CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Residential Retrofits

Cost-effectiveness Analysis Results Webinar
October 14, 2020



SDGE A Sempra Energy utility
SoCalGas A Sempra Energy utility
Southern California Edison An EDISON INTERNATIONAL Company
PG&E Pacific Gas and Electric Company

Agenda

- Welcome and Introductions
- Overview
- Methodology, Measures, and Assumptions
- Analysis Results
- Summary
- Q&A

Overview

Study Development

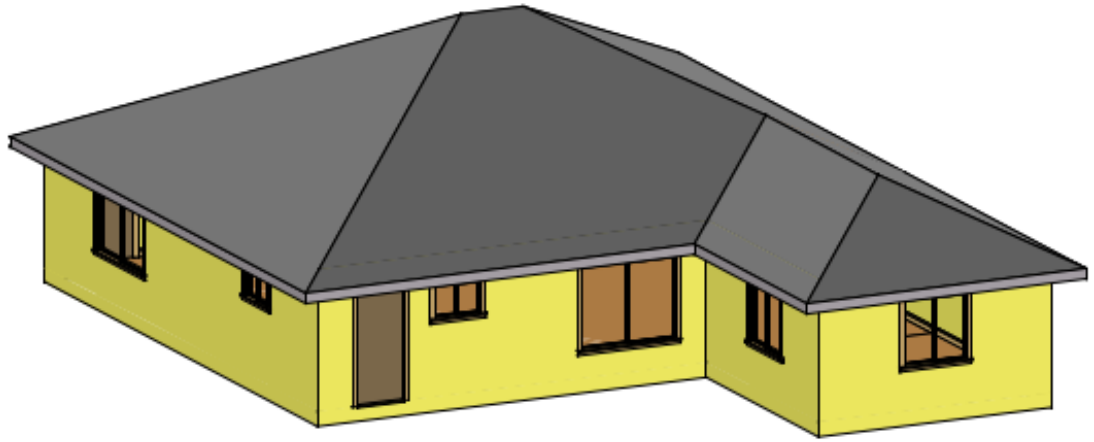
- Triggered by major activities: remodels, additions
- Requires upgrades to features not included in original project scope
- Designed to be feasible across a wide range of existing conditions
- February 2020: Initial 2019 report released.
  - Limited update to 2016 version.
  - On-bill results only.
  - Identified several new measures and packages.

Current Analysis

- February 2021 report includes:
  - Additional efficiency measures
  - Scoring structure to support more flexibility
  - PV and battery storage systems
  - New weather files
  - TDV-based analysis
    - 2019 and 2022

Methodology & Assumptions

Building Prototypes



<u>3 vintages</u>

- Pre-1978
- 1978-1991
- 1992-2005

- 1,665 ft^2 1-story 3-bed single family prototype with garage
- Base case defined by typical construction practice or T24 standards by vintage
- Mixed fuel existing conditions
- All 16 climate zones
- CBECC-Res 2019 v1.3 & CBECC-Res 2022.0.1

8-unit low-rise multifamily prototype analysis in process

Base Case Efficiency Characteristics

Building Component Efficiency Feature	Vintage Case		
	Pre-1978	1978-1991	1992-2005
Exterior Walls: 2x4, 16"o.c.	R-0	R-11	R-13
Foundation Type & Insulation	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 2-15) Raised floor, R-19 (CZ 1 & 16)
Ceiling Insulation	Vented attic, R-11 Vented attic, R-5 (CZ 6 & 7)	Vented attic, R-19	Vented attic, R-30
Roofing Material & Color	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)		
Window Type: **U-factor / SHGC**	Metal, single pane: 1.16 / 0.76	Metal, dual pane: 0.79 / 0.70	Vinyl, dual pane Low-E: 0.55 / 0.40
House Infiltration	15 ACH50	10 ACH50	7 ACH50
Heating Efficiency	78 AFUE	78 AFUE	78 AFUE
Cooling Efficiency	10 SEER	10 SEER	13 SEER, 11 EER
Duct Location & Details	Attic, R-2.1, 30% leakage	Attic, R-2.1, 25% leakage	Attic, R-4.2, 15% leakage
Water Heater Efficiency	0.575 Energy Factor	0.575 Energy Factor	0.575 Energy Factor
Water Heater Tank	40gal uninsulated tank	40gal uninsulated tank	40gal uninsulated tank
Pipe Insulation	None		
Hot Water Fixtures	Standard, non-low flow		
Lighting	Mix of incandescent, CFLs, LEDs		

Cost Effectiveness

- 2 methodologies
  - On-bill customer based
    - IOU TOU rates based on region + SMUD & CPAU
    - Modest escalation over time
    - Upgrades financed at 4% 30-yr loan
  - Time Dependent Valuation (TDV) per CEC methodology
    - Both 2019 & 2022 evaluated
- 30-year evaluation period
  - Except lighting & water heating
- Net Present Value (NPV) & Benefit-to-Cost Ratio (BCR)

