Equitable Strategies for Residential Building Energy Efficiency and Electrification in San José, California

July 2024

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National Renewable Energy Laboratory

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List of Acronyms

ACH	Air Changes per Hour
Communities LEAP	Communities Local Energy Action Program
HSPF	Heating Seasonal Performance Factor
HVAC	Heating, ventilation, and air conditioning
LEAD	Low-income Energy Affordability Data
NEC	National Electrical Code
NREL	National Renewable Energy Laboratory
PUMA	Public Use Microdata Area
SEER	Seasonal Energy Efficiency Ratio
UEF	Uniform Energy Factor

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Background

Hotter summers, heat waves, wildfires, and droughts are already affecting San José, California residents. The City of San José has ambitious goals to make the city carbon-neutral by 2030 and serve as an example for cities to accelerate climate action around the world. In addition to reducing community-wide greenhouse gas emissions, the City's *Pathway to Carbon Neutrality by 2030* plan will support the community's vision of the "Good Life 2.0" and community-defined priorities for safety, health, freedom, community, and positive experiences for all residents. Engaging community voices, including historically marginalized communities hit first and worst by the impacts of climate change, are key priorities for the city and recognized as essential to decarbonizing while improving quality of life for all residents [5].

Climate Smart San José has identified the residential building sector as a linchpin in the path to decarbonization and the "Good Life 2.0" [5]. The City has taken a number of steps to reduce energy consumption and associated emissions from residential buildings, including the Electric Homes San José: Building Electrification Program [6], a building reach code requiring almost all new buildings to be fully electric [5], a prohibition on new natural gas infrastructure for both private and municipally owned facilities [5], a building performance ordinance requiring large commercial and multifamily residential buildings to report energy and water use on an annual basis [5], and a zero-emissions neighborhood (ZEN) pilot program [5]. However, designing policies and programs to support cost-effective upgrades in existing homes can be a challenge and requires robust, quantitative analysis to identify energy efficiency and electrification measures best suited to a diverse range of building types. The City aims to carefully design strategies to minimize or mitigate any potential increases in household energy bills, particularly for low-income households that already pay a disproportionate share of their income on energy bills, also known as a high energy burden. Energy burden is defined as the percentage of gross household income spent on energy costs. A household with 6% or greater energy burden is considered to be a high energy burden household [9].

The urgent threat posed by climate change provides a strong driving force for San José's climate goals, and a slate of supportive policies and programs at the federal, state, and local level provide an unprecedented opportunity to make considerable strides toward achieving these ambitious objectives.

In 2022, the City of San José was selected as one of 24 communities in the Communities Local Energy Action Program (Communities LEAP) pilot, a technical assistance program intended to assist community-led transitions to a clean energy economy and build a healthier, more equitable, and sustainable future [1]. Working with the National Renewable Energy Laboratory (NREL), the city and its community partners assessed opportunities to improve energy access and affordability in low-income, high-energy-burden neighborhoods. This technical assistance built upon the Electrify San Jose: Framework for Existing Building Electrification to identify actionable strategies to make single- and multifamily buildings both energy-efficient and all-electric. This report is intended to provide the San José Climate Smart team and their partners with relevant data, insights, and actionable analysis to aid in-depth and nuanced engagements with key stakeholders. In particular, the findings in this report highlight opportunities and challenges for San José City Council, residents, building owners, developers, financial institutions, and utility partners, who are instrumental in building support and earning buy-in for energy efficiency and electrification upgrades in existing buildings.

This study was designed to support implementation of the Climate Smart San José *Existing Building Electrification Framework* by characterizing the residential housing sector in eight census tracts that are low-income, historically marginalized, and/or overburdened by energy bills with a statistical analysis of residential housing technical characteristics as well as household socioeconomic and demographic conditions. This characterization informed selection of the following four prominent building types presenting the greatest challenges and opportunities for more equitable electrification in San José:

- Multifamily, 5+ units, built 1940 to 1979
- Multifamily, 5+ units, built 1980 or later
- Single-family detached, built 1940 to 1979
- Single-family attached, built 1940 to 1979.

Data from ResStock, a tool developed by NREL that enables highly granular modeling of the U.S. housing stock, was then used to evaluate potential impacts of 16 different energy efficiency and electrification measures for these housing types in the eight census tracts based on relative environmental, economic, and resilience costs and benefits. This analysis addresses two research questions identified by the community coalition:

- What are the relative costs, benefits, and implications of available strategies for the city to pursue whole-home energy efficiency and electrification in target communities?
- What are the relative costs, benefits, and implications of individual technology upgrades for space heating and cooling and hot water heating in target communities?

