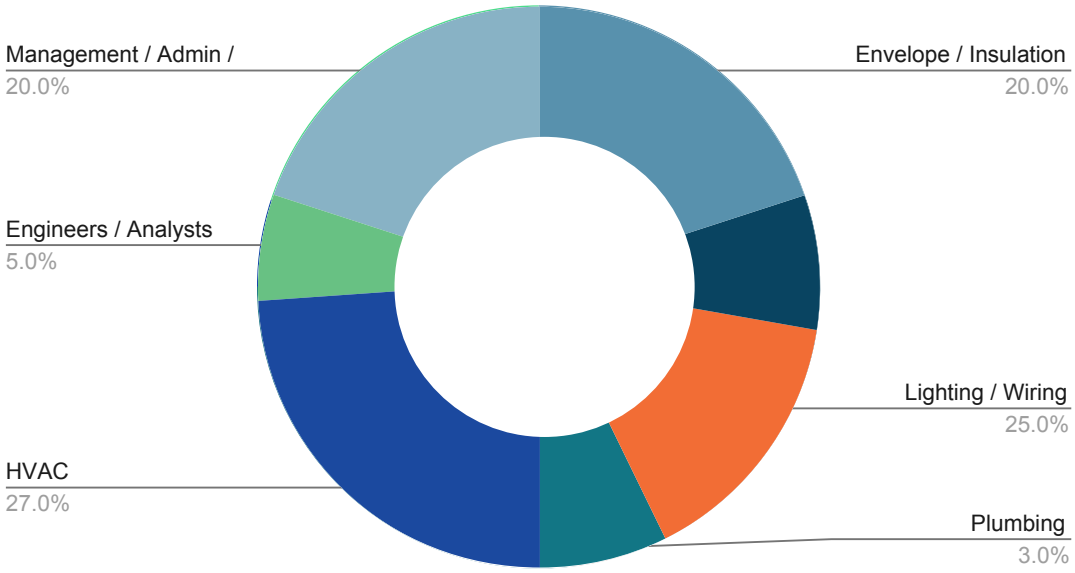


Table 7. Jobs and Careers Supported by Investments in Beneficial Electrification Retrofits

	Space Heating & Cooling Electrification	Water Heating Electrification	Whole Building Electrification*
Single Family Jobs	54,200 - 57,000	10,200 - 10,500	70,600 - 79,200
Incremental Jobs	*12,800 - 13,900*	*2,900 - 3,000*	*21,200 - 24,300*
All Small MF Jobs	11,800 - 14,500	1,600 - 3,700	16,400 - 33,400
Incremental Jobs	*1,800 - 3,300*	*700 - 2,000*	*5,700 - 17,900*
All Large MF Jobs	8,200 - 8,600	300 - 400	10,100 - 12,100
Incremental Jobs	*1,700 - 2,000*	*100 - 200*	*3,300 - 4,400*
Sum of Total Work Hours	133.6 - 144.1M	21.7 - 26.4M	174.7 - 224.6M
Total Investment Cost	$20.0 - 21.6B	$3.0 - 3.8B	$27.8 - 35.8B
Incremental Cost	*$4.4 - 5.2B*	*$1.0 - 1.5B*	*$9.8 - 15.4B*
New/Additional 25-Year Careers Supported (Incremental Work)	650 - 770	150 - 210	1,210 - 1,860

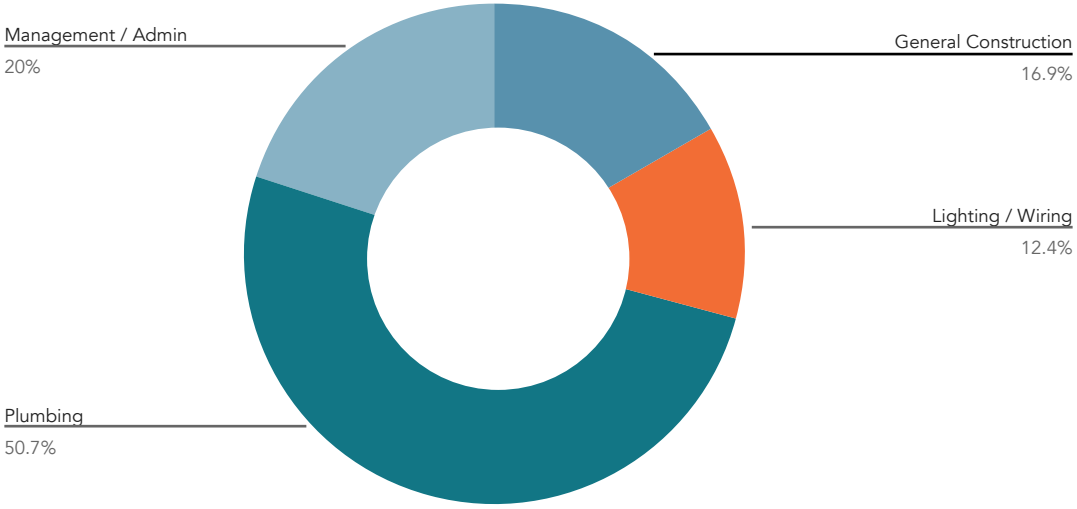
*Whole Building Electrification includes gas disconnections, miscellaneous appliance electrification, and panel upgrades, assumed to be required for 35 percent of buildings.

The primary sources of jobs in residential electrification are space heating/cooling and electric service and panel upgrades. With the replacement of water heaters, stoves, and dryers with efficient electric alternatives, much of the cost is the equipment itself, with little work required to install other than running a dedicated circuit for appliances. In the case of heat pump water heaters, plumbing and sometimes duct work is also required. What makes residential electrification practically challenging is the small scale and multi-craft nature of it.

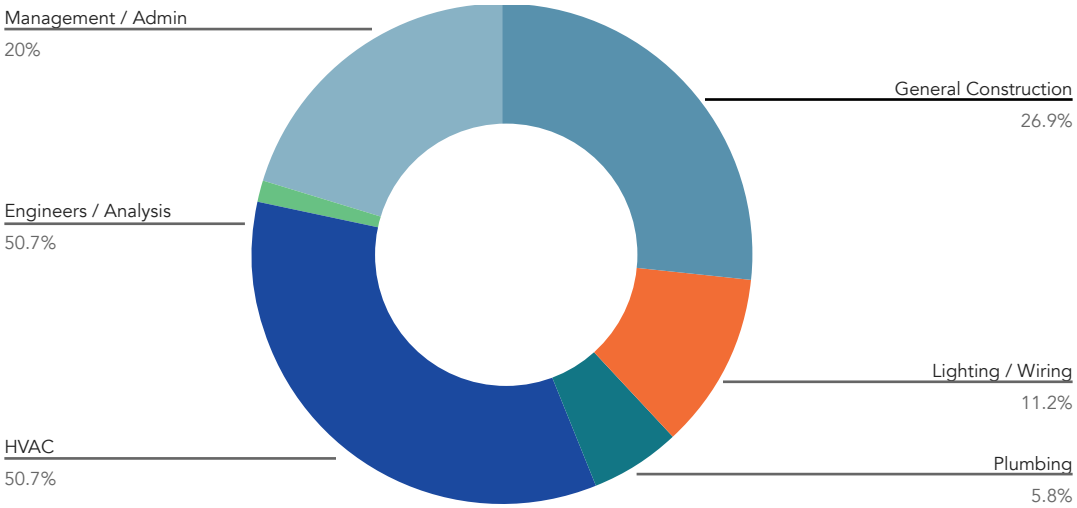
To address both this tendency towards inefficiency and the job quality concerns flagged above, one solution to consider and pilot is neighborhood scale decarbonization. Ideal targets would be neighborhoods in need of major gas infrastructure repair. This would require cooperation with both the gas and electric utilities as well as affected residents.