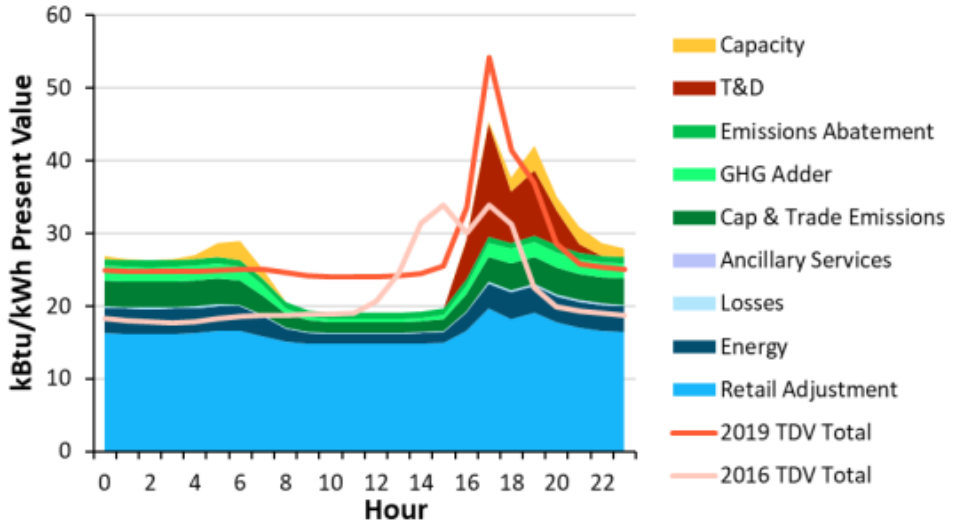
$$NPV = PV\ of\ benefit\ - PV\ of\ cost$$