Data and Methods

Data on building types, income, and race were obtained from the Low-Income Energy Affordability Data (LEAD) tool for the eight census tracts identified by the city. The LEAD tool compiles data from the 2020 American Community Survey by the U.S. Census Bureau [9]. To analyze building energy use and reductions from residential energy efficiency and electrification upgrades, the eight census tracts were converted to corresponding Public Use Microdata Areas (PUMAs) using the Census Reporter website [10]. PUMAs are geographically distinct units used by the U.S. Census Bureau to provide statistical and demographic information. Each state is partitioned into PUMAs containing no fewer than 100,000 people [11]. The eight census tracts are contained within two PUMAs—060 08510 and 060 08514—which were then used to develop a statistically representative sample of residential buildings in those communities with ResStock, which draws on 2018 building stock distributions of building types and characteristics reported in the Residential Energy Consumption Survey and tens of other nationwide data sources [8].

Energy consumption was modeled for baseline and upgrade scenarios for roughly 83,000 housing units in the two identified PUMAs using the ResStock physics-based simulation model from NREL using Actual Meteorological Year 2018 weather data. The End-Use Load Profiles and End-Use Savings Shapes, two ResStock datasets, quantify how and when energy is used in residential buildings on an annual basis with a 15-minute temporal resolution [8, 12]. The building energy efficiency and electrification upgrade packages analyzed in this study are described in Table 1. Detailed methodology and data associated with the ResStock Communities LEAP Pilot Household Energy Efficiency Analysis for San José and seven other Communities LEAP pilot communities is available from the NREL Data Catalog.

Table 1. Description of Upgrade Measures

For full details, see End-Use Savings Shapes Technical Documentation.

Upgrade Type	Description	Technical Details
Minimum Efficiency Heat Pump with Existing Heat Backup	Heat Pump Specifications	Centrally ducted single-speed heat pump Seasonal Energy Efficiency Ratio (SEER) 15, 9 Heating Seasonal Performance Factor (HSPF), sized to Air Conditioning Contractors of America Manual S for dwelling units with ducts and no heat pump or less-efficient heat pump. Ductless single-speed mini-split SEER 15, 9 HSPF, sized to max load for dwelling units with no ducts and no heat pump or less-efficient heat pump.
	Backup Heating	Existing heating retained as backup, active when heat pump cannot meet load for dwelling units with no ducts or dwelling units with ducts and electric resistance backup or existing heating as independent backup. Existing heating retained as backup, active below switchover temperature (41°F) for dwelling units with ducts and existing heating-sharing ducts.
Heat Pump Water Heater	Heat Pump Specifications	For dwelling units with an existing water heater other than an electric tankless water heater: □ 50-gallon, 3.45-Uniform Energy Factor (UEF) heat pump for dwelling units with 1-3 bedrooms □ 66-gallon, 3.35-UEF heat pump for dwelling units with 4 bedrooms □ 80-gallon, 3.45-UEF heat pump for dwelling units with 5+ bedrooms.
Basic Enclosure	Wall and Attic Floor Insulation	R-13 drill-and-fill insulation applied to homes with wood stud walls and no insulation. Attic floor insulation up to International Energy Conservation Code-Residential 2021 levels (R-49) for dwelling units with vented attics and lower-performing insulation (R-30 or less).
	General Air-Sealing	30% reduction in ACH_{50} applied to dwelling units with 10 ACH_{50} or higher infiltration.
	Duct-Sealing	Ducts improved to 10% leakage, R-8 insulation added to homes with leakier or less-insulated ducts.
High-Efficiency Whole-Home Electrification	High-Efficiency Heat Pump	Centrally ducted variable-speed mini-split heat pump SEER 24, 13 HSPF, sized to Air Conditioning Contractors of America (ACCA) Manual S for dwelling units with ducts and no heat pump or less-efficient heat pump. Ductless variable-speed mini-split heat pump SEER 29.3, 14 HSPF, sized to max load for dwelling units with no ducts and no heat pump or less-efficient heat pump.

Upgrade Type	Description	Technical Details
		Backup heat provided by electric resistance when heat pump cannot meet load.
	Heat Pump Water Heater	For dwelling units with an existing water heater other than an electric tankless water heater: □ 50-gallon, 3.45-UEF heat pump for dwelling units with 1-3 bedrooms □ 66-gallon, 3.35-UEF heat pump for dwelling units with 4 bedrooms □ 80-gallon, 3.45-UEF heat pump for dwelling units with 5+ bedrooms.
	Dryers	Ventless heat pump dryer (combined energy factor = 5.2) for all dwelling units with non-electric or less-efficient electric dryers.
	Cooking	Electric oven and induction range for all dwelling units.
Basic Enclosure + High-Efficiency Whole-Home Electrification		All measures included in Basic Enclosure upgrades. All measures included in High-Efficiency Whole-Home Electrification.

