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

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Notice

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Introduction

About Communities LEAP

- The U.S. Department of Energy's Communities LEAP (Local Energy Action Program) pilot supports community-driven action plans for clean energy-related economic development.
- This opportunity is open to low-income, energy-burdened communities that experience environmental justice challenges and/or direct economic impacts from reducing reliance on fossil fuels.
- Communities LEAP reflects the Biden-Harris Administration's commitments to:
    - Combat climate change through community-led transitions toward a more equitable and sustainable future.
    - Deliver 40% of the overall benefits of federal climate, clean energy, affordable and sustainable housing, clean water, and other investments to communities that have been historically marginalized, underserved, and overburdened by pollution.

24 Competitively Selected Pilot Communities

- The Communities LEAP pilot provides customized, high-quality technical assistance to 24 communities to develop clean energy-related economic development pathways.
- In each community, coalitions of local partners contribute to project oversight and delivery.
- The National Renewable Energy Laboratory (NREL) is the primary technical assistance (TA) provider.

Technical Assistance Pathways

The National Renewable Energy Laboratory (NREL) provides technical assistance for 24 communities in the following pathways:

- Clean Energy and Energy Efficiency
- Clean Energy Planning and Development
- Clean Transportation Planning and Investment
- Community Resilience Microgrid and Energy Storage
- Energy-Efficient Buildings and Beneficial Electrification Planning and Investment
- New or Enhanced Manufacturing and Industry

The U.S. Department of Energy's Office of Fossil Energy and Carbon Management provides technical assistance in the following pathway:

- Carbon Capture and Storage and Critical Minerals

San José's Goals & Objectives for Communities LEAP

- Detailed characterization of residential housing sector in eight low-income, high energy-burdened census tracts to identify prominent housing and household types.
- Comparative analysis of 16 energy efficiency and electrification upgrade strategies to identify cost-effective opportunities to reduce energy consumption, emissions, and burdens in eight census tracts with disproportionately high energy burden.
- Aid in-depth and nuanced engagements with stakeholders, and formation of a community-informed action plan to support all-electric retrofits while enabling the “Good Life 2.0” for all residents.

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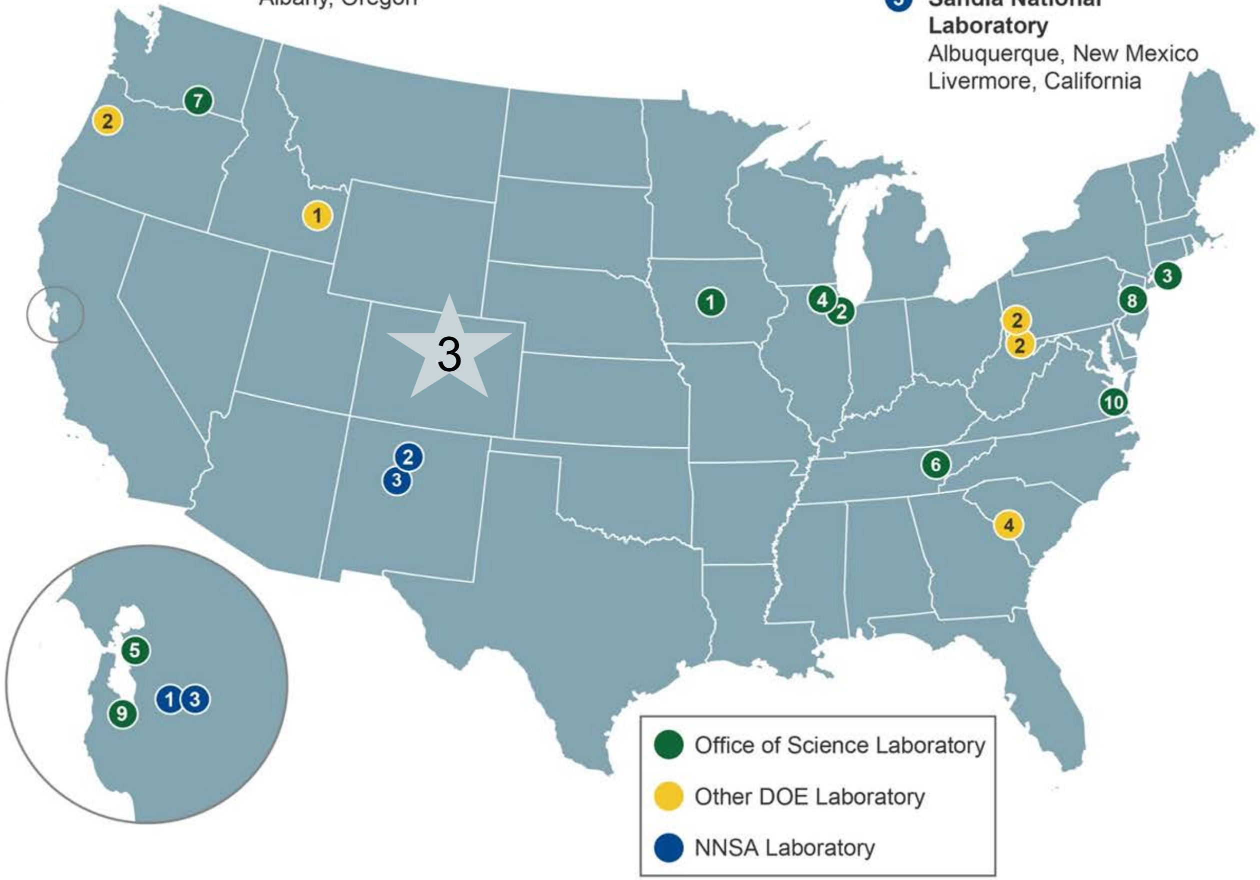


Source: U.S. Department of Energy

NREL Laboratory Capabilities

Renewable Energy

- Solar
- Wind
- Water
- Geothermal

Sustainable Transportation

- Bioenergy
- Vehicle Technologies
- Hydrogen

Energy Efficiency

- Buildings
- Advanced Manufacturing
- Government Energy Management

Energy Systems Integration

- Conventional Technologies
- High-Performance Computing
- Data, Analysis, and Visualizations

Residential Building Stock Characteristics

Modeling Assumptions & Limitations

- Analysis is based on ResStock™-<u>modeled</u> energy consumption; all models have uncertainties.
- Modeling is aggregated across collections of housing units; results for individual housing unit can vary substantially.
- 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.
- Utility rates were provided by San José Clean Energy.
- Specific measures and measure packages were modeled (not all potential technologies/performance levels and packages).
- Heat pumps were modeled with existing heating system as backup and also separately modeled with electric backup; 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.
- Building upgrades required for electrification (remediation, new electric panel) were not considered.

See detailed description of ResStock Communities LEAP modeling assumptions/limitations here: https://data.nrel.gov/submissions/224

Summary of Analysis for San José, CA

- Analyzed four housing types identified by the community coalition for 16 different energy efficiency and electrification upgrades:
  - Multifamily, 5+ units, vintage year 1940–1979
  - Multifamily, 5+ units, vintage year 1980+
  - Single-family detached, vintage year 1940–1979
  - Single-family attached, vintage year 1940–1979.
- Sample results for five packages selected by the community coalition:
  - Basic Enclosure Upgrades
  - High-Efficiency Whole-Home Electrification
  - High-Efficiency Whole-Home Electrification with Basic Enclosure Upgrades
  - Minimum-Efficiency Heat Pump with Existing Heat Backup
  - Heat Pump Water Heater.
- Metrics evaluated:
  - Annual energy use and emissions reductions
  - Annual energy bill impacts
  - Average upgrade cost without incentives
  - Average change in energy burden
  - Percentage change in hourly electricity demand in extreme cases.

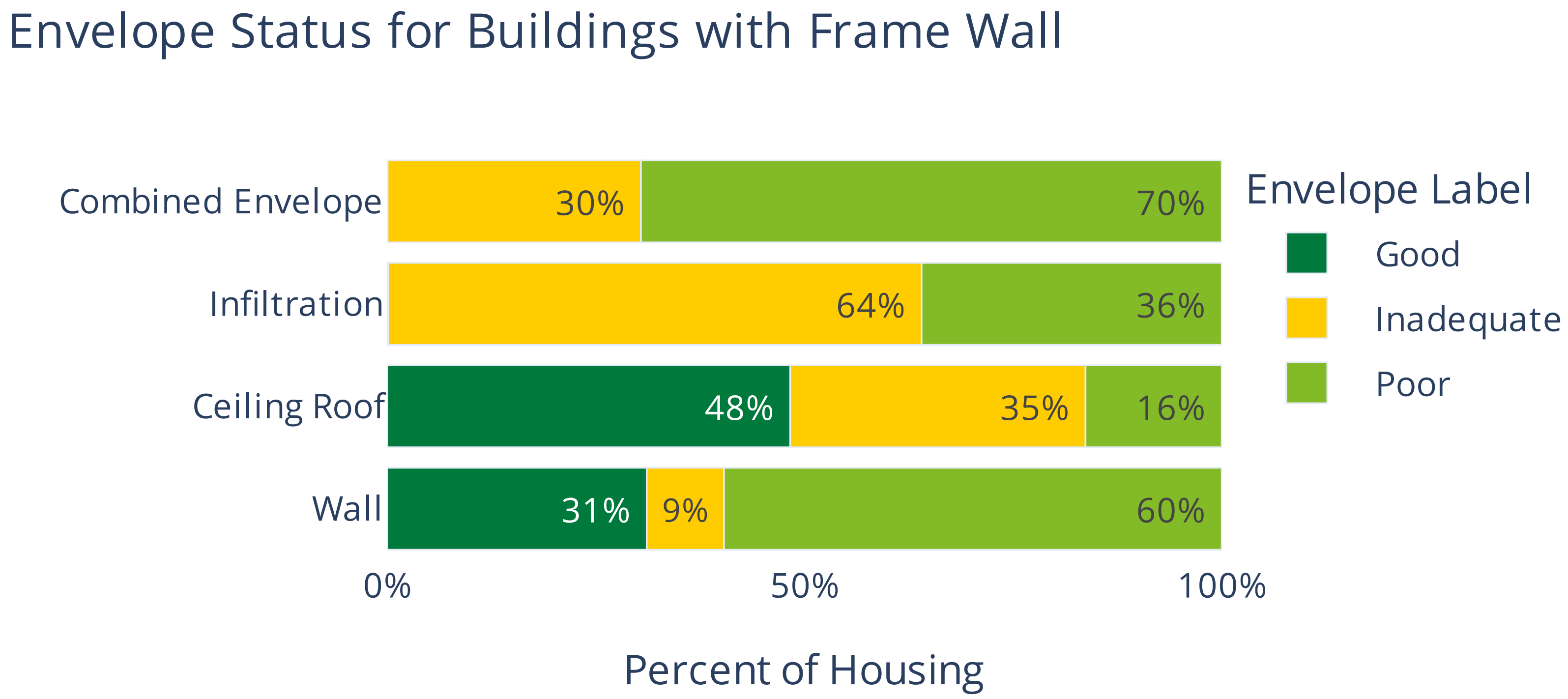
Table 1. Dominant Residential Building Types in Modeled Census Tracts in San José

- This analysis used the State Median Income (SMI) as the income indicator because California has higher cost of living than many states. SMI is the midpoint of the state's income distribution—half of households in a region earn more than the median and half earn less than the median.
  - Low: income <= 60% SMI (*The Federal Reserve definition for low-income is <50%, but the LEAD data only have 40% and 60% cut-offs)
  - Moderate: 60% SMI < income <= 80% SMI
  - High: income > 80% SMI

Building Type	Percentage of Low-Income Dwelling Units	Percentage of Total Dwelling Units
Multifamily (5+ units), built after 2000	25.4%	20.3%
Multifamily (5+ units), Built 1940–1979	22.3%	16.7%
Multifamily (5+ units), Built 1980–1999	14.0%	13.8%
Multifamily (2-4 units), Built 1940–1979	6.7%	5.9%
Single-family attached, Built 1940–1979	5.0%	5.6%

Figure 1. Envelope Status for Existing Residential Buildings in modeled census tracts in San José