$$BCR = \frac{PV\ of\ benefit}{PV\ of\ cost}$$

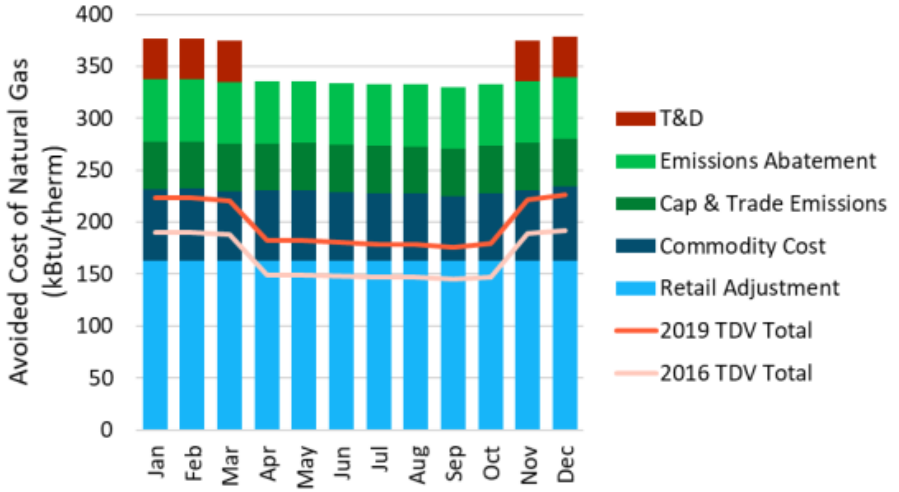
TDV Cost Effectiveness

Major updates to 2022 TDV

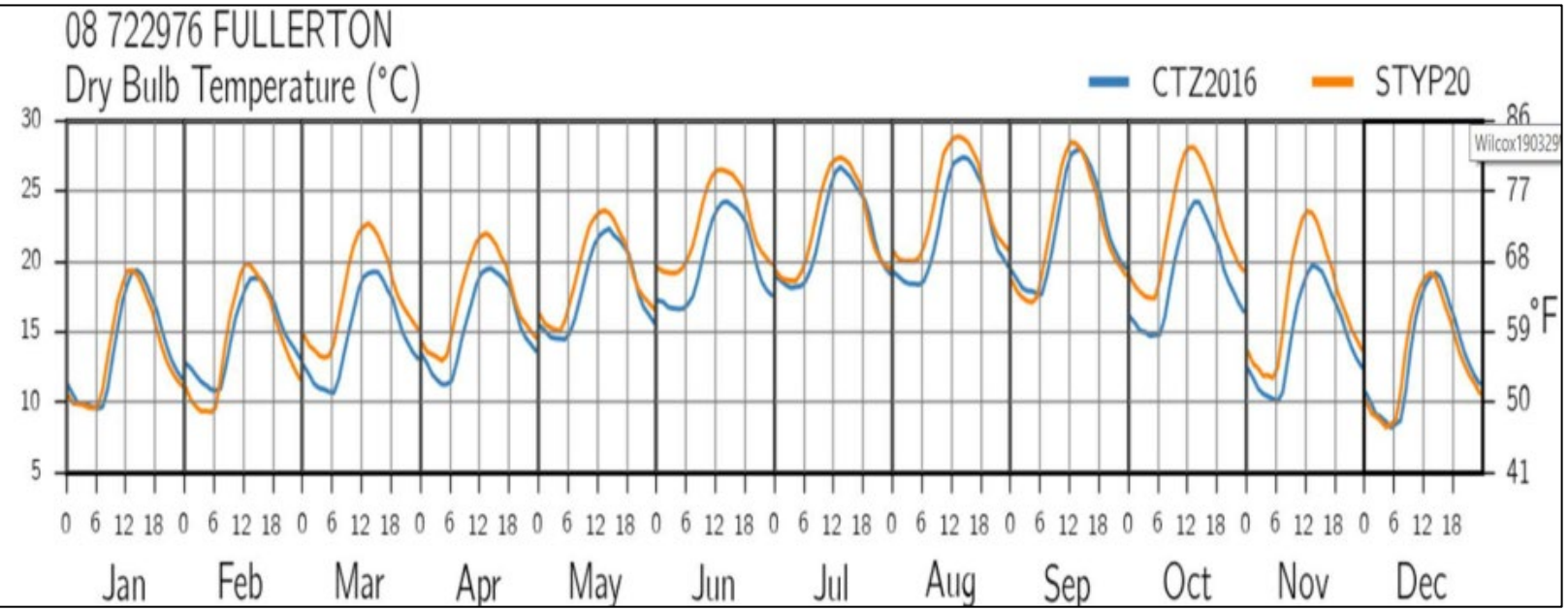
- Updated weather
- Carbon emission valuation
- Non-combustion emissions
- Retail rate adjustments
- New electrification/renewables load profiles



Source: California Energy Commission.
2022 TDV and Source Energy Metric Data Sources and Inputs



Weather Files



Source: California Energy Commission. Presentation - Weather Data for 2022 Standards. 10/17/19.

- Using 2022 weather files for all analysis
- 2019 files last updated for 2013 code cycle, based on data through 2009
- 2022 update better reflects current and changing weather
- Significantly higher cooling loads, particularly in mild climates
- 30% decrease in heating loads statewide

Retrofit Measures

Envelope Efficiency Measures

Measure	Base Condition	Performance Level	Incremental Cost		
			Pre 1978	1978–1991	1992-2005
Wall Insulation	Uninsulated 2x4 wall	R-13	$3,360	n/a	n/a
Raised Floor Insulation	Uninsulated floor	R-19	$3,147	n/a	n/a
Attic Insulation	Uninsulated to R-30	R-49	$2,851	$2,393	$1,852
		R-49 + recessed can retrofit	$3,332	$2,874	$2,333
Air Sealing	15 to 7 ACH50	Reduce infiltration ~30%	$1,474		
Cool Roof	Aged solar reflectance ≥ 0.10	Aged solar reflectance ≥ 0.25	$778		
New Windows	Metal pane or single pane windows	0.30 U-factor / 0.23 SHGC	$9,810		n/a

HVAC/DHW/Lighting Efficiency Measures

Measure	Base Condition	Performance Level	Incremental Cost		
			Pre 1978	1978 – 1991	1992 - 2005
Duct Sealing	>=15% total leakage	10% total leakage	$683		$423
Entirely New Ducts	All	R-8 ducts 5% total leakage	$3,986		
Water Heater Blanket	Uninsulated water heaters	R-6	$40 (6-yr lifetime)		
Hot Water Pipe Insulation	Uninsulated	3/4” (R-3)	$42 (15-yr lifetime)		
Low Flow Fixtures	Standard	CALGreen	$126 (15-yr lifetime)		
LED Lamps (interior & exterior)	CFL or incandescent (savings based on CFL)	11W screw-in bulb	$3.99 First Cost ($1.52 PV after CFL replacements)		
Exterior Photosensor	LED	Screw-in light sensor	$9.95 (5-yr lifetime)		

Efficiency Packages

Package	R-49 Attic Insulation	Air Sealing	Duct Sealing	New Ducts	Wall Insulation	New Windows
R-49 & Air Sealing	X	X				
R-49 & Duct Sealing	X		X			
R-49, Air & Duct Sealing	X	X	X			
R-49, Air Sealing & New Ducts	X	X		X		
Advanced Envelope Package (Pre 1978 home only)	X	X	X		X	X

Package	Blanket	Pipe Insulation	Low Flow Fixtures	LED Lamps	Photosensor
Water Heating Package	X	X	X		
Lighting Package				X	X

