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Electrifying Homes in California: the Consumer Cost Perspective

Findings from “Residential Building Electrification in California”

Sponsored by SCE, LADWP and SMUD

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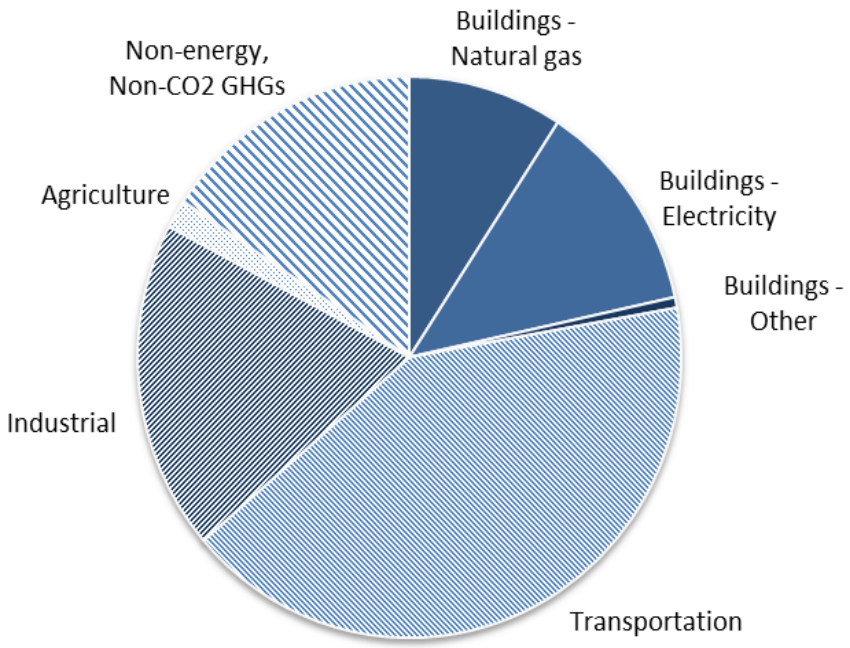
Agenda

+ **Why building electrification?**
+ **Study design**
+ **Results**
  - Greenhouse Gas Savings
  - Consumer Bill Savings
  - Lifecycle Savings
+ **Key findings and recommendations**

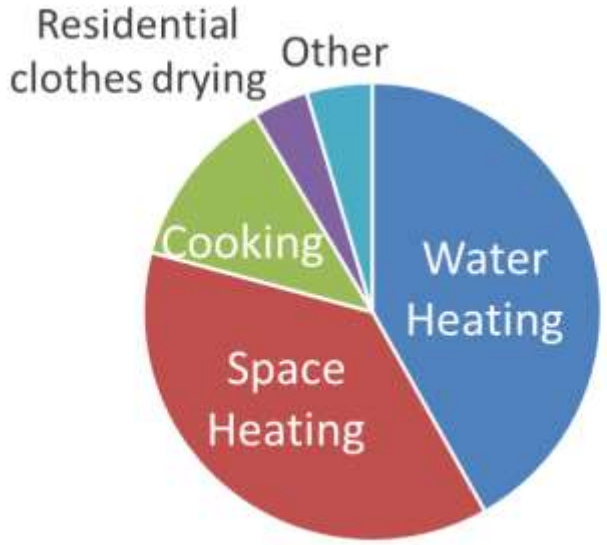
Natural gas combustion in buildings represents ~10% of California's GHG emissions today

