AGENDA: 3

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Air District Regulation of Appliances

Climate Protection Committee
November 19, 2020

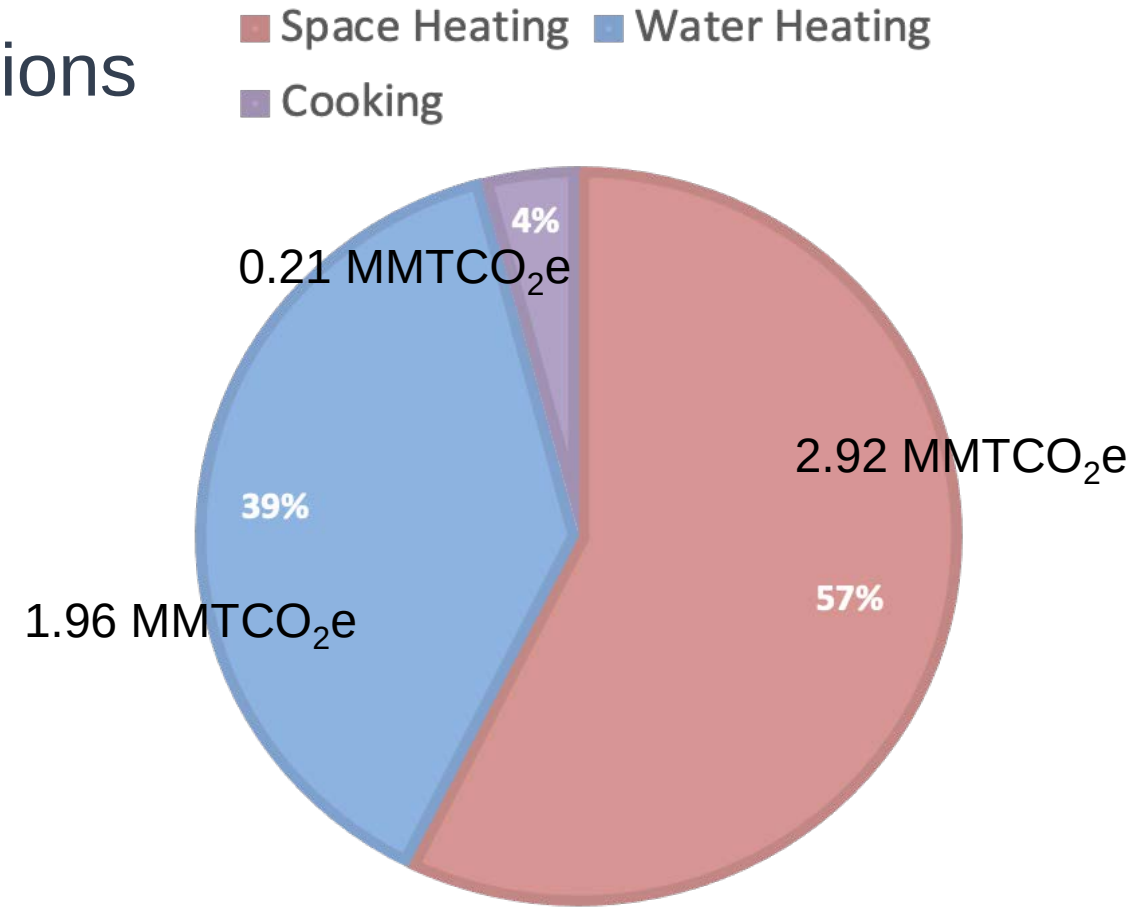
Jennifer Elwell
Senior Air Quality Specialist

Agenda

- Residential appliance emissions
- Current Air District rules – Bay Area and beyond
- Equipment cost comparison and greenhouse gas implications
- Further considerations

Appliance Emissions

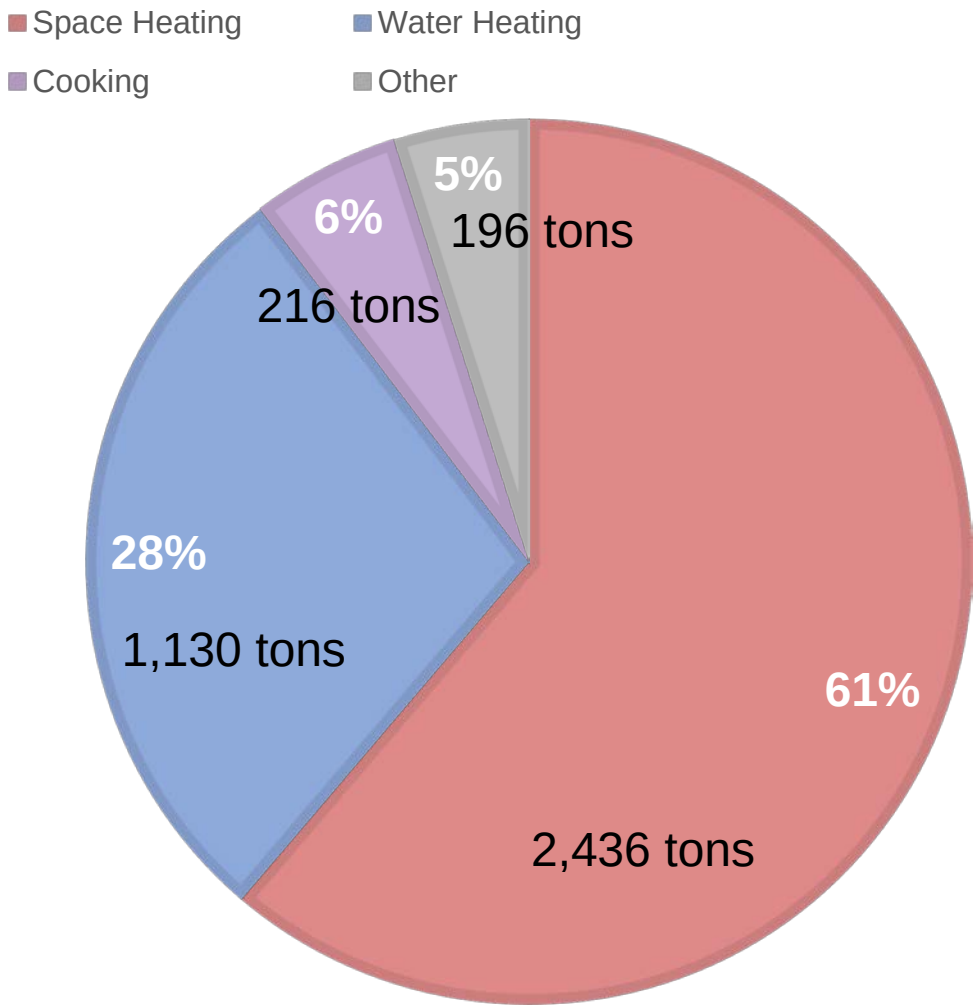
2019 Greenhouse Gas Emissions ($MMTCO_2e$)



Residential: 5.09 $MMTCO_2e$

Appliance Emissions

2019 NO_X Emissions (tons)



Residential: 3,978 tons

Current Air District Rules

Nitrous Oxide point of sale regulations:

- Rule 9-4: Fan Type Residential Central Furnaces
  - 40 ng NOx/joule of useful heat delivered

- Rule 9-6: Natural Gas-Fired Boilers and Water Heaters
  - 10-40 ng NOx/joule useful heat delivered
  - Dependent on size and year installed

Current Air District Rules (cont.)