Figure 3. Distribution of Jobs by Trade, Residential Eelectrification

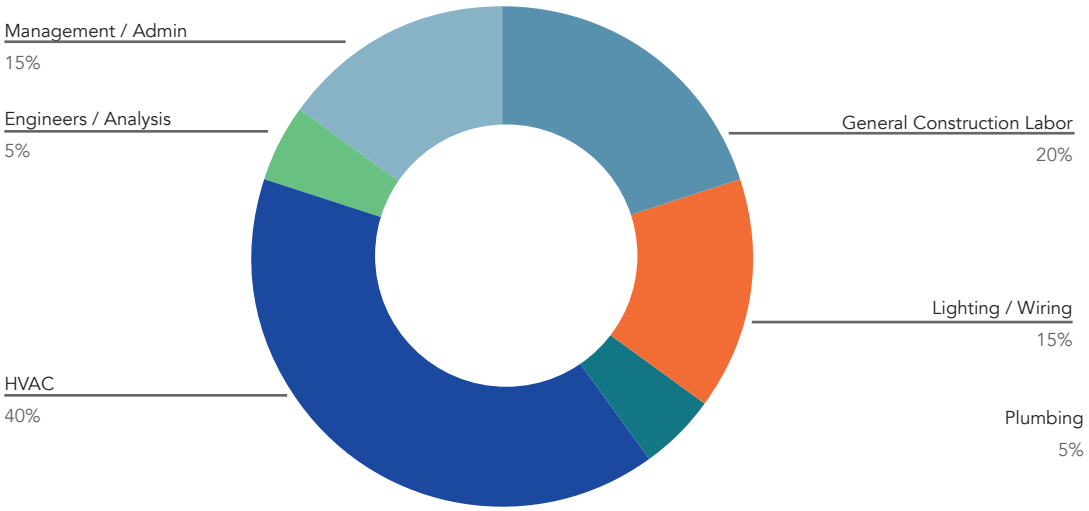
Residential Water Heating Electrification



Residential Space Heating Electrification



Residential Whole Building Electrification



Affordable Housing Results

To support advocacy for programmatic investments in retrofits of Los Angeles affordable housing, we estimated the job potential and investment requirements for energy efficiency upgrades and beneficial electrification for LA's deed-restricted and naturally-occurring affordable housing. Because of the need for public funding for affordable housing decarbonization and rehabilitation, there is the opportunity to attach labor standards, targeted hire standards, and supplier diversity metrics to subsidies and incentives in order to support job quality and equitable access. This can be accomplished through responsible contractor pre-qualification, skill standards, wage standards, targeted hire metrics for individuals from low-income zip codes or specified high-road training programs, or a combination of these levers.

These sorts of workforce standards are most effective when there are simultaneous investments on the workforce education, training, and support services side. Programs that provide wide-ranging support services for disadvantaged workers and capacity building training for minority contractors can ensure equitable outcomes for underserved and under-represented populations. It is essential to calibrate workforce education and training with market demand so that programs are not training people for jobs that don't yet exist. It is also essential that the jobs created provide career potential and upward mobility.

Table 8. Jobs and Careers Supported by Investments in Affordable Housing Building Efficiency Retrofits and Table 9 show that deep efficiency retrofits and beneficial electrification of LA's affordable housing would require a total upfront investment of $11.5–18.7 billion. If invested over a 10-year period, this would support 4,560–7,360 careers for city residents. A 10-year investment, however, assumes early replacement of existing gas appliances and is therefore a higher cost solution than an electrify-upon-burnout solution.

Table 8. Jobs and Careers Supported by Investments in Affordable Housing Building Efficiency Retrofits

	Basic Efficiency 10–14%	**Mid-Efficiency 15–30%**	**Deep Efficiency >30%**
Affordable Housing (deed restricted) Jobs	1,400 - 2,400	2,500 - 3,500	4,400 - 7,000
Sum of Work Hours	2.6 - 4.3M	4.5 - 6.3M	7.9 - 12.5M
Total Investment Cost	$160 - 270M	$470 - 660M	$1.3 - 2.0B
Affordable Housing (naturally occurring) Jobs	7,100 - 11,800	10,300 - 14,500	25,800 - 40,900
Sum of Work Hours	12.8 - 21.2M	18.5 - 26.1M	46.4 - 76.6M
Total Investment Cost	$810M - $1.3B	$2.3 - 3.2B	$6.0 - 9.5B
10-Year Careers Supported	850 - 1,420	1,280 - 1,800	3,020 - 4,790

Table 9. Jobs and Careers Supported by Investments in Affordable Housing Beneficial Electrification Retrofits

	Space Heating & Cooling Electrification	**Water Heating Electrification**	**Whole Building Electrification***
Affordable Housing (deed restricted) Jobs	2,800 - 3,000	100 - 200	3,500 - 4,500
Incremental Jobs	*600 - 700*	*100*	*1,100 - 1,800*
Sum of Work Hours	5.0 - 5.4M	250 - 400K	7.9 - 12.5M
Total Investment Cost	$640 - 690M	$50 - 70M	$860M - 1.1B
Incremental Cost	*$130 - 160M*	*$20 - 30M*	*$300 - 490M*
Affordable Housing (naturally occurring) Jobs	8,900 - 10,400	900 - 2,000	11,900 - 21,200
Incremental Jobs	*1,500 - 2,300*	*400 - 1,100*	*4,000 - 10,600*
Sum of Work Hours	16.0 - 18.6M	1.7 - 3.7M	21.4 - 38.1M
Total Investment Cost	$2.3 - 2.7B	$280 - 610M	$3.3 - 6.1B
Incremental Cost	*$390 - 610M*	*$120 - 320M*	*$1.3 - 3.6B*
New/Additional 10-Year Careers Supported (Incremental Work)	210 - 300	50 - 120	510 - 1,240

*Whole Building Electrification includes gas disconnections, miscellaneous appliance electrification, and panel upgrades, assumed to be required for 35 percent of buildings.

Commercial Sector

Non-residential gas use in Los Angeles County accounts for 60 percent of total natural gas consumption, but most of that is industrial use. Commercial buildings in the Southern California Gas territory consume 17.5 percent of total gas use (30 percent of gas used in buildings).[21] Labor market dynamics in the small commercial sector are similar to those in the residential sector: cost is the key factor firms use to secure competitive advantage, and this can result in low-paying jobs.