Share of California's GHG emissions among sectors



Source: E3's California PATHWAYS model based on 2015 GHG emissions data

Share of natural gas use in buildings

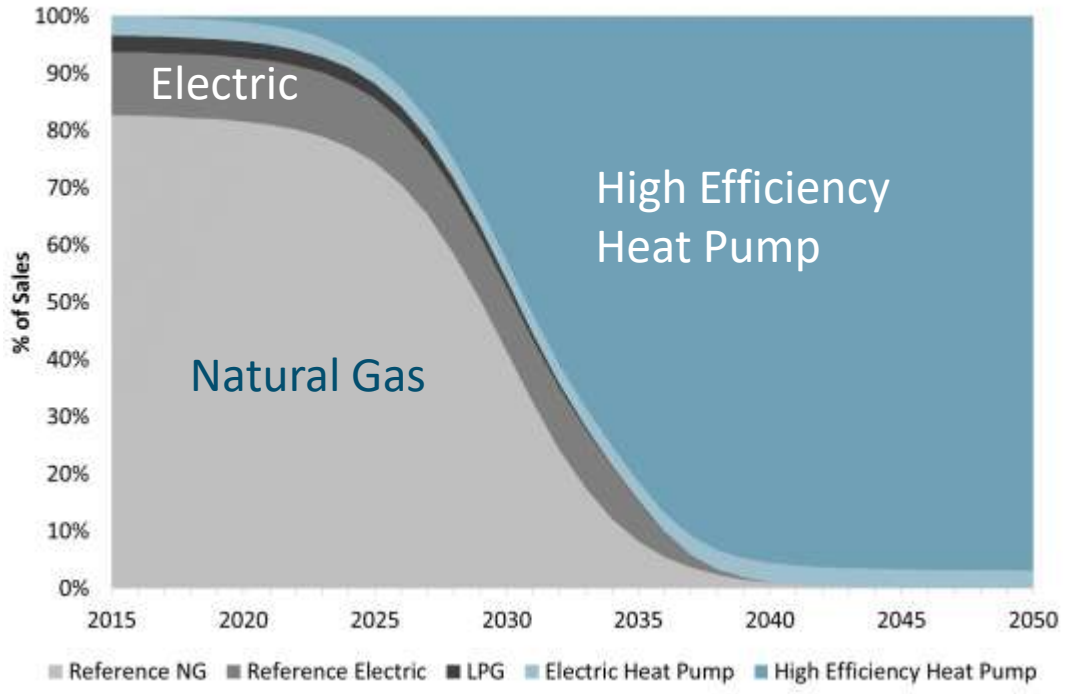


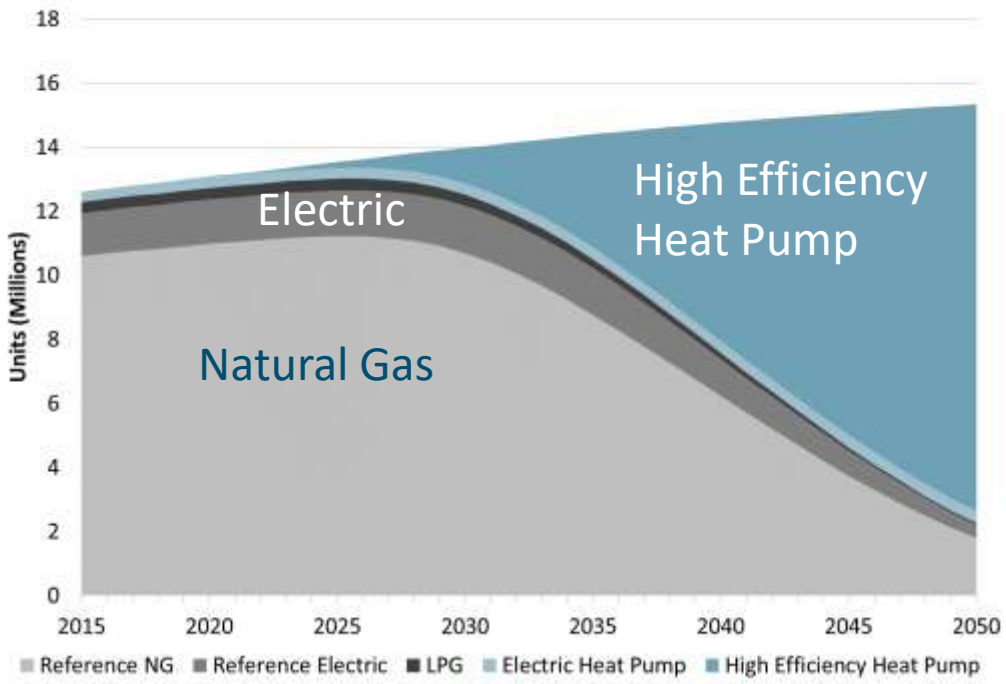
+ **80% of natural gas in buildings is used for space & water heating, with equal contributions from each.**

Achieving California's climate goals may require high building electrification

Residential Space Heating Technology
(CEC PATHWAYS High Electrification Scenario)

Sales Share → **Equipment Stock**





- Is this a realistic scenario?
- What policies or technology changes would be needed to achieve this future?

Study Approach

Building Simulations

- Technology screening and efficiency assumptions
- Hourly energy demands
- Site energy consumption

GHG Analysis & Lifecycle Costs

- Consumer bill savings, current & projected
- Equipment, and installation costs
- Lifecycle savings

Recommend-ations

- Near-term opportunities for building electrification
- Near-term market barriers
- Policy recommendations

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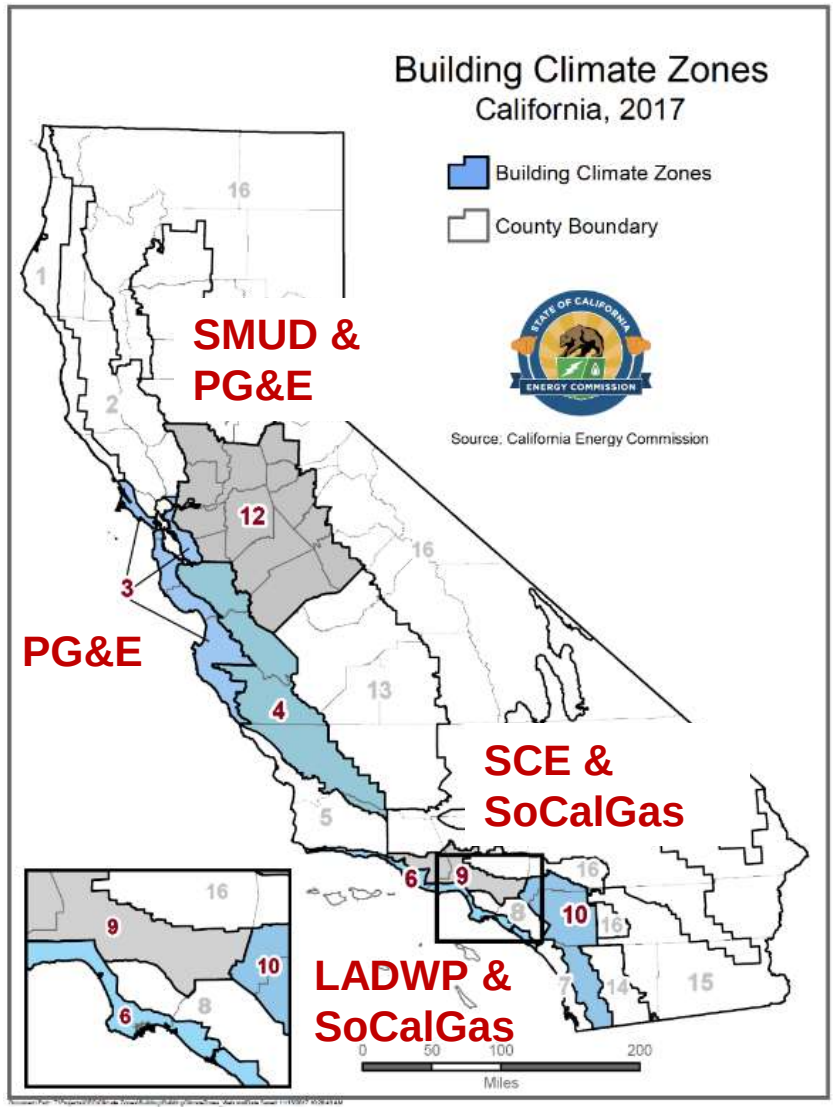
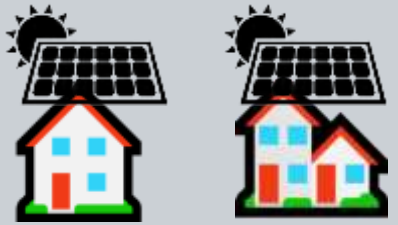
Study design

Six climate zones studied cover ~50% of California's population



Climate Zone	6 Major Cities	3 Vintages	2 low-rise housing types
CZ03	San Francisco	**Retrofit (Pre-1978)** (No insulation, single pane windows)	
CZ04	San Jose		
CZ12	Sacramento	**Retrofit (1990s)** (T24 building code 1992 construction)	
CZ06	Coastal LA		
CZ09	Downtown LA	**New Construction** (2019 T24 building code)	
CZ10	Riverside		

Studied home appliance technologies

	Gas Home	Electric Home
HVAC	 Gas Furnace + AC	 Packaged Terminal Heat Pump;  Mini-split Heat Pump;  Ducted Split Heat Pump
Water Heating	 Gas Storage WH (retrofits);  Gas Tankless WH (new)	 Heat Pump Water Heater
Cooking and Clothes Drying	 Gas Stove;  Gas Dryer	 ELECTRIC;  INDUCTION;  ELECTRIC;  HEAT PUMP