Rule 9-7: NOx and CO from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters

Emission Limit	Rated Heat Input (million BTU/hr)	Fuel	NOx Limit (ppmv, dry at 3% oxygen)	CO Limit (ppmv, dry at 3% oxygen)
307.1	>2 to 5	gaseous, except landfill or digester gas	30	400
307.2	>5 to <10		15	400
307.3	10 to <20		15	400
307.4	20 or more, load-following unit		15	400
307.5	20 to <75		9	400
307.6	75 or more		5	400
307.7	1 or more	landfill or digester gas	30	400
307.8	1 or more	non-gaseous	40	400
307.9	1 or more	multiple fuels	heat-input weighted average limit	400

(Adopted 7/30/2008; Amended 5/4/2011)

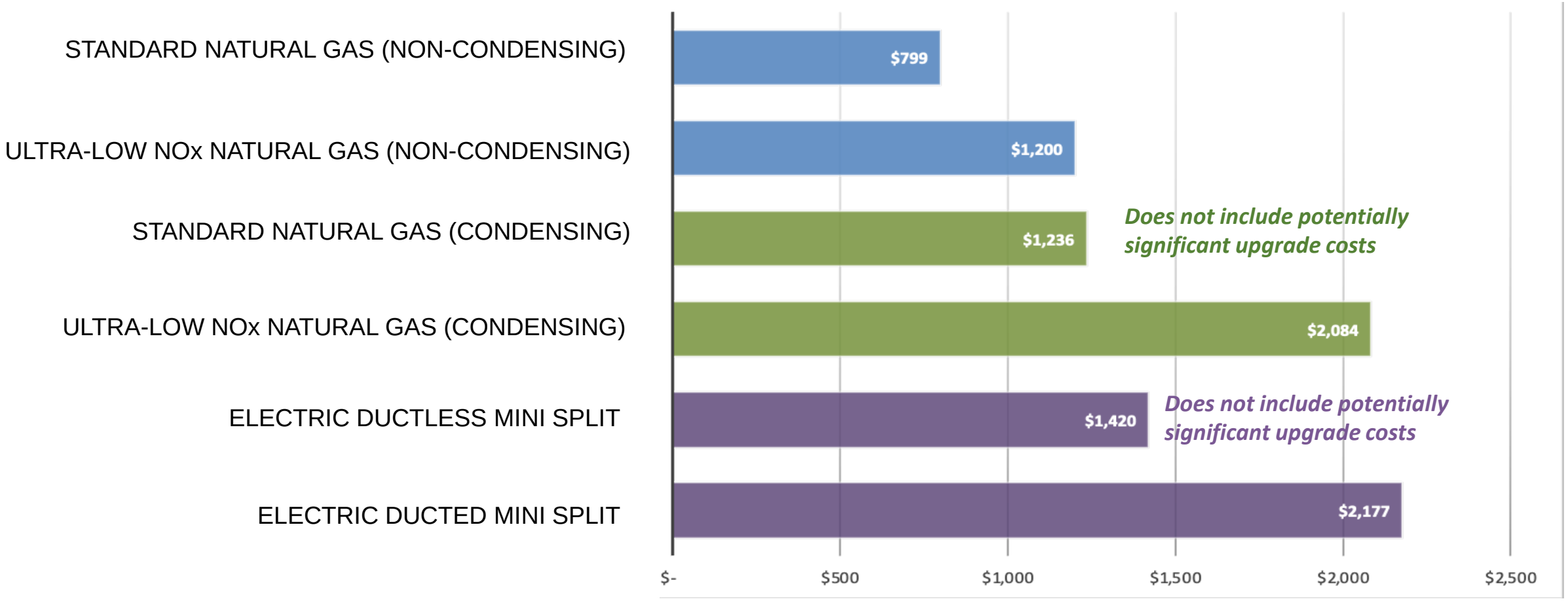
Other Air Districts

- South Coast Air Quality Management District (SCAQMD)
  - Rule 1121: Water Heaters: 10-40 ng NOx/joule
    - List of approved appliances
  - Rule 1111: Furnaces, updated 2018: 14 ng NOx/joule
- San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD)
  - Rule 4902: Water Heaters: 10-40 ng NOx/joule
  - Rule 4905: Furnaces, updated 2018: 14 ng NOx/joule