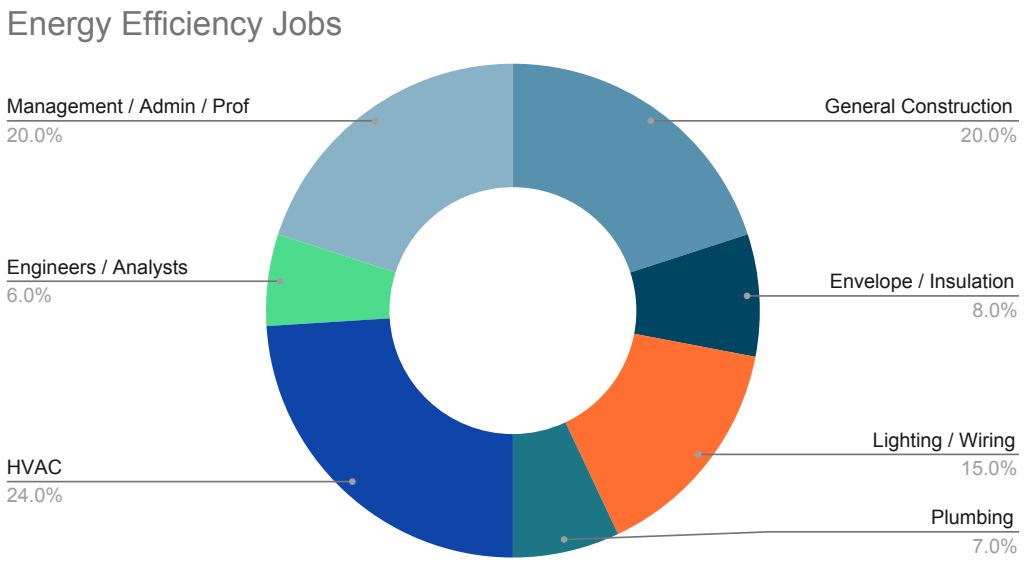
Table 10. Jobs and Careers Supported by Investments in Commercial Building Efficiency Retrofits and Table 11 show significant energy efficiency job opportunities in both the small and large commercial sectors. Requirements to improve building energy performance would lead to a combination of efficiency and fuel switching improvements.

Table 10. Jobs and Careers Supported by Investments in Commercial Building Efficiency Retrofits

	Basic Efficiency 10–14%	**Mid-Efficiency 15–30%**	**Deep Efficiency >30%**
All Small Commercial Jobs	6,800 - 11,100	15,100 - 20,100	37,300 - 44,700
Sum of Work Hours	12.3 - 19.9M	27.1 - 36.2M	67.1 - 80.5M
Total Investment Cost	$890M -1.4B	$2.9 - 3.9B	$11.5 - 13.8
All Large Commercial Jobs	3,500 - 5,700	8,400 - 11,200	19,300 - 23,100
Sum of Work Hours	6.4 - 10.3M	15.1 - 20.2M	34.7 - 41.6M
Total Investment Cost	$460 - 740M	$1.5 - 2.0B	$6.0 - 7.1B
25-Year Careers Supported	410 - 670	940 - 1,250	2,260 - 2,710

Efficiency jobs are widely distributed across different trades. Large whole-building energy efficiency projects also require engineering-grade energy audits.

Figure 4. Distribution of Jobs by Trade, Commercial Efficiency Retrofits



21 California Energy Commission, "Gas Consumption by Entity," CA.gov, accessed June 1, 2021, https://ecdms.energy.ca.gov/gasbyutil.aspx.

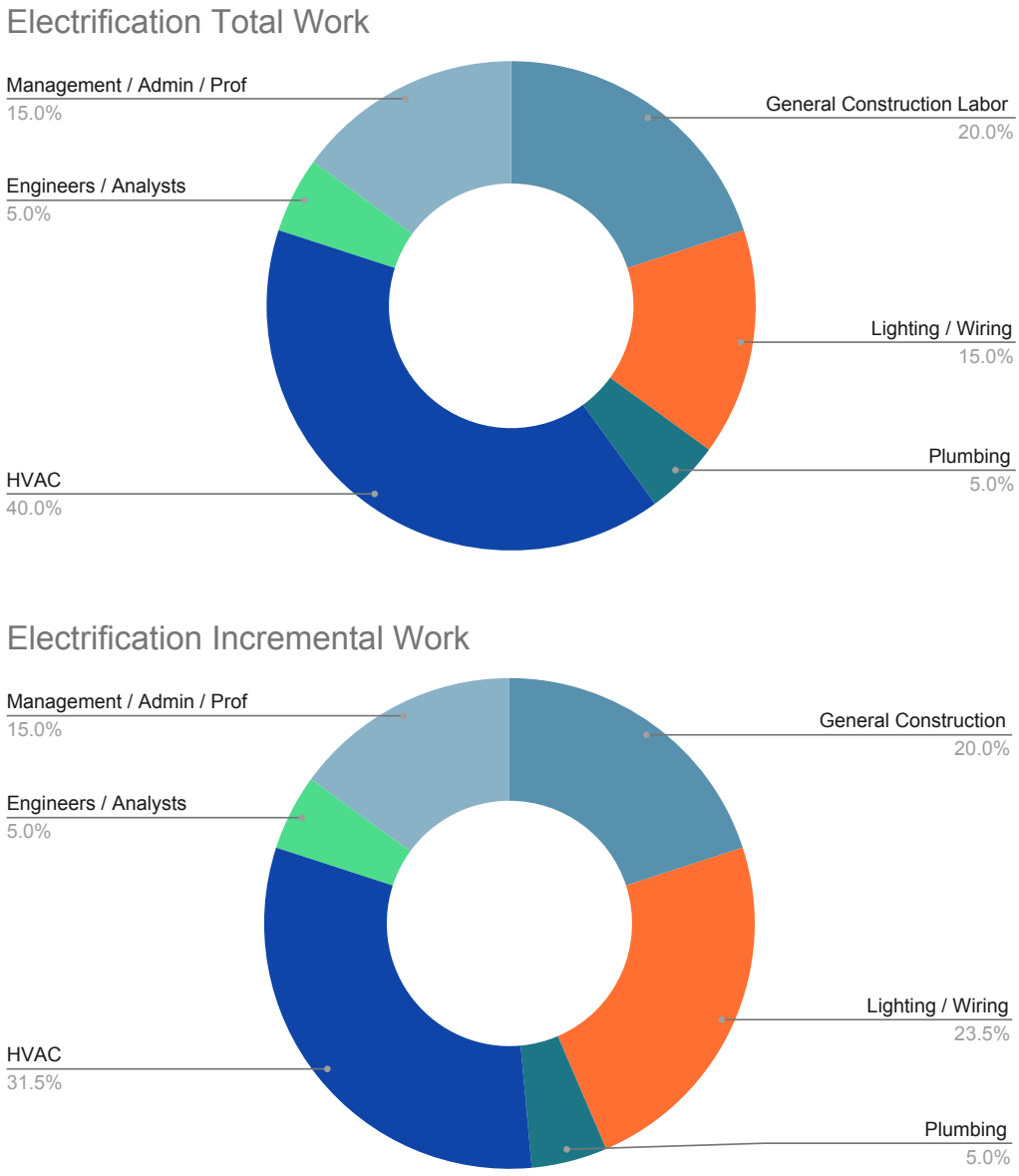
Table 11. Jobs and Careers Supported by Investments in Commercial Beneficial Electrification Retrofits

	Space Heating & Cooling Electrification	Water Heating Electrification	Whole Building Electrification*
All Small Commercial Jobs	2,400 - 6,800	500 - 600	4,500 - 9,400
Incremental Jobs	*800 - 2,600*	*150 - 200*	*2,300 - 5,300*
Sum of Work Hours	4.3 - 12.2M	900K - 1.0M	8.0 - 17.0M
Total Investment Cost	$600M - 1.6B	$170 - 190M	$1.2 - 2.6
Incremental Cost	*$190 - 620M*	*$50 - 70M*	*$580M - 1.4B*
All Large Commercial Jobs	8,600 - 12,700	200 - 300	9,100 - 13,400
Incremental Jobs	*1,500 - 2,600*	*100*	*1,900 - 3,200*
Sum of Work Hours	15.5 - 22.8M	400 - 500K	16.5 - 24.1M
Total Investment Cost	$2.1 - 3.0B	$60 - 70M	$2.3 - 3.3B
Incremental Cost	*$430 - 740M*	*$30 - 40M*	*$540 - 920M*
New/Additional 25-Year Careers Supported (Incremental Work)	90 - 210	10	170 - 340

*Whole Building Electrification includes gas disconnections, miscellaneous appliance electrification, and panel upgrades, assumed to be required for 35 percent of buildings.