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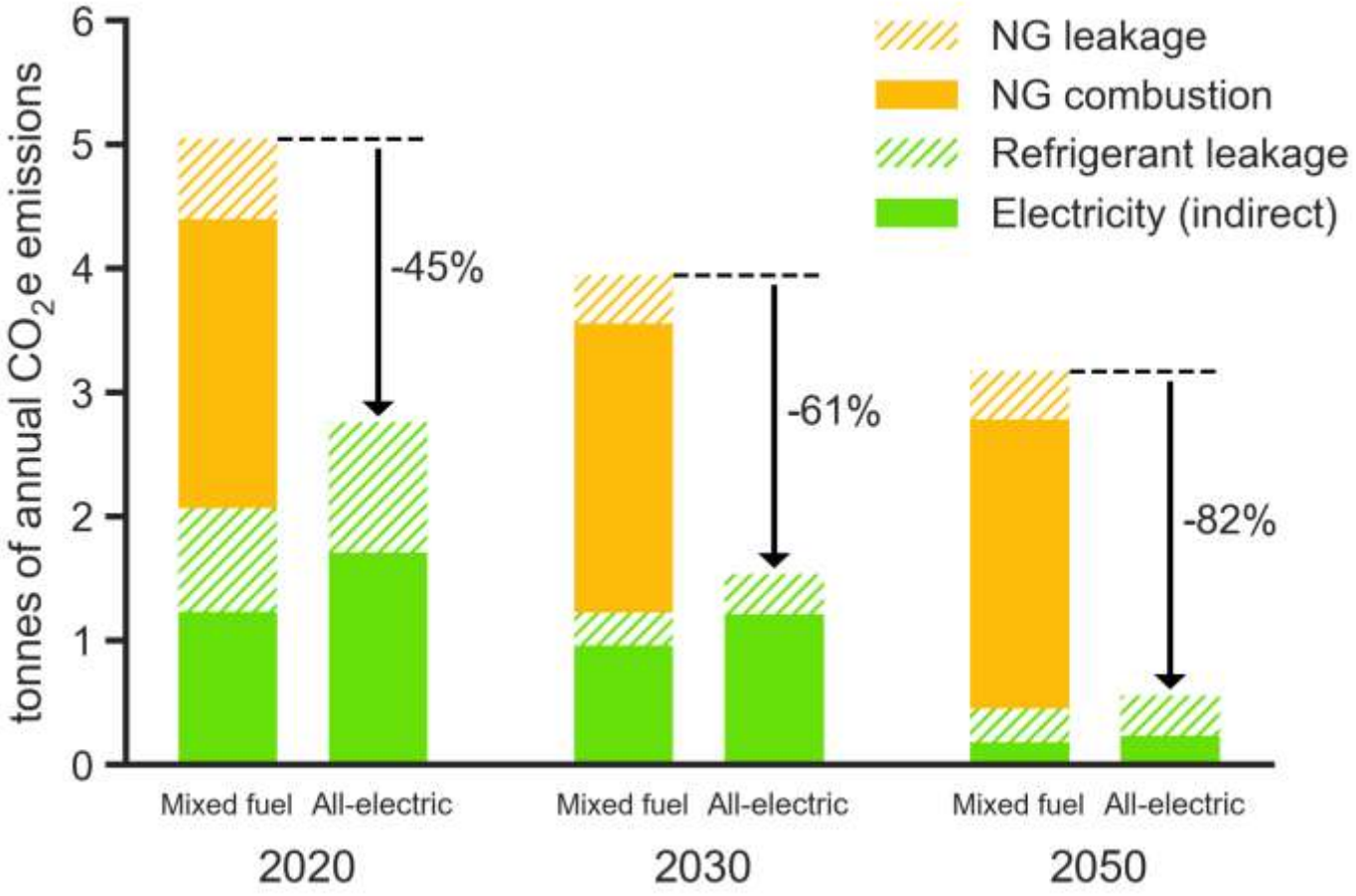
Results

Up to 60% GHG emission reductions can be achieved in the near term by electrifying a whole home

Greenhouse Gas Savings

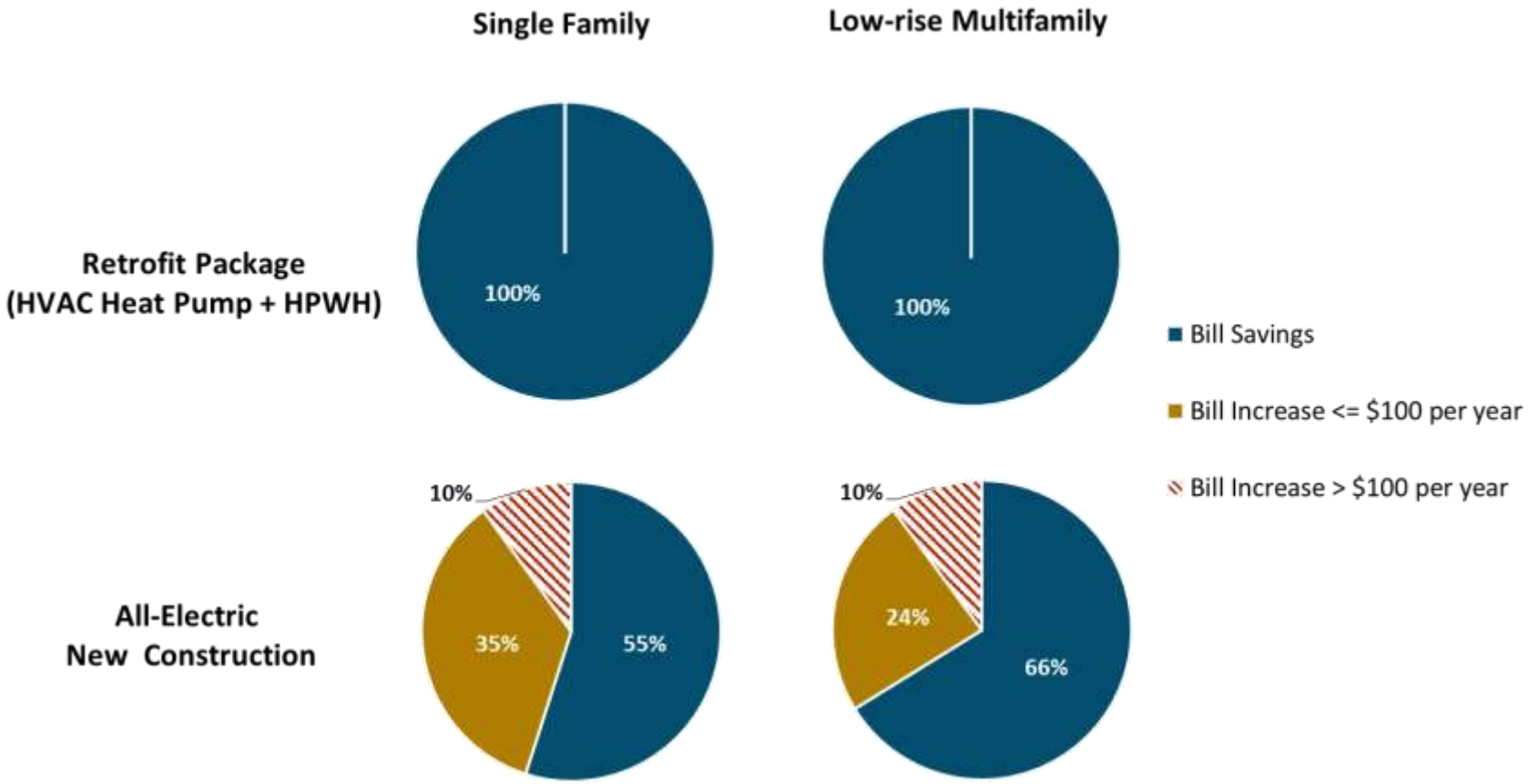
1990s vintage Single-Family Home (Sacramento)



