CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