PV & Battery Measures

Measure	Performance Level	Incremental Cost All Vintages
Solar PV	1 kW	$3,986 ($3.99/W-DC)
	Sized to 2019 new construction standards.: System size varies by climate (2-4 kW)	$8,108 - $16,213 ($3.99/W-DC)
Battery Storage	5 kWh, Time-of-use controls	$656 / kWh

Fuel Substitution Measures

Heat pump technology at HVAC or DHW replacement

Measure	Base Condition	Heat Pump Efficiency	Incremental Cost: First Cost	Incremental Cost: Lifetime	Incremental Cost: PV ($2020) including replacement
Space Heating Heat Pump - Ducted Split	14 SEER, 11.7 EER, 80 AFUE	14 SEER, 11.7 EER, 8.2 HSPF	$363	HP: 15-yrs Gas/AC: 20-yrs	$1,555
		16 SEER, 13 EER, 9 HSPF	$1,155		$4,024
Heat Pump Water Heater	0.63 UEF, 50-gal gas storage water heater	2.0 UEF, 50-gal	$2,418	15-yrs (HPWH & gas)	$2,594
		NEEA Tier 3, 3.45 UEF, 80 gal	$2,555		$2,775

- Costs include:
  - Labor / Materials
  - 240V electrical at appliance
- Does not include:
  - Service panel upgrade

Results

Single Family Efficiency Measures

Climate Zone		CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
R-49 Attic Insulation	Pre-1978	On-Bill	Both	N/A	Both	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	N/A	Both	N/A	Both / TDV	N/A	N/A	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1992-2005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV	N/A	On-Bill	N/A	TDV	N/A
Duct Sealing	Pre-1978	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	Both	Both	Both	Both	Both / TDV	Both	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1992-2005	Both	TDV	N/A	TDV	N/A	N/A	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both
Cool Roof	Pre-1978	N/A	Both	N/A	Both	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	On-Bill
	1978-1991	N/A	TDV	N/A	Both / TDV	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	N/A
	1992-2005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Both	Both	Both	Both	Both / TDV	Both	Both	Both	N/A
Insulate Walls	Pre-1978	Both	TDV	N/A	N/A	N/A	N/A	N/A	N/A	TDV	TDV	Both	Both / TDV	Both	Both	Both	Both
Windows	Pre-1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV / Both	Both	Both / TDV	Both	Both	Both	N/A
	1978-1991	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	Both	TDV	Both	TDV / Both	Both	N/A