ResStock used national average technology costs from 2019, adjusted with a local multiplier factor reflecting differences in local cost of living relative to the national average, and supplemented with local, regional, or state-wide cost estimates when possible. Cost estimates are inclusive of equipment and labor costs to the greatest extent possible, but do not consider new electric panel requirements, which may be necessary in some buildings that lack sufficient capacity for additional electric appliances. Cost estimates also do not reflect applicable federal, state, regional, and/or local incentives and rebates. Actual costs will vary depending on several factors, including the price of materials, choice of contractor, size of project, and current incentive programs. Cost assumptions and data sources are summarized in Table 2.

Table 2. Assumed Average Costs for Select Upgrade Technologies Used in San José Analysis

Technology	Local Cost	Data Source
Reduce infiltration by 30%	$1.80 per square foot	City of Berkeley Existing Buildings Electrification Strategy [13].
Duct sealing to 10% leakage, R-8 insulation	$410 to $2,700 per home (depending on existing level of duct insulation and sealing)	Average costs reported by Central Coast Energy Services, Inc. and by Contra Costa County Weatherization Assistance Program
Drill and fill insulation to R-13 on walls that have no insulation	$4.50 per square foot	Average estimated cost reported by Central Coast Energy Services, Inc. and Contra Costa County Weatherization Assistance Program
Mini-split heat pump with SEER 15 and 9.0 HSPF max load	$6,550 per unit	Richmond, California estimates for Zero Net Carbon Ready Homes program
50-gallon water heater	$2,096 per unit	City of Berkeley Existing Buildings Electrification Strategy [13]
50-gallon heat pump water heater	$3,761 per unit	City of Berkeley Existing Buildings Electrification Strategy [13]
80-gallon heat pump water heater	$4,651 per unit	City of Berkeley Existing Buildings Electrification Strategy [13]
Electric dryer with combined energy factor of 2.7	$1,255 per unit	Richmond, California estimates for Zero Net Carbon Ready Homes program
Electric range with cooktop efficiency of 0.74 and oven efficiency of 0.11	$1,700 per unit	Average costs reported by Central Coast Energy Services, Inc.
Ventless heat pump dryer	$2,507 per unit	City of Berkeley Existing Buildings Electrification Strategy [13]

To estimate average residential household energy bill reductions from the selected upgrade strategies, average time-of-use electricity rates and volumetric natural gas, propane, and fuel oil rates were obtained from the U.S. Energy Information Administration and local providers. Emissions reductions were calculated from a long-run marginal emissions rate with low renewable cost [12]. Vacant housing units were not included in the ResStock analysis of energy consumption and associated emissions.

Table 3 details assumed average costs for a typical household for the four housing types and five upgrade strategies included in this analysis. These assumed average costs account for the specific type of upgrade and technology deemed applicable by ResStock's modeling, as well as the assumed cost to perform the upgrade based on best-available data on equipment and labor costs. Actual costs for individual households and buildings will depend upon several factors excluded from this analysis, including any potential panel upgrades or rewiring, variability and discrepancies in local labor costs, and unique features of individual buildings. As such, the results are presented here as general estimates to provide a relative comparison among upgrade strategies, so results based on these assumptions carry substantial uncertainty.

Table 3. Assumed Average Upgrade Costs per Dwelling Unit for San José Analysis

Upgrade Type	Multifamily 5+ Units, 1940–1979	Multifamily 5+ Units, 1980+	Single-Family Detached, 1940–1979	Single-Family Attached, 1940–1979
Basic Enclosure	$2,800	$1,400	$14,100	$7,000
High Efficiency Whole-Home Electrification	$26,700	$29,200	$42,300	$34,700
Basic Enclosure + High-Efficiency Whole-Home Electrification	$28,200	$30,000	$50,500	$38,900
Heat Pump Water Heater	$3,800	$3,800	$4,200	$3,900
Minimum-Efficiency Heat Pump With Existing Heat Backup	$7,600	$7,800	$14,700	$10,500

For some homes, electrification upgrade measures may require additional electrical panel upgrades or rewiring, which can incur additional costs for individual homeowners and apartment building owners. Analyzing the likelihood that a home energy retrofit will require an upgrade to the electrical service or electrical panel requires three pieces of information: What electrical panel size does the home have before the retrofit, what new loads does the retrofit add, and what are the compliance requirements for avoiding an electrical panel upgrade? The End-Use Savings Shapes dataset contains housing characteristics that can be used to estimate existing panel sizes. It also provides details of the retrofit upgrades that can be used to estimate new loads and electrical service compliance based on code.