HVAC and water heating systems in existing buildings require ongoing maintenance, repair, and, eventually, replacement. The most cost-effective opportunity to reduce gas use in buildings is to replace gas equipment at the end of its useful life when it needs to be replaced anyway. Figure 5. Distribution of Jobs by Trade, Beneficial Electrification, Commercial Sector shows the distribution of total work hours involved in electrifying LA's commercial buildings and the distribution of the new (incremental) work hours involved in beneficial electrification. Electrifying at the time of equipment replacement shifts the distribution of work slightly, increasing the demand for electricians. Electrifying a building when equipment burns out requires more workers than business-as-usual, and there is no system (i.e., electrical, plumbing, HVAC, general carpentry, etc.) requiring fewer hours of work in this situation.

Figure 5. Distribution of Jobs by Trade, Beneficial Electrification, Commercial Sector



Schools and Hospitals Results

To tackle building energy performance in non-residential buildings in a way that is compatible with good jobs and community benefits, investments could be made in schools and other public-service sectors such as universities and hospitals. Table 12. Jobs and Careers Supported by Investments in School and Hospital Building Efficiency Retrofits and Table 13 show these employment projections of these investments in schools. For a total investment of $220–370M, Los Angeles could decarbonize (mid-efficiency plus full electrification) all K-12 school buildings. We estimate that $50–110 million of this amount would be required anyway for necessary repairs and replacements of gas-burning equipment.

There are local and state funding sources that could complement new city investments in improved energy performance of these buildings. For example, Measure RR provides $7 billion for improved building facilities and safety measures in the Los Angeles Unified School District, and AB 841 provides funding for school efficiency in territory served by investor-owned utilities, including Southern California Gas. When concentrated public investments are made, contracts such as project labor agreements or community workforce agreements can specify labor and wage standards, as well as targeted hire metrics, to ensure that the investments are supporting job quality and job access.

Table 12. Jobs and Careers Supported by Investments in School and Hospital Building Efficiency Retrofits

	Basic Efficiency 10–14%	**Mid-Efficiency 15–30%**	**Deep Efficiency >30%**
K-12 Schools Jobs	300 - 500	600 - 900	1,600 - 1,900
Sum of Work Hours	520 - 850k	1.2 - 1.5M	2.9 - 3.4M
Total Investment Cost	$40 - 60M	$130 - 170M	$490 - 590M
10-Year Careers Supported	30 - 50	60 - 90	160 - 190
Universities & Hospitals Jobs	300 - 500	800 - 1,000	1,800 - 2,200
Sum of Work Hours	590 - 960k	1.4 - 1.9M	3.2 - 3.9
Total Investment Cost	$40 - 70M	$140 -190M	$560 - 670M

Table 13. Jobs and Careers Supported by Investments in School and Hospital Beneficial Electrification Retrofits

	Space Heating & Cooling Electrification	Water Heating Electrification	Whole Building Electrification*
K-12 Education Jobs	200 - 600	30 - 40	300 - 700
Sum of Work Hours	390K - 1.1M	60 - 70k	580K - 1.3M
Total Investment Cost	$50 - 150M	$11 - 13	$90 - 200M
Incremental Jobs	70 - 230	10 - 15	140 - 350
Incremental Cost	$20 - 60M	$3 - 4M	$40 - 90M
10-Year Careers Supported**	20 - 60	3 - 4	30 - 70
Universities & Hospitals Jobs	1,500 - 2,200	30	1,600 - 2,300
Sum of Work Hours	2.7 - 3.9M	50 - 60k	2.8 - 4.1M
Total Investment Cost	$360 - 520M	$7-9M	$390 - 570M
Incremental Jobs	300 - 500	10	300 - 600
Incremental Cost	$80 - 130M	$4 - 5M	$90 - 160M

*Whole Building Electrification includes gas disconnections, miscellaneous appliance electrification, and panel upgrades, assumed to be required for 35 percent of buildings.

**An accelerated timeline could lead to some electrification of gas appliances before the end of their useful life.

Summary of Employment Projections

Summarizing the above findings, we aggregated the results into the "low-road" and "high-road" market sectors. The numbers in Table 14. Summary Building Decarbonization Careers (2021–2050) (Deep Efficiency + Electrification)can be interpreted as full-time jobs lasting 29 years (2021–2050). Continuous investment in building energy performance could support 8,820–12,270 *new, full-time* workers in LA's construction industry for 29 years (2021–2050).

Without policy action to change course, however, 85 percent of these jobs will be in traditionally "low-road" market sectors, where firms compete by outbidding each other. This ultimately proves problematic for consumers who, unable to evaluate the quality of a new air source heat pump installation for example, experience comfort or cost problems due to poor quality installation or commissioning. Firms who do invest in a skilled and trained workforce have trouble competing and may get out of residential work altogether. Without efforts to evaluate and ensure work quality in the residential and small commercial sectors, on behalf of consumers, work quality and job quality will remain, at best, highly variable, which is problematic for market transformation.

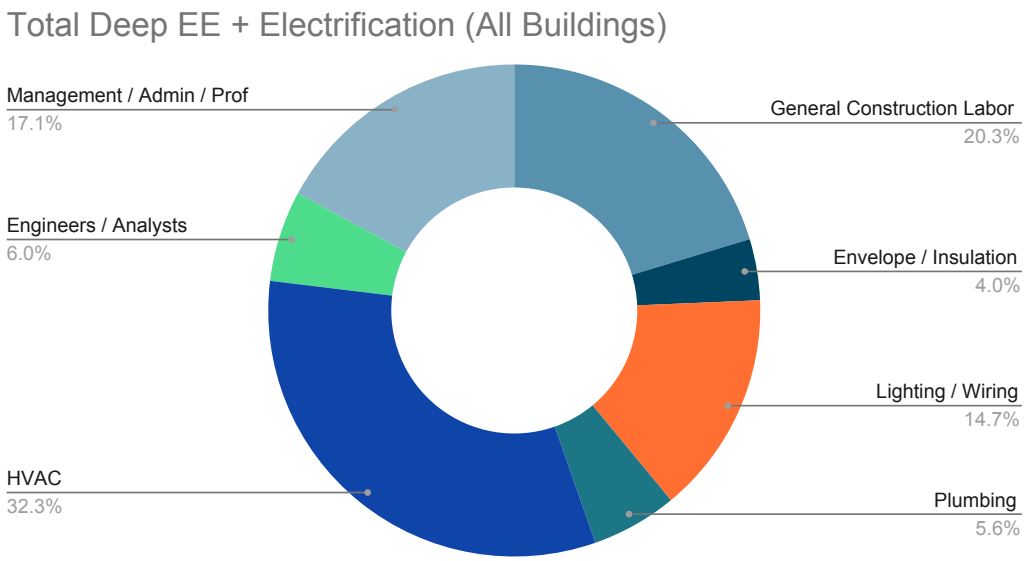
When early adopters pay for a service anticipating that it will enhance their lives and save them money and those benefits are not realized, market transformation grinds to a halt. For this reason, incentives to encourage electrification must be tied to responsible contractor criteria and rigorous inspection and quality assurance processes.