- In the long-term, switching to an **all-electric home** reduces **GHG emissions** by **80-90% or more** if the grid and refrigerants become cleaner
- Emission reduction is mainly due to switching away from NG combustion with small increase in electricity emissions
- Phasing out **high-GWP refrigerants** and using low-GWP substitutes shows significant GHG reduction potentials

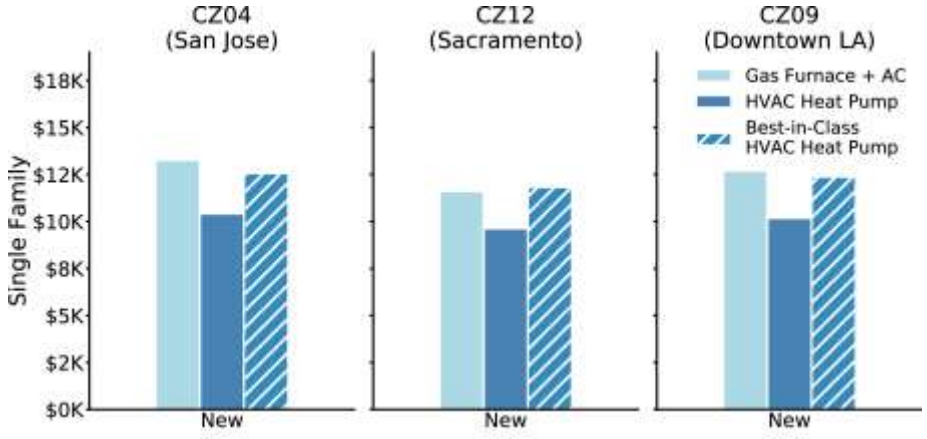
Electrifying major home appliances saves energy costs in all retrofit homes and the majority of new construction

Consumer Bill Impacts of Building Electrification



HVAC and water heating systems using heat pump technology save upfront costs relative to gas-fueled systems

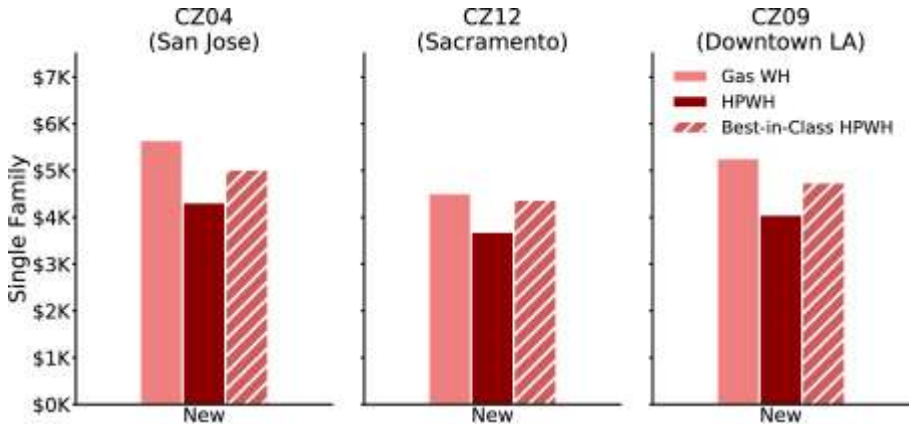
Capital Costs of HVAC Systems



Efficiency of HVAC Systems

HVAC Technology	Modeled Efficiency
Furnace	80 AFUE ducted attic furnace
Split AC	14 SEER, 12.2 EER, 2-speed
HVAC Heat Pump (Ducted Split)	18 SEER, 14 EER, 10 HSPF, 2-speed
Best-in-Class HVAC Heat Pump	21 SEER, 15 EER, 13 HSPF