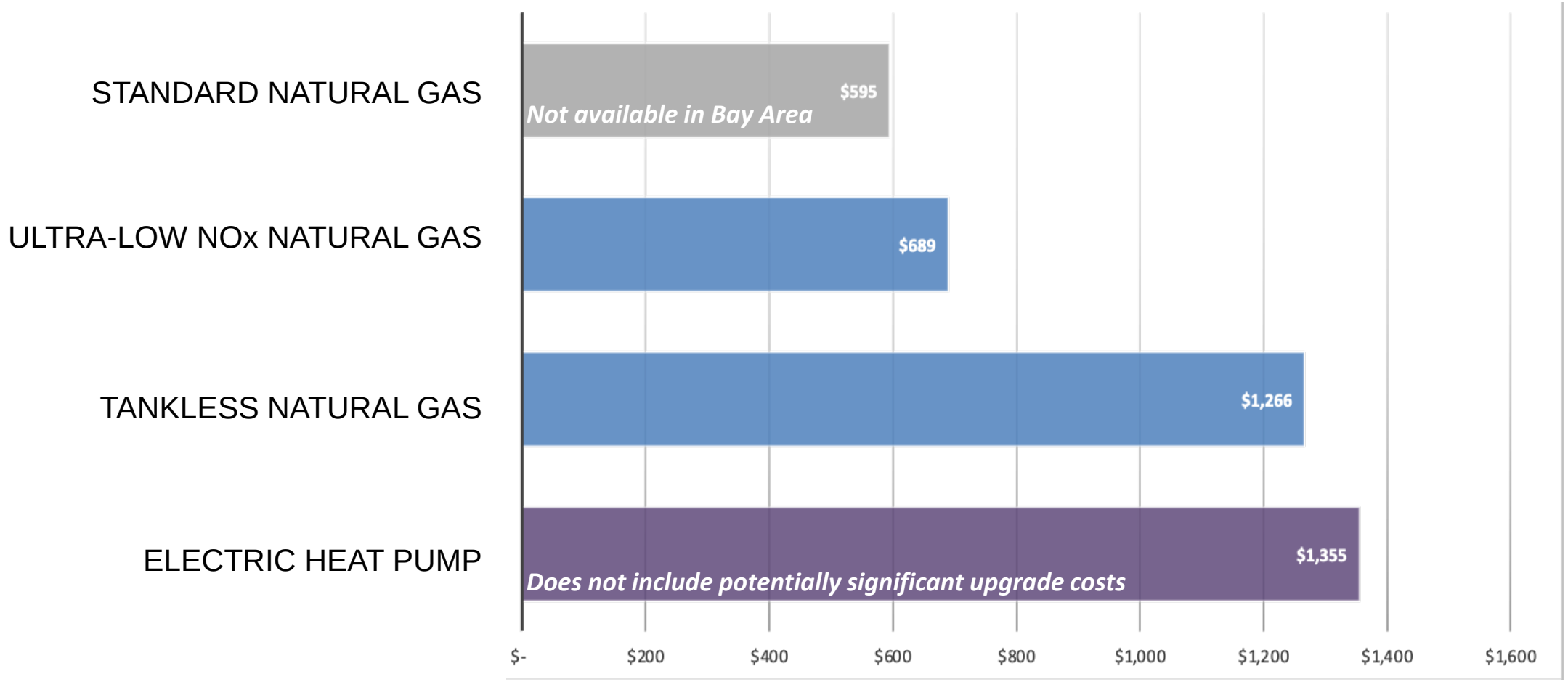
NO_X Limit Comparison

BAAQMD Rule	Equipment Type	Equipment Size (MMBTU/hr)	BAAQMD Existing Standard	Reduction per Unit	SCAQMD Standard	SJVUAPCD Standard
9-4	Natural Gas Fired Residential Fan Type Furnaces	<0.175[2]	40 ng/J	65%	14 ng/J	14 ng/J
9-7	Boiler/SG/Process Heater, gaseous	> 2 to 5	30 ppm	70%	9 ppm	9 ppm
9-7	Boiler/SG/Process Heater, gaseous	> 5	15 ppm	40%	9 ppm	15 ppm or 9 ppm
9-7	Boiler/SG/Process Heater - landfill gas	>1	30 ppm	17%	25 ppm	N/A
9-7	Boiler/SG/Process Heater - digester gas	>1	30 ppm	50%	15 ppm	N/A

Space Heating Equipment Costs



Water Heater Equipment Costs



Further Considerations

- Air District rules govern point of sale for appliances
  - Title 24 (California Energy Commission) sets building codes for new construction, including energy usage
- Large scale switch to electric appliances would:
  - Require increased infrastructure
  - Result in stranded natural gas assets
  - Raise equity concerns for consumers bearing these costs

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

AGENDA: 4

Update On the State 2022 Building Energy Code Update

Climate Protection Committee
November 19, 2020

Abby Young
Climate Protection Manager

The California Building Standards Code (Title 24)

Created by the California Building Standards Commission in 1978 in response to a legislative mandate to reduce California's energy consumption

Title 24 is Composed of 12 "Parts," Described Below:

- Part 1 - California Building Standards Administrative Code
- Part 2 - California Building Code - Vol. I & II
- Part 3 - California Electrical Code
- Part 4 - California Mechanical Code
- Part 5 - California Plumbing Code
- Part 6 - California Energy Code
- Part 7 - No longer published in Title 24; see Title 8 CCR
- Part 8 - California Historical Building Code
- Part 9 - California Fire Code
- Part 10 - California Existing Building Code
- Part 11 - California Green Building Standards Code
- Part 12 - California Reference Standards Code

Parts 6 and 11 address building energy use and are currently being updated

The California Energy Code (Title 24 Part 6)

The Warren Alquist Act, establishing the California Energy Commission (CEC), was signed into law in 1974 by Governor Ronald Reagan, and launched by Governor Jerry Brown in 1975

The CEC oversees and updates the California Energy Code every three years:

- Addresses energy use in residential and non-residential building construction, additions, and alterations
- Requirements must be cost-effective
- Enforced through the local permit process

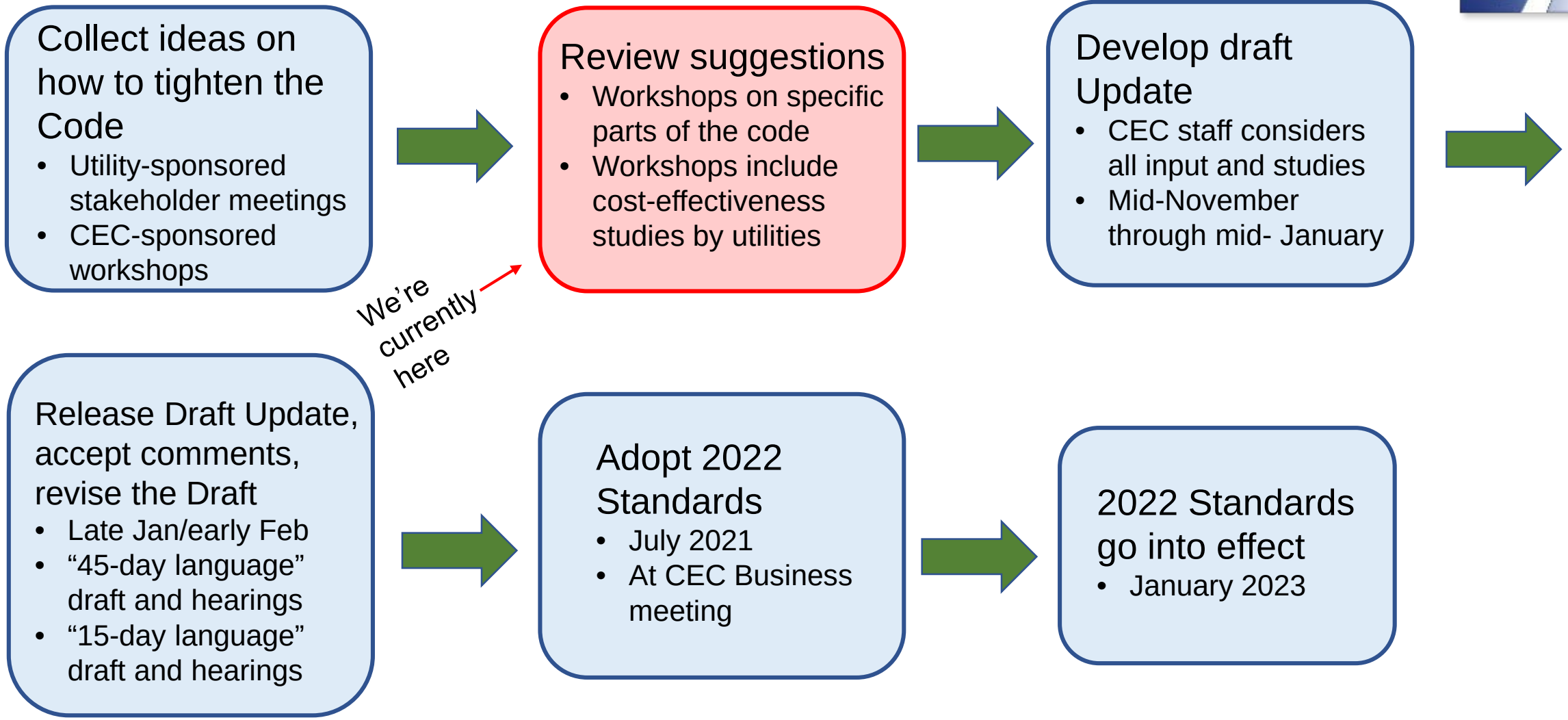
CalGreen (Title 24 Part 11)

First enacted in 2008 to address environmental aspects of building construction beyond energy use:

- Planning and design
- Energy efficiency
- Water efficiency and conservation
- Material conservation and resource efficiency
- Environmental quality

- Includes mandatory minimum requirements
- Provides optional “tiers” to allow local governments to set higher standards
- Previews new requirements that might be included in the next triennial update to the Energy Code

Energy Code Update Process



Key Issues - Electrification

Biggest issue: *How far toward building electrification will this update go?*

The CEC is considering options:

1. **Remove barriers to electrification within the existing Energy Code**
2. **Provide incentives (compliance credits) for builders to include electric appliances in buildings**
3. Include requirements for some appliances to be electric
4. Include an all-electric requirement

Considerations:

- CEC is mandated to consider cost-effectiveness
- There has been a great deal of input and opinion from all sides

Key Issues – Indoor Air Quality

Gas stoves emit nitrogen dioxide, carbon monoxide, and formaldehyde, which can exacerbate various respiratory and other health ailments.