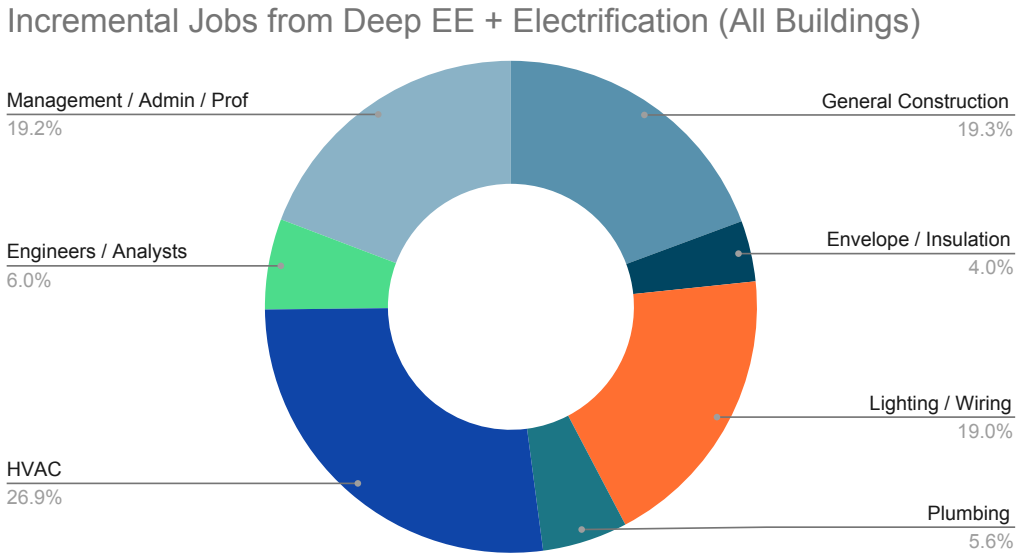
Table 14. Summary Building Decarbonization Careers (2021–2050) (Deep Efficiency + Electrification)

	Deep EE*	Whole Building Electrification**	Total Decarbonization
Careers, Low-Road (Small Residential and Small Commercial, Except Schools)	6,360 - 9,760	3,150 - 4,200	11,000 - 15,600
Total Investment Cost	$37.1 - 55.2B	$26.5 - 35.4B	$63.6 - 90.7B
Incremental Jobs		1,000 - 1,630	7,530 - 11,530
Incremental Cost		$9.5 - 15.6B	$46.6 - 70.8B
Careers, High-Road (Large Buildings + Schools, Universities, Hospitals)	1,100 - 1,470	700 - 940	1,750 - 2,340
Total Investment Cost	$9.9 - 13.1B	$4.9 - 6.7B	$14.8 - 19.8B
Incremental Jobs		190 - 280	1,280 - 1,740
Incremental Cost		$1.4 - 2.2B	$11.3 - 15.3B
Total Careers (Supported 2021–2050)	7,460 - 11,230	3,850 - 5,130	12,750 - 17,940
Total Investment Cost	$47.0 - 68.4B	$31.5 - 42.1B	$78.4 - 110.5B
Incremental Jobs		1,190 - 1,910	8,820 - 13,270
Incremental Cost		$10.9 - 17.8B	$57.9 - 86.2B

*Assumes that no EE happens without policy or program.
**Assumes that 35 percent of building require electric panel and service upgrades.

Figure 6. Distribution of Jobs by Trade, Deep Energy Efficiency and Beneficial Electrification, Existing Buildings in Los Angeles





District Energy Approach

Rather than approach building decarbonization as a challenge that can only be solved by replacing gas with electric equipment, some buildings are good contenders for networked solutions. The gas distribution system is a network, as is the electricity distribution system, but neither is designed to take advantage of buildings themselves as sources of beneficial energy and sinks for waste energy. District energy systems connect buildings with complementary heating and cooling needs, so that waste heat for one building like a grocery store or data center can be used as source heat for another building or cluster of buildings like an office or apartment complex.

Traditionally, district energy systems have been known as district heating. A combustion process heats water to steam in a central plant, and heat is distributed (as steam) to a network of buildings connected to a loop of underground pipes. Many district heating systems make use of combined heat and power, where the steam used to generate electricity is used again to provide heating to buildings (or in an industrial setting, for process heat).

Today, district systems around the world are using renewable energy and waste heat to produce hot water rather than steam. Water is piped underground to networked buildings where it is used to either provide heat or absorb heat through heat exchangers, thus providing both heating and cooling. These systems can use geothermal, solar electricity or thermal energy, or even unconventional sources of energy like heat from sewage or wastewater to warm water.[22] In addition to providing heating and cooling to buildings, these systems are sometimes used for hot water needs in buildings as well.

A district energy system might connect just two buildings, like in downtown Seattle where the new Amazon headquarters is heated with 5 MW of waste heat from a nearby data center.[23] Or the system might connect several hundred buildings, like at Stanford University, where they connected 155 campus buildings, heated water through a central heat pump powered with solar PV. At Stanford, the university managed to reduce greenhouse gas emissions by almost 75 percent from this project alone.[24]

22 "District Energy In Cities Initiative | United Nations Environment Program (UNEP)," accessed May 5, 2021, http://www.districtenergy-initiative.org/.
23 "The Super-Efficient Heat Source Hidden below Amazon's Seattle Headquarters," About Amazon, November 16, 2017, https://www.aboutamazon.com/news/sustainability/the-super-efficient-heat-source-hidden-below-amazons-seattle-headquarters.
24 Lisa Lapin and Kate Chesley, "New Stanford Energy System Cuts Greenhouse Gas Emissions 68 Percent and Fossil Fuel 65 Percent," *Stanford News*, April 16, 2015, https://news.stanford.edu/features/2015/sesi/.

Beyond the climate benefits, district energy systems provide a range of other critical benefits including:

- **Enhanced energy system reliability and resiliency**. A range of energy sources and systems will minimize over-reliance on the electrical grid and could reduce the need for costly and unpopular transmission and distribution system upgrades and expansion.
- **Improved energy efficiency and reduced costs**, by moving waste heat from places where it is a liability, such as data centers or refrigeration facilities, to places with high demands for heat, such as private residences or offices.
- **A new line of business**, as an energy provider rather than a fuel provider, for utilities negatively affected by reduced demand for gas; and
- **Quality job opportunities** for skilled and trained workers, including those in the gas utility and construction business, in installation and maintenance. Stanford University's overhaul of their district energy system employed 72 different signatory subcontractors and created union jobs across the skilled construction trades, including jobs for insulators, pipefitters, boilermakers, and others.

District energy systems are practical for a wide range of buildings in cities, including in retrofit situations. In particular, the most suitable locations have the following attributes:

- **High load and density of buildings** where short distances of distribution piping can interconnect several buildings of reasonable size, for example, at airports, college and university campuses, large hospital complexes, large office and industrial complexes/ campuses, casinos, sports stadiums and arenas, and downtown central business districts of larger urban centers;
- **Diversity of building uses** in order to balance heating and cooling loads across the connected system of buildings;
- **Developments with high capital costs** such as new developments where extending infrastructure for gas is expensive and otherwise undesirable; and
- **Ability to finance investment** with a long payback and depreciation schedules such as utilities, government facilities, airports, college and university campuses, and hospital campuses.

Jobs Potential

If 5–10 percent of Los Angeles' existing buildings (114–227 million square feet) were connected to a modern carbon-free district energy system, the construction alone would create 22,000–44,000 direct construction jobs and require 1000–2600 ongoing operations and maintenance jobs.[25] The required upfront investment would be $4.4–8.8 billion, based on the cost of the Stanford project of $39/sq ft of building space. Other projects across North America have cost less.

