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Steven Winter Associates, Inc.
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San José Customer Economics Analysis for Residential Building Electrification

Completed February 2022

Appendix E1 of the *Electrify San José Framework*

Contents

Editorial (non-substantive) updates were added to this document in September 2022.

Purpose

City of San José staff worked with the Building Electrification Institute (BEI) to better understand the cost impacts of electrification in typical homes in San José. This analysis includes:

- **A detailed cost analysis of single-family and low-rise multifamily homes** (the most common building typologies in San José), including:
  - An estimate of total installation costs ("capital costs") of electrification compared to gas alternatives*
  - An estimate of utility bill ("operating cost") impacts for electrified buildings, by building system, compared to new gas alternatives
- **Additional measures to consider** that can improve health, safety, and/or operating costs across all residential buildings
- **An estimated total cost range of electrifying all residential buildings** in San José by 2030

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*Note that this analysis does not consider who pays for these costs, which could be the owner, tenant, or a combination. This analysis also does not evaluate the incentives, rebates, and/or grants that could also be used to help pay for costs.

Methodology Overview

To complete this analysis, BEI used the following methodology:*

1. Segment San José's residential building stock into typologies based on number of units and age of buildings
2. Extract key assumptions from a study by E3, *Residential Building Electrification in California*, ("E3 Study") for available building typologies in California, including:
    - Installation cost estimates for replacing existing gas equipment with new electric equipment
    - Installation cost estimates for replacing existing gas equipment with new gas equipment
    - Energy use for typical homes by gas and electric systems in the San José climate
3. Apply residential energy rates from San José Clean Energy (SJCE) to the estimated energy use in each building type
4. Apply installation cost estimates from the E3 Study for each building system in each building type
5. Calculate installation and operating costs for the package of system replacements (or retrofits) for each building type and each system, covering:
    - Heating, Ventilation, Air Conditioning (HVAC)
    - Water heating
    - Laundry
    - Cooking (range/oven)
6. Sum the installation costs for each building type, totaling the citywide cost to retrofit all residential buildings in San José.**

*For more details on methodology and assumptions refer to "Detailed Methodology Process & Assumptions."
**Note that this model extrapolated the most common building types to the remaining building types to cover all residential buildings in San José.

Residential Building Types Analyzed

The following four typologies represent nearly 95% of San José's building stock.*

Typology	Older Single-Family (Pre-1990)	Newer Single-Family (Post-1990)	Older Low-Rise Multifamily Building (Pre-1990)	Newer Low-Rise Multifamily Building (Post-1990)
Description	A home with one unit built before 1990.	A home with one unit built after 1990.	A building less than 4 stories tall with 3 or more units, built before 1990.	A building less than 4 stories tall with 3 or more units, built after 1990.
Example				
Total Number of Buildings in San José	313,700	33,770	39,890	6,900
% of Residential Buildings	75%	8%	10%	2%

*These four typologies were chosen for cost analysis based on their prevalence in San José and available cost data.

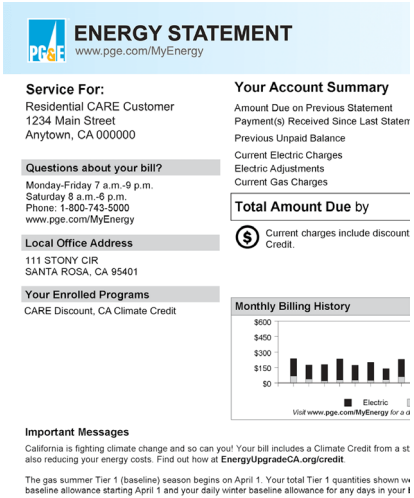
Costs of Building Electrification

There are two types of costs to consider:

Installation costs

- **Retail or "hard" costs of new equipment** (including electrification technologies and other related systems, such as solar PV)
- **Labor costs** for installation of this equipment
- **Other "soft" costs** associated with system installation (engineering design, permits, fees, etc.)

Operating costs



- **Utility bills** for electric and gas use in the home
- **Maintenance & repair** of existing equipment to ensure continued operation

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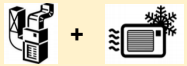
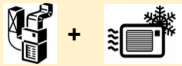
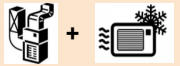
Source: The Greenlining Institute, *Equitable Building Electrification Framework*
Image Source: PG&E

Equipment Replacement Scenarios

This analysis uses the following start and end points for HVAC systems:*

	Older single-family (Pre-1990)	Newer single-family (Post-1990)	Older Low-Rise Multifamily Building (Pre-1990)	Newer Low-Rise Multifamily Building (Post-1990)
Starting Point: Building with gas equipment	**Gas Furnace** with **Window AC** (assumes the building does not have ducts) 	**Gas Furnace** with **Central AC** (assumes the building has ducts) 	**Gas Furnace** with **Window AC** per apartment (assumes the building does not have ducts) 	**Gas Furnace** with **Central AC** per apartment (assumes the building has ducts) 
End Point: Replacement of gas equipment with new gas systems	**Gas Furnace** with **Window AC** 	**Gas Furnace** with **Central AC** 	**Gas Furnace** with **Window AC** 	**Gas Furnace** with **Central AC** 
End Point: Conversion from gas equipment to all-electric systems	**Mini - split heat pump** 	**Ducted central heat pump** 	**Packaged terminal heat pumps (PTHP)** 	**Ducted heat pump per apartment** 

All end points assume that homes will retrofit or replace their homes to include sufficient cooling.