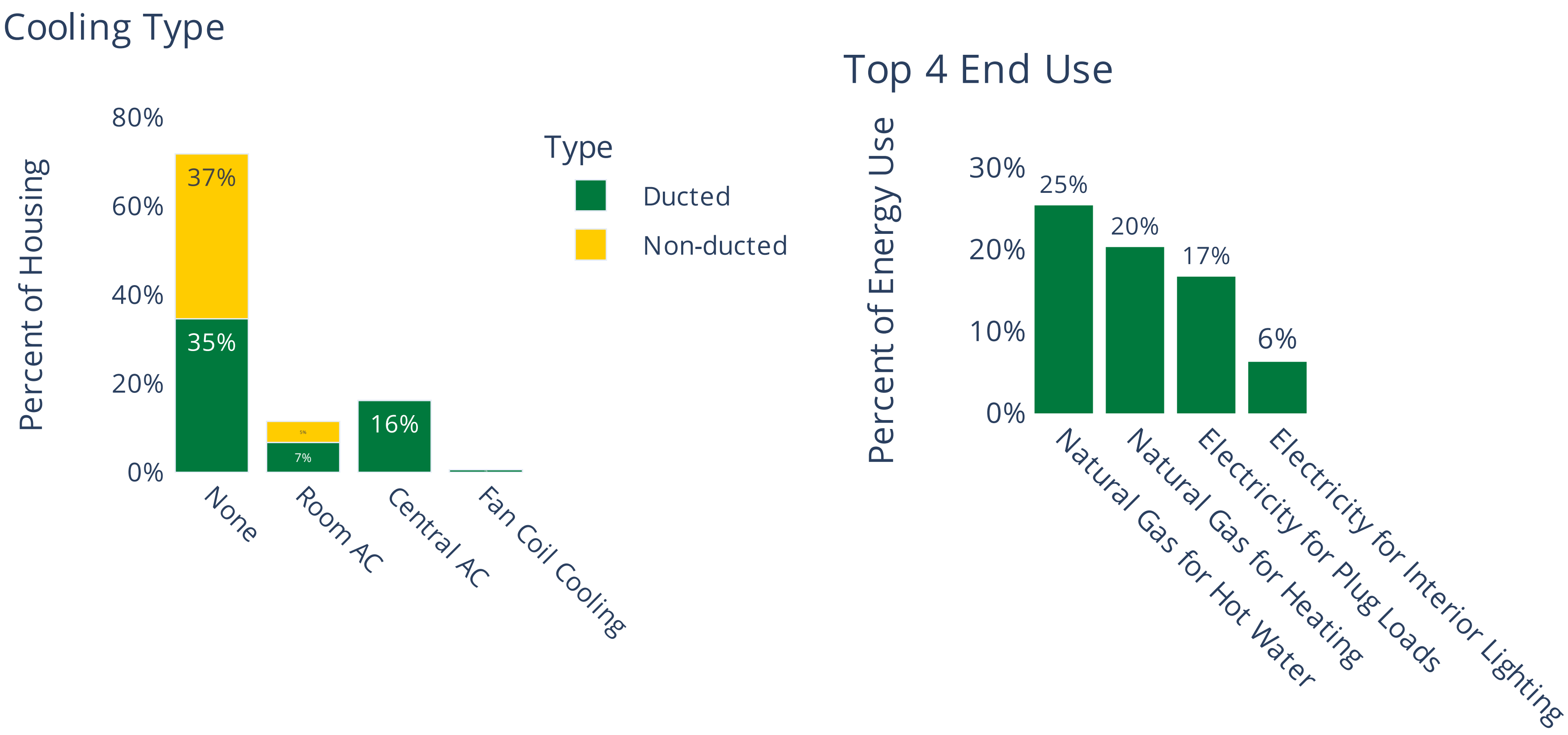
Roughly 70%–94% of homes in modeled census tracts in San José have building envelopes with energy performance levels below modern building codes. Inadequate insulation and sealing allows air in and out of homes and increases costs of heating and cooling.



This work presents energy efficiency and electrification modeling results for dwelling units using ResStock EUSS 2022.1, which is a statistical representation based on modeling predictions of energy use and reductions. Actual results may vary. Access the methodology document at https://data.nrel.gov/submissions/224

Figure 2. Heating and Cooling Fuels and Technologies in Existing San José Residential Buildings modeled in this Analysis

The overwhelming majority—roughly 94%— of San José homes modeled in this analysis rely on natural gas for hot water and space heating, which account for 25% and 20% of total residential site energy use, respectively. Roughly 70% of households lack any form of air conditioning, which may contribute to health and safety risks in a warmer climate.



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Description of Upgrade Measures

Table 2. Technical Specifications for Heat Pump Upgrade Measures

Upgrade Type	Description	Technical Details
Minimum Efficiency Heat Pump with Existing Heat Backup	Heat Pump Specifications	Centrally ducted single-speed heat pump SEER 15, 9 HSPF, sized to ACCA 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 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.

Additional documentation on the energy efficiency and electrification packages as well as the emissions calculations can be found at https://oedi-data-lake.s3.amazonaws.com/nrel-pds-building-stock/end-use-load-profiles-for-us-building-stock/2022/EUSS_ResRound1_Technical_Documentation.pdf

Table 3. Technical Specifications for Whole-Home Upgrade Packages

Upgrade Type	Description	Technical Details
Basic Enclosure	Wall & Attic Floor Insulation	R-13 drill-and-fill insulation applied to homes with wood stud walls and no insulation. Attic floor insulation up to IECC-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 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. 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 (CEF = 5.2) for all dwelling units with nonelectric 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.

Additional documentation on the energy efficiency and electrification packages as well as the emissions calculations can be found at https://oedi-data-lake.s3.amazonaws.com/nrel-pds-building-stock/end-use-load-profiles-for-us-building-stock/2022/EUSS_ResRound1_Technical_Documentation.pdf

Assumed Average Upgrade Costs

Table 4. 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

Note: Actual costs for individual households and buildings will depend upon 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.

Whole-Home Strategies: Potential Impacts to Energy Use, Emissions, and Energy Bills

Figure 3. Total Annual Emissions Reductions by Housing Type and Upgrade Strategy in San José

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. Among the housing types analyzed, pursuing these upgrades in all eligible single-family detached homes built between 1940 and 1979 shows the greatest annual emissions reductions of any housing segment.

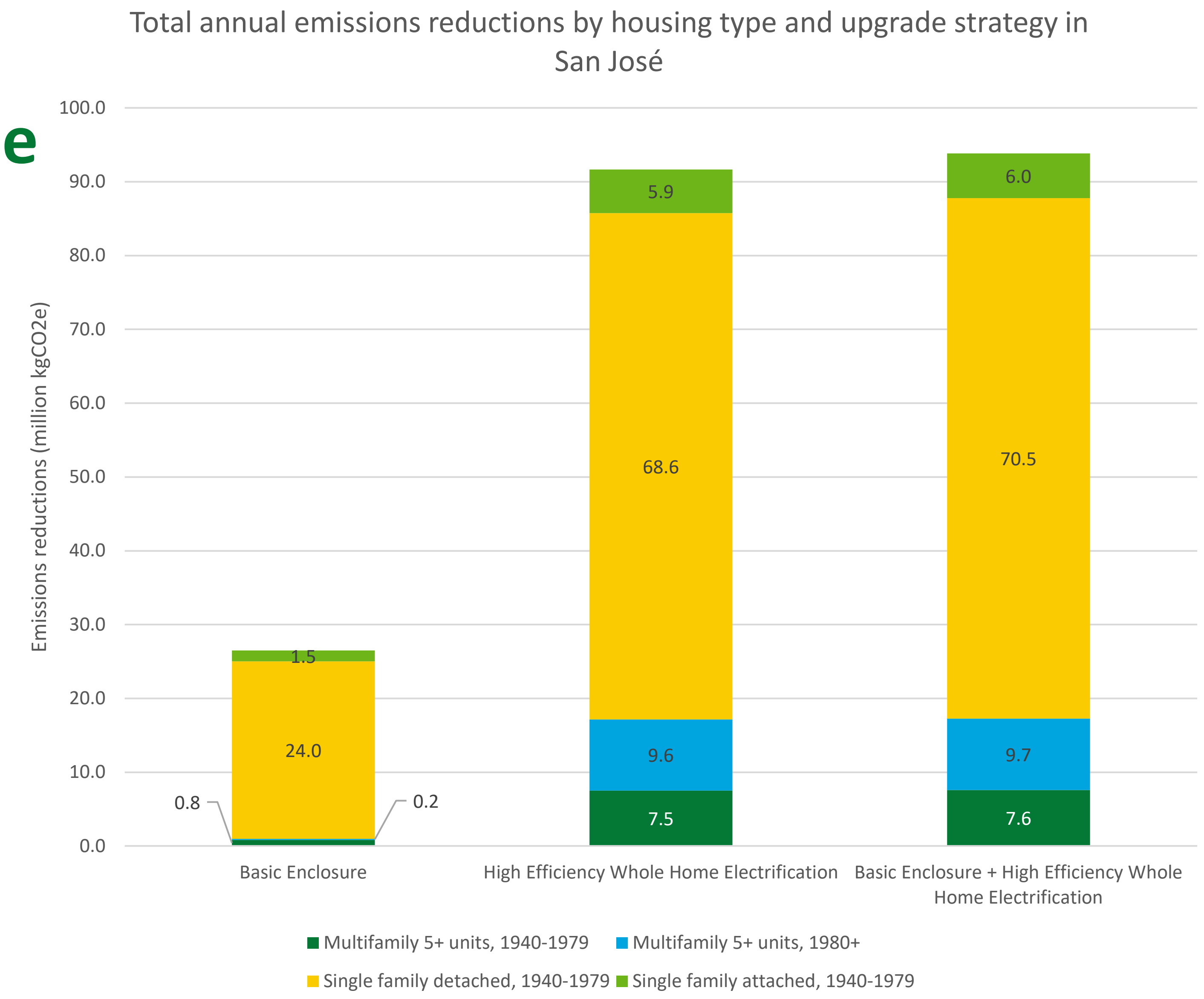

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Figure 4. Total Annual Site Energy Reductions by Housing Type and Upgrade Strategy in San José

Adding basic enclosure upgrades to whole-home electrification upgrades can increase total energy reductions from all fuel types—electricity, natural gas, and fuel oil—by more than 7% community-wide for the housing types analyzed. These reductions are greatest in single-family detached homes built between 1949 and 1970.

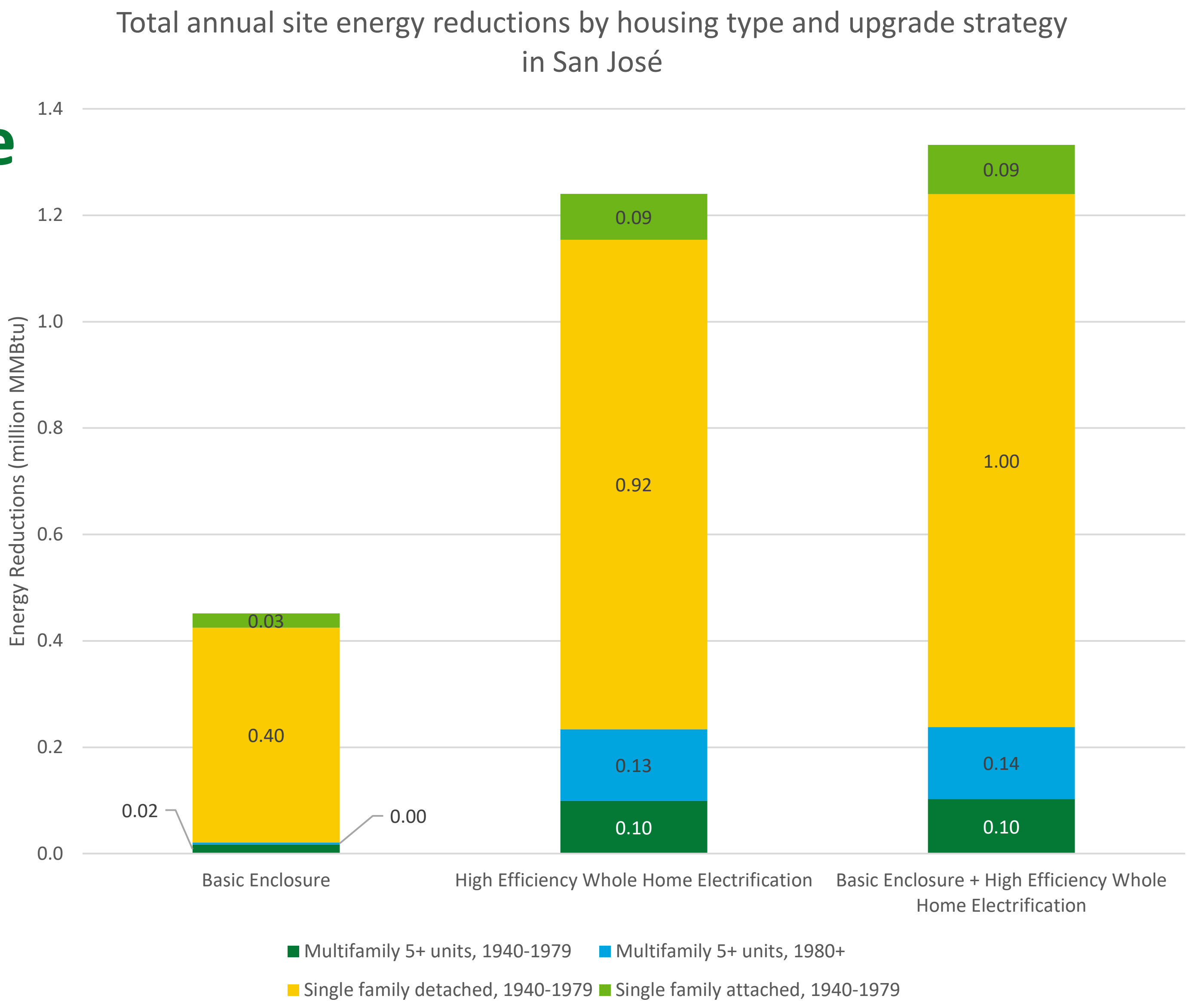

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Figure 5. Average Annual Emissions Reductions per Dollar Invested by Housing Type and Upgrade Strategy in San José

For all housing types analyzed, investments in high-efficiency whole-home electrification offer the greatest emissions reductions per dollar invested. Average potential emissions reductions-to-investment ratios for whole-home efficiency and electrification upgrades are greatest for single-family detached homes built between 1940 and 1979.