Capital Costs of Water Heating Systems

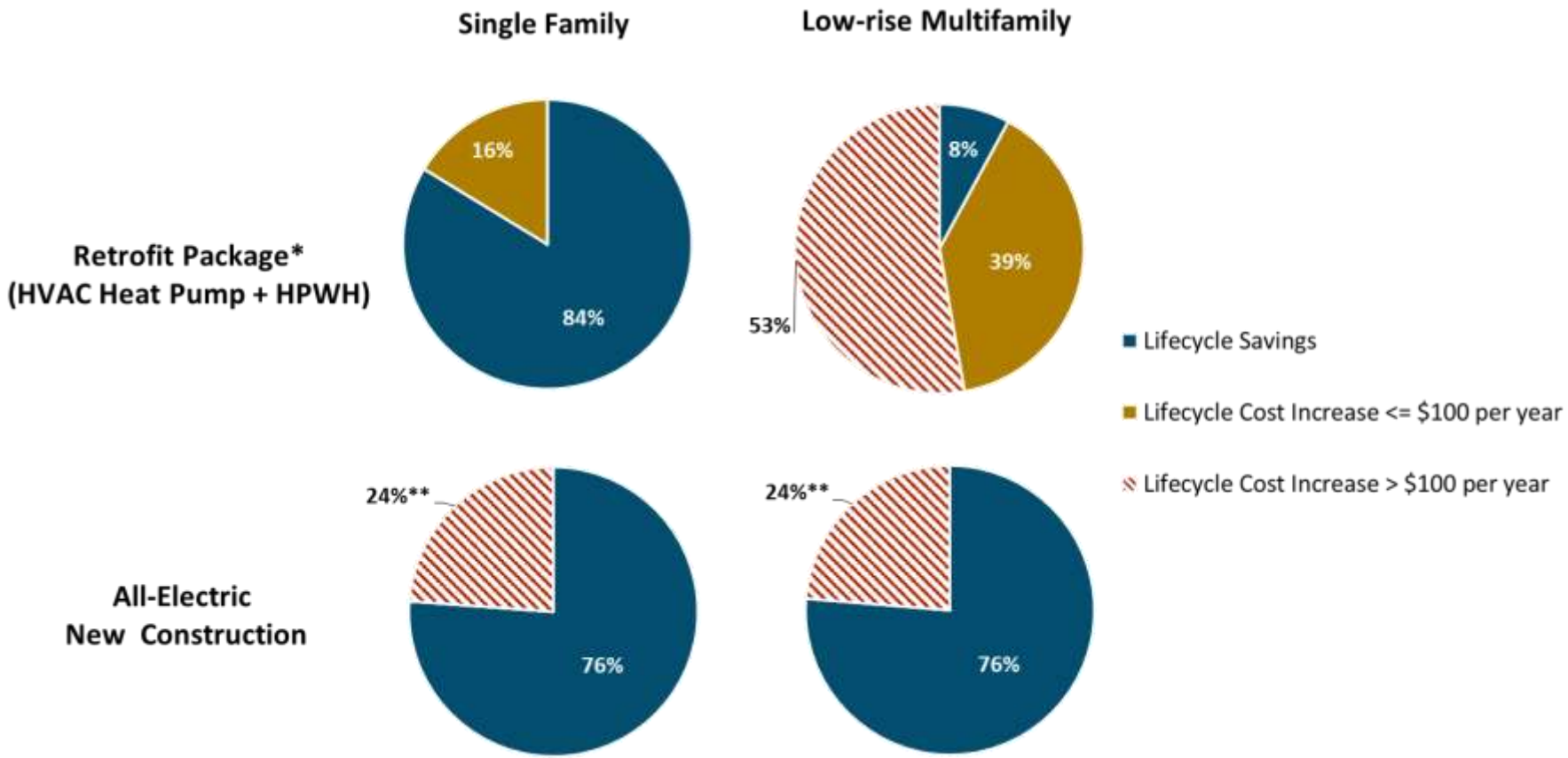


Efficiency of Water Heating Systems

Water Heating Technology	Modeled Efficiency
Gas Storage	0.63 UEF (0.60 EF)
Gas Tankless	0.81 UEF (0.82 EF)
Heat Pump	3.0 EF, NEEA Tier 3, 3.5 COP
Best-in-Class Heat Pump	3.4 EF, NEEA Tier 3, 4.3 COP

Building electrification can generate savings for most homes in both equipment and energy costs

Lifecycle Costs of Building Electrification



* We assume that all consumers in retrofit homes have or would install air conditioning in the mixed fuel baseline.
** This category corresponds to buildings modeled in San Francisco (Climate Zone 3) that we assumed would not install air conditioning in the gas baseline home. 100% of all-electric new construction single family and low-rise multifamily homes that include air conditioning show lifecycle savings.

Take-away Messages

- **Electrifying a whole home can reduce greenhouse gas emissions by up to 60% even with today's grid, and will get better as the grid & refrigerants get cleaner**
- **Near-term opportunities for both equipment and energy cost savings:**
  - **All-electric new construction** –**saves $130-$540/year** relative to gas-fueled new homes over the lifetime of the equipment
  - **Retrofit single family homes** –most can **save up to $400/year** if electrifying HVAC and water heater together
  - **High-efficiency heat pump HVAC** –all homes with a need for **air conditioning** are expected to **save up to $500/year** relative to gas furnace and air conditioner combined
- There are **near-term cost barriers** for electrifying **old homes**, **homes without a need for cooling**, and appliances such as **cookstoves** and **clothes dryers**
- **Policy** needs to overcome **non-economic barriers** for consumers to be willing to electrify homes, and to reach the level of adoption needed for climate goals

Recommendations

- **Incentivize all-electric new construction and update the building code**
- **Incentivize high-efficiency heat pump HVAC, particularly in areas with high air conditioning loads**
- **Ensure efficient price signals are conveyed in electric and natural gas rates**
  - More efficient electricity rates
  - Higher carbon prices, or complementary policies aimed at reducing the GHG emissions from natural gas
- **Develop a building electrification market transformation initiative**
  - Consumer education and workforce training
  - Retrofit-ready electrification technology options
  - Technology transfer from other markets –higher efficiency, ultra-low global warming potential refrigerants, or low-voltage options
- **Align energy efficiency goals and savings with GHG savings opportunities**

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Thank You

Our report “Residential Building Electrification in California” can be found at the link below:

https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

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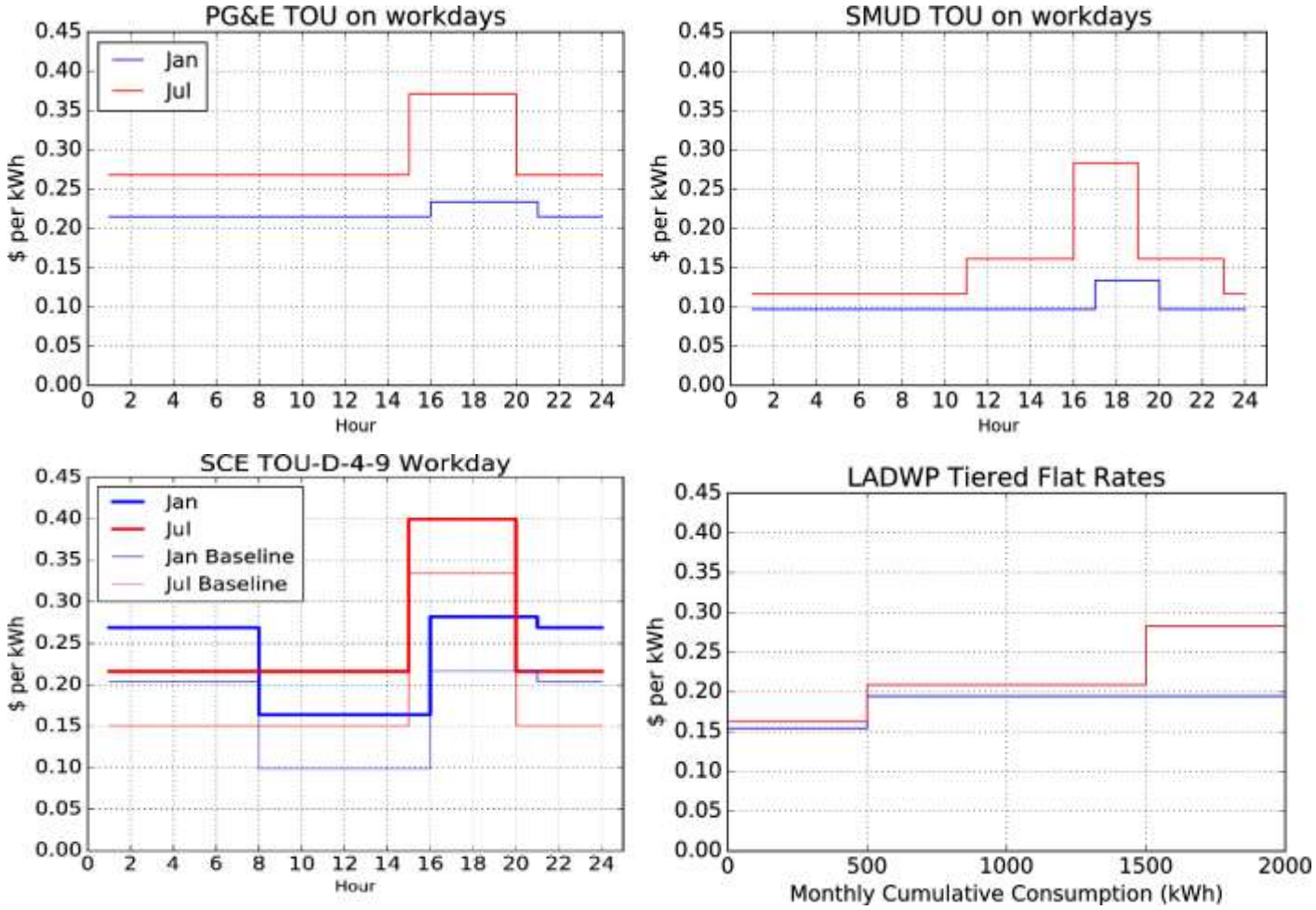
Supplementary Information

Electric and Gas Rates

Electric Rates ($ per kWh)



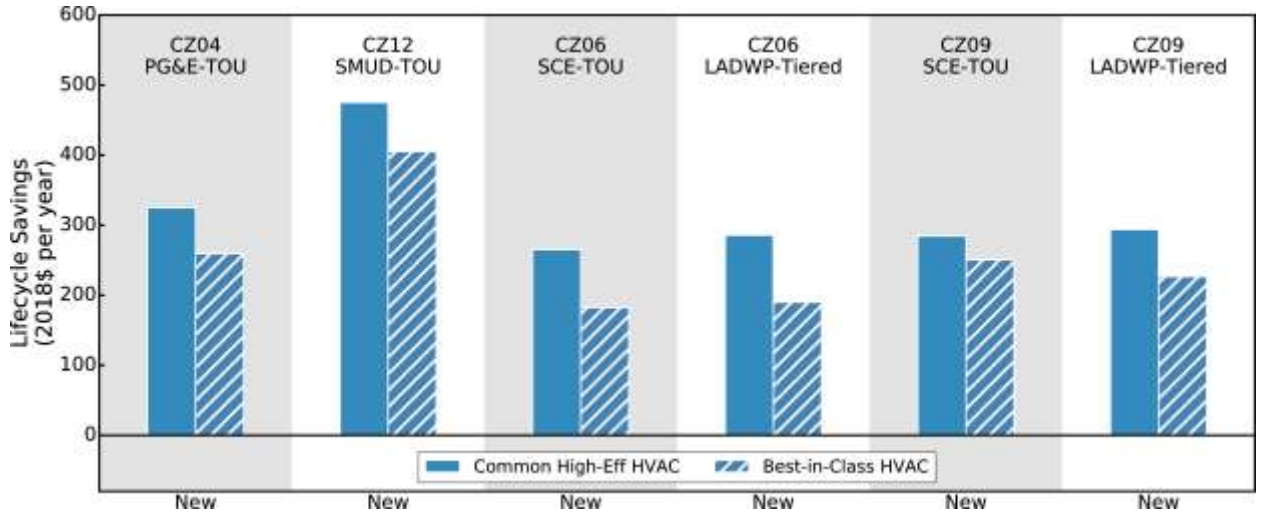
Natural Gas Rates ($ per therm)

	Tier-1	Tier-2
PG&E	$1.3	$1.8
SoCalGas	$0.9	$1.2

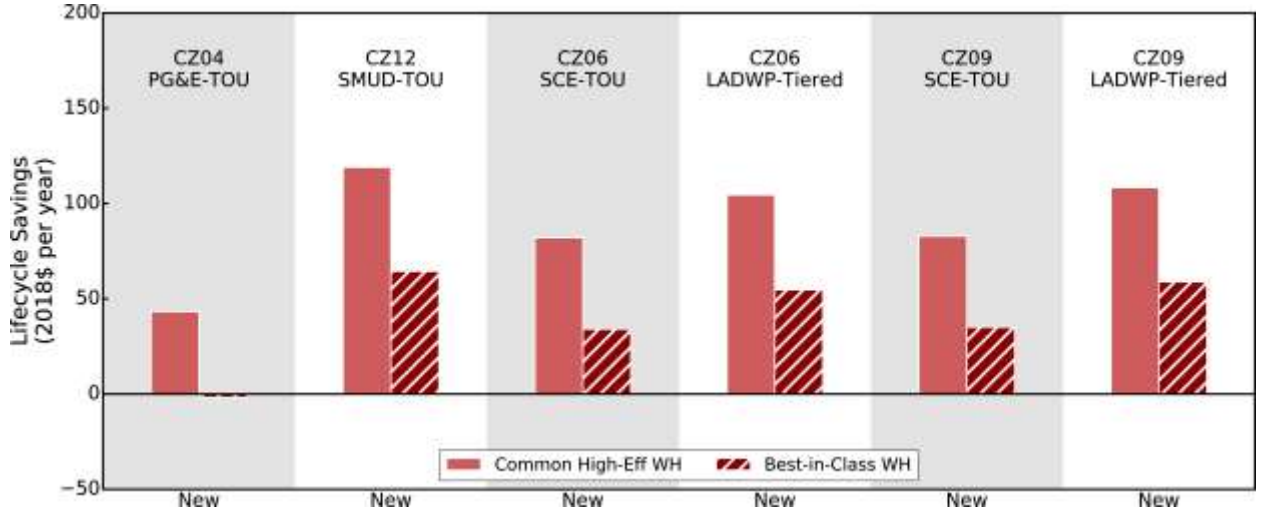
* Average rates, actual modeled rates vary by season and climate region and fixed charges