CEC is considering two routes to healthier stoves

<u>Require electric stoves</u>

- Ban on gas stoves in multi-family housing
- Eases health impacts on lower income families

<u>Improve ventilation of gas stoves</u>

- Permanently running vents in kitchens
- Usage sensors trigger ventilation

Next Steps

- CEC wrapping up final workshops this month
- Draft 2022 Code Update out in late January/early February 2021
  → 45 days to review and comment
- Revised Draft Update out in Spring 2021
  → 15 days to review and comment
- Final 2022 Energy Code Update to CEC business meeting July 2021

AGENDA: 5

Energy+Environmental Economics

Residential Building Electrification in California

Consumer economics, greenhouse gases and grid impacts

Bay Area Air Quality Management District
Climate Protection Committee

November 19, 2020

Amber Mahone

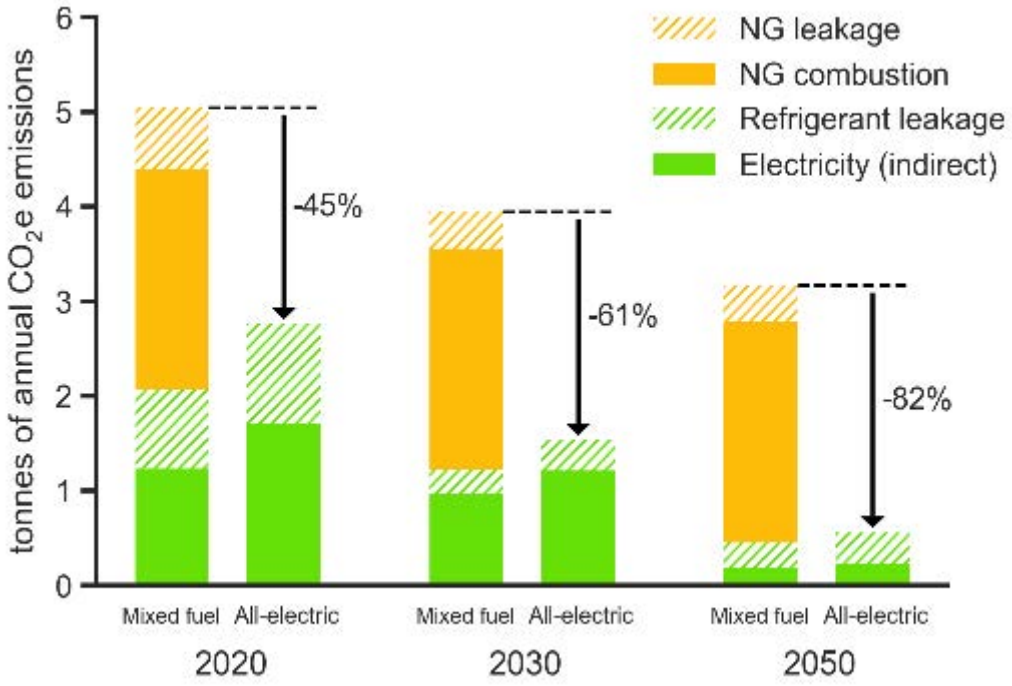
Agenda

- **Greenhouse gas savings & air quality benefits of building electrification**
- **Buildings and technologies**
- **Consumer economics of building electrification**
  - Capital costs
  - Bill savings
  - Lifecycle savings
- **Conclusions and Recommendations**

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)

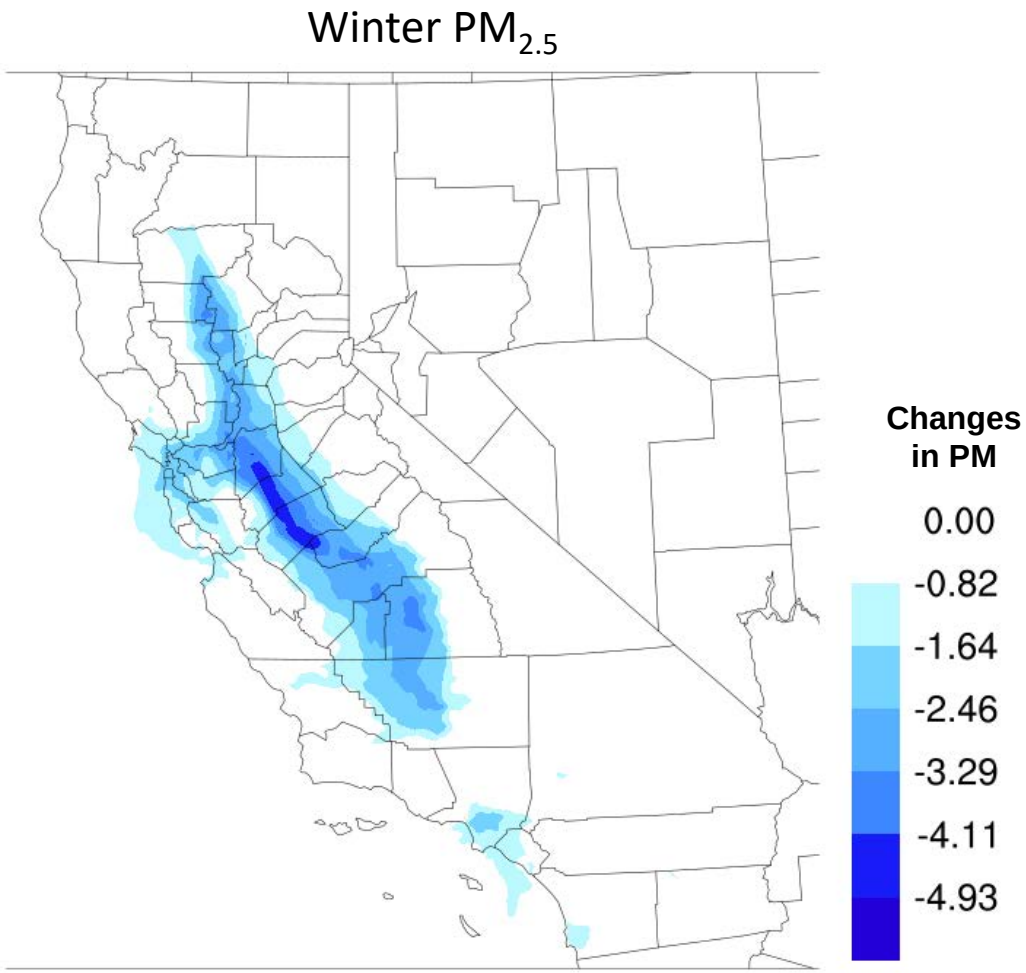


- In the long-term, switching to an **all-electric home** reduces **GHG emissions** by **80-90% or more** if the grid and refrigerants become cleaner
- Emission reduction is mainly due to switching away from NG combustion with small increase in electricity emissions
- Phasing out **high-GWP refrigerants**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