Types of Heat Pumps

Ductless Mini-split Heat Pump	Ducted Central Heat Pump	Packaged Terminal Heat Pump
		
Ductless mini-splits are decentralized heating and cooling systems that allow the user to control the temperatures in individual rooms or spaces. Mini-split systems have two main components -- an outdoor compressor/condenser and an indoor air-handling unit(s). The mini-split transfers heat between a house and the outside air via refrigerant lines, not requiring the use of ducts.	**Ducted heat pumps** are centralized heating and cooling systems that act much like traditional central heating and cooling systems. The heat pump unit sits outdoors, and the indoor fan coil works to move conditioned air into living spaces through vents via a duct system.	**Packaged Terminal Heat Pumps (PTHPs)** are decentralized heating and cooling systems that allow the user to control the temperatures in individual rooms or spaces. PTHPs transfer heat between a house and the outside all within the unit. PTHPs are typically found in openings under windows, not requiring the use of ducts.

Image Source (Mini Split Heat Pump): U.S. Department of Energy
Image Source (Ducted Central Heat Pump): EnergyStar.Gov
Image Source (Packaged Terminal Heat Pump): Lawrence Berkeley Lab

Equipment Replacement Scenarios

This analysis uses the following start and end points for other building systems:

	Older Single-Family (Pre-1990)	Newer Single-Family (Post-1990)	Older Low-Rise Multifamily Building (Pre-1990)	Newer Low-Rise Multifamily Building (Post-1990)
Starting point: Building with gas equipment	Existing Gas Storage Water Heater 			
	Existing Gas Stove / Oven 			
	Existing Gas Dryer 			
End Point: Replacement of gas equipment with new gas systems	*New* Gas Storage Water Heater 			
	New Gas Stove / Oven 			
	New Gas Dryer 			
End Point: Conversion to all-electric systems	Heat Pump Water Heater 			
	Electric Resistance Stove / Oven 			
	Heat Pump Dryer 			

Installation Costs | Single-Family Homes

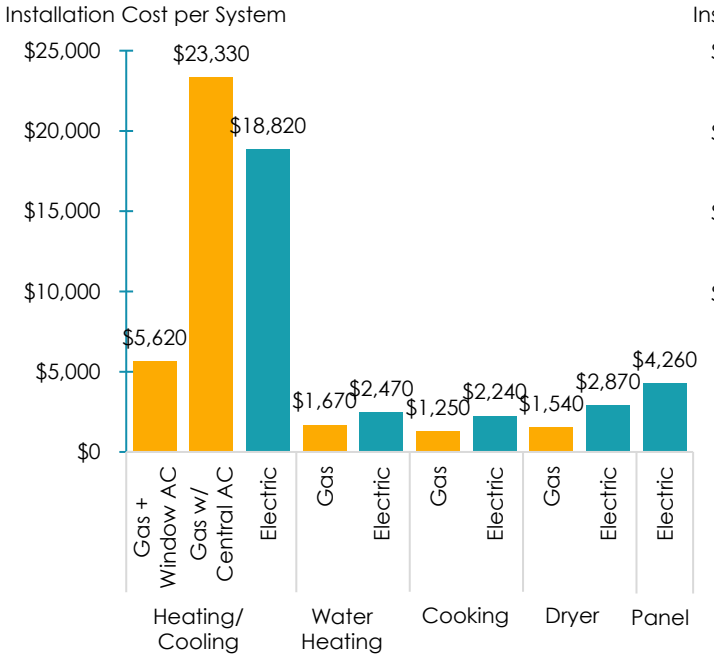
The graphs on the following two pages demonstrate the installation cost difference by system for retrofitting an existing single-family home to new gas systems versus new electric systems.

Key Findings:

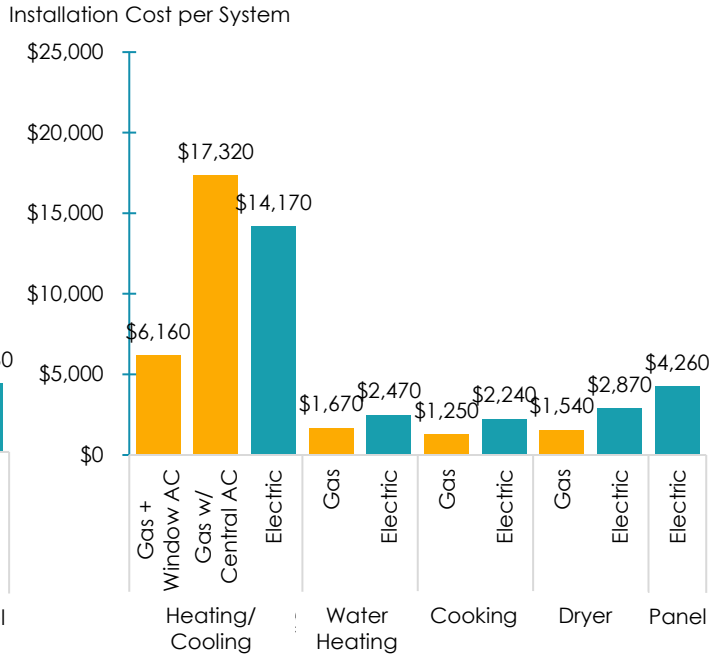
- Full home electrification installation costs are $3,000-$4,000 higher compared to a gas replacement and central A/C scenario. However, when comparing only the replacement of the two priority systems (HVAC and water heating), the installation costs for electric equipment are comparable to their gas counterparts.
- Gas and electric equipment have different installation costs. Often, electric equipment is more expensive to install than gas equipment, but this is not always the case.
- A gas furnace combined with window air conditioners (A/Cs) is currently the cheapest option for an HVAC system in single family homes, however may not provide sufficient cooling for a home, especially as summers become increasingly hot in San José due to climate change.
- Installing an all-electric HVAC system that provides both heating and cooling is less expensive than replacement a gas heating system and installing a central A/C system.
- For homes that currently use gas for heating and hot water, electrifying both systems likely requires upgrading the central electrical panel. This may not be necessary, however, if one of the two is already electric.

Installation Costs | Single-Family Homes by System

Older (Pre-1990) Single-Family Home



Newer (Post-1990) Single-Family Home



Notes and Assumptions:

1. *Costs assume a starting point of all gas equipment.*
2. *Installation costs include equipment costs and labor costs.*
3. *When a system breaks, it can be replaced with either gas or electric equipment. The difference in installation costs between new gas vs. new electric equipment is shown here, and is called the "incremental" cost.*
4. *Panel upgrades are needed in some cases, but this should be determined with a licensed contractor.*

Total Incremental Cost
(Cost difference between new gas vs new electric equipment):*
$3,000-$4,000

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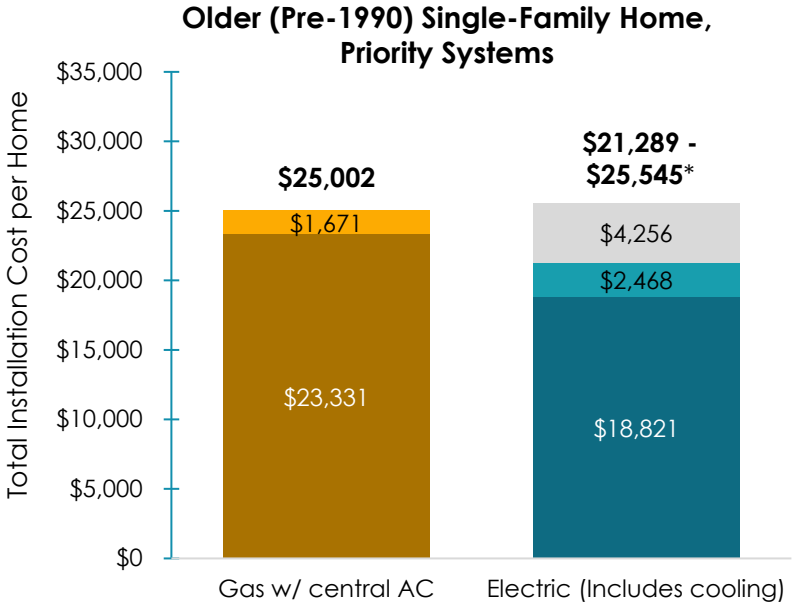
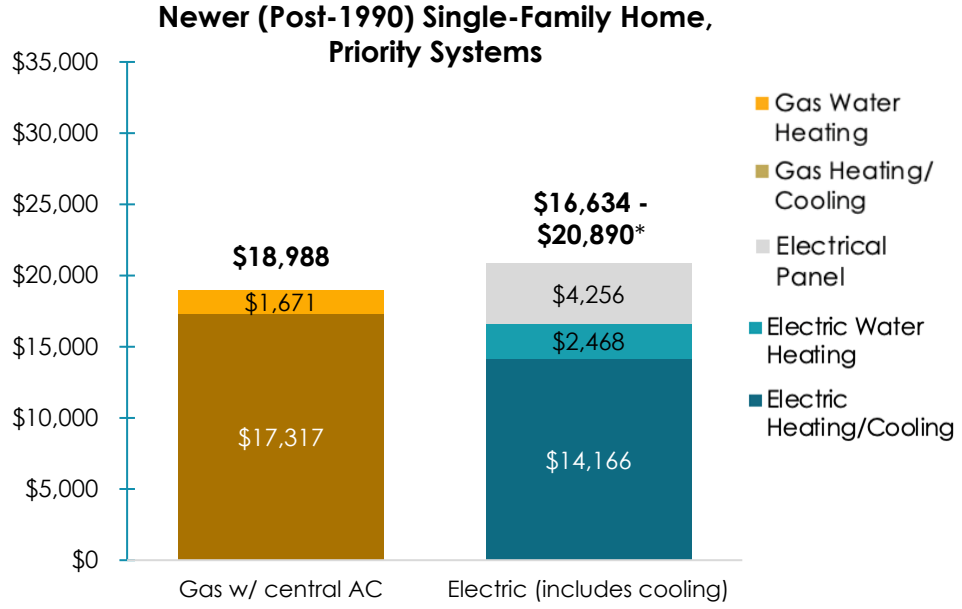
*Note: The total installation cost difference assumes homes must install central cooling to provide sufficient cooling as summers get hotter due to climate change. The "Gas + Window AC" scenario does not include the installation of central cooling and assumes existing window A/Cs are not upgraded.