The negotiation of a new franchise agreement with Southern California Gas provides both the City of Los Angeles and the gas utility an opportunity to consider district energy expansion to replace gas distribution.

25 Estimated data from Norway provided in Betony Jones and Nikki Luke, "District Energy Decarbonization: Addendum to California Building Electrification Workforce Needs and Recommendations" (Luskin Center for Innovation [UCLA] and Inclusive Economics, November 2019), https://innovation.luskin.ucla.edu/wp-content/uploads/2019/11/California_Building_Decarboniza-

Job Loss Methodology and Data

There are two industries in which job loss is expected to be most acute: construction pertaining to gas infrastructure and utilities pertaining to the sales and distribution of gas.

1. **All-electric new construction**
   For new construction, there are but few and conflicting studies on the relative increase or decrease in costs of all-electric buildings. Cost increases are typically attributed to more expensive equipment while cost savings are attributed to reduced labor costs, but the case data is insufficient to estimate job loss.[26] We assume that plumbers and pipefitters will be the occupation most adversely affected by the shift away from gas, and provide plumber and pipefitter occupational data to bookend the potential impacts

2. **Utility job loss**
   Reduced gas sales will adversely affect the gas utility and its workforce. While the size of the gas utility workforce is more a function of the size of the system than the fuel moving through it, reduced throughput could have a destabilizing effect on the industry, triggering price increases and accelerating economic electrification. Overall, LA County is responsible for 23 percent of gas consumption in the state.[27]

   As of 2019, the natural gas distribution industry in Los Angeles County employed 8,580 individuals across a wide range of occupations.[28] Commercial and residential gas use accounts for 60 percent of gas consumption in the state but a larger share of the gas workforce, particularly on the service and sales side. If the City of LA succeeds in eliminating gas use in residential and commercial buildings by 2050, many of these workers would need to seek employment in different industries. This will be easier for some workers than others. Over 56 percent of the workers employed in this industry are in white collar occupations, mainly administrative, business, and management positions, where transitioning to new employment is relatively straightforward. Some 44 percent of the workers are in blue collar occupations, mainly maintenance, production, and construction. Many of the blue collar workers have developed specialized skills and experience for servicing the gas distribution system. Finding other work to make use of those skills may prove difficult.

   The occupational breakdown for the natural gas industry is shown in Table 14.[29] For a more detailed table of specific occupations, see Appendix C.

---

tion-Addendum.pdf.

26 This report shows cost savings of $6,412 for all-electric new construction due to savings from not piping gas from the street or plumbing of gas pipes to the kitchen, dryer, water heater, and furnace. Asa S. Hopkins et al., "Decarbonization of Heating Energy Use in California Buildings: Technology, Markets, Impacts, and Policy Solutions" (Synapse Energy Economics, Inc., December 1, 92AD), https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf.

27 California Energy Commission, "Gas Consumption by Planning Area," CA.gov, accessed May 5, 2021, https://ecdms.energy.ca.gov/gasbyplan.aspx.

28 IMPLAN Group, LLC. IMPLAN 2021. Huntersville, NC. IMPLAN.com.

29 U.S. Bureau of Labor Statistics, "May 2020 National Industry-Specific Occupational Employment and Wage Estimates | NAICS 221200 - Natural Gas Distribution," accessed May 5, 2021, https://www.bls.gov/oes/current/naics4_221200.htm.

3. **Workforce and Equity Challenges of Declining Gas Use in Los Angeles**

Between 2011 and 2019, residential gas use in LA County decreased by about 10 percent, while non-residential gas consumption increased by about 7.5 percent over the same time frame.[30] For the Southern California Gas planning area as a whole, gas consumed in buildings (both residential and commercial) declined 3.4 percent while non-building gas use increased.[31] This is important because fixed costs are primarily paid by core customers (residential and commercial building users), so declining gas use in buildings could lead to disproportionate rate increases for remaining customers. This is a concern for the gas industry, as rate increases will accelerate economic electrification. This also poses ongoing energy affordability challenges for energy-burdened customers unable to invest in electrification.

Occupation Profile: Plumbers and Pipefitters

LA metropolitan area has an estimated 15,550 plumbers and pipefitters, approximately 10,000 of whom are in the County of LA.[32,33] Plumbers and pipefitters will be one of occupations most affected by a shift away from gas; they represent 4 percent of the natural gas distribution workforce.[34] This means that roughly 360 plumbers and pipefitters are employed directly in the natural gas distribution industry in Los Angeles. LA Metro area has an estimated 590 pipelayers, about 415 of whom are in LA County.[35,36] About 18 pipelayers are employed by the natural gas industry in LA County.

While the occupational data conveys that only a small percentage of pipefitter and pipelayers are employed in the gas distribution industry, workers installing and maintaining gas lines in and to buildings may be counted in the construction industry rather than the utility industry. Construction plumbers and pipefitters are responsible for water and sewer lines in addition to gas lines.

UA Local 78 has 1650 members, and in 2018 there were 672 active plumber/pipefitter apprentices.[37] The journey-person wage for Local 78 is $48.13/hr, which is about 50 percent higher than the national average hourly wage for plumbers and pipefitters in the natural gas industry.[38] Installing and maintaining gas infrastructure in the City of LA accounts for a portion of these good-paying jobs and apprenticeships.

30 California Energy Commission, "Gas Consumption by County," CA.gov, accessed May 5, 2021, http://www.ecdms.energy.ca.gov/gasbycounty.aspx.
31 California Energy Commission, "Gas Consumption by Planning Area," CA.gov, accessed May 5, 2021, https://ecdms.energy.ca.gov/gasbyplan.aspx.
32 U.S. Bureau of Labor Statistics, "Los Angeles-Long Beach-Anaheim, CA - May 2020 OEWS Metropolitan and Nonmetropolitan Area Occupational Employment and Wage Estimates," accessed May 5, 2021, https://www.bls.gov/oes/current/oes_31080.htm#47-0000.
33 State of California Employment Development Department (EDD), "Occupation Profile: Plumbers, Pipefitters, and Steamfitters," CA.gov, accessed May 5, 2021, https://www.labormarketinfo.edd.ca.gov/cgi/databrowsing/occExplorerQSDetails.asp?menuChoice=&socCode=472152&occByTraProg=true&location=0604000037.
34 U.S. Bureau of Labor Statistics, "May 2020 National Industry-Specific Occupational Employment and Wage Estimates | NAICS 221200 - Natural Gas Distribution," accessed May 5, 2021, https://www.bls.gov/oes/current/naics4_221200.htm.
35 U.S. Bureau of Labor Statistics, "Los Angeles-Long Beach-Anaheim, CA - May 2020 OEWS."
36 State of California Employment Development Department (EDD), "Occupation Profile: Pipelayers," CA.gov, accessed May 5, 2021, https://www.labormarketinfo.edd.ca.gov/cgi/databrowsing/occExplorerQSDetails.asp?searchCriteria=pipelayers&careerID=&menuChoice=&geogArea=0604000037&soccode=472151&search=Explore+Occupation.
37 Data from California Department of Industrial Relations, "Division of Apprenticeship Standards," CA.gov, accessed May 5, 2021, https://www.dir.ca.gov/das/das.html.
38 UA Local Union 78 (Los Angeles), "Apprentice Information," United Association Plumbers Local 78, accessed May 5, 2021, https://www.uaplumber78.com/apprentice-applicant.