To estimate current electrical panel sizes in San José homes, a machine learning model under development by the Lawrence Berkeley National Laboratory was used to predict panel capacity based on a set of housing attributes. The regression model is a gradient-boosted decision tree trained using several datasets, including a home energy scoring program in California and a survey of buildings in the Pacific Northwest. The datasets contain housing characteristics for over 25,000 program participants and recorded housing attributes such as building type, floor area, and panel size. Using the ResStock housing metadata for San José, the model predicts the panel size for each dwelling unit model based on its building type, vintage, floor area, and heating fuel.

Two methods from Section 220 of the 2023 National Electrical Code (NEC) were used to conduct load calculations to estimate whether existing panel capacity could support the new loads from each retrofit package. A service upgrade is required when the total demand between existing loads and new loads exceeds the capacity of the panel, but it can be avoided otherwise. The two methods are summarized below:

- NEC Section 220.83 (Load Summing Method):
  - Estimate general lighting and receptacle loads based on floor area
  - Add the nameplate ratings of large and permanently connected electric appliances (e.g., range, dryer, heating, ventilation, and air conditioning [HVAC], water heater, pool/spa heater)
  - Account for at least two branch circuits for the kitchen and at least one for the laundry
  - Apply demand factor to the total demand as follows: 100% for the first 8 kVA and 40% for additional demand over 8 kVA.
- NEC Section 220.87 (Maximum Demand Method):
  - Existing load can be determined as 125% of the maximum demand of a recent 1-year period if metered energy data is available.
  - ResStock 15-min time series data is used to estimate existing load for occupied homes only. For vacant homes, which do not have realistic peak demands due to missing occupant activities, 220.83 is used instead.

For both methods, once the existing load was estimated, new loads per the nameplate rating of new electrical appliances were added to determine the final total demand.

Limitations

This report provides two sets of estimates to assess what fraction of homes in San José are likely to require an electrical panel service upgrade in any given retrofit scenario. However, a few limitations should be noted when reviewing these results. First, there is uncertainty in the prediction of existing or pre-retrofit panel sizes due to limitation of the datasets used to train the decision tree model. 95% of the data came from single-family homes, which could mean reduced fidelity of predictions for multifamily and mobile homes. Similarly, the datasets contain predominantly (95% for each) natural gas-heated homes and homes with square footage at or above 1,000, which could result in higher uncertainty predictions for electrically heated homes and smaller-size homes, respectively. Furthermore, the panel upgrade model was originally developed for state, regional, and national estimates. There is likely greater uncertainty in results when applying the model at smaller scales, as was done in this work.

The training data for the panel upgrade model only considers whether various technologies are present; it does not include technologies' nameplate ratings data (which NEC considers in its load calculations). Additionally, the training datasets do not account for all loads or equipment specifications that could impact panel sizing, such as hot tubs, pool heaters, and tankless electric water heaters. This, in combination with the stochastic nature of the model prediction, could cause discrepancy between the panel size assigned and the NEC calculation of existing load, which is based on the full set of housing metadata in ResStock. Conversely, while the ResStock metadata is rich, it still does not include all appliances or end uses that could impact the total demand of the home. For example, garbage disposal motors and electric vehicles are not included in ResStock estimates. Additionally, the nameplate rating assumed for each piece of electric equipment in the NEC calculation is less diverse than real life. The HVAC sizing routine in ResStock may also be different from real-world practice, in that it is sensitive to the envelope specification of the home, whereas industry practice may be more based on rules of thumb and is additionally limited by the availability of tonnage options.

ResStock used national average technology costs from 2019, adjusted with a local multiplier factor reflecting differences in local cost of living relative to the national average, and supplemented with local, regional, or state-wide cost estimates when possible. Costs do not include rebates or other incentives, and costs for any individual project can vary substantially. Specific measures and measure packages were modeled and may not capture all potential technologies and/or performance levels and packages. Heat pumps were modeled with the existing heating system as backup and also separately modeled with electric backup and sized for cooling loads, which can produce more-conservative estimates. Households without existing cooling systems were assumed to use cooling after a heat pump upgrade, which adds a new service and improved thermal comfort, but can also substantially affect the cost-effectiveness of packages.