Installation Costs | Single-Family Homes with Central A/C

Assuming a single-family home installs central cooling, the installation cost for priority systems (HVAC and hot water) are comparable to a retrofit to new gas equipment plus central cooling.*





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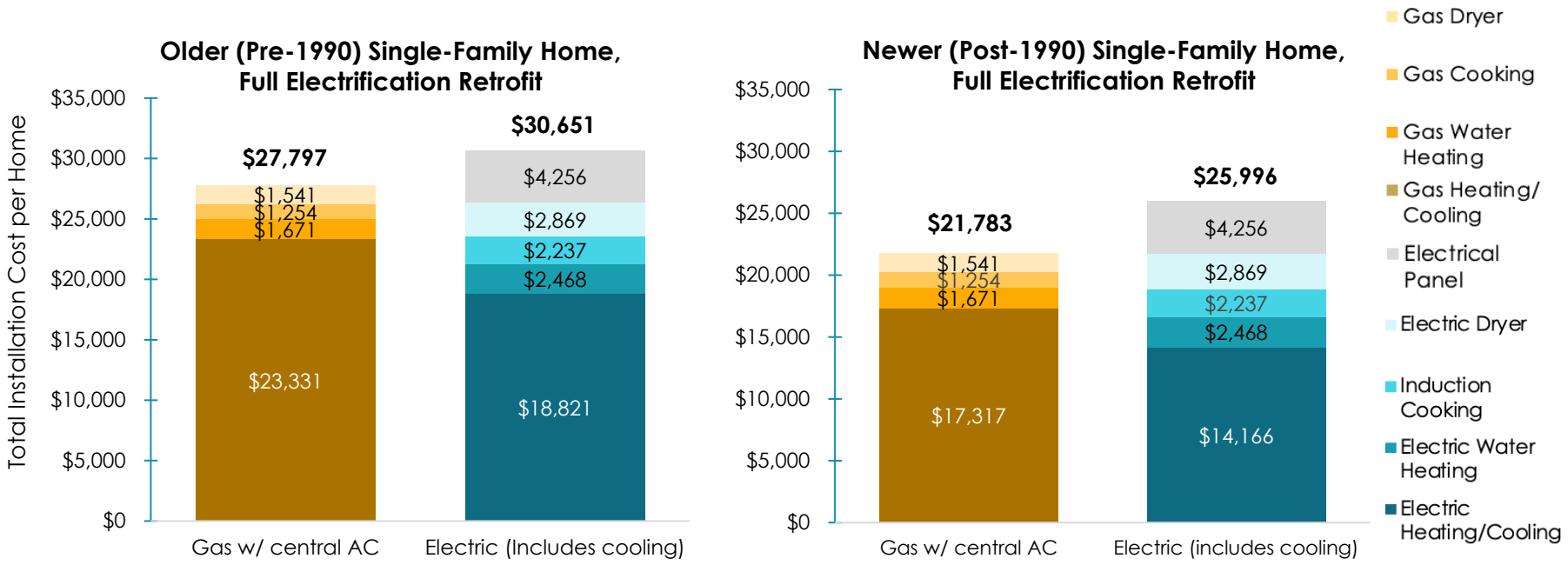
*Notes: HVAC and hot water systems make up the majority of both energy use and installation costs. The higher end of the range includes the cost of an electric panel upgrade, which is likely to be required in homes that currently use gas for both heating and hot water. However, this may not be necessary in all cases and should be determined with a licensed contractor.

Installation Costs | Single-Family Homes with Central A/C

The cost of a full electrification retrofit in a single-family home, however, is $3,000-$4,000 higher than a retrofit to new gas equipment plus central cooling.



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Installation Costs | Low-rise Multifamily

The following two pages demonstrate the installation cost difference by system for retrofitting an existing low-rise multifamily home to new gas systems versus new electric systems.