Color Legend
C/E TDV & On-Bill
C/E On-Bill Only
C/E TDV Only
Not C/E

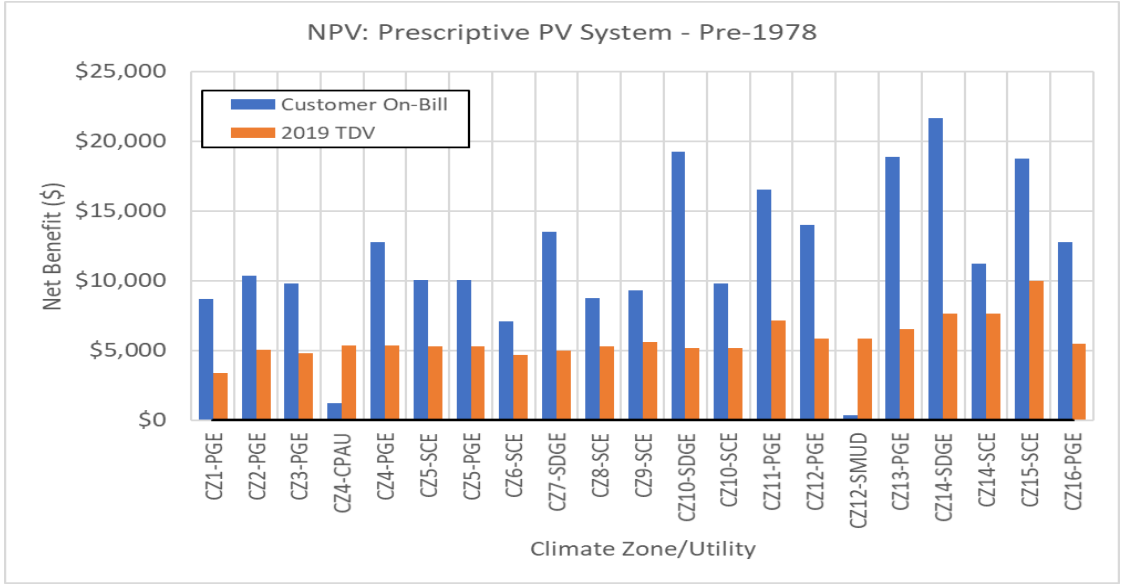
Single Family Efficiency Packages

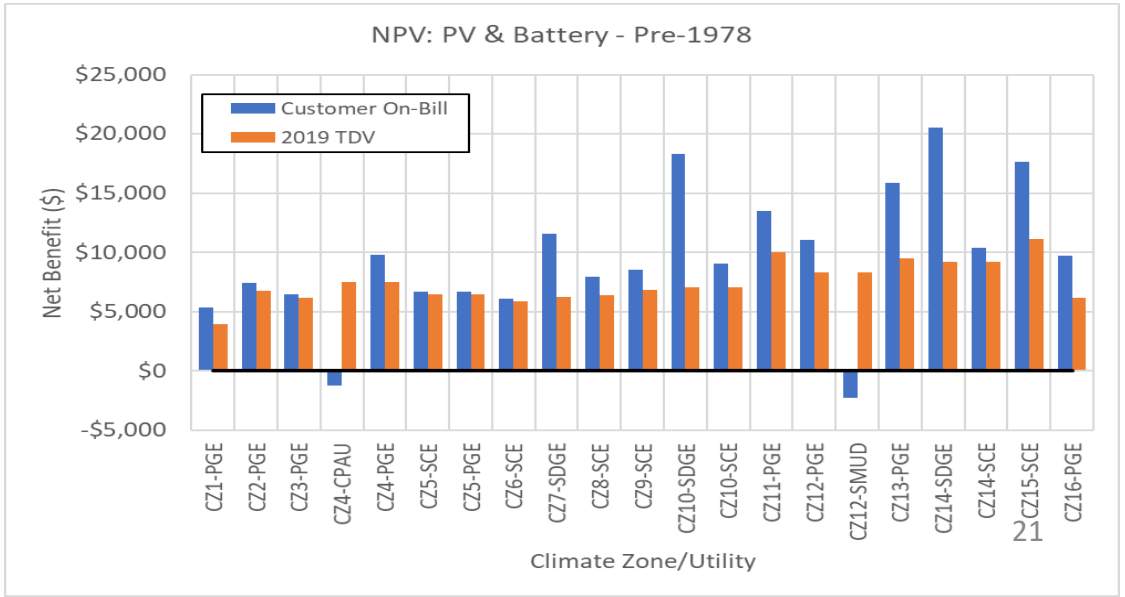
Climate Zone		CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
Utility		PG&E	PG&E	PG&E	PG&E / CPAU	PG&E / SCG	SCE	SDG&E	SCE	SCE	SCE / SDGE	PG&E	PG&E / SMUD	PG&E	SCE / SDGE	SCE	PG&E
R-49 & Duct Sealing Package	Pre-1978	Both	Both	N/A	Both	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	Both	Both	N/A	Both / TDV	N/A	N/A	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1992-2005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A / On-Bill	Both	TDV	Both	TDV / Both	Both	N/A
R-49, Air Sealing & Duct Sealing Package	Pre-1978	Both	Both	N/A	Both	N/A	TDV	On-Bill	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1978-1991	On-Bill	TDV	N/A	TDV	N/A	N/A	N/A	Both	Both	Both	Both	Both	Both	Both	Both	Both
	1992-2005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TDV	N/A	Both	N/A	Both	N/A
Advanced Envelope Package	Pre- 1978	N/A	TDV	N/A	TDV	N/A	N/A	N/A	N/A	TDV	Both	Both	Both / TDV	Both	Both	Both	Both
Water Heating Package	All Vintages	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill
Lighting Package	All Vintages	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill	On-Bill