Finally, this analysis only evaluated electrical service or panel upgrades from a capacity standpoint. A panel upgrade may be required in other circumstances, such as to bring the panel to code because it was in poor operating condition. More importantly, this analysis did not address panel upgrade need due to breaker slot constraints. This could happen even if the existing panel has enough capacity to serve additional loads and is more likely triggered by retrofits that include rooftop solar, energy storage, or other devices requiring their own dedicated circuits. Furthermore, low-power alternatives were not considered for this analysis and could also help mitigate the need for panel upgrades.

Results

Detailed results of modeled housing units in San José are presented in the Equitable Strategies for Residential Building Energy Efficiency and Electrification in San Jose presentation.[1] Key takeaways from this modeling in San José indicate:

- The overwhelming majority of low- and moderate-income households in San José rely on natural gas to heat their homes and hot water, and an estimated 60% lack any form of air conditioning. Most of these homes have building envelopes with energy performance levels below modern building codes, contributing to excessive energy costs for heating and cooling.

- For the housing types most prevalent in San José's low-income, high energy-burdened census tracts, electrifying all eligible housing units while improving building enclosures shows the greatest potential annual emissions reductions. Including basic enclosure upgrades, like more exterior insulation or reducing infiltration, with whole-home electrification can increase total energy and emissions reductions and help mitigate anticipated increases in electricity demand as homes shift from fossil fuels to electricity. On a per-dollar basis, investments in basic enclosure upgrades can deliver similar or better energy and emissions reductions relative to more costly whole-home electrification retrofits.

- Based on the modeled results, home energy efficiency and electrification upgrades, on their own or combined, can deliver meaningful energy bill reductions for San José residents. For example, modeling suggests residents of single-family detached homes built between 1940–1979 in the modeled communities could reduce their energy bills by an average of $825 per year by combining high-efficiency whole-home electrification with basic enclosure upgrades.

- Combined strategies to improve building envelopes while installing high-efficiency electric appliances can provide the greatest energy burden reductions across all housing types. Energy burden reductions from high-efficiency whole-home electrification are largest for newer multifamily units built after 1980, which could reduce their energy burden by 1.5% per household, on average. The marginal reductions in energy burden from basic enclosure upgrades as part of a comprehensive whole-home electrification program are largest in pre-1980 single-family homes. Note that energy burden reductions are a result of bill reductions and does not consider upgrade costs.

- Some homes, particularly older homes or homes with panels providing less than 200-Amp service, may not be ready for electrification, and may require electrical panel upgrades or rewiring before installing new electric appliances. These electric panel upgrades can significantly impact overall project costs for individual homeowners and apartment building

[1] Results can be found at https://www.nrel.gov/docs/fy24osti/88285.pdf.

owners pursuing electrification. Additionally, panel upgrades require obtaining the proper electrical permit and inspection, which can add to the time and complexity of the project.

  - Basic enclosure upgrades do not increase electricity demand and can generally be implemented in most households without triggering the need for a panel upgrade.
  - Even with high-efficiency appliances and heat pumps, a moderate-to-high proportion[2] (41%–46%) of modeled dwelling units in San José might require panel upgrades to fully electrify.
  - Basic improvements in building enclosure efficiency from wall and attic insulation and air- and duct-sealing could help mitigate the increased electricity demand associated with electrification and reduce the proportion of homes that might face costly barriers to electrification. This is in part because an improved enclosure allows a smaller capacity heat pump to be installed, which reduces both the need for a panel upgrade and the cost of the heat pump.
  - A moderate-to-high proportion (27%–43%) of modeled households in San José across all income levels may require electrical panel or other infrastructure upgrades to support additional loads for minimum-efficiency heat pump HVAC systems.
  - Nearly all modeled low- and moderate-income households in San José are expected to have existing capacity for electric heat pump water heaters, and only a low proportion (0%–1%) of households might require panel or other infrastructure upgrades to support heat pump water heaters. However, this proportion could be higher when also considering other panel constraints, such as not having at least two breaker slots to support this additional 240-V appliance.

- Based on the modeled results for San José, heat pump technologies can provide most of a home's space heating and cooling while retaining existing heating sources as supplemental backup heating when the heat pump cannot meet demand. For some households that currently lack any form of cooling (an estimated 70% of modeled households in San José), providing this new service could increase energy-related emissions on an annual basis for some housing segments. While the new cooling service can enhance thermal comfort and resilience against heat waves, strategies to mitigate potential increases in bills may be necessary to ensure these households can access cleaner, more-efficient forms of heating and cooling without increasing energy burdens.

- Based on the modeled results, upgrading to heat pump water heaters could reduce household energy bills in the eight census tracts an average of $115–$200 per year.