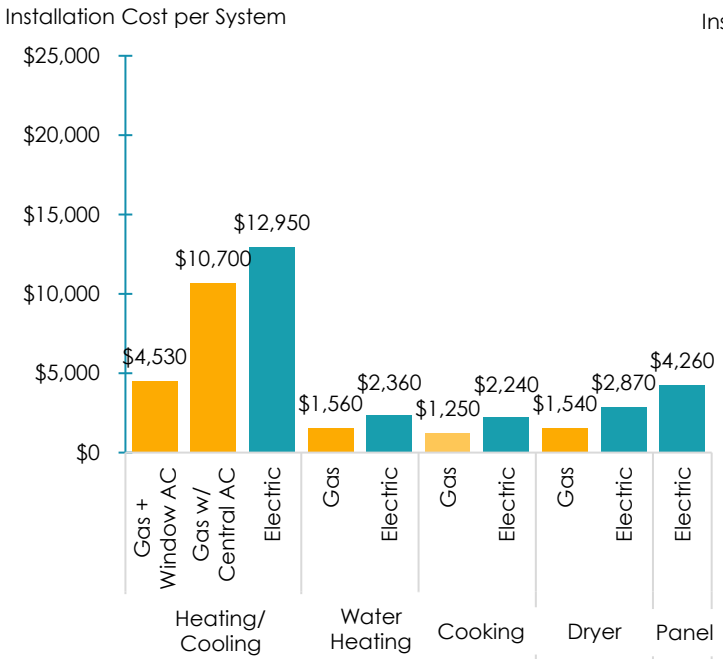
Key Findings:

- Full home electrification installation costs for low-rise multifamily buildings are $6,000-$10,000 higher compared to a gas replacement scenario.
- Similar to the findings for single-family homes, the installation costs for most electric equipment is more than the installation costs for gas equipment.
- When replacing HVAC systems, installing a gas furnace with window A/Cs is the cheapest option in multifamily buildings. However, window A/C may not provide sufficient cooling for a home, especially as summers become increasingly hot in San José due to climate change.
- In older multifamily buildings (built before 1990), installing a new gas furnace with a central A/C system is less expensive than installing a heat pump system to provide both heating and cooling for the whole building. In newer multifamily buildings however, the heat pump system is less expensive.*
- For many multifamily buildings, upgrading the central electrical panel will also be necessary in order to electrify both the heating and hot water systems.

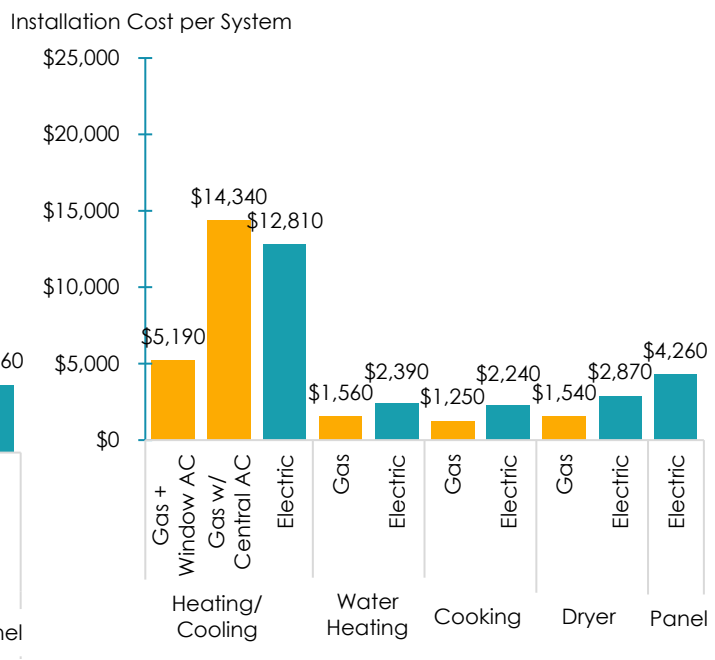
*Older homes were assumed to not have ductwork and would retrofit using a ductless HVAC system. This is a more expensive retrofit than the newer buildings, which were assumed to have existing ductwork that could be reused.

Installation Costs | Low-rise Multifamily Homes by System

Older (Pre-1990) Multi-Family Home



Newer (Post-1990) Multi-Family Home



Notes and Assumptions:

1. *Costs assume a starting point of all gas equipment and are displayed per dwelling unit.*
2. *Installation costs include equipment costs and labor costs.*
3. *When a system breaks, it can be replaced with either gas or electric equipment. The difference in installation costs between new gas vs. new electric equipment is shown here, and is called the "incremental" cost.*
4. *Panel upgrades are needed in some cases, but should be determined with a licensed contractor.*

Total Incremental Cost
*(Cost difference between new gas vs new electric equipment)**:
$6,000-$10,000