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Figure 6. Average Annual Site Energy Reductions per Dollar Invested by Housing Type and Upgrade Strategy in San José

Across residential homes using all types of energy sources— electricity, natural gas, and fuel oil— investments in basic enclosure upgrades can offer the most cost-efficient site energy reductions for multifamily and single-family homes built before 1980. For newer multifamily units built after 1980, investments in high-efficiency whole-home electrification offer the most cost-efficient energy reductions per dwelling unit.

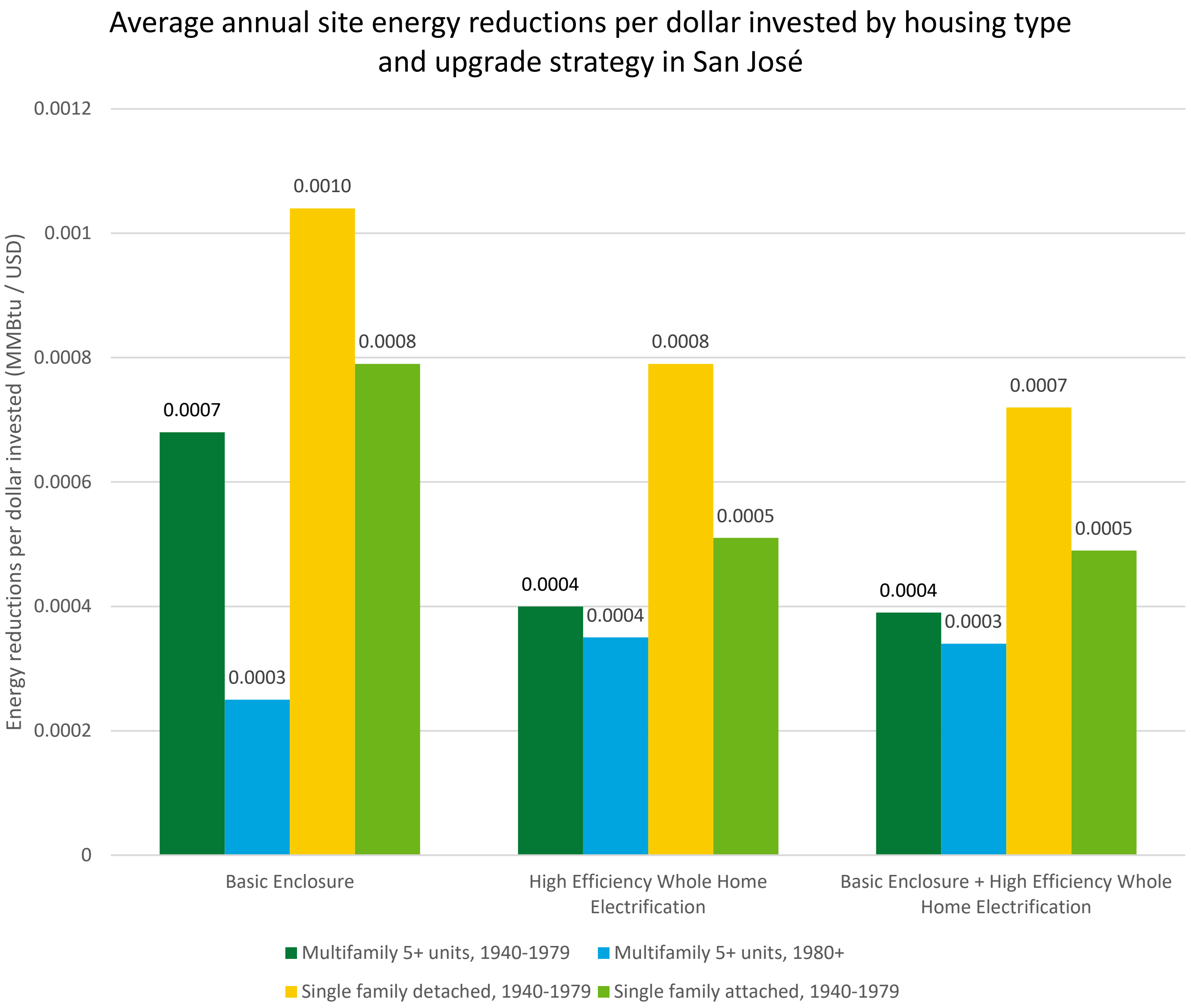

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Figure 7. Average Annual Energy Bill Reductions by Housing Type and Upgrade Strategy in San José

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. Per household, the marginal benefits of basic enclosure upgrades as part of a comprehensive whole-home electrification approach are greatest for single-family detached homes built between 1940 and 1979. Residents in these housing types could reduce an average of $825 per year on energy bills, with roughly $126 of those reductions representing marginal benefits of basic enclosure upgrades.

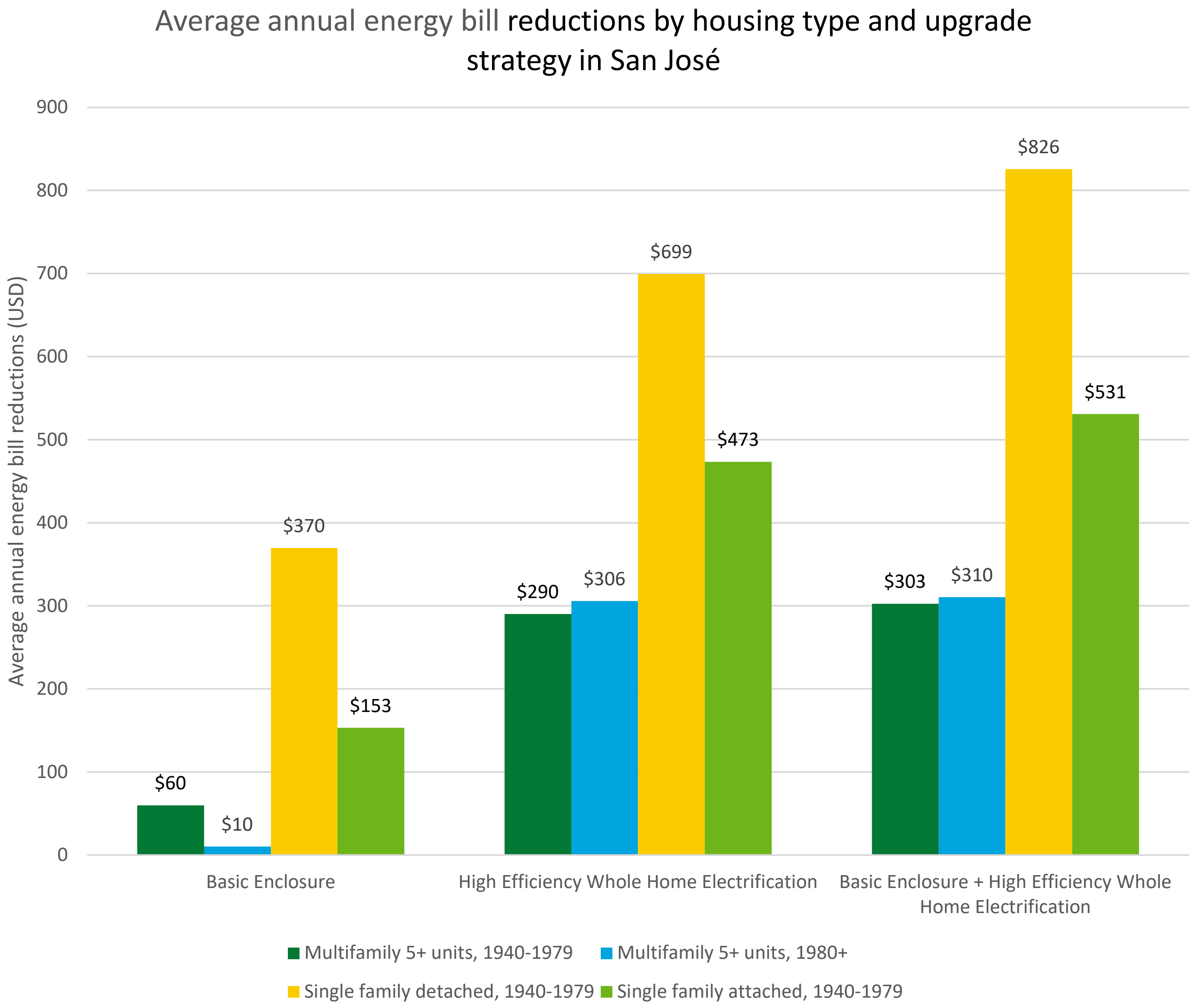

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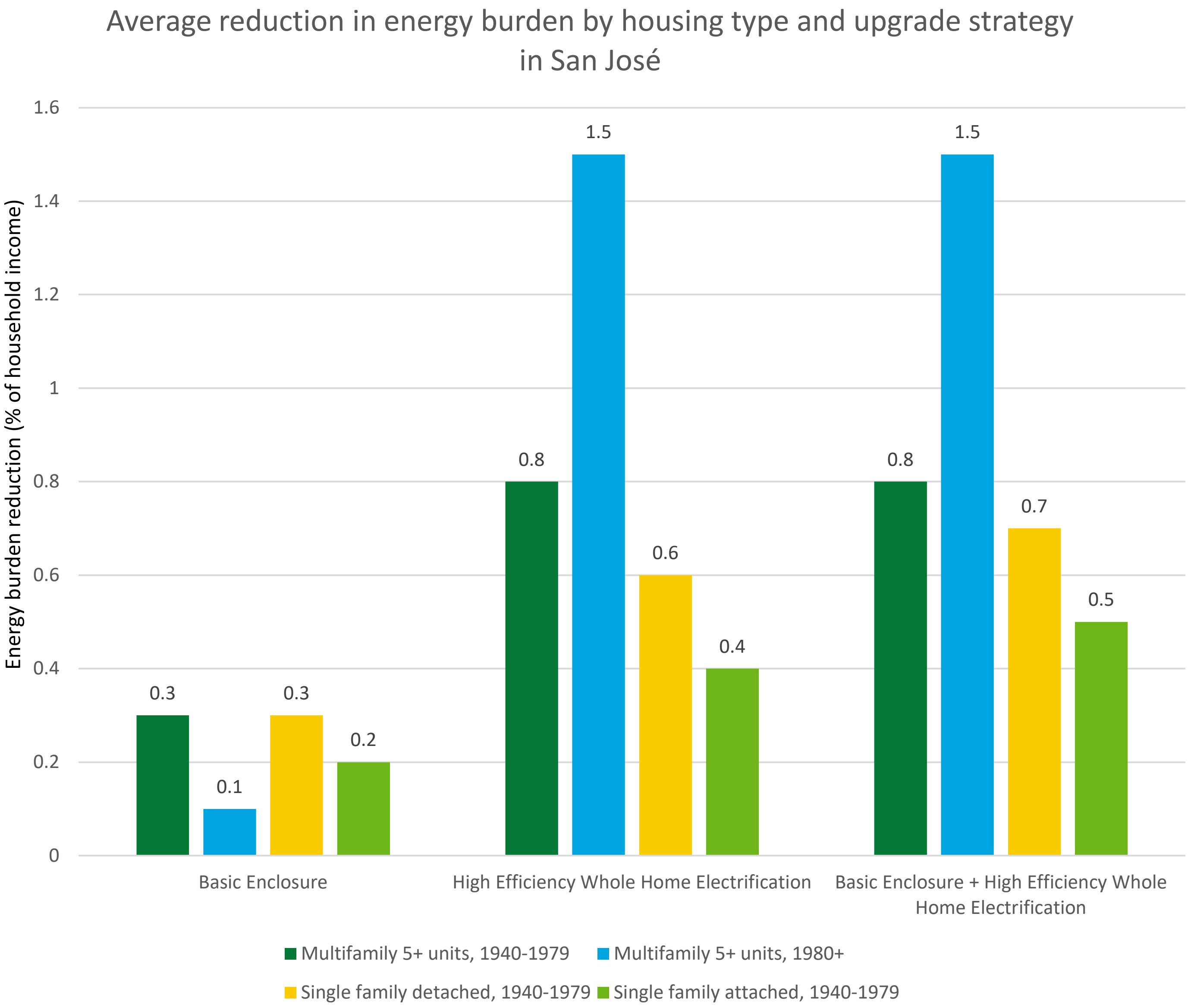
Figure 8. Average Energy Burden Reduction by Housing Type and Upgrade Strategy in San José

Based on the modeled results, energy efficiency and whole-home electrification can reduce energy burdens for households across all modeled housing types in San José. 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 but does not consider upgrade costs.



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Estimating Electrical Panel Upgrades

Multiple calculations were conducted to estimate whether upgrading the electrical service or panel capacity is needed as a part of electrification. These calculations utilize three pieces of information:

- Electrical panel size in the home before the retrofit.
- New loads added by the retrofit.
- Compliance requirement for avoiding an electrical panel upgrade.

Using ResStock housing metadata for San José, (e.g., building type, vintage, fuel type, floor area) a machine learning model under development by Lawrence Berkeley National Laboratory was used to estimate electrical panel size in each home, and new loads added by the retrofit.