[2] Estimated percentages of modeled housing units that would require panel upgrades to support new loads were categorized on a five-part scale: Low = 0%–20% of units; Moderate = 20%–40% of units; High = 40%–60% of units; Very high = 60%–80% of units; and Extreme = 80%–100% of units.

Average potential bill reductions per household are greatest for older single-family detached homes and newer multifamily homes.

- Modeled results for San José indicate that installing minimum-efficiency heat pump HVAC systems, without other accompanying efficiency and electrification measures, may lead to an increase in average annual energy bills for most housing types analyzed. For homes that currently lack any form of air conditioning, this increase could be in part due to new space cooling capabilities provided by heat pump HVAC systems.

- Modeled results indicate residential electricity demand in San José's low- and moderate-income communities is currently highest in colder winter months, but that could change as more homes install heat pumps with both heating and cooling capabilities. Improving thermal comfort and safety can benefit public health and climate adaptation goals. However, based on modeled results in San José, a community-wide program installing minimum-efficiency heat pumps using existing heat as backup could increase hourly electricity demand on hot summer days by an estimated 170% over baseline in extreme cases (on an example very hot day).

    - Whole-home electrification programs in San José that replace existing gas appliances and heating systems with high-efficiency heat pumps, hot water heaters, cooking stoves, and dryers can help to mitigate this increased electricity demand and keep it to an estimated 120%–130% over baseline on the example day, instead of the 170% with just installing minimum-efficiency heat pumps.

    - By improving building enclosure efficiency and air-sealing with basic enclosure upgrades (in addition to high-efficiency whole-home electrification), this demand can be further mitigated to less than 80% above baseline for the example day.

Examples of Policy and Program Approaches

These results suggest home energy efficiency and electrification upgrades can deliver meaningful energy, emissions, and utility bill reductions for modeled housing units in San José. The technical information from this work can help inform San José leaders' efforts to develop and implement strategies, on their own or in combination, to capture these benefits and balance the City's energy, climate, and equity goals.

In addition to the multitude of policies and programs at the state, regional, and local level already working to decarbonize homes in San José [4], Table 4 provides examples of policy and program solutions enacted by municipalities across the United States to address potential community goals around electrification and decarbonization of existing buildings. Policy approaches to increase electrification of existing buildings can be organized into two main categories:

Approaches that require that building owners take certain actions to meet energy or electrification standards

Approaches that encourage, but do not require, building electrification or decarbonization upgrades.

For more details and resources, refer to the Introduction to Local Policy and Program Approaches for Existing Building Electrification and Decarbonization.

Table 4. Local Residential Building Decarbonization Implementation Strategies and Examples

Taken from Introduction to Local Policy and Program Approaches for Existing Building Electrification and Decarbonization

Implementation Strategies Taken by Communities	Specific Examples
Goal 1. Community-wide electrification will reduce overall energy consumption and will not exceed the current electric utility grid's capacity.	
1a. Encouraging or requiring building envelope improvements in conjunction with electrification upgrades. This can be achieved through building code amendments, energy benchmarking or disclosure requirements, incentives, or other partnerships.	The City of Encinitas, California's, building code requires that any residential additions/alterations valued at $50,000 or more must choose from a menu of energy efficiency and electrification measures or meet a minimum Home Energy Score rating. The Home Energy Score is required, but how it is met is left up to the homeowner. The City of Boston, Massachusetts', energy benchmarking policy requires annual reporting of energy and water use to the city for nonresidential buildings larger than 20,000 square feet, multifamily residential buildings with 15 or more units, and buildings owned by the City of Boston or the Boston Housing Authority. The City of Austin, Texas', energy disclosure policy requires an energy audit to be done and provided to potential buyers when selling a residential property that is at least 10 years old and has fewer than four units. Owners or managers of multifamily buildings with five or more units must conduct energy audits for buildings that are 10 years or older and make them available to current and potential renters. The City of Sacramento, California, invested in the XeroHome tool for city residents to conduct an informal energy audit of their home to estimate what different upgrades or upgrade combinations might cost and how they might impact utility bills. Coordinate with local Weatherization Assistance Program agency, which offers free home energy retrofits for low-income households across the United States.
1b. Encouraging or requiring higher-efficiency appliances and equipment to maximize electricity reductions.	California's Building Energy Efficiency Standards establishes minimum efficiency requirements for heat pumps and other appliances, and all standards are required to be cost-effective. The City of Boulder, Colorado's, Smart Regs program requires an inspection and evaluation using a menu of options for property owners to meet energy requirements with higher points for heat pumps and higher points for higher-efficiency heat pump models.
Goal 2. Community-wide electrification will result in decreases or minimal increases to annual average resident utility bills, especially for low- to moderate-income households.	
2a. See all approaches under Goal 1. Any effort that reduces energy consumption can also be expected to decrease or minimize increases in utility bills.	