Higher-performance Equipment

HVAC



Water Heaters



Modeled Equipment Efficiency

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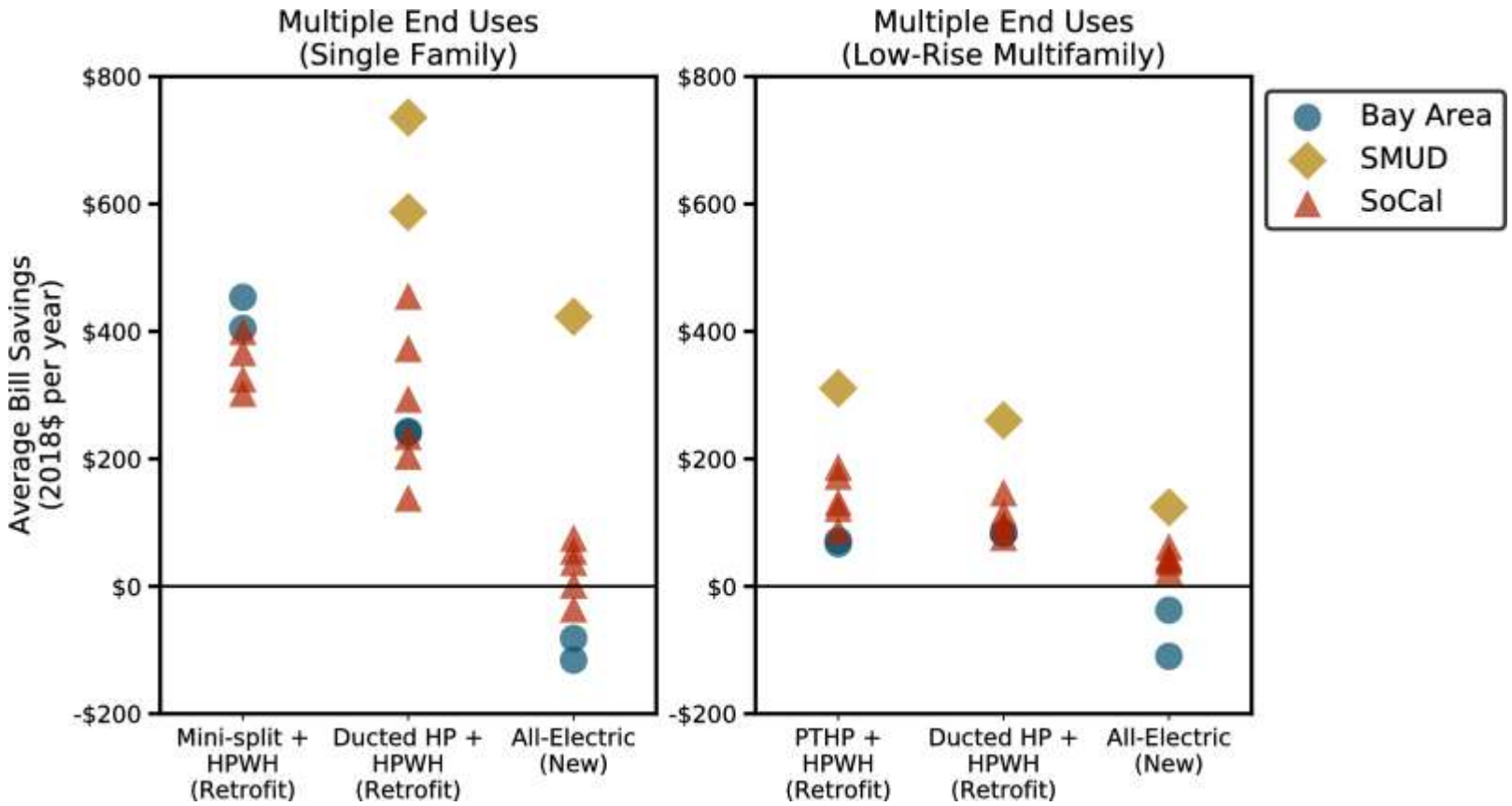
Heat Pump	3.0 EF, NEEA Tier 3