Color Legend
C/E TDV & On-Bill
C/E On-Bill Only
C/E TDV Only
Not C/E

Single Family PV & Batteries

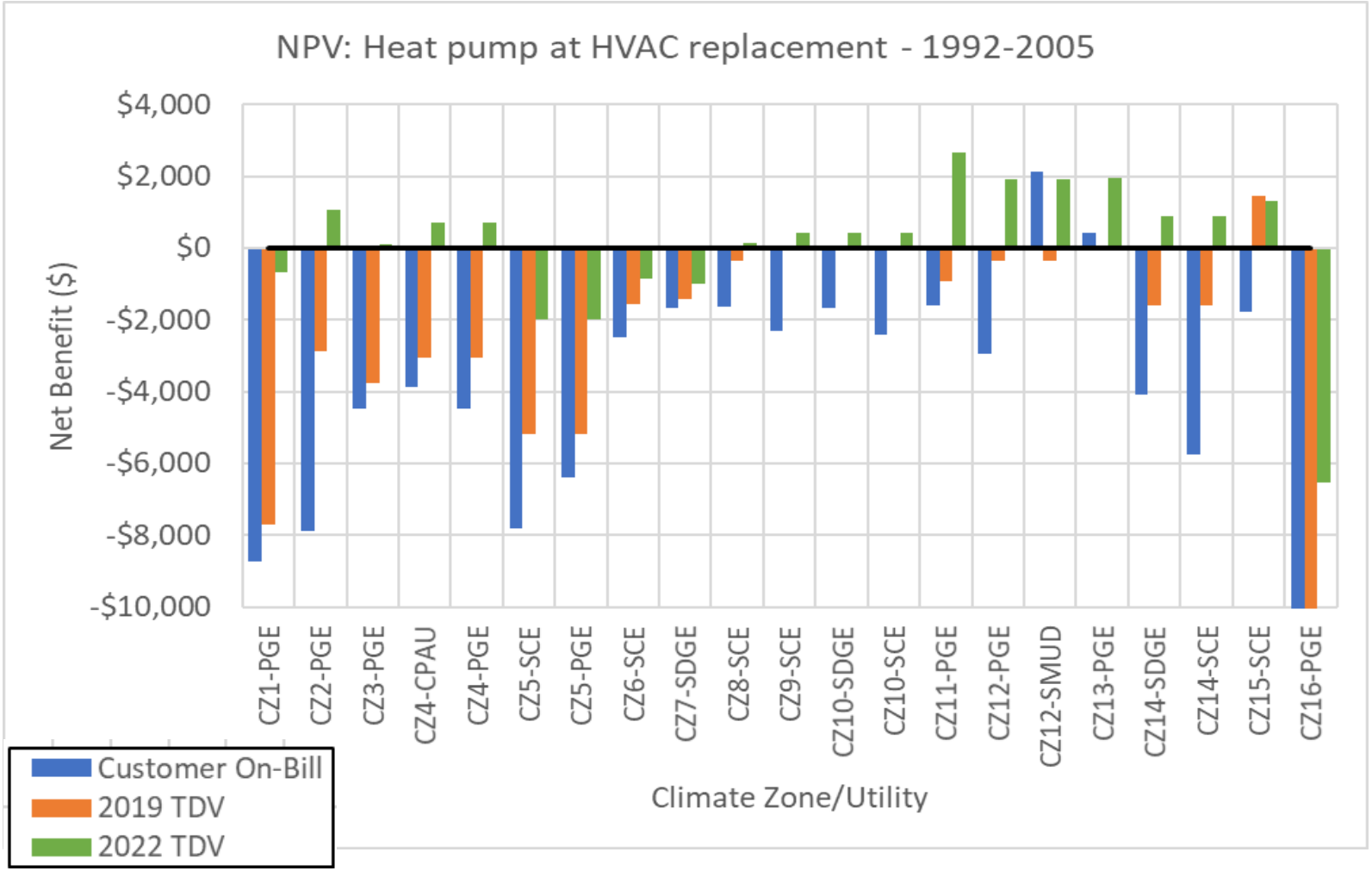
- PV cost-effective in all climates
  - C/E not sensitive to vintage
  - TDV: Average BCR = 1.6
  - Typically more c/e on-bill
  - Less cost-effective on-bill w/ SMUD and CPAU rates
- PV + Batteries cost-effective in all climates
  - Typically more c/e TDV
  - Not c/e with SMUD or CPAU rates