Source: “Residential Building Electrification in California”, E3, 2019
https://www.ethree.com/e3-quantifies-the-consumer-and-emissions-impacts-of-electrifying-california-homes/

Building electrification improves outdoor air quality, particularly when paired with other electrification

- **Building electrification improves outdoor air quality, particularly in the Central Valley and South Coast air basin**
  - Winter episode air quality improvements from building electrification are shown in blue on map
  - Health savings estimated at $166 to $249 million for the modeled two-week winter episode
  - Reductions in secondary PM2.5 are from avoided NOx from gas appliances
  - Indoor air quality benefits of building electrification were not quantified in this study but may also be significant



-4.93 ug/m^3 peak difference in the San Joaquin Valley

Source: "The Challenge of Retail Gas in California's Low Carbon Future", CEC-500-2019-055
https://ww2.energy.ca.gov/2019publications/CEC-500-2019-055/CEC-500-2019-055-F.pdf

Energy+Environmental Economics

Buildings and Technologies

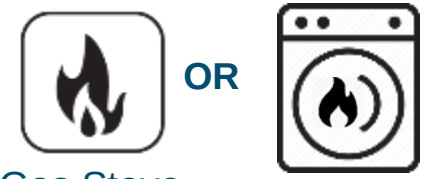
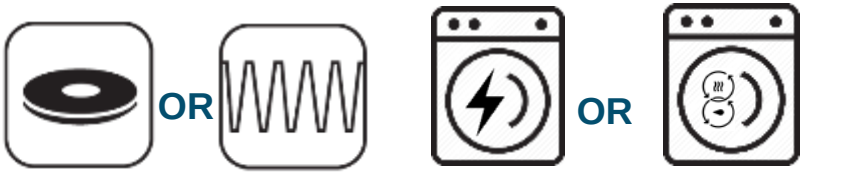
Six low-rise residential building types are simulated

- **Using BEopt & EnergyPlus**
- **All retrofit single family homes are assumed to upgrade to ducted air conditioning systems for comparable comfort levels to electric heat pump homes**

3 Vintages	Single family 	Low-rise multi-family 
Retrofit (Pre-1978) (No insulation, single pane windows)	**1,400 sf**	**8 units** (780 sf/unit and 960 sf/unit)
Retrofit (1990s) (T24 building code 1992 construction)	**2,100 sf**	**6 units** (1,500 sf/unit)
New Construction (2019 T24 building code)	 **2,700 sf**	 **8 units** (780 sf/unit and 960 sf/unit)

Studied residential end use technologies

- Heat pumps exceed code minimum, but represent commonly available tech.
- "Best-in-class" higher efficiency options are evaluated in sensitivity analysis

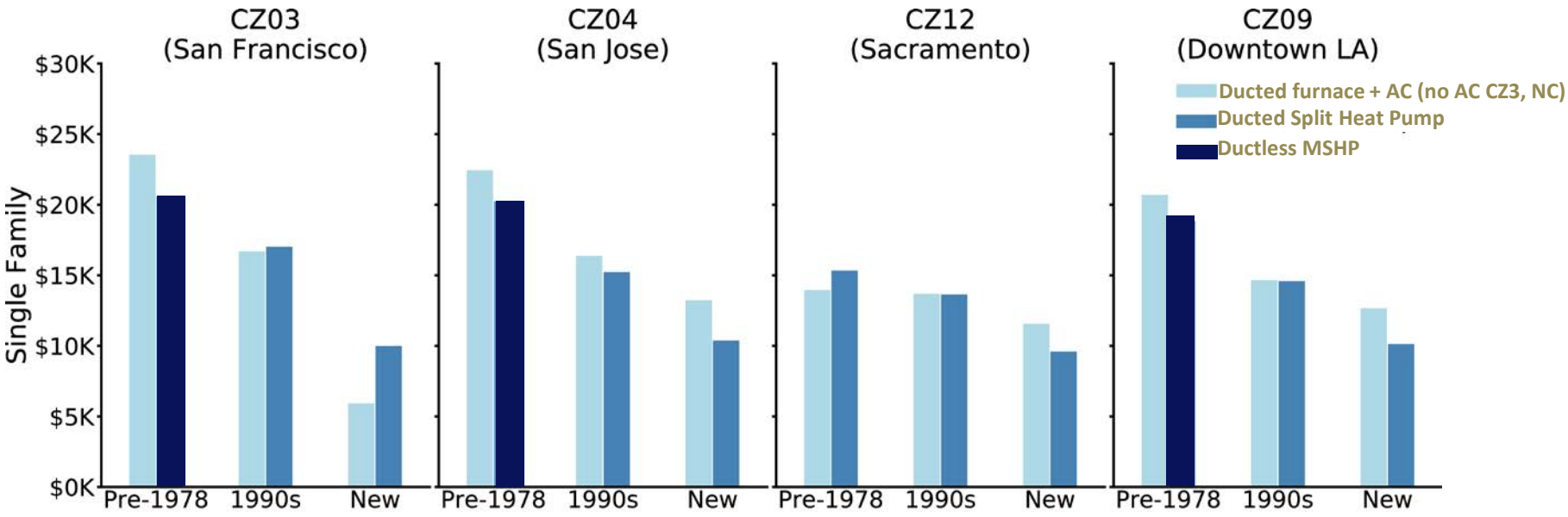
	Gas Home	Electric Home
HVAC	 **Gas Furnace + AC**	 **Packaged Terminal Heat Pump** OR **Mini-split Heat Pump** OR **Ducted Split Heat Pump**
Water Heating	 **Gas Storage WH (retrofits)** OR **Gas Tankless WH (new)**	 **Heat Pump Water Heater**
Cooking and Clothes Drying	 Gas Stove OR Gas Dryer	 ELECTRIC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