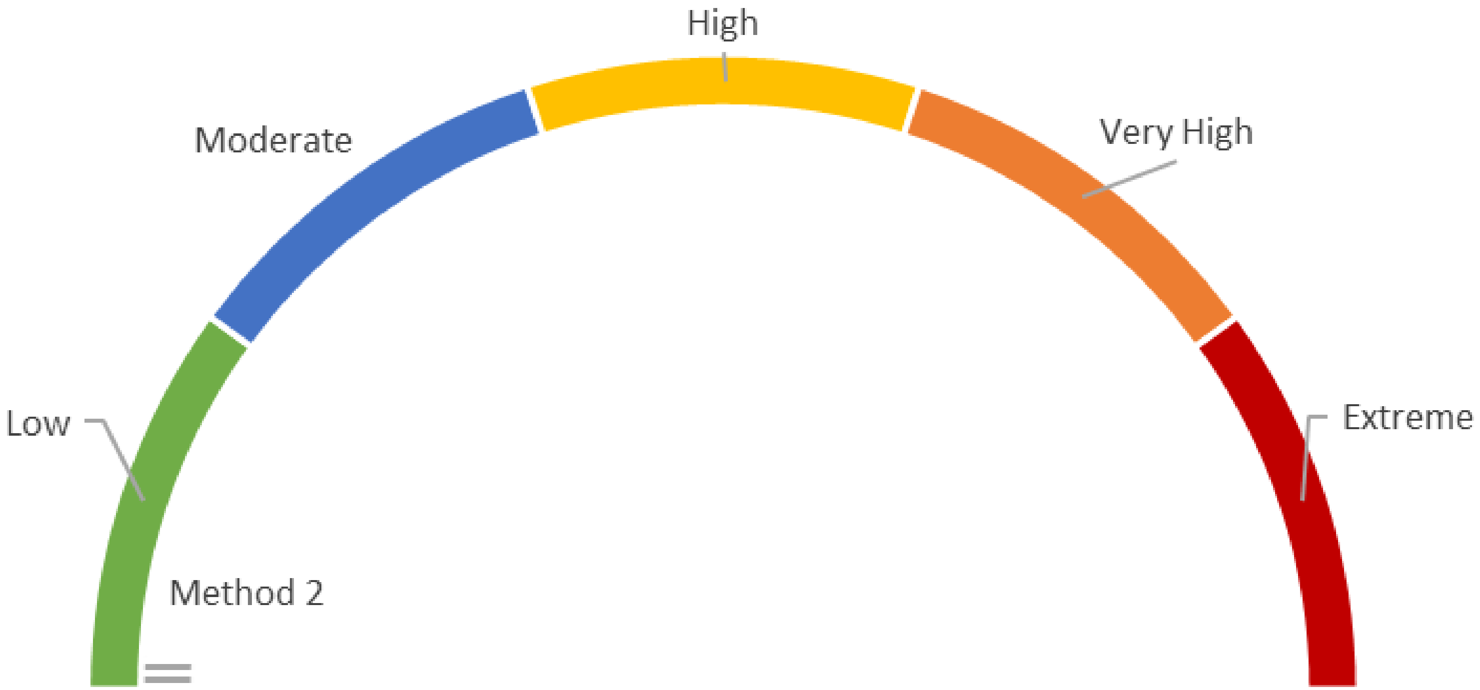
To estimate the percentage of homes that would have existing panel capacity to support new loads, two calculation methods from Section 220 of the National Electric Code were used:

- NEC 220.83: Existing load based on nameplate ratings of appliances.
- NEC 220.87: Existing load based on electrical peak demand of previous year.

Graphical Representations of Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for Home Energy Upgrades

Estimated percentages of modeled housing units that would require panel upgrades to support new loads were categorized in 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
- Extreme = 80%–100% of units.



Limitations

Sources of uncertainty in estimates of electrical panel size in the home before the retrofit:

- 95% of the training data for the regression models comes from single-family homes and may be less accurate for other housing types.
- Natural gas was the dominant heating fuel for homes included in the training data, and the model may be less accurate for electrically heated homes.
- Training data came from voluntary energy efficiency program participants, who may be more affluent households with larger homes and thus larger panel sizes, and the model may be less accurate for smaller and lower-income households.
- 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.

Sources of uncertainty in ResStock-modeled housing characteristics used for NEC calculations:

- Does not include all appliances or end-uses that could impact total residential demand (e.g., garbage disposal motors, electric vehicles).
- Heating, ventilation, and air conditioning (HVAC) sizing considers building envelope specifications, which may be degraded compared to when the home was built and the HVAC system originally sized and installed, which may result in oversizing estimated HVAC systems.
- Does not consider other causes for panel upgrades, such as bringing panels up to code or breaker slot constraints. Furthermore, low-power alternatives were not considered for this analysis and could also help mitigate the need for panel upgrades.

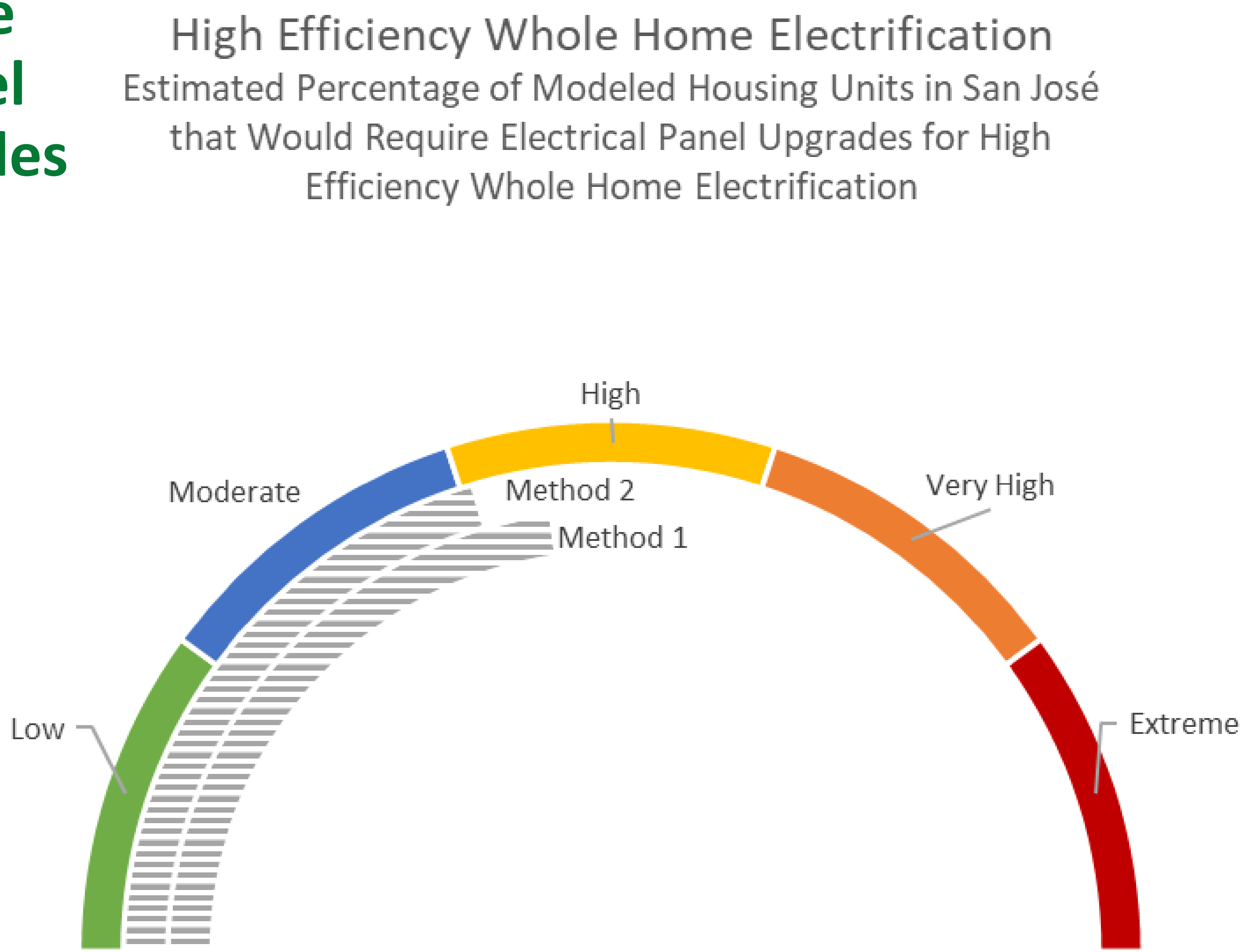
This work presents energy efficiency and electrification modeling results for dwelling units using ResStock EUSS 2022.1, which is a statistical representation based on modeling predictions of energy use and reductions. Actual results may vary. Access the methodology document at https://data.nrel.gov/submissions/224

Figure 9. Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for Home Energy Upgrades

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 owners pursuing electrification. Based on the modeled results, even with high-efficiency appliances and heat pumps, a moderate to high proportion of dwelling units might require panel upgrades to electrify.

Note: This figure reflects estimates obtained using two distinct calculation methods (see methods on Slide 29):

- Method 1 reflects NEC 220.83: Existing load based on nameplate ratings of appliances.
- Method 2 reflects NEC 220.87: Existing load based on electrical peak demand of previous year.



High Efficiency Whole Home Electrification

Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for High Efficiency Whole Home Electrification

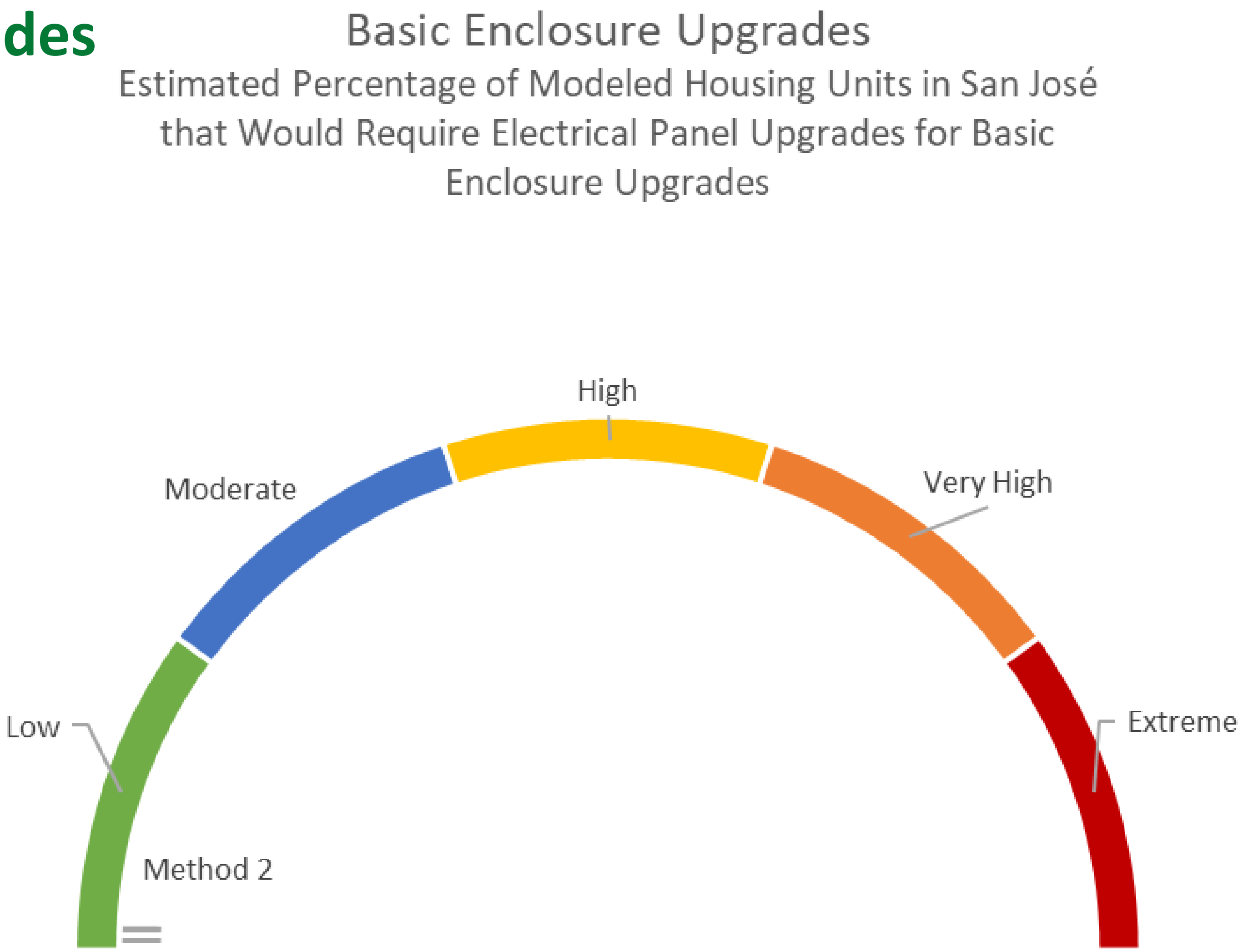
Figure 10. Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for Home Energy Upgrades

The cost of a panel upgrade can vary depending on the home’s location and the level of service involved. And as more households on a given distribution feeder upgrade their electric service, there can be large financial costs upstream to upgrade the distribution grid.

Basic enclosure upgrades do not increase electricity demand and can be implemented in most households without triggering the need for a panel upgrade.

Note: This figure reflects estimates obtained using two distinct calculation methods (see methods on Slide 29):

- Method 1 reflects NEC 220.83: Existing load based on nameplate ratings of appliances.
- Method 2 reflects NEC 220.87: Existing load based on electrical peak demand of previous year.



Basic Enclosure Upgrades

Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for Basic Enclosure Upgrades

Figure 11. Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for Home Energy Upgrades

Upgrading electric panels could be more costly and time-consuming for apartment buildings. There is typically a main service entrance into the building and then separate or sub-panels going into each apartment. If enough households are upgrading, there may be a need to overhaul the entire electrical wiring for the building.