Efficiency of Other Appliances

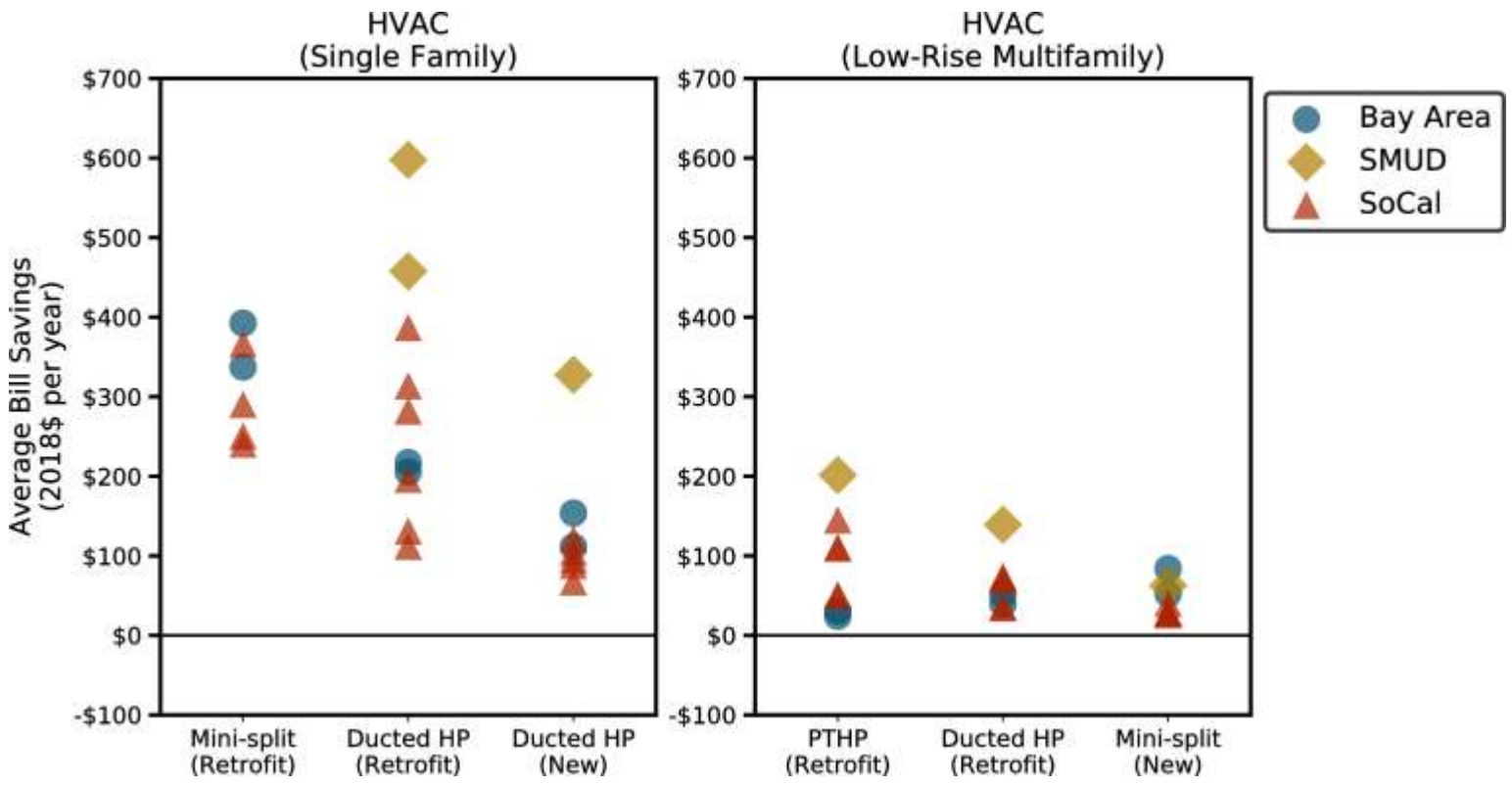
Appliances	Efficiency
Cooking	Cooktop: 0.4 Energy Factor Oven 0.058 Energy Factor Cooktop: 0.74 Energy Factor Oven 0.11 Energy Factor Cooktop: 0.84 Energy Factor Oven 0.11 Energy Factor
Clothes Dryer	2.75 Energy Factor 3.1 Energy Factor 4.2 Energy Factor
Clothes Washer	1.41 MEF

All simulation parameters and schedules are based on NREL's BEopt and the House Simulation Protocols

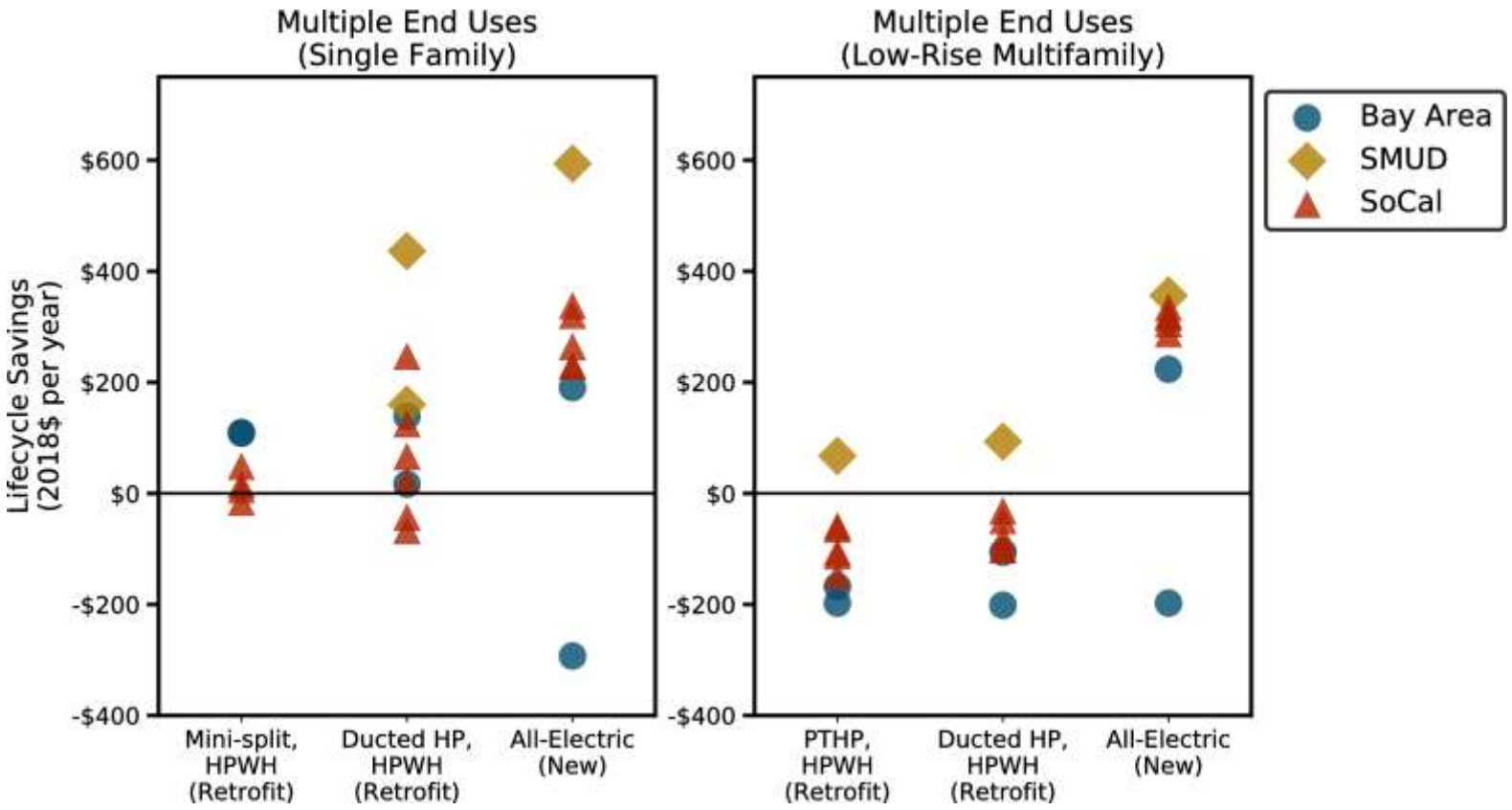
Bill Savings –Multiple End Uses



Bill Savings –Heat Pump HVAC



Lifecycle Savings –Multiple End Uses



Bill Savings –Heat Pump Water Heater