Energy+Environmental Economics

Consumer Economics
Capital costs

Single family HVAC capital costs

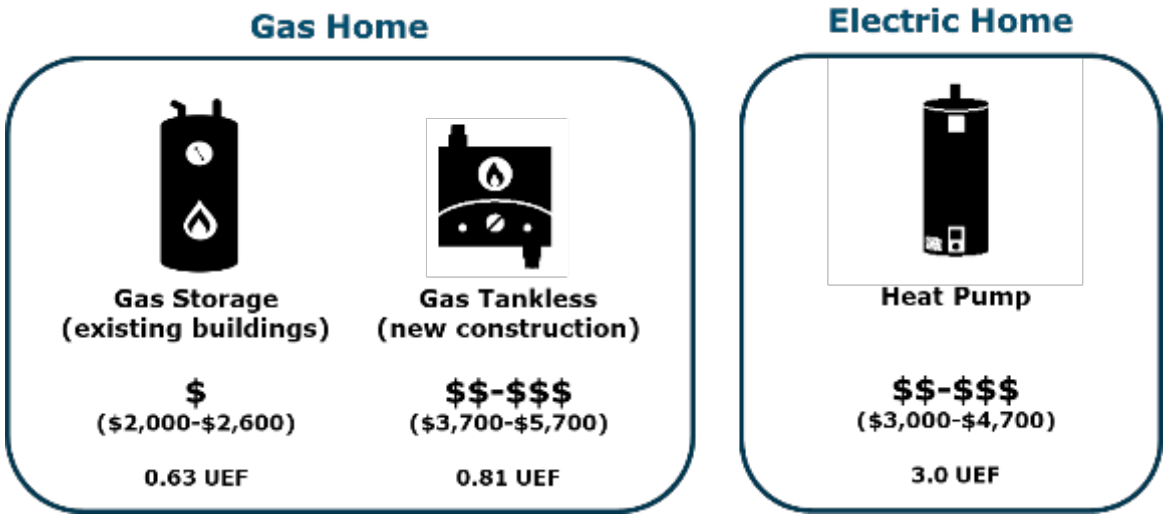
- Heat pump HVAC systems see capital cost savings in most homes with AC
- Retrofit assumptions matter a lot – are you adding ductwork for central AC?

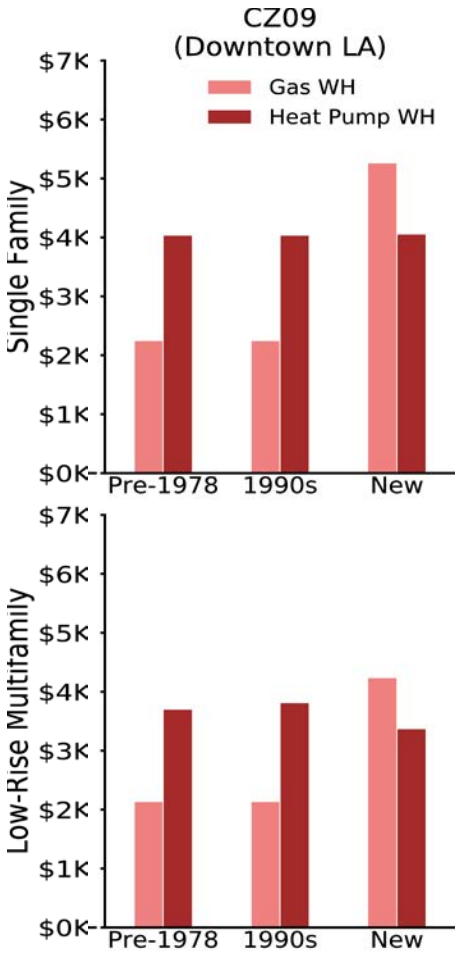


Existing system	CZ03 (San Francisco)	CZ04 (San Jose)	CZ12 (Sacramento)	CZ09 (Downtown LA)
Pre-1978	Wall furnace, no AC	Wall furnace, window AC	Ducted furnace + AC	Wall furnace, window AC
1990s	Ducted furnace, no AC	Ducted furnace + AC	Ducted furnace + AC	Ducted furnace + AC

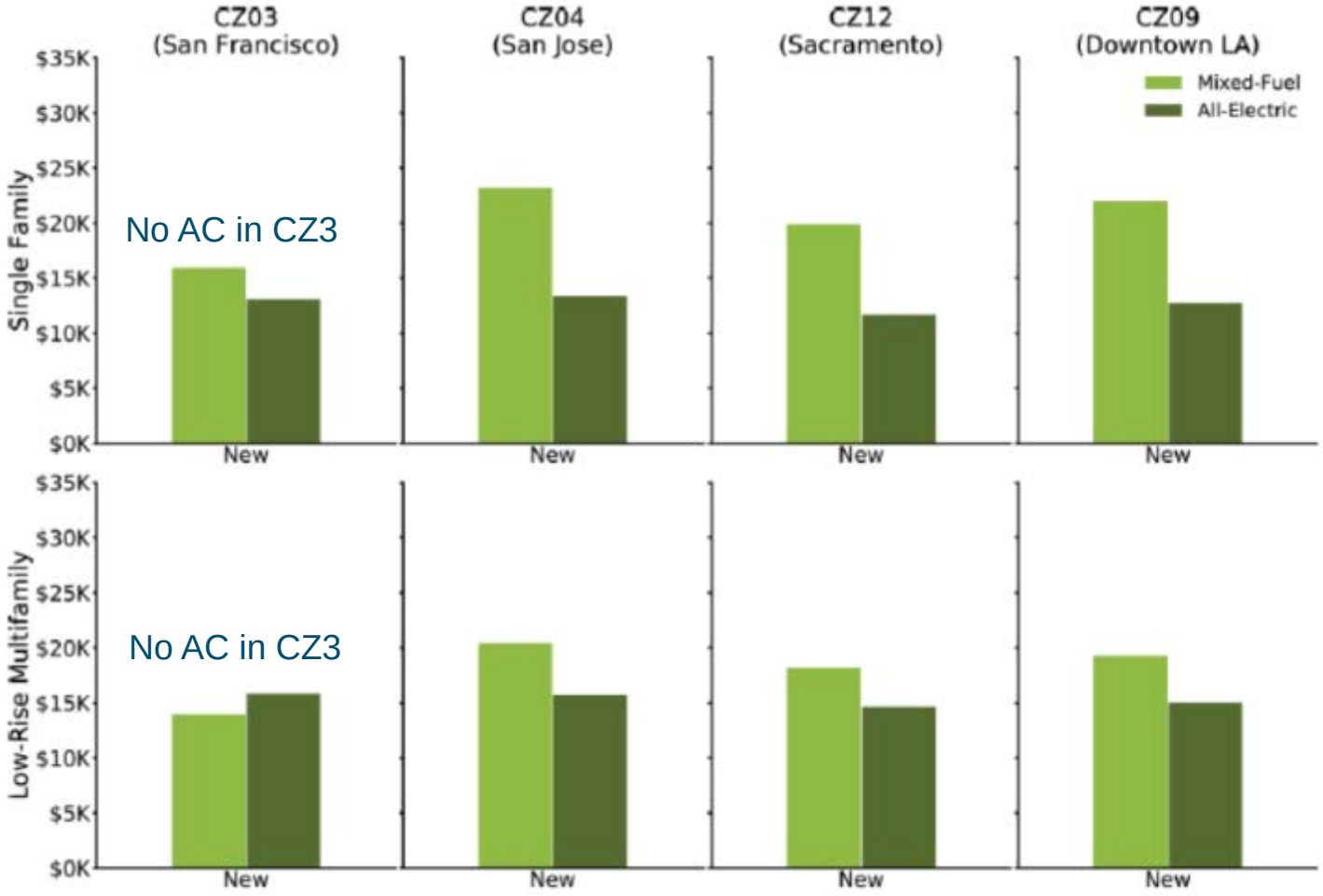
Single Family
Hot Water Heater Capital Costs

- **Heat pump water heaters are more expensive than gas storage water heaters (retrofit)**
- **Heat pump water heaters are less expensive than tankless gas water heaters (new construction)**