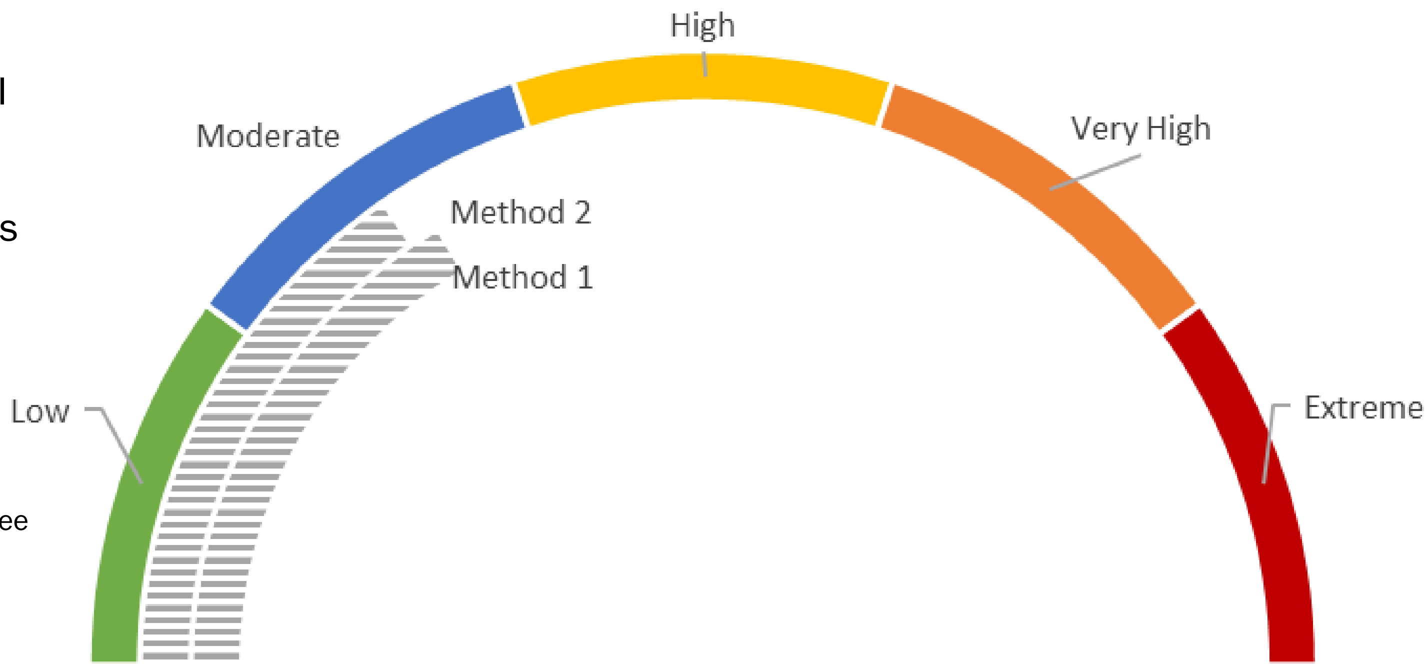
Based on the modeled results for San José, basic improvements in enclosure efficiency from wall and attic insulation and air-sealing could help mitigate the increased electricity demand associated with electrification and reduce the proportion of homes that might face costly barriers to electrification.

Note: This figure reflects estimates obtained using two distinct calculation methods (see methods on Slide 29):

- Method 1 reflects NEC 220.83: Existing load based on nameplate ratings of appliances.
- Method 2 reflects NEC 220.87: Existing load based on electrical peak demand of previous year.

High Efficiency Whole Home Electrification with Basic Enclosure Upgrades

Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for High Efficiency Whole Home Electrification with Basic Enclosure Upgrades



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Single-Measure Strategies: Potential Impacts to Energy Use, Emissions, and Energy Bills

Figure 12. Total Annual Emissions Reductions by Housing Type and Upgrade Strategy in San José

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 lead to increased annual electricity consumption and energy-related emissions for some housing segments. Strategies to mitigate potential increases may be necessary to ensure these households can access cleaner, more efficient forms of heating and cooling without increasing energy burdens.

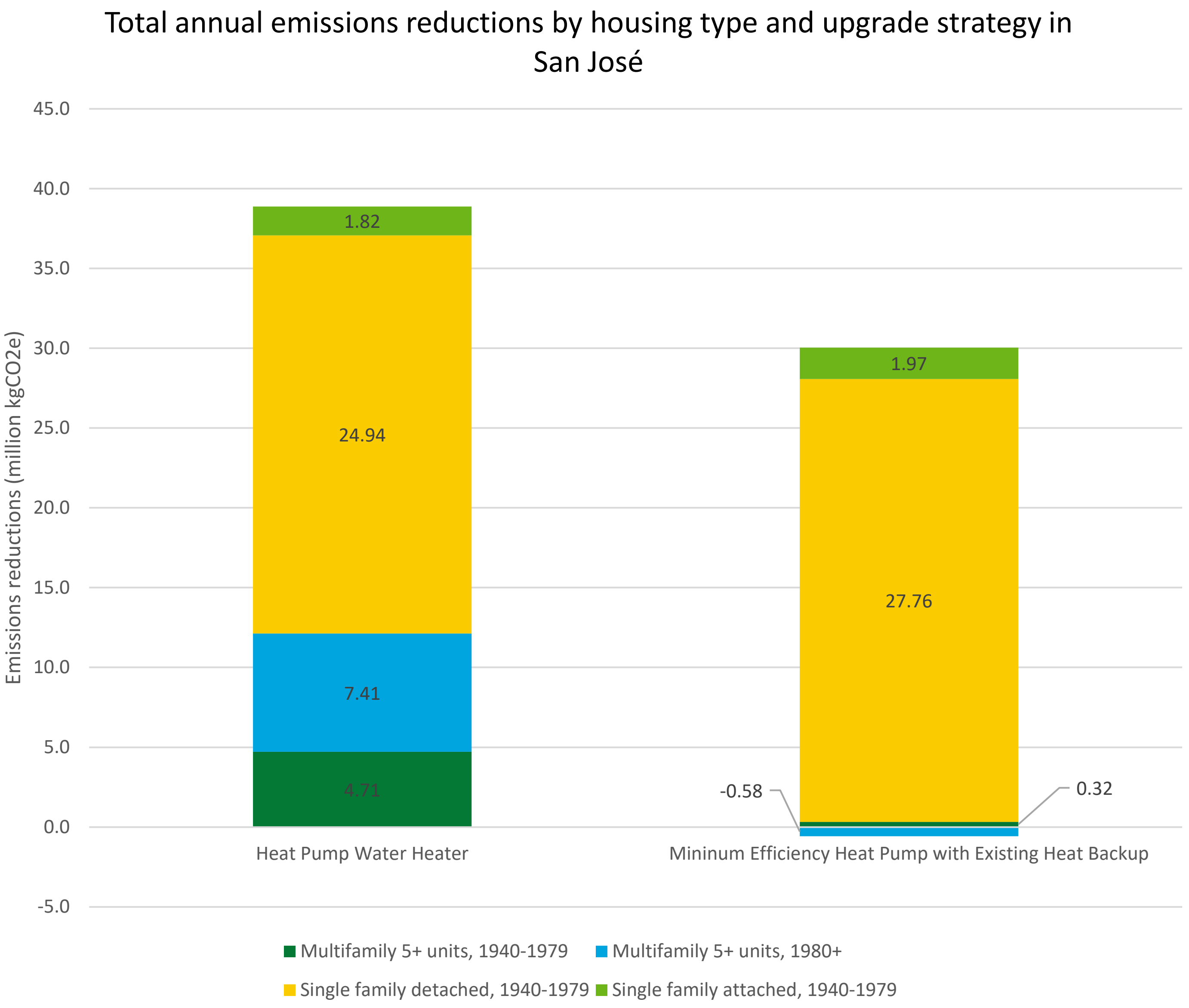

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Figure 13. Total Annual Site Energy Reductions by Housing Type and Upgrade Strategy in San José

Based on the modeled results, potential annual energy reductions from heat pump technologies are greatest in older modeled single-family detached homes in San José. Homes that currently lack any form of air conditioning could see annual energy use increase due to new space cooling capabilities provided by heat pump HVAC systems. While air conditioning services can be an important strategy to provide more comfortable and safe indoor environments in a warmer climate, providing this new service could increase annual site energy use. Strategies to mitigate potential increases may be necessary to ensure these households can access cleaner, more efficient forms of heating and cooling without increasing energy burdens.

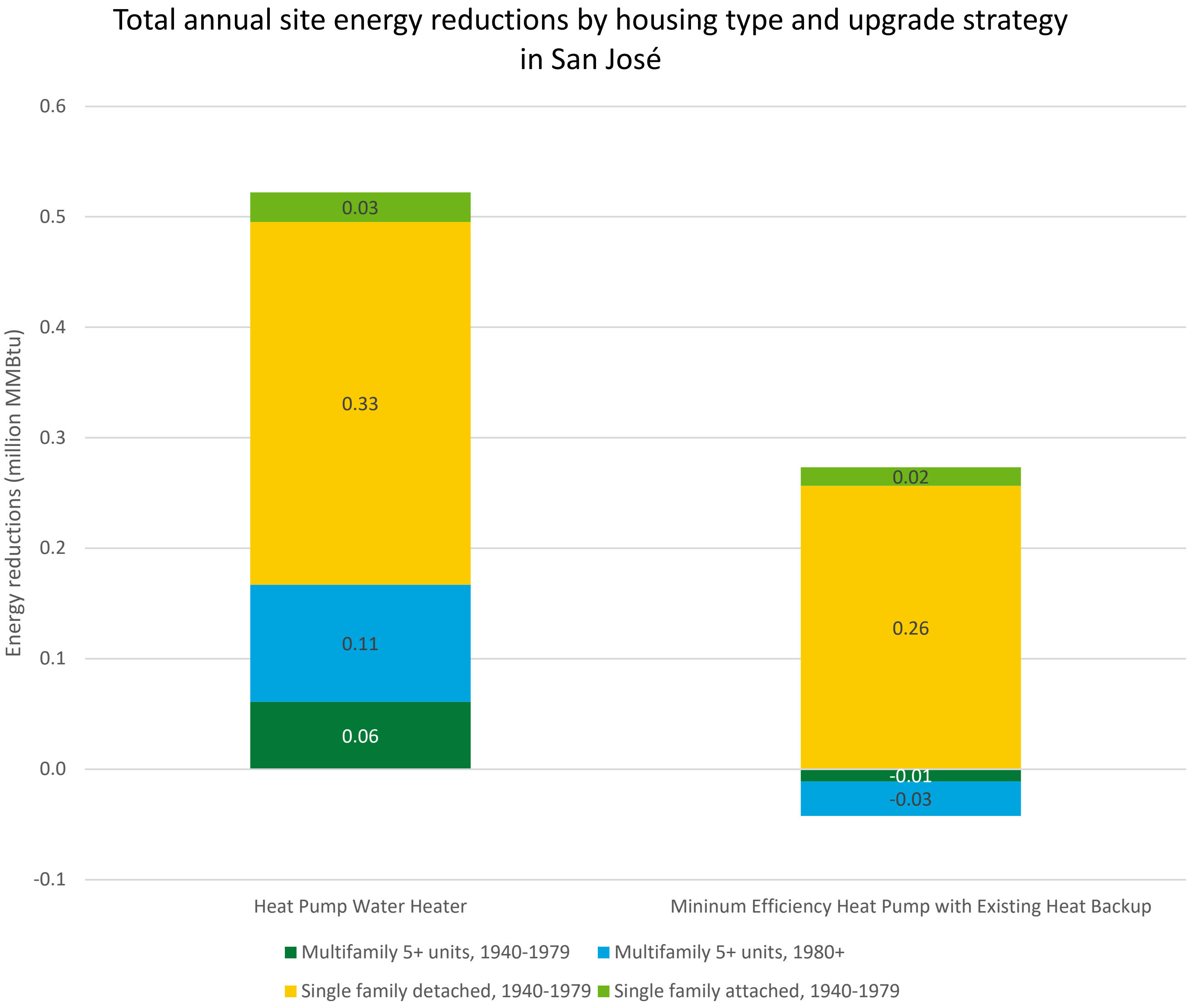

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Figure 14. Average Annual Emissions Reductions per Dollar Invested by Housing Type and Upgrade Strategy in San José

Across all housing types in this analysis, investments in heat pump water heaters can offer average annual emissions reductions near or above 0.1 kg carbon dioxide equivalent (CO_2e) per dollar invested. Among these four housing types, average potential emissions reductions-to-investment ratios for heat pump water heaters are greatest for single-family detached homes built between 1940 and 1979, which could see more than double the estimated emissions reductions per dollar invested relative to single-family attached homes of similar age. For multifamily units, heat pump water heaters offer significant positive emissions reductions per dollar invested. Emissions reductions-to-investment ratios for minimum-efficiency heat pump HVAC systems in multifamily units may depend upon the ability to mitigate increased energy demand for space cooling.