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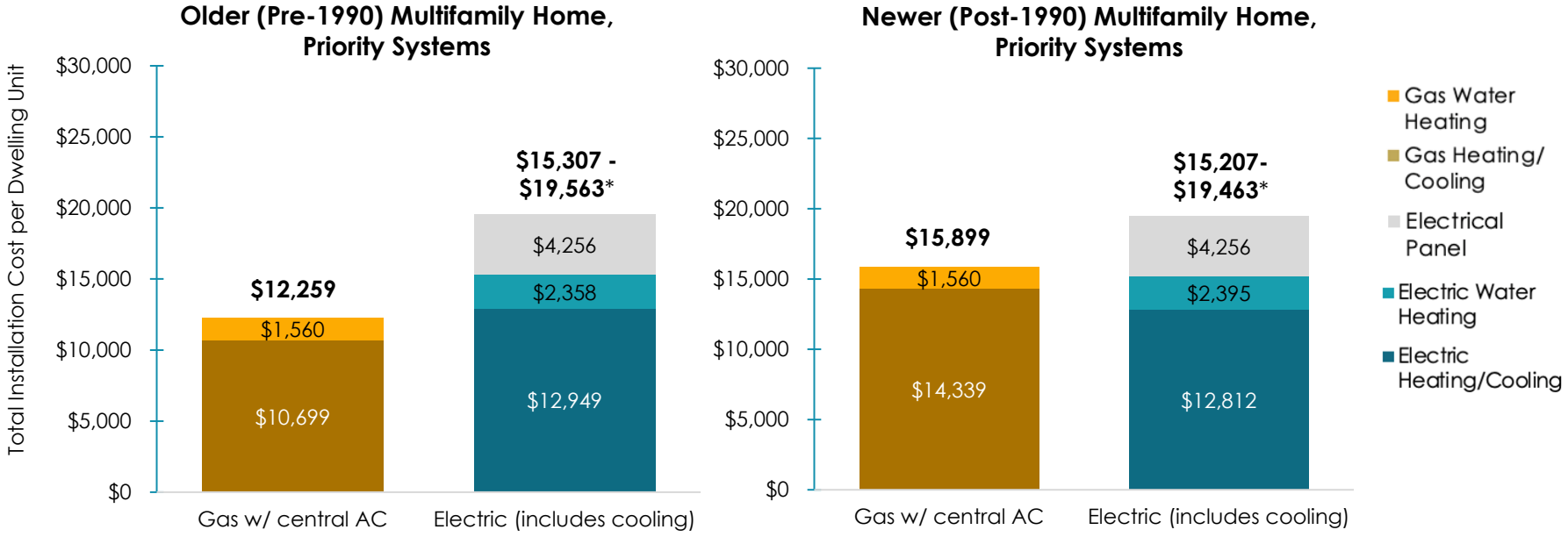
*Note: The total installation cost difference assumes homes must install central cooling to provide sufficient cooling as summers get hotter due to climate change. The "Gas + Window AC" scenario does not include the installation of central cooling and assumes existing window A/Cs are not upgraded.

Installation Costs | Low-rise Multifamily with Central A/C

The installation cost for priority systems (HVAC and hot water) could roughly break even in a multifamily building, or could range up to $7,000 higher.



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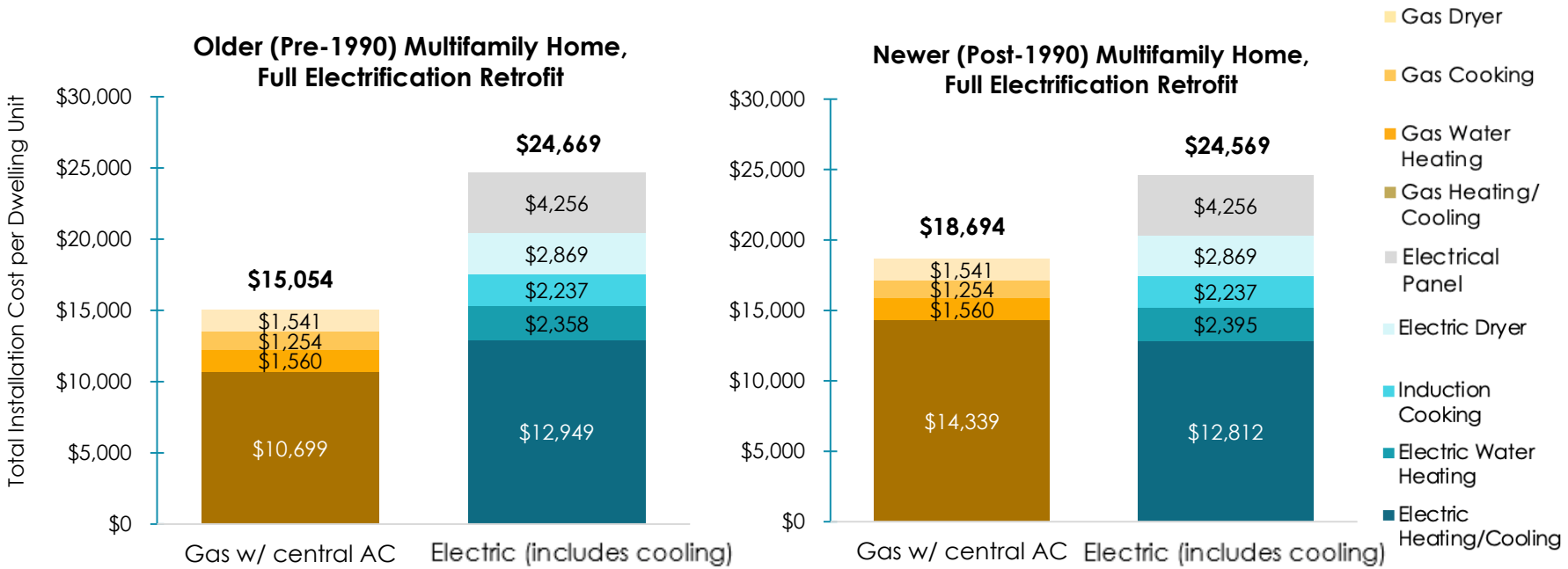
*Note: HVAC and hot water systems make up the majority of both energy use and installation costs. The higher end of the range includes the cost of an electric panel upgrade, which is likely to be required in homes that currently use gas for both heating and hot water. However, this may not be necessary in all cases and should be determined with a licensed contractor.