Table 15. Number of Workers Employed in Natural Gas Distribution Industry in LA County, by Occupation

Occupation code	Occupation title (click on the occupation title to view an occupational profile)	Employment	Percent of total employment	National Mean hourly wage	National Annual mean wage
49-0000	Installation, Maintenance, and Repair Occupations	1,853	21.6%	$36.49	$75,900
51-0000	Production Occupations	880	10.3%	$40.12	$83,450
47-0000	Construction and Extraction Occupations	870	10.1%	$34.79	$72,370
53-0000	Transportation and Material Moving Occupations	183	2.1%	$31.39	$65,280
33-0000	Protective Service Occupations	9	0.1%	$39.20	$81,530
37-0000	Building and Grounds Cleaning and Maintenance Occupations	3	0.0%	$25.87	$53,810
Blue Collar Total/Average		**3,798**	**44.3%**	**$36.69**	**$76,323**
43-0000	Office and Administrative Support Occupations	1,529	17.8%	$29.32	$60,980
13-0000	Business and Financial Operations Occupations	1,182	13.8%	$44.92	$93,430
11-2000	Management Occupations	625	7.3%	$71.58	$148,900
17-0000	Architecture and Engineering Occupations	613	7.1%	$47.91	$99,660
15-0000	Computer and Mathematical Occupations	390	4.6%	$48.97	$101,870
41-0000	Sales and Related Occupations	306	3.6%	$38.47	$80,010
19-0000	Life, Physical, and Social Science Occupations	70	0.8%	$44.93	$93,450
23-0000	Legal Occupations	33	0.4%	$80.39	$167,200
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	30	0.4%	$44.86	$93,300
White Collar Total/Average		**4,780**	**55.7%**	**$43.96**	**$91,442**

Solutions, Strategies, and Recommendations

Decarbonizing LA's buildings will require both programs and policies, designed and deployed to address key workforce and equity concerns. By programs, we mean the use of incentives, coordination between different funding sources and partners, pilot programs for innovative approaches, and direct public investments. By policies, we mean regulations, such as reach codes, building performance standards, time of sale requirements, time of equipment replacement requirements, etc. The City must recognize that regulatory policy designed to reduce gas use in buildings can negatively affect non-regulated building owners and tenants, thus programmatic efforts will be needed to mitigate negative impacts and provide broadly shared community benefits. Key concerns from stakeholders in LA are bulleted below with mitigation strategies identified in Summary of Concerns and Potential Solutions on page 9.

- High upfront investment costs of building retrofits could mean that low-income consumers will be left stranded with inefficient, unhealthy appliances and buildings.
- While reducing emissions from buildings is important, improving the health and safety and general quality of housing is also important, and sometimes more urgent than climate change goals.
- Landlords who make investments in building and energy improvements will seek to recoup such investments with high rents, triggering displacement.
- Reduced gas throughput resulting from economic and environmental electrification will increase gas rates, thus exacerbating energy burden for remaining gas customers.
- Displacement of good-paying union jobs associated with gas infrastructure and delivery, particularly for utility workers and plumbers and pipefitters.
- In the private construction market, there are no assurances that the jobs created will be high-road jobs.
- Investing in efficiency and beneficial electrification may not result in the anticipated energy savings and performance improvements.
- Jobs and business opportunities created to respond to growing demand for building rehabilitation and retrofits may not be accessible to disadvantaged workers or small women and minority-owned businesses.
- Community stakeholders do not have the time, resources, or capacity to meaningfully engage on building decarbonization issues, but without their engagement, policies and programs will not be responsive to their needs.
- Electrification of buildings and transportation puts new demands on the grid and the workers charged with maintaining grid reliability while accelerating the development of carbon-free electricity.

The City's building policies and programs must confront head on, and in concert, the climate, equity, and workforce and housing challenges associated with building decarbonization. This means creating good, union jobs, improving public health, reducing energy burden, and supporting housing reservation and stabilization by adopting mitigation strategies to address key concerns.

Programmatic Efforts

1. Consolidate state, city, and LADWP resources for energy retrofits and upgrades in LAUSD schools and affordable housing.
    a. *Invest in school upgrades.*
        i. *AB 841 signed in 2020 reallocates unspent IOU energy efficiency dollars for school energy, health, and safety upgrades.*
        ii. *Measure RR allocates $7 billion to LAUSD facility, technology, and safety improvements.*
        iii. *LADWP spends over $130 million annually across dozens of energy efficiency incentive programs[39] and should redeploy its efficiency dollars to augment the AB 841 and Measure RR funding for schools.*
    b. *Invest in affordable housing upgrades.[40]*
        i. *SOMAH and LIWP are state funding sources for solar and energy efficiency improvements in affordable housing.*
        ii. *Measures HHH, JJJ, and M could be augmented by LAWDP to provide substantial incentives (linked to restrictions on rent increases) to multifamily affordable housing of all sizes.*
        iii. *Deferred maintenance issues should be prioritized and holistic retrofits should include health and safety as well as adaptation and resilience.*

2. Pilot, expand, and decarbonize district energy systems to provide low-cost water and space heating and cooling to networked buildings.
    a. *Piecemeal electrification, in which each building's energy use is considered independent of its neighboring buildings, is not always the best way to reduce emissions. Often, neighboring buildings have complementary heating and cooling needs, and connecting them through a district network can reduce energy consumption, emissions, and tap sources of renewable energy like solar thermal, waste-to-energy, geothermal, and waste heat recovery from sewage or industry, that are not cost effective at the scale of a single building.[41] This reduces demand from the electricity grid. Low-carbon cities of the future are investing in decarbonized district energy today.[42,43]*
    b. *While this networked approach is complex, the city could pursue a pilot or feasibility study to identify which neighborhoods in LA are the best candidates for such an approach.*

39 Grace Relf et al., "2020 Utility Energy Efficiency Scorecard" (American Council for an Energy-Efficient Economy, February 2020), https://www.aceee.org/sites/default/files/pdfs/u2004%20rev_0.pdf.
40 Last year, the City of Seattle committed to invest $20 million a year to support low-income homeowners in Seattle in switching their home heating systems away from fossil fuels such as oil and gas to cleaner, safer electric heating while weatherizing and improving energy efficiency. "Seattle Poised to Invest in Green New Deal Programs," Sierra Club, July 15, 2020, https://www.sierraclub.org/press-releases/2020/07/seattle-poised-invest-green-new-deal-programs.
41 "How to Decarbonise Your City's Heating and Cooling Systems," C40 Knowledge Hub, March 2019, https://www.c40knowledgehub.org/s/article/How-to-decarbonise-your-city-s-heating-and-cooling-systems?language=en_US.
42 Vancouver's Southeast False Creek Neighborhood Energy Utility Project provides district heating for 7,000 residential units, with 70% of the heating energy obtained from raw wastewater. See more examples at "How to Decarbonise Your City's Heating and Cooling Systems."
43 United Nations Environment Program (UNEP), "District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy," January 2015, https://www.c40knowledgehub.org/s/article/District-Energy-in-Cities-Unlocking-the-Potential-of-Energy-Efficiency-and-Renewable-Energy?language=en_US.