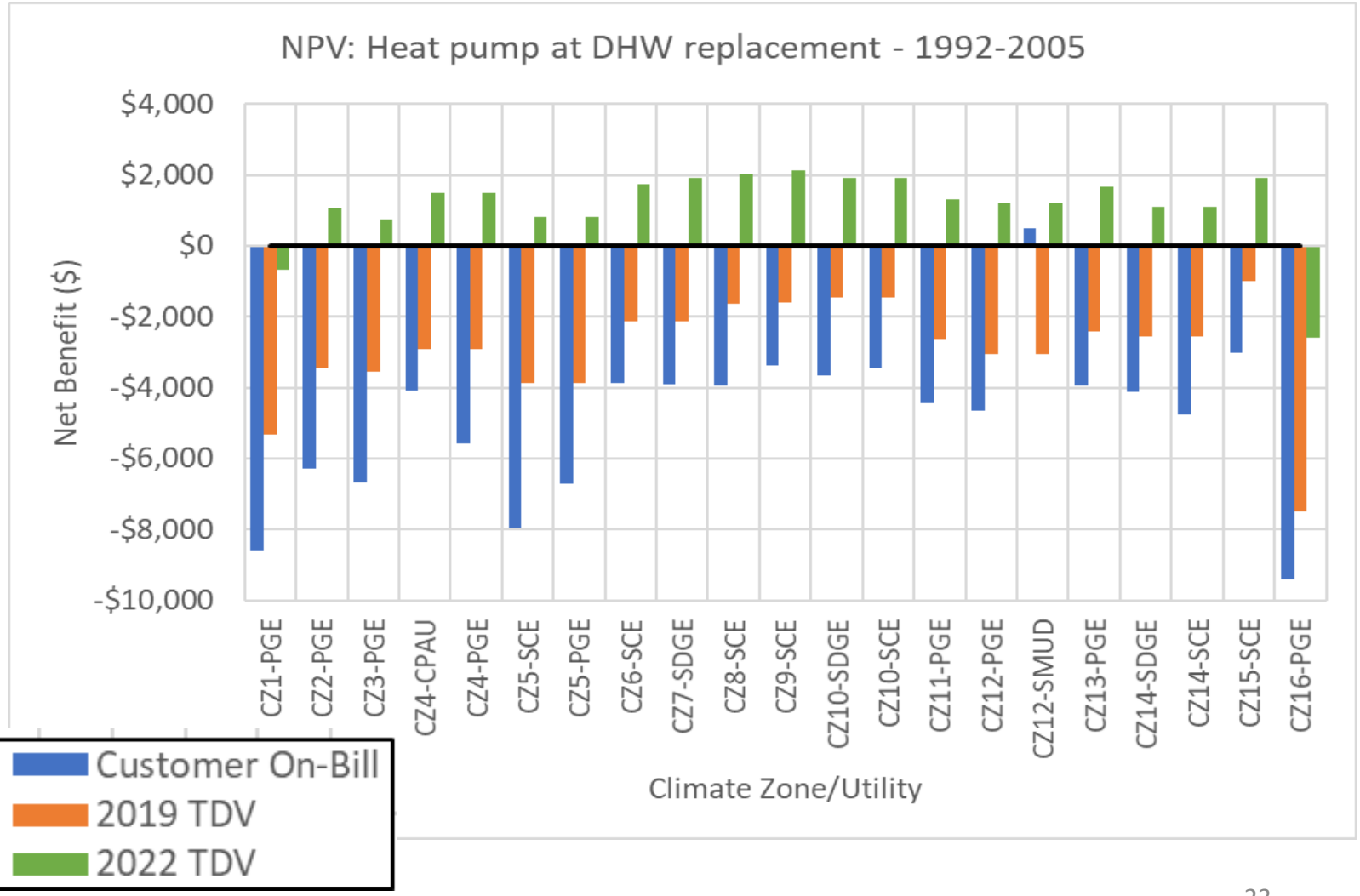
Heat Pump at HVAC Replacement

- Minimum efficiency equip.
- Incremental first cost = $363
- Lifecycle inc. cost = $1,555
  - 15 yr life for heat pump vs 20 yr life for furnace/AC
- Cost-effective on-bill in CZ13 and CZ12 / SMUD
  - Slight increase in utility costs in most cases
- Cost-effective w/ 2022 TDV in some climates (CZ 2-4, & 8-15)



HPWH at DHW Replacement

- Minimum efficiency equip.
  - 2.0 UEF
- Incremental cost = $2,418
- Not c/e on-bill
  - Increase in utility costs
  - Exception SMUD
- Not c/e w/ 2019 TDV
- Cost-effective w/ 2022 TDV except CZ 1, 16
- NEEA Tier 3 HPWH
  - Lower operating cost
  - Not c/e on-bill, but c/e with 2022 TDV in CZ 1