All-electric new construction sees lower capital cost than mixed fuel homes

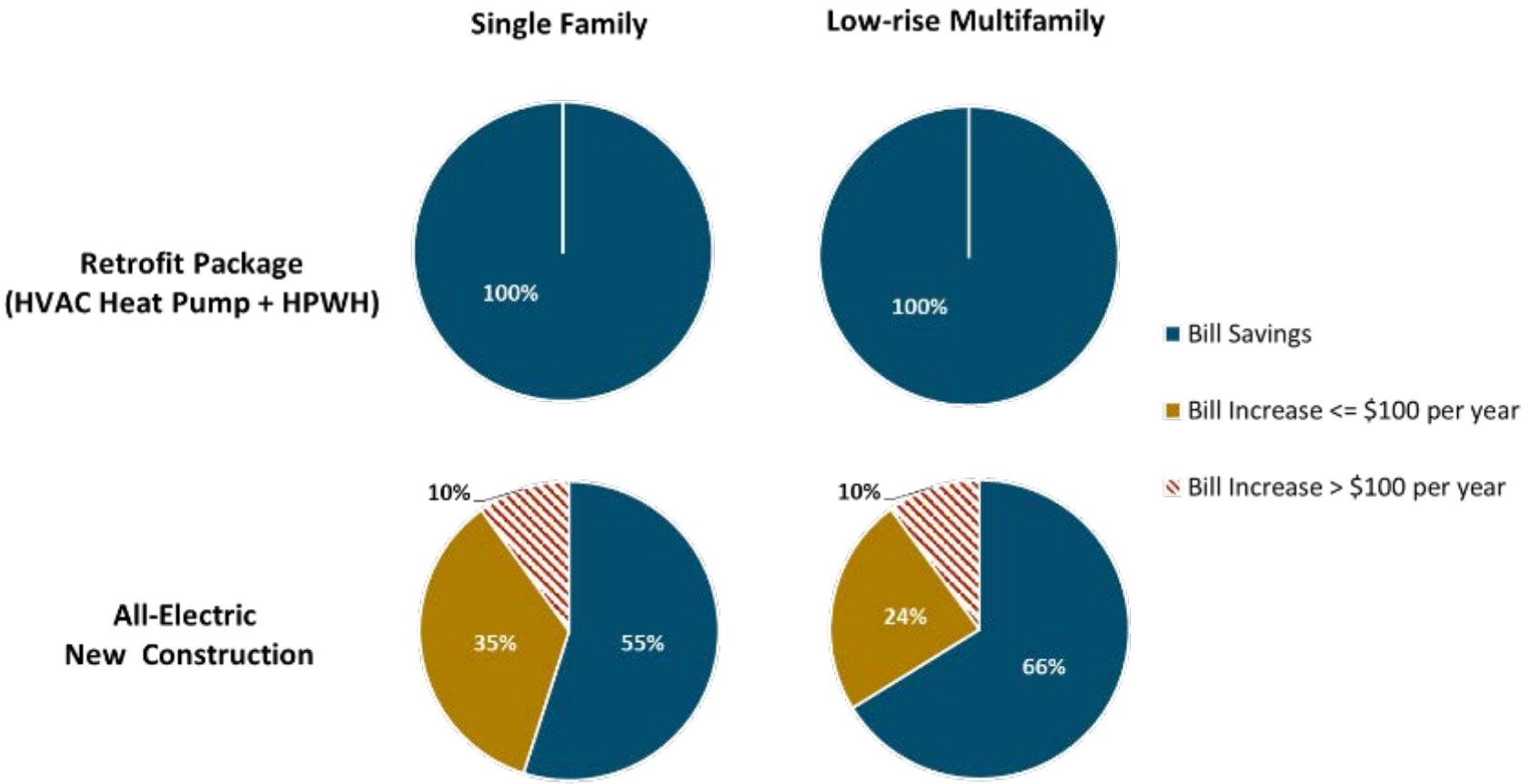


Energy+Environmental Economics

Consumer Economics
Bill Savings

Heat pumps save energy costs in all retrofit homes and the majority of new construction

Consumer Bill Impacts of Building Electrification

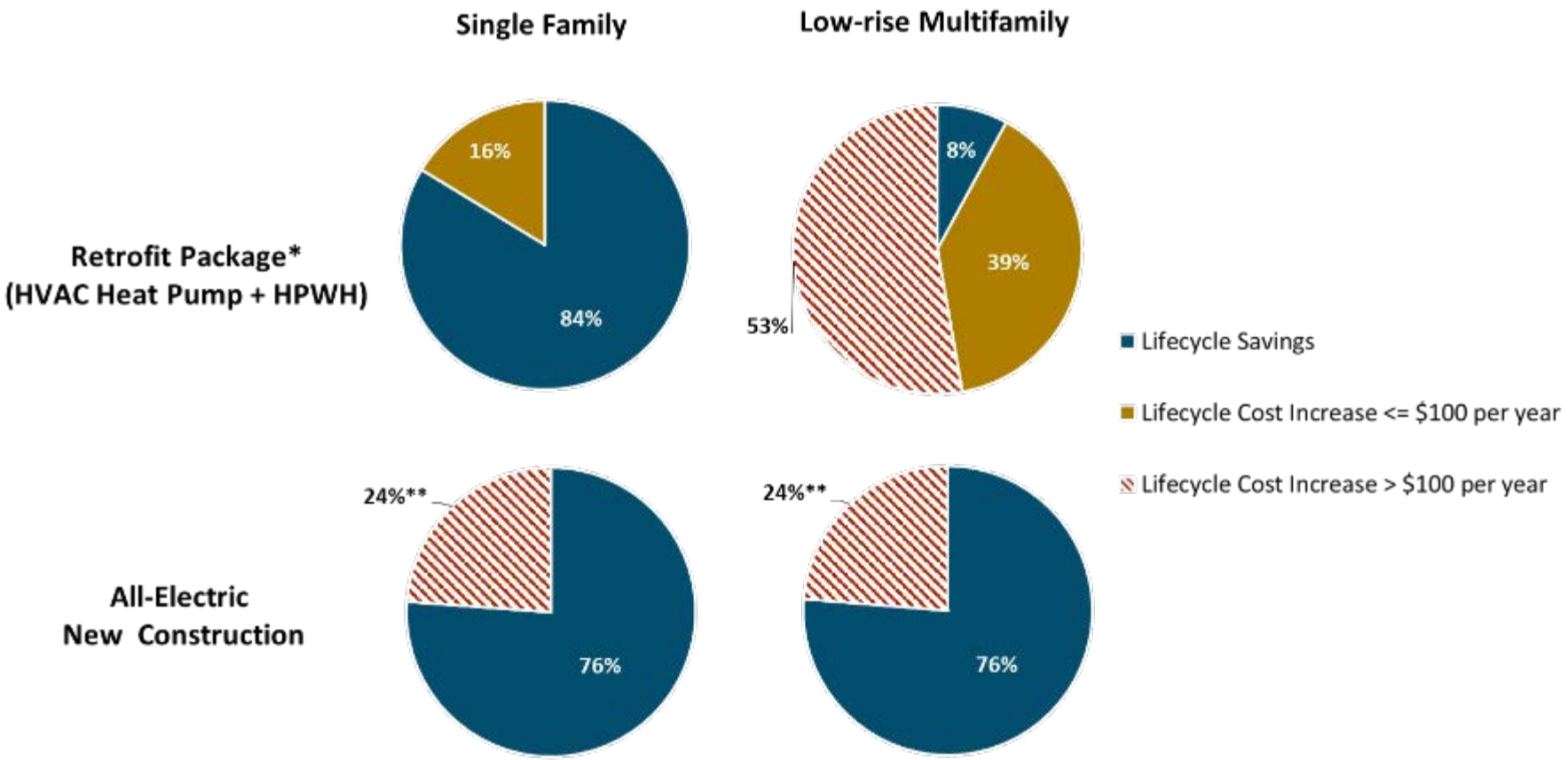


Energy+Environmental Economics

Consumer Economics
Lifecycle Savings

Heat pumps generate lifecycle savings in many retrofits & new construction homes

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.