Installation Costs | Low-rise Multifamily with Central A/C

The cost of a full electrification retrofit in a multifamily home is $6,000-$10,000 higher per unit than a retrofit to new gas equipment plus central cooling.



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Measures to Consider | Health & Safety

Although not every home needs this work, additional upgrades may be required to address health, safety, or other needs in a building, which can add to installation costs:

Electrical Panel Upgrade

(this adds capacity for more electrical appliances and may also be necessary for electric car charging stations)

Rewiring

(i.e. replacing knob-and-tube wiring)

Lead, Mold, Pest, or Asbestos Removal

Ductwork Update

(i.e. reconfiguring, sealing, insulating)

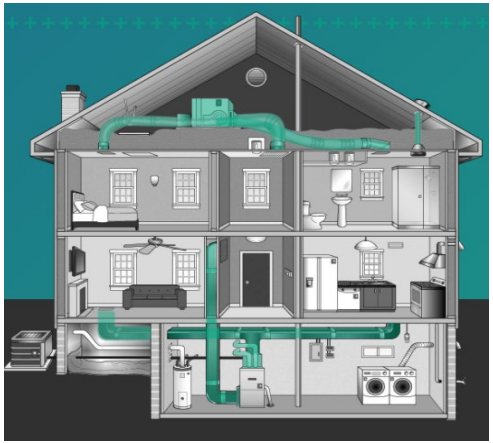

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Image Source (Electrical Panel): City of Portland
Image Source (Rewiring): International Association of Certified Home Inspectors
Image Source (Asbestos):San Diego County Air Pollution Control District
Image Source (Insulation): BayREN

Measures to Consider | Energy Efficiency & Resiliency

These are additional technologies to consider that may *add* to upfront costs, but help *reduce* operating costs.

Energy Efficiency

Insulation and air sealing (a jacket for your home), smart controls and energy efficient appliances which can reduce energy load.

Rooftop Solar

Renewable energy can provide credit to your electricity bill and therefore reduce costs.

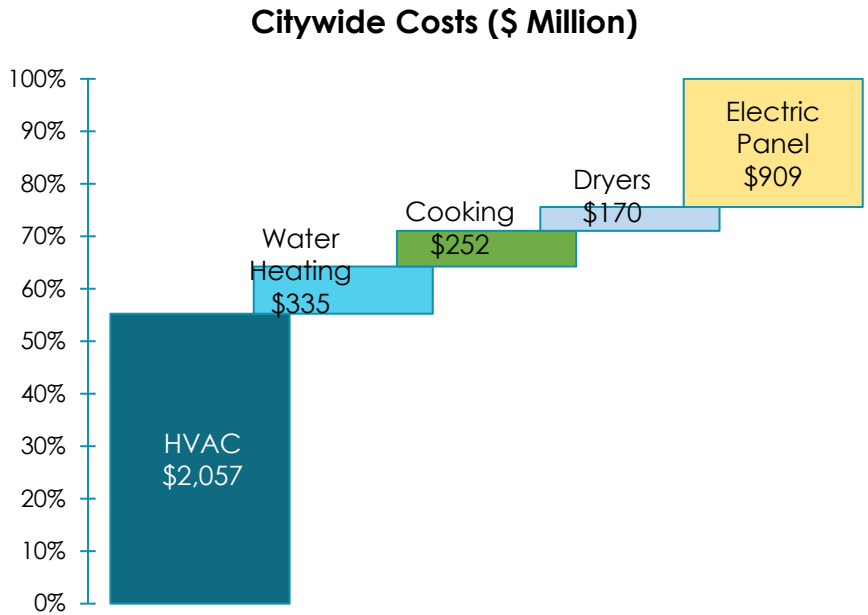
Battery Storage

Energy that you can use while electricity rates are lower or during emergencies, increasing your home's resiliency.

Image Source (Insulation): BayREN
Image Source (Solar): Grid Alternatives
Image Source (Battery): Energy.Gov

Citywide Residential Installation Costs

With a goal of electrifying all residential buildings by 2030, total installation costs for San José's residential buildings range from $2.7 to $4.7 billion.*



Notes on Approach:

- This analysis calculated an estimate for city wide total costs which represents a combination of incremental and total cost:
  - This estimate includes the *incremental cost* of installing electric equipment for all equipment that will be replaced at the end of its useful life by 2030.
  - This estimate also includes the *total cost* of installing electric equipment for those pieces of equipment that *will* not reach the end of their useful life by 2030 (and therefore would need to be replaced early).
- These costs are scaled up based on the total number of residential buildings in San José.