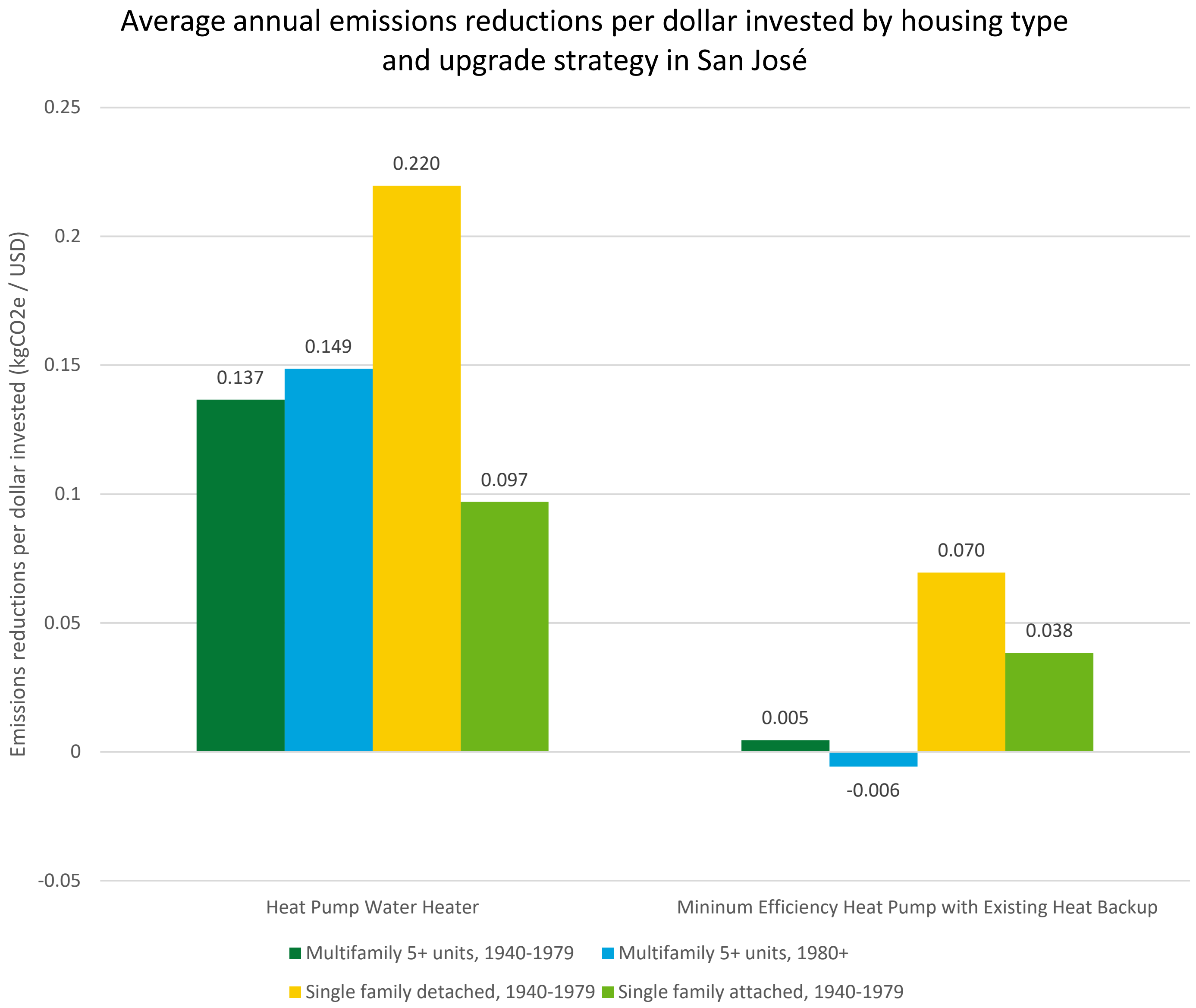

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Figure 15. Annual Site Energy Reductions per Dollar Invested by Housing Type and Upgrade Strategy in San José

Across all housing types in this analysis, investments in heat pump water heaters can offer average annual site energy reductions above 1,400 BTU per dollar invested. Among these four housing types, average potential site energy reductions-to-investment ratios for heat pump water heaters are greatest for single-family detached homes built between 1949 and 1970, which could see more than double the estimated site energy reductions per dollar invested relative to single-family attached homes of similar age. For multifamily units, heat pump water heaters offer significant positive site energy reductions per dollar invested. Annual site energy reductions-to-investment ratios for some multifamily households may be negative due to increased energy demand for space cooling, which would be provided as a new service in housing units lacking any form of air conditioning.

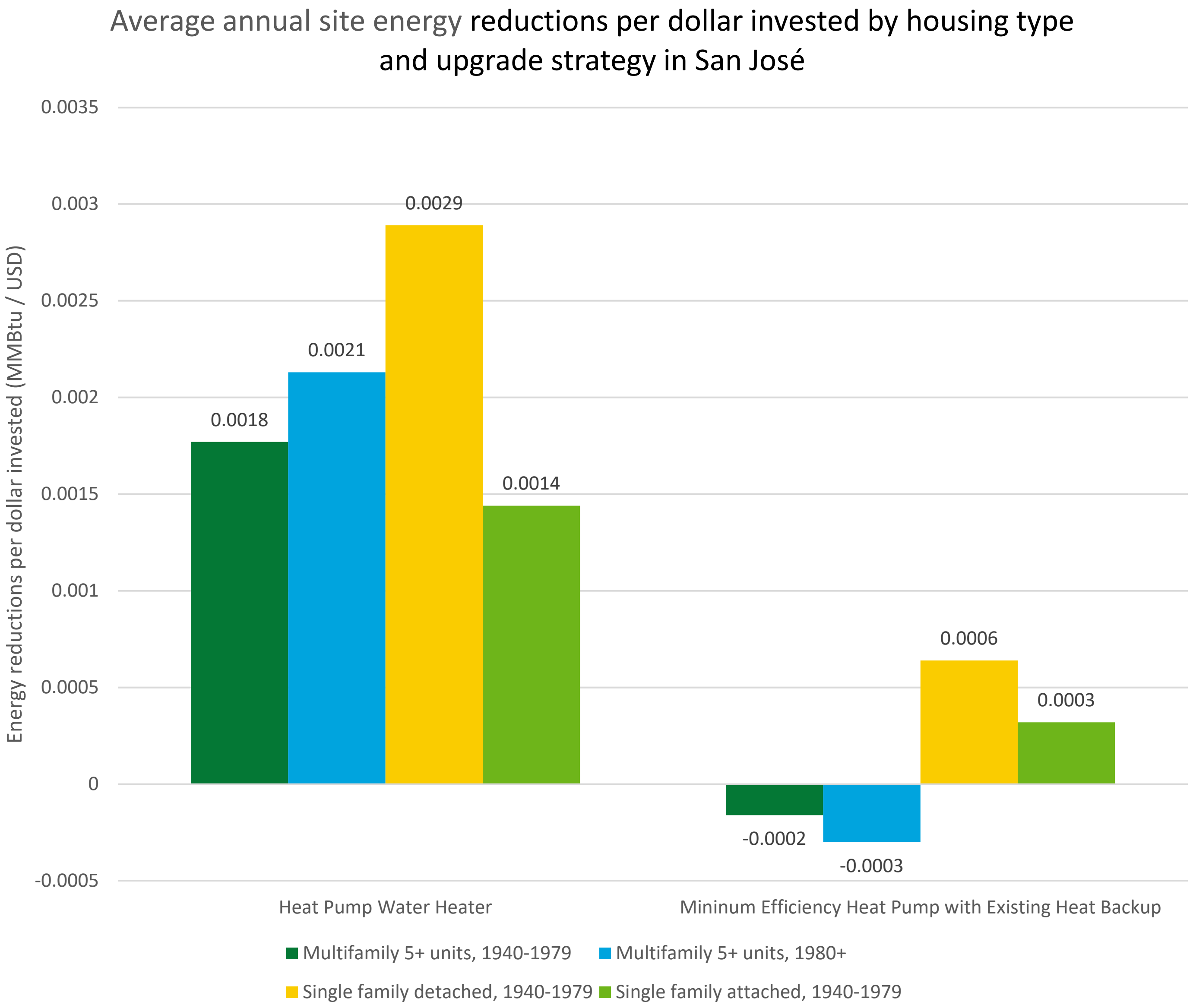

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Figure 16. Average Annual Energy Bill Reductions by Housing Type and Upgrade Strategy in San José

Based on the modeled results, upgrading to heat pump water heaters could reduce household energy bills by an average of $115-$200 per year. 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 of housing types analyzed. For homes that currently lack any form of air conditioning, this increase could be due to new space cooling capabilities provided by heat pump HVAC systems.

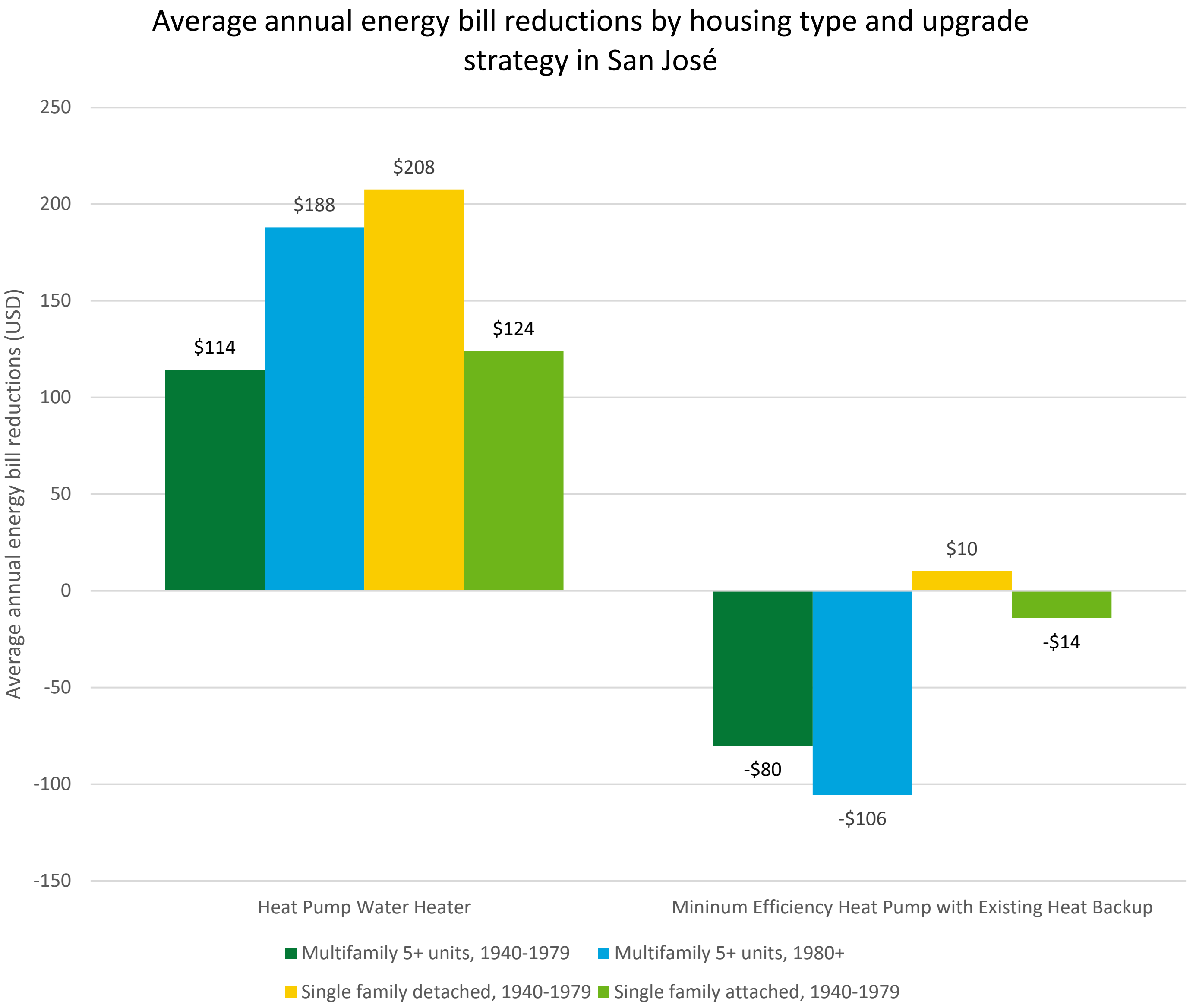

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Figure 17. Average Energy Burden Reduction by Housing Type and Upgrade Strategy in San José

Based on modeled results, all analyzed household types in San José could see a reduction in average energy burden (0.2%–1.4%) by switching to heat pump water heaters. Minimum-efficiency heat pump HVAC systems, without any other energy efficiency measures, could increase energy bills and thus increase energy burden for the household types analyzed in San José.