Energy Scoring

Scoring Methodology

Motivation

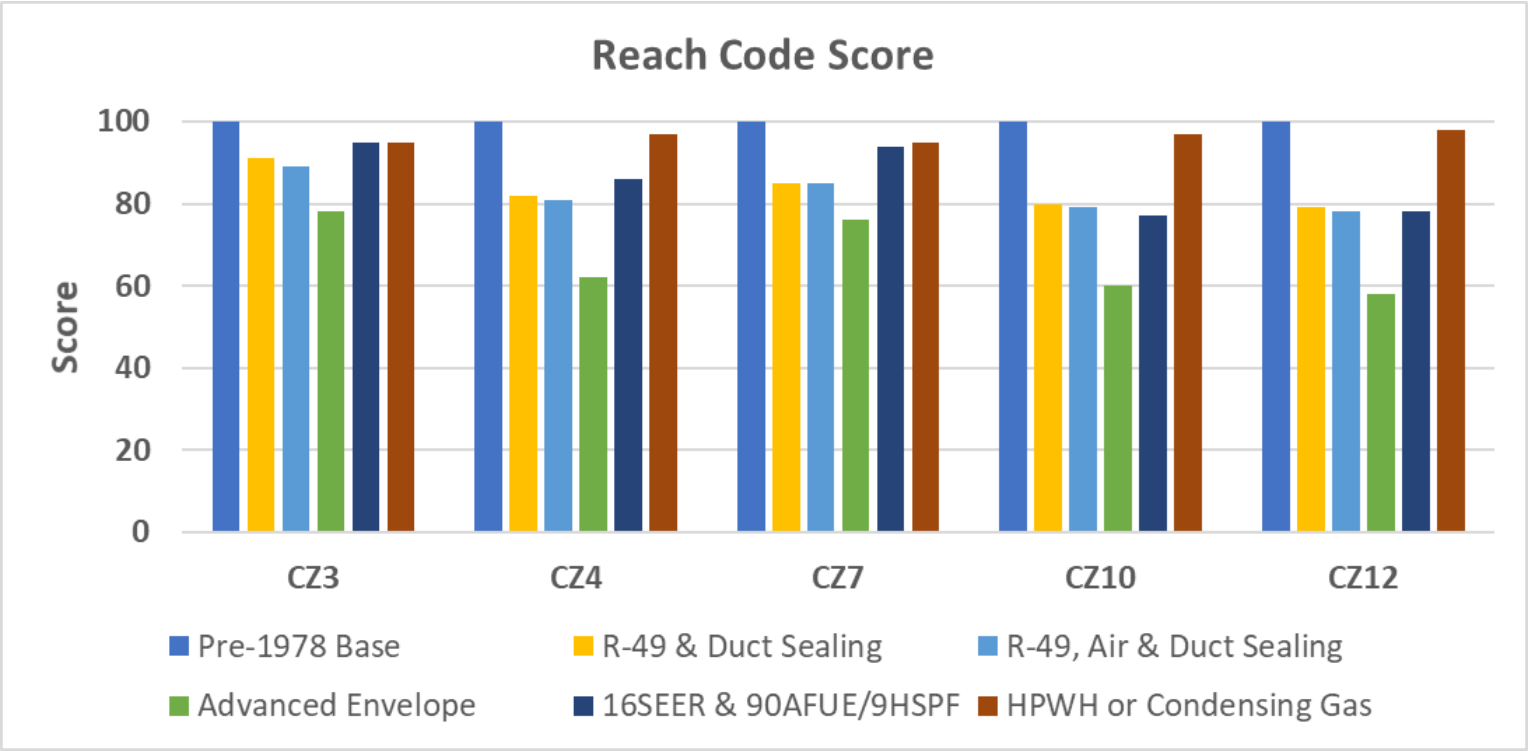
- Building stock is varied
- Provide flexibility to jurisdictions

Application

- Score home to determine which retrofit measures apply
- Select measures from a menu of upgrades
- Based on 2019 TDV

Climate Zone	Pre-1978	1978-1991	1992-2005
1	100	89	65
2	100	87	67
3	100	90	76
4	100	89	70
5	100	90	79
6	100	88	76
7	100	91	88
8	100	90	74
9	100	89	69
10	100	90	68
11	100	89	63
12	100	89	66
13	100	89	68
14	100	88	62
15	100	90	62
16	100	88	67

Reach Code Score



Key Takeaways

- Impact of measures climate dependent
- High efficiency HVAC equivalent to R-49 & air/duct sealing package in hot climates
- High efficiency DHW more valuable in mild climates
- Fuel neutral

Summary

Conclusions

- Many options of measures & packages that are cost effective within most climate zones
- PV & batteries cost effective in all climate zones
- Fuel switching increases utility costs under most rate structures
  - Improves with higher efficiency equipment
  - Electric rate design has significant impact

Local energy ordinances must…

- Meet all state and local ordinance requirements
- Be more stringent than state requirements
- Be cost effective, as determined by local jurisdiction
- Not preempt federal regulations
  - Must be based on energy or equivalent cost
  - May not specifically require high efficiency HVAC and DHW equipment or any other appliances for which there is a federal standard

Potential Ordinance Structures

Trigger Options

- At major remodels, additions, new dwelling unit (ADU), Time of Sale/Listing

Requirements

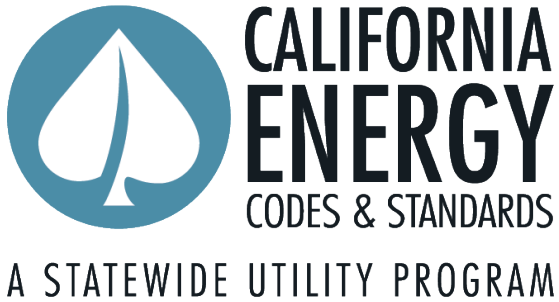
- All cost-effective measures
- Select from menu of measures
- Option to select non-cost-effective measures
- Document previous efficiency improvements
  - HES Score, Title 24/permit documents

Consider feasibility and cost-based exemption to address unusual or challenging site circumstances

Request for Feedback

- Are there other measures / packages you'd like to see covered?
- What cost effectiveness metric is most useful to you?
  - On-Bill
  - 2019 TDV
  - 2022 TDV
- Does the energy scoring provide value?
  - Should it be fuel neutral

Thank You!



We Appreciate your time!

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