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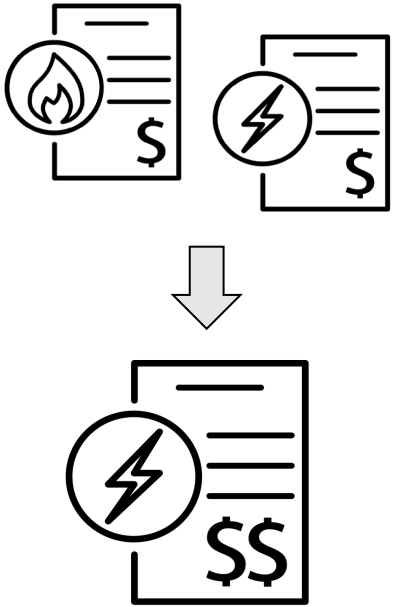
*The BEI team determined cost ranges based on several assumed proportions of systems that could reach the end of their useful life by 2030. Installation costs therefore include a mix of both incremental and total costs of system replacement. The chart above represents the average of this cost range.

Operating Costs

Operating costs in San José's residential buildings will depend on a range of factors:

- Cost of gas versus electricity (rates)
- Efficiency of the new system(s) compared to the old system(s)
- Heating and cooling loads, which can be reduced through energy efficiency of home (insulation & air sealing)
- On-site renewable energy (solar PV)
- Behavior of residents
- Increased need for heating and/or cooling, which could occur as a result of climate change



Opportunities which can help reduce operating costs:

- Ensure eligible customers are on discounted electricity rates (e.g. CARE & FERA)
- Scale up on-site solar PV and the use of smart controls, which can reduce usage or use it at the right time
- Lower SJCE's electricity rates

For more information, refer to the Housing & Energy Costs section within the Plan.

Operating Costs | Impacts by System

	Gas Starting Point	Electrification End Point	Operating Cost Impacts*	
HVAC	 Gas Furnace + Central AC OR  Gas Furnace + Window AC	 PTHP OR  Mini-Split HP OR  Ducted Split HP	↑ *For those starting with a window AC:* ***Costs to Consumer*** Single-family and Multifamily: $100-$200/year	↓ *For those starting with central AC:* ***Savings to Consumer*** • Single-family: $300-$400/year • Multifamily: $100-$150/year
Water Heating	 **Gas Storage Water Heater**	 **Heat Pump Water Heater**	↓ **Savings to Consumer** Single-family and Multifamily: $50-$100 / year	
Cooking	 **Gas Stove**	 **Electric Resistance**	↓ **Savings to Consumer** Single-family and Multifamily: Up to $20/year	
Clothes Drying	 **Gas Dryer**	 **Heat Pump Dryer**	↑ **Costs to Consumer** Single-family and Multifamily: $50-$100/year	
Addition of Solar	**N/A**	 **On-site Solar PV** 3kW per SF home or per MF apartment	↓ **Savings to Consumer** Single-family and Multifamily: $700 / year	

*Based on our analysis using San José Clean Energy rates, most system replacements see operating bill savings. However, these assumptions can change from house to house.

Operating Cost | Whole Home Impacts

Below is a summary of whole home operating costs impacts, based on the starting point and depending on the addition of solar.

Annual Operating Costs (positive(green)=savings)) All homes starting with all gas equipment and ending with all electric equipment.		**No Solar**	**With Solar**
Single-Family	Window AC in baseline	-$240 to $50	$500 to $710
	Central AC in Baseline	$240 to $410	$980 to $1070
Multifamily	Window AC in baseline	-$230 to -$210	$360 to $360
	Central AC in Baseline	$30 to $90	$620 to $650

*Changes to current NEM structure could alter the cost impacts, however this was not evaluated as part of this analysis.

Key Takeaways:

- **Most homes in San José will see energy bill savings** of up to $1,000 per year as a result of whole home electrification, although some homes may see bill increases of up to $240 per year.
- **The addition of on-site solar PV will guarantee annual energy bill savings** across all homes.*
- **Homes with central AC today will see greater bill savings** from electrification than those that currently have window A/Cs.

When to Consider Electrification for Your Home

Because electrification will eliminate GHG emissions and improve the health and safety of your home, electrification should always be considered if you are in the financial position to do so.

An electrification retrofit will most likely have positive economic benefits when:

- Undertaken as part of a major renovation where all or most systems will be replaced anyways.
- Specific equipment needs to be replaced because it is at the end of its useful life. In particular, when the furnace and the central cooling system needs replacement, a heat pump can replace both with just one, significantly more efficient system.
- Completed along with energy efficiency upgrades to reduce heating loads
- The home already as on-site solar PV, or there are plans to install it
- Rebates, incentives, or grants exist to help cover the costs
- The home uses an electric resistance, fuel oil, or propane heating system (instead of natural gas), which is less common in San José but is common in other regions.

*All upgrades should be discussed with a contractor who can understand the specific needs of your home. You can also receive advice and assistance for free with BayREN's Home Energy Advisor Program.**

*BayREN provides a free Home Energy Advisor service. For homeowners, please call 1-866-878-6008.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