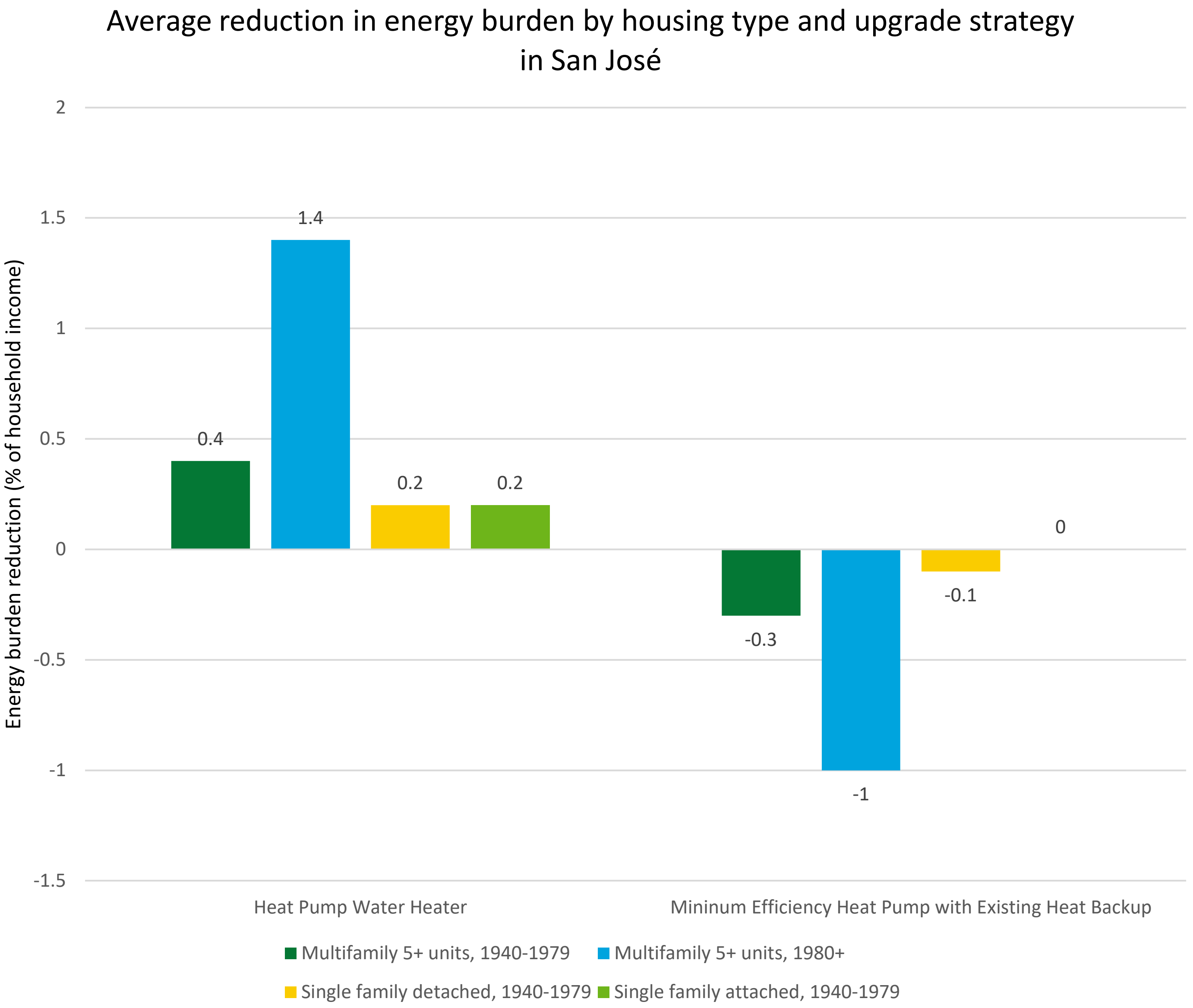

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Figure 18. Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for Home Energy Upgrades

Based on the modeled results for San José, a moderate to high proportion of households may require electrical upgrades to support additional electrical loads for minimum-efficiency heat pump HVAC systems. These estimates utilize three pieces of information:

- Electrical panel size in the home before the retrofit.
- New loads added by the retrofit.
- Compliance requirement for avoiding an electrical panel upgrade.

ResStock's modeled housing characteristics for San José were used to estimate required heat pump HVAC sizes for all modeled housing units. Housing attributes affecting building envelope conditions, such as wall insulation and air infiltration, impact the estimated required HVAC size.

Note: This figure reflects estimates obtained using two distinct calculation methods (see methods on Slide 29):

- Method 1 reflects NEC 220.83: Existing load based on nameplate ratings of appliances.
- Method 2 reflects NEC 220.87: Existing load based on electrical peak demand of previous year.

Minimum Efficiency Heat Pump with Existing Heat Backup

Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for Mininum Efficiency Heat Pump Upgrades with Existing Heat Backup

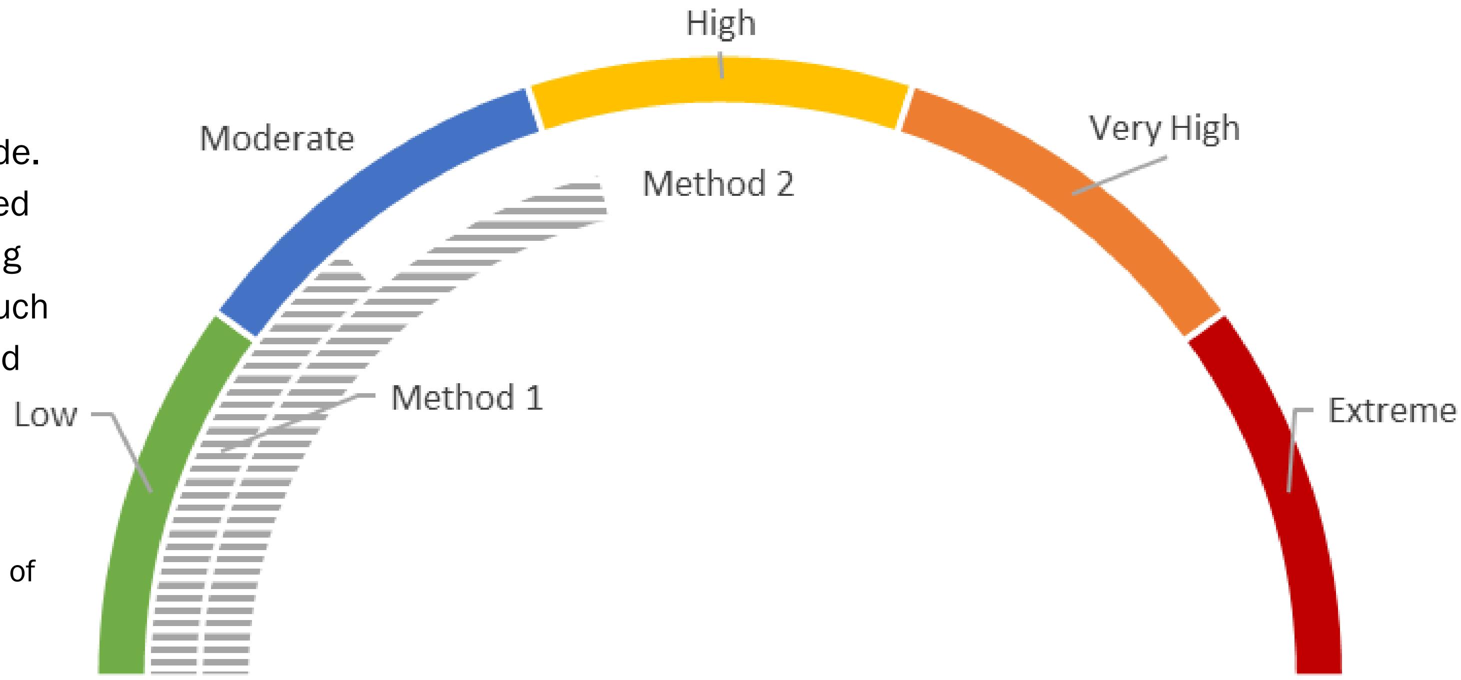

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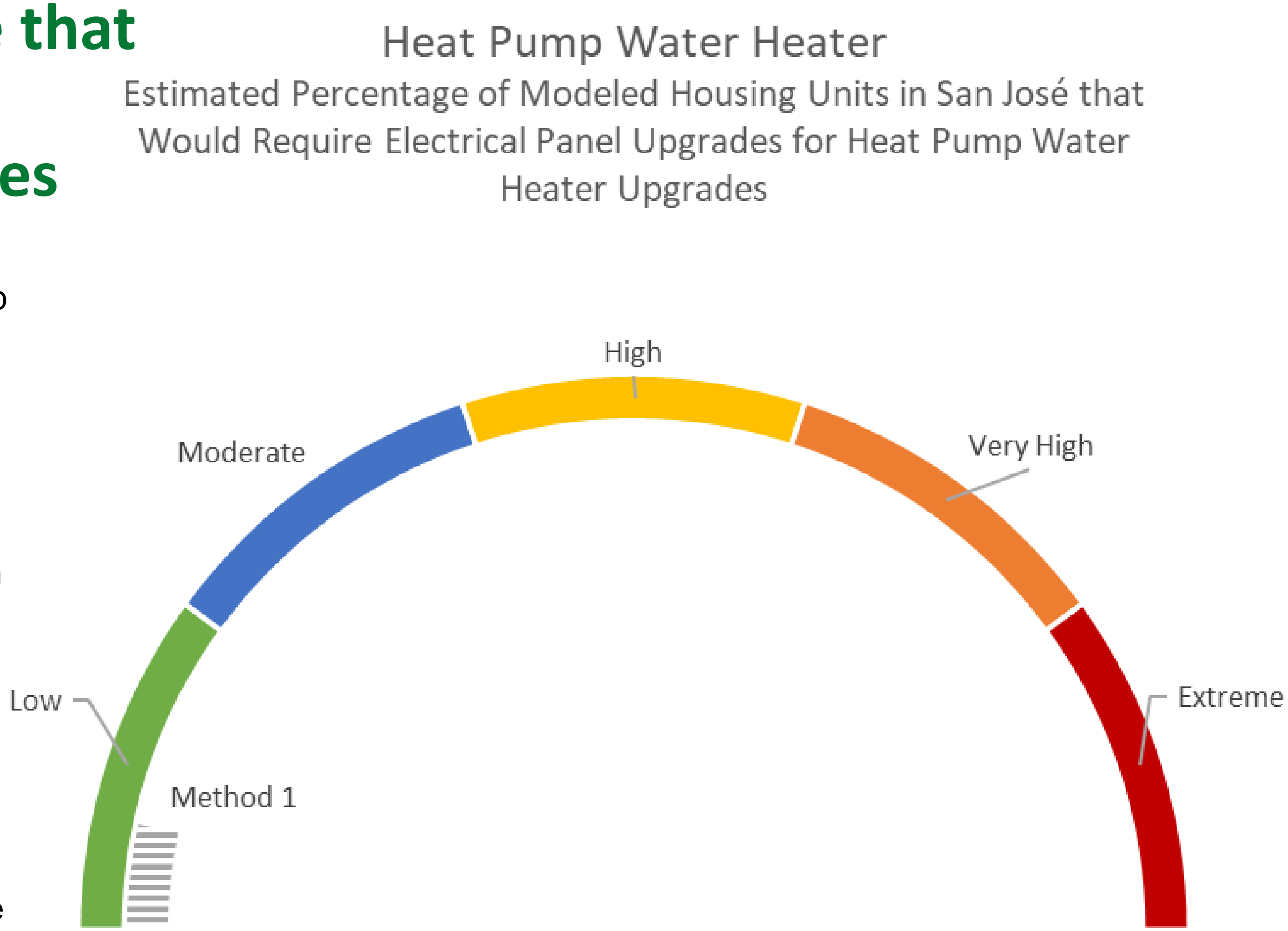
Figure 19. Estimated Percentage of Modeled Housing Units in San José that Would Require Electrical Panel Upgrades for Home Energy Upgrades

Based on the modeled results for San José, the majority of housing units across all income groups analyzed are expected to have existing capacity for electric heat pump water heaters and only a low proportion of households might require panel upgrades to support heat pump water heaters. According to the U.S. Department of Energy (DOE), these systems can be two to three times more energy efficient than conventional electric resistance water heaters. Homeowners and building owners can find more information about how the technology works, how to select an appropriate system for their building, installation and maintenance considerations, and energy-saving strategies to help lower water heating bills from the DOE's Energy Saver site.

Note: This figure reflects estimates obtained using two distinct calculation methods (see methods on Slide 29):

- Method 1 reflects NEC 220.83: Existing load based on nameplate ratings of appliances.
- Method 2 reflects NEC 220.87: Existing load based on electrical peak demand of previous year.