Implementation Strategies Taken by Communities	Specific Examples
2b. Prioritizing electrification for homes or buildings that already have air conditioning systems.[3]	The Town of Portola Valley, California, requires homeowners to install an electric heat pump, providing both space heating and cooling instead of replacing or installing air conditioners.
2c. Connecting at-risk residents with existing utility bill support programs or funding new ones.	The Low-Income Housing Energy Assistance Program is a federally funded program that provides utility bill financial assistance to low-income households across the United States.
Goal 3. Electrification measures will be cost-effective for households over the life of the measures.[4]	
3a. See all approaches under Goals 1 and 2. Any effort that reduces energy consumption and helps reduce utility bills will help improve the overall cost-effectiveness of measures.	
3b. Encouraging or requiring cost comparisons between fossil fuel and electric appliances.	The Town of Minturn, Colorado, requires building owners to obtain and submit an electrification retrofit bid when applying to the town for a permit to replace a gas-fired furnace or traditional air-conditioning/condensing unit. All provisions in California's Building Energy Efficiency Standards are required by state mandate to be cost-effective.
3c. Funding additional rebates or grants to reduce the upfront cost of electrification measures (for all or specifically for low- to-moderate-income households).	The City of Albany, California, offers rebates for heat pump/air conditioning systems and electrical panel upgrades, with higher incentive amounts for moderate- and low-income households. The Burlington, Vermont, Electric Department (municipally owned utility) funds rebates that can cover up to 75% of the installed cost of a heat pump space heating system. The Portland, Oregon, Clean Energy Community Benefits Fund provides grants for energy and electrification upgrades, as well as workforce and contractor training.
3d. Coordinating with utility to develop on-bill financing for electrification upgrades.	The Roanoke Cooperative utility in North Carolina offers on-bill financing for building envelope and heat pump electrification upgrades through their Upgrade to Save program.
3e. Offering economic hardship exemptions to building code electrification requirements.	The City and County of Denver, Colorado, requires heat pumps for space and water heating in large commercial and multifamily buildings when it is at or near cost parity with like-for-like gas appliances.
3f. Hiring or contracting with an entity to coordinate and maximize	The City of Berkeley, California's, Just Transition Residential Electrification Pilot Program sought a qualified firm or firms to manage

[3] Research indicates that heat pumps can be more cost-effective for households using them as a replacement for both gas furnace and traditional central air-conditioning systems (https://www.clasp.ngo/research/all/3h-hybrid-heat-homes-an-incentive-program-to-electrify-space-heating-and-reduce-energy-bills-in-american-homes/). However, communities will need to assess if there are any equity considerations regarding which households already have access to cooling and which do not. The effectiveness and equity of this approach may vary by community.

[4] "Cost-effective" in this context generally means that expected utility bill reductions over the lifetime of the measures will meet or exceed either the total or incremental upfront investment. However, local communities may have different definitions.

Implementation Strategies Taken by Communities	Specific Examples
incentives and rebates for households.	their low-income residential electrification program, including coordinating all rebates. The City of Ithaca, New York's, Green New Deal partnered with funders and financing organizations to raise capital, has provided city funding, and is coordinating implementation through a single agency to support its goal of decarbonizing all existing buildings in the city.
Goal 4. Landlords will pursue electrification of rental housing units, including both deed-restricted and naturally occurring affordable housing.[5]	
4a. Focusing holistic efforts and resources toward multifamily affordable housing.	The City of Denver, Colorado's, electrification policy offers additional funding and services to "Equity Priority Buildings," which include deed-restricted and naturally occurring affordable housing.
4b. Adopting an equity framework or tenant protections to support any new requirements or incentives.	The California Energy Commission's Equitable Building Decarbonization Direct Install Program Guidelines include requirements to minimize rent increases or evictions. The City of Berkeley, California's, Electrification Strategy includes "Equity Guardrails" and tenant protection recommendations.
Goal 5. Buildings will be, or will have access to resources to become, electrification-ready by addressing additional repairs or upgrades that may be needed to make electrification upgrades possible.[6]	
5a. Encouraging or requiring buildings to prepare for future electrification, without requiring the electrification measures themselves.	The City of Cambridge, Massachusetts, requires that any natural gas, fuel oil, or propane appliance installations also provide dedicated branch circuits in electrical panels.
5b. Developing programs to minimize the need for, or provide funding to offset, electric service panel upgrades.	The City of Piedmont, California, offers rebates for service panel upgrades, in addition to heat pumps, heat pump water heaters, and mini-split heat pumps. Rebate levels are doubled for low-to-moderate-income households. The State of Minnesota established a grant program to provide financial assistance to residential property owners to upgrade their service panels to either higher amperage or a smart panel.
5c. Funding, coordinating, or establishing partnerships with organizations or companies that provide general home repair services to support electrification or related measures.	The nonprofit Brothers Redevelopment, Inc. in Denver, Colorado, coordinates with multiple cities and counties in the Denver metropolitan area to provide free health and safety upgrades to the homes of low-income residents. Most programs are funded by local Community Development Block Grants.