Policy Efforts

3. In lieu of more prescriptive approaches, such as electrification requirements, adopt technology-neutral codes and standards, such as a Building Performance Standard, for new construction and large building retrofits to reach City and State carbon neutral goals by 2045.
    a. *Develop alternate compliance pathways (as Vancouver, BC has done) that provide flexibility in reaching the established carbon standard.*
    b. *Integrate both water and energy efficiency to ensure construction of buildings that are efficient and climate resilient. Consider dual plumbing code requirements to make use of recycled or reclaimed water.*
    c. *Require that all work in buildings >50,000 sq ft is performed by a skilled and trained workforce and that work quality is inspected and verified by licensed and qualified professionals.*
    d. *Provide programmatic support for smaller buildings, schools, and affordable housing to meet or exceed the established standards.*

Cross-Cutting Efforts

4. Support workforce training and women and minority contractor capacity building by investing in integrated demand and supply side supports for disadvantaged workers and contractors.[44]
    a. *Support upskilling, apprenticeship programs, and pre-apprenticeship partnerships to train the next generation of workers with the skills and education required to build, operate, and maintain an efficient and low-carbon city ecosystem.*
    b. *Support small MWBE capacity building.*
    c. *Use public incentives and subsidies for building decarbonization to create inclusive economic opportunities for disadvantaged workers through targeted hire metrics and for women and minority contractors through supplier diversity metrics.*

Table 16 shows the job potential for different building types, the estimated total investment required to fully decarbonize, and the potential policy levers to ensure equitable outcomes and quality job opportunities for residents.

44 Inclusive Economics, "High-Road Jobs and Workforce Development for Climate Action Guidebook" (Urban Sustainability Directors Network, April 2021), https://www.usdn.org/projects/workforce-and-economic-inclusion.html.

Table 16. Job Calculations for Building Decarbonization by Sector

Sector (Existing Buildings)	Deep Efficiency + Electrification Job Years	Upfront Investment Required	Proposed Decarb Policy Lever
Schools	2 - 3 thousand	$0.6 - 0.8B	Direct public investment (i.e., AB 841, DWP, Bond, Federal funding, etc.)
Affordable Housing (deed restricted)	8 - 12 thousand	$2 - 7B	
Affordable Housing (naturally occurring)	38 - 62 thousand	$9 - 16B	Incentives with rent control requirements and eviction prevention
Universities & Hospitals	3 - 5 thousand	$1 - 1.2B	Direct public or utility investment in district energy systems
Large Commercial (>50,000 sq ft)	28 - 37 thousand	$8 - 10B	Mandate with BPS, with apprenticeship and quality inspection standards
Large MF Residential (>50,000 sq ft)	21 - 29 thousand	$5 - 8B	
Small & Medium Commercial (<50,000 sq ft)	42 - 54 thousand	$13 - 16B	Voluntary targets, neighborhood district energy pilots technical and financial assistance for low-income homeowners
Small MF Residential	63 - 109 thousand	$14 - 25B	
Single Family Residential	177 - 251 thousand	$37 - 50B	

Appendix A. Gas Saturation by End Use

Sector	End Use	Gas Saturation
Single Family Residential	Space Heating	90%
	Water Heating	95%
	Cooking	84%
	Clothes Drying	58%
Small MF Residential	Space Heating	69%
	Water Heating	77%
	Cooking	83%
	Clothes Drying	9%
Large MF Residential	Space Heating	79%
	Water Heating	63%
	Cooking	66%
	Clothes Drying	9%
Schools	Space Heating	84%
	Water Heating	93%
	Cooking	60%
	Miscellaneous	15%
Hospitals	Space Heating	85%
	Water Heating	86%
	Cooking	70%
	Miscellaneous	50%
Colleges/Universities	Space Heating	84%
	Water Heating	66%
	Cooking	36%
	Miscellaneous	50%
Large Commercial	Space Heating	73%
	Water Heating	65%
	Cooking	24%
	Miscellaneous	7%
Small Commercial	Space Heating	40%
	Water Heating	61%
	Cooking	37%
	Miscellaneous	16%

Appendix B. Cost Estimates

https://docs.google.com/spreadsheets/d/1RItjOx6dXW_xyeJG6cOrR5UL0bScMy6wz7PPzH0qC-0/edit?usp=sharing

Appendix C. Number of Workers Employed in Natural Gas Distribution Industry in LA County, by Detailed Occupation

Occupation code	Occupation title (click on the occupation title to view an occupational profile)	Employment	Percent of total employment	Mean hourly wage	Annual mean wage
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	851	9.9%	$33.55	$69,790
51-8092	Gas Plant Operators	384	4.5%	$36.09	$75,060
47-2152	Plumbers, Pipefitters, and Steamfitters	348	4.1%	$33.13	$68,910
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	239	2.8%	$44.93	$93,460
49-9041	Industrial Machinery Mechanics	200	2.3%	$34.71	$72,190
51-1011	First-Line Supervisors of Production and Operating Workers	156	1.8%	$50.77	$105,600
47-2073	Operating Engineers and Other Construction Equipment Operators	115	1.3%	$33.02	$68,680
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	91	1.1%	$42.03	$87,420
43-4051	Customer Service Representatives	585	6.8%	**$28.60**	$59,480
13-1198	Project Management Specialists and Business Operations Specialists, All Other	335	3.9%	$47.38	$98,550
43-5041	Meter Readers, Utilities	227	2.6%	$27.89	$58,020
43-9061	Office Clerks, General	189	2.2%	$27.84	$57,900
13-1111	Management Analysts	182	2.1%	$47.50	$98,790
11-1021	General and Operations Managers	151	1.8%	$69.87	$145,330
13-2011	Accountants and Auditors	142	1.7%	$42.59	$88,580
15-1211	Computer Systems Analysts	130	1.5%	$48.48	$100,840
43-1011	First-Line Supervisors of Office and Administrative Support Workers	128	1.5%	$39.75	$82,680
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	121	1.4%	$38.25	$79,550
41-3091	Sales Representatives of Services, Except Advertising, Insurance, Financial Services, and Travel	117	1.4%	$37.88	$78,790
17-2071	Electrical Engineers	116	1.4%	$54.20	$112,740

Appendix D. References for Gas Saturation Data in Inclusive Economics Decarbonization Jobs Model

California Energy Commission (2019). Gas Consumption by Entity. Accessed September 5, 2019. http://www.ecdms.energy.ca.gov/gasbyutil.aspx.

Itron, Inc. (2006). *California Commercial End Use Survey*. Accessed September 5, 2019. http://capabilities.itron.com/CeusWeb/ChartsSF/Default2.aspx.

KEMA, Inc. (2010). *2009 California Residential Appliance Saturation Study.* California Energy Commission. Publication number: CEC-200-2010-004-ES. See pp. 10–14 in http://www.energy.ca.gov/2010publications/CEC-200-2010-004/CEC-200-2010-004-ES.PDF.

U.S. Energy Information Administration. (2019). *Natural Gas Consumption by End Use.* U.S. Department of Energy. Washington, DC. Accessed April 19, 2019. http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_sca_m.htm.

U.S. Census Bureau. (2016). *2012–2016 American Community Survey Table, 5-Year Estimates.* Washington, DC. Accessed April 21, 2018. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk.

U.S. Census Bureau. (2016). *2012–2016 American Community Survey Table, 5-Year Estimates.* Accessed April 21, 2018. https://factfinder.census.gov/bkmk/table/1.0/en/ACS/16_5YR/S2504/0400000US06.

U.S. Energy Information Administration (EIA). (2013). "Table HC.1.11- Fuels Used and End Uses in Homes in West Region, Divisions, and States, 2009." U.S. Department of Energy. Washington, DC. Accessed April 21, 2018. https://www.eia.gov/cocinsumption/residential/data/2009/hc/hc1.11.xls.

U.S. Energy Information Administration. (2016). *Commercial Building Energy Consumption Survey.* U.S. Department of Energy. Washington, DC. See Tables B4 and B5: Census region and division, number of buildings and floor space, 2012. https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b4.php.