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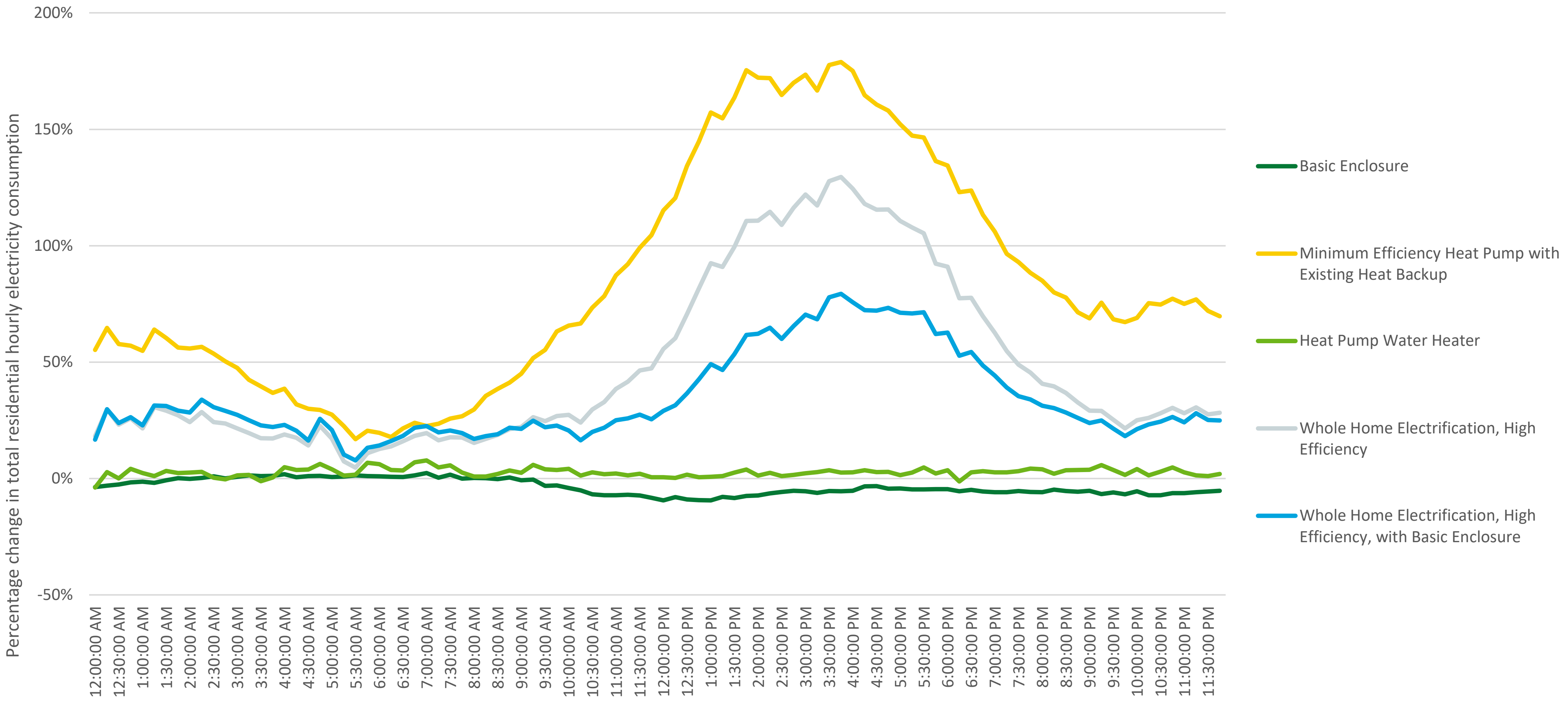
Considerations for Grid Infrastructure and Resilience

Electricity Grid Impacts: Potential Implications for Residential Electricity Time-of-Use and Infrastructure

- Based on modeled results, 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.

Figure 20. Percentage Change in Hourly Total Residential Electricity Use by Upgrade Package on an Example Very Warm Day in San José (August 6)



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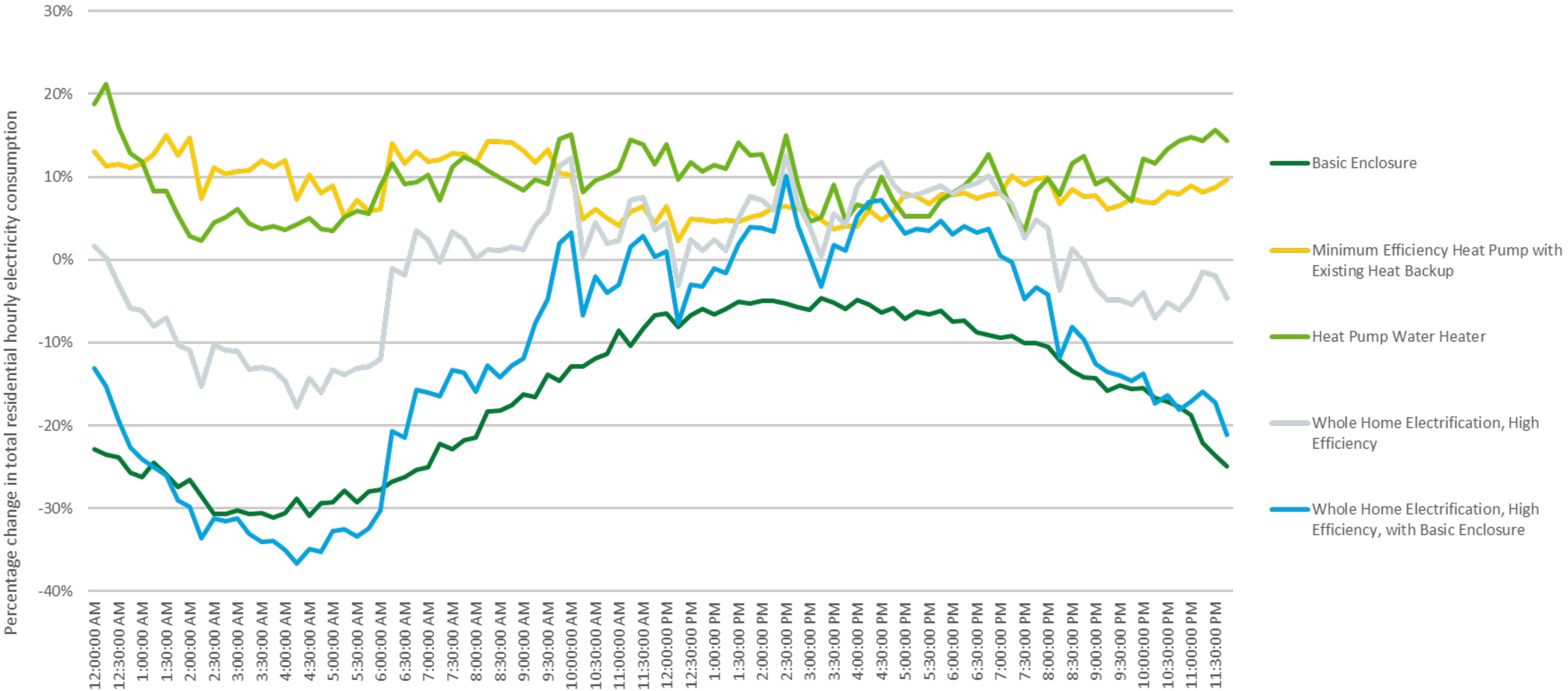
Percentage Change in Hourly Total Residential Electricity Use by Upgrade Package on an Example Warm Day

- Figure 20 shows the modeled change in electricity demand for each upgrade scenario relative to baseline modeled electricity demand for an example* warm day in San José. These changes are important considerations to ensure the electric transmission and distribution grid can handle increased electricity demand for electrification.
- In afternoon hours when demand for heat pump air conditioning is highest, the difference between expected impact in a Whole-Home Electrification scenario (grey) and expected impact in a Whole-Home Electrification with Basic Enclosure Upgrades scenario (blue) is greater than the expected impact in a scenario with Basic Enclosure Upgrades alone (dark green). Two possible explanations that could account for this include:
    - Whole-Home Electrification adds cooling (heat pumps) and associated electricity use to many homes that previously did not have cooling; thus, also improving enclosure efficiency has a substantial impact on electricity loads for the hot day.
    - Furthermore, basic enclosure also helps to reduce the size of the heat pump necessary, helping reduce the peak power.

*Example results are shown for just one day for a limited sample of homes. Load profiles vary day-to-day depending on many factors and a more in-depth analysis would be needed to estimate potential grid impacts.

Figure 21. Percentage Change in Hourly Total Residential Electricity Use by Upgrade Package for an Example Cold Day in San José (February 22)



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Percentage Change in Hourly Total Residential Electricity Use by Upgrade Package on an Example Cold Day

- Figure 21 shows the modeled change in residential electricity demand for each upgrade scenario relative to baseline modeled electricity demand on an example* cold day in San José when the dry bulb outdoor temperature drops to just above 41° Fahrenheit (5° Celsius)**. These changes are important considerations to ensure the electric transmission and distribution grid can handle increased electricity demand for electrification.
- Upgrade strategies replacing existing space and hot water heating systems with heat pump technologies without additional electrification and efficiency measures (yellow and light green lines) result in slight increases in residential electricity demand during the colder morning hours relative to baseline electricity demand for the example day.
- Upgrade strategies featuring Basic Enclosure (dark green line), High-Efficiency Whole-Home Electrification (grey line), and High-Efficiency Whole-Home Electrification with Basic Enclosure (blue line) measures show reduced modeled electricity demand reduction relative to baseline, even in the coldest hours of the example day, due in part to improvements in building insulation and heating technology efficiency. These upgrade strategies have the potential to reduce energy demand and energy burden while improving thermal comfort.

*Example results are shown for just one day for a limited sample of homes. Load profiles vary day-to-day depending on many factors and a more in-depth analysis would be needed to estimate potential grid impacts.
**See Appendix for an example day where the outdoor temperature drops below the assumed backup heat switchover temperature (41°F) for homes with backup gas heating systems that share ductwork with the heat pumps.

Thank You

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by the National Renewable Energy Laboratory (NREL).
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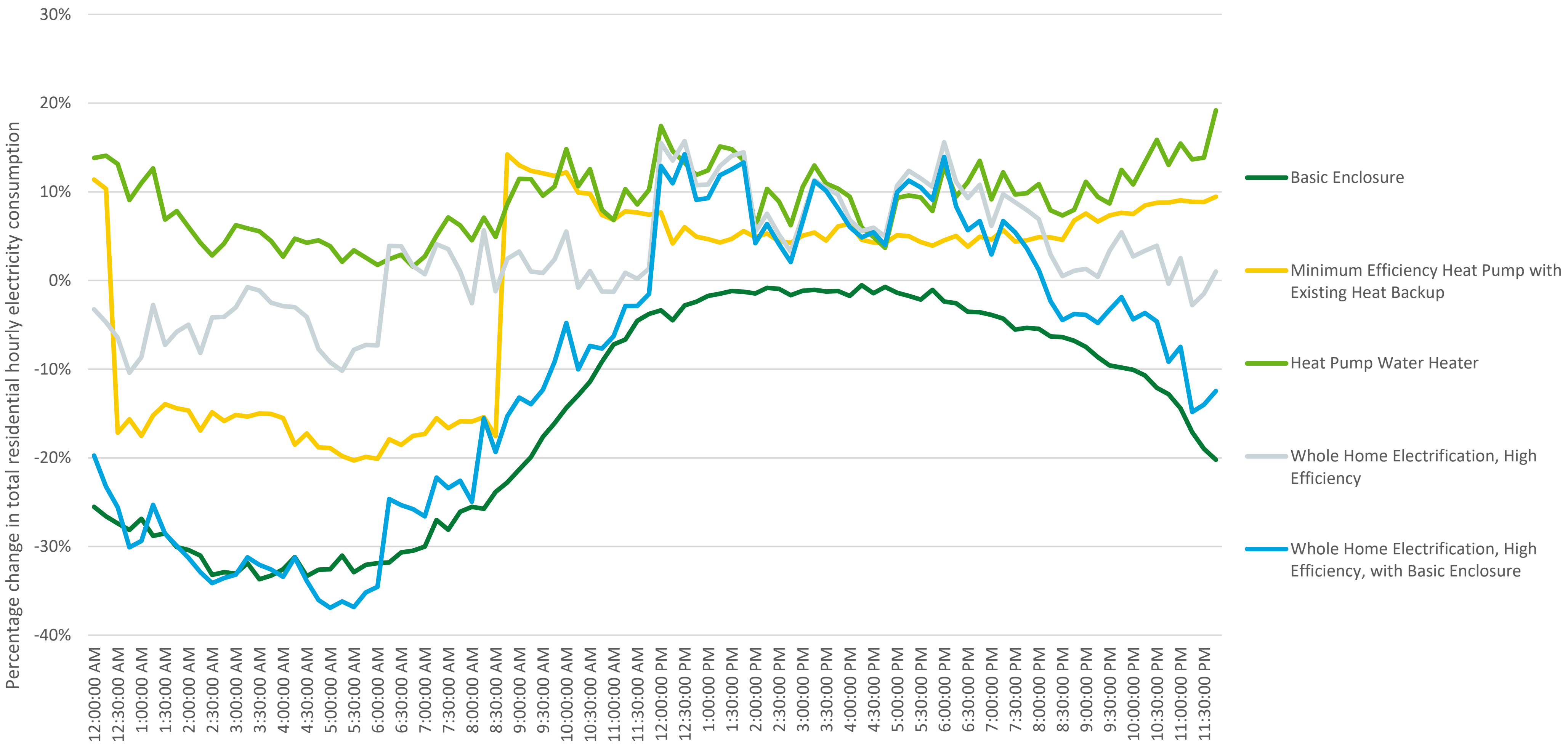
Appendix

Figure A1. Percentage Change in Hourly Total Residential Electricity Use by Upgrade Package for an Example Cold Day in San José (February 24)



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Percentage Change in Hourly Total Residential Electricity Use by Upgrade Package on an Example Cold Day

- Figure A1 shows the modeled change in electricity demand for each upgrade scenario relative to baseline modeled electricity demand on an example* cold day in San José when the dry bulb outdoor temperature drops below 41º Fahrenheit (5º Celsius). These changes are important considerations to ensure the electric transmission and distribution grid can handle increased electricity demand for electrification.
- For the “Minimum-Efficiency Heat Pump w/ Existing Heat Backup Scenario” (yellow), during the early morning hours on the example day the outdoor temperature falls below the assumed backup heat switchover temperature (41ºF) for homes with backup gas heating systems that share ductwork with the heat pumps, leading to step changes in modeled electricity consumption when the gas backup kicks on and off. Also, the net modeled reductions relative to baseline for this scenario is driven by the reductions from heat pumps in homes with backup electric heat, where the backup is only used as supplemental heat for any portion of the load not met by the heat pump.

*Example results are shown for just one day for a limited sample of homes. Load profiles vary day-to-day depending on many factors and a more in-depth analysis would be needed to estimate potential grid impacts.