Energy+Environmental Economics

Conclusions and Recommendations

Key conclusions

- **Electrifying a single-family home in California can reduce greenhouse gas emissions by 30% - 60% even with today's grid, and will get better as the grid & refrigerants get cleaner & reduce NOx and secondary PM2.5**
- **Near-term opportunities for both equipment and energy cost savings:**
  - **All-electric res. new construction saves $130 - $540/year** relative to gas-fueled new homes **with air conditioning** over the building's lifetime
  - **Retrofit single family homes** – 87% of modeled homes in study area see lifecycle savings when electrifying HVAC and water heater together
  - **High-efficiency heat pump HVAC makes sense when replacing a gas furnace and air conditioner** – 100% of modeled homes with A/C needs see lifecycle savings
- There are **near-term cost barriers** for electrifying **old homes** and **homes without a need for cooling**, and for electric 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**

Energy+Environmental Economics

Thank You

Capital Costs

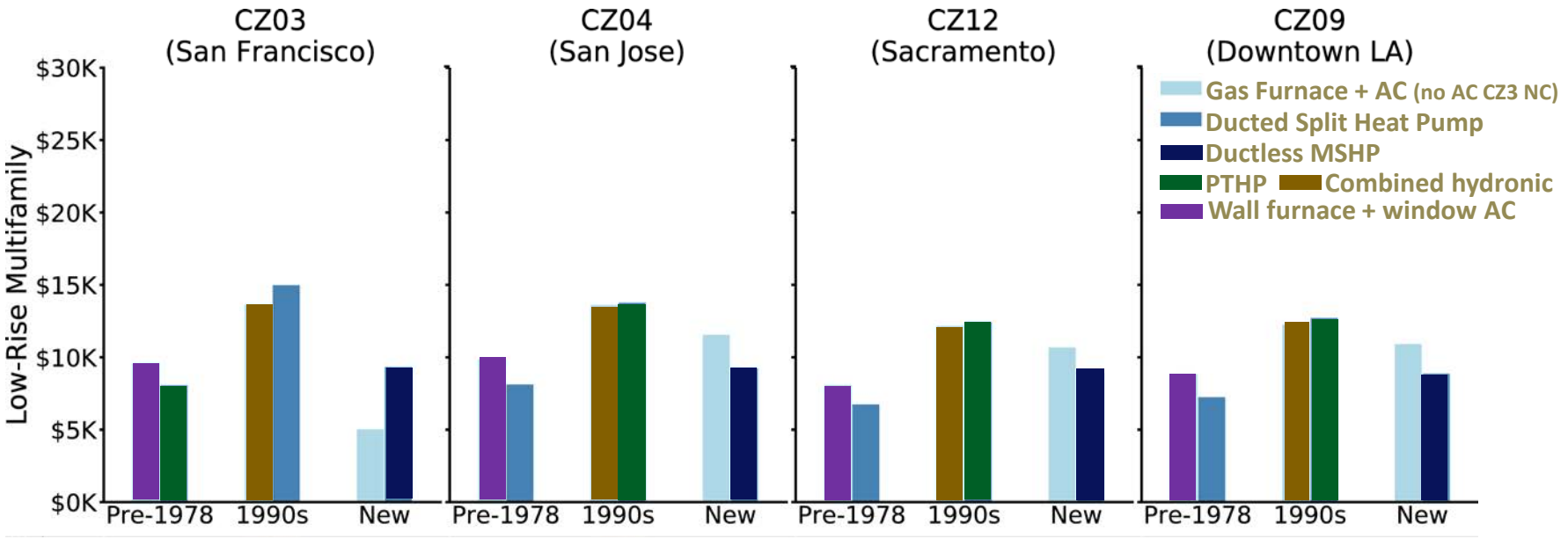
Example of installed equipment capital cost data developed for this analysis: Singe family HVAC heat pump retrofit, 1990s vintage, CZ06

- **This study relied on a professional cost estimator (AECOM) to create a consistent set of data across technologies and climate zones**
  - Cost assumptions for labor rates & mark-ups, installation, equipment
- **Retrofits of HVAC account for the value of delayed AC replacement when gas furnace is replaced on burnout**
- **Panel upgrade costs applied to pre-1978 homes retrofitting to electric heat pump HVAC and DHW**
- **Avoided costs of natural gas infrastructure applied to all-electric new construction**
- **Capturing the variability in costs is a challenge, retrofit costs in particular are heterogeneous and site-specific**

Demolition		
Remove existing furnace		
Labor		680
Disposal		500
		1,180
Installation		
Furnace	*Included in heat pump*	
New Furnace, equipment price		
Heating included in split system heat pump		
Miscellaneous supplies		
Labor		
Air Conditioner		
New Air Conditioner, equipment price	$	5,400
Ducted split heat pump AHU in attic,		
3-ton 18 SEER/14 EER, 10 HSPF, two-	$	-
Concrete pad, precast	$	100
Refrigerant piping and refrigerant	$	400
Miscellaneous supplies	$	400
Labor	$	1,360
Controls		
Thermostat & wiring	$	400
Gas and Electrical Supply		
New electrical circuits to equipment	$	190
Panel and main service modification	*Not required*	
Gas supply piping	*Not required*	
Labor	$	340
Ductwork modifications	$	-
Miscellaneous supplies	$	250
Labor	$	680
	$	9,520
Subtotal	$	10,700
	$	-
General Conditions and Overhead	$	1,605
Design and Engineering	$	1,231
Permit, testing and inspection	$	169
Contractor Profit/Market Factor	$	274
Recommended Budget	$	13,979

Low rise multi-family HVAC capital costs

- Heat pump HVAC systems see capital cost savings in most homes with AC
- Multi-family HVAC costs are lower than single-family due to smaller sq.ftage



Existing system	CZ03 (San Francisco)	CZ04 (San Jose)	CZ12 (Sacramento)	CZ09 (Downtown LA)
Pre-1978	Wall furnace, no AC → wall furnace, window AC	Wall furnace, window AC	Wall furnace, window AC	Wall furnace, window AC
1990s	Combined hydronic, no AC	Combined hydronic, split AC	Combined hydronic, split AC	Combined hydronic, split AC