[5] Research suggests landlords that do not pay for utilities (utilities paid by renters) may avoid unrequired electrification or other energy upgrades, or may pass-on electrification costs to renters if required to upgrade.

[6] A secondary goal is to make electrification easier to minimize unpermitted upgrades, which could have negative health and reductions implications. See page 12 of https://www.bayren.org/sites/default/files/2021-11/ee-and-electrification-white-paper_final_12.28.2020.pdf.

Implementation Strategies Taken by Communities	Specific Examples
	A Weatherization Assistance Program in Wisconsin partnered with the local Habitat for Humanity affiliate to resolve health and safety issues, allowing more homes to be eligible for energy upgrades.
Goal 6. Electrification investments will have positive local employment/economic development impacts.	
6a. Including quality labor standards (including prevailing wage), equitable hiring policies, and/or hiring preferences for local workers in new programs.	The California Energy Commission's Equitable Building Decarbonization Direct Install Program Guidelines include labor standards. The City of Berkeley, California's, Just Transition Residential Electrification Pilot Program includes labor standards and local hire provisions. NOTE: Examples and sample policy language are available in this 2020 report published by the Blue Green Alliance (not specific to building electrification).
6b. Offering contractor training and capacity-building programs.	The Boston, Massachusetts, Contractor Academy trains and supports minority-owned contractors to prepare them to better compete for and win bids for energy efficiency and clean energy projects. In Chicago, Illinois, Elevate ran a series of Contractor Accelerators to support minority-owned contractors.
6c. Incentivizing local contractors to join preferred vendor lists for electrification and other energy programs.	The City of Piedmont, California, and the City of Albany, California, both offer contractor signing bonuses to local contractors who register to help administer electrification rebate programs.
6d. Coordinating with local labor unions, workforce agencies, and/or community-based organizations to manage workforce efforts related to an electrification program.	The City of Berkeley, California, awarded contracts to the Construction Trades Workforce Initiative and Rebuilding Together East Bay North to ensure that their Just Transition residential electrification program would place traditionally underrepresented workers in the jobs created by their investments. The City of Ithaca, New York, contracted with the nonprofit BlocPower to manage financing, implementation, and job training to meet the city's electrification goals.
Goal 7. Electrification upgrades will improve indoor air quality for residents.	
7a. Requiring or incentivizing improvement of ventilation standards through any of the approaches described earlier in this document.	The New Buildings Institute Existing Buildings Decarbonization Model Code addresses increased ventilation related to energy and envelope projects in existing buildings. Coordinate with a local Weatherization Assistance Program agency, which requires health and safety measures as part of any envelope or efficiency improvements for low-income households.
7b. Coordinating with local health agencies to support programs linking building upgrades with health improvements.	The Bay Area, California Healthy Homes Initiative provides home energy assessments, retrofits, and indoor air monitoring for multifamily buildings and high-risk asthma patients.

Implementation Strategies Taken by Communities	Specific Examples
	In North Carolina, Blue Cross Blue Shield partnered with the local Weatherization Assistance Program to fund health and safety repairs that align with or support energy efficiency measures.
Goal 8. Community residents, including at-risk or underserved populations and households, will understand the requirements, opportunities, and benefits of electrification.	
8a. Prioritizing equitable engagement with residents and business owners to educate them on new programs or policies.	The City of Berkeley, California's Electrification Strategy and City of Sacramento DRAFT Building Electrification Strategy address the need for the city to build trust, lead by example, and ensure equitable benefits in their electrification approaches.
8b. Implementing a neighborhood-based approach to prioritize upgrades in key at-risk locations.	The City of Minneapolis, Minnesota, designated "Green Zones" for increased city clean energy investment in neighborhoods that have historically faced environmental harms.
8c. Developing an engagement program with multifamily building owners/managers.	The City of Thornton, Colorado, runs a Multifamily Community Managers partnership program through the City Housing Division and Police Department that organizes quarterly meetings with property managers to share resources and requirements and to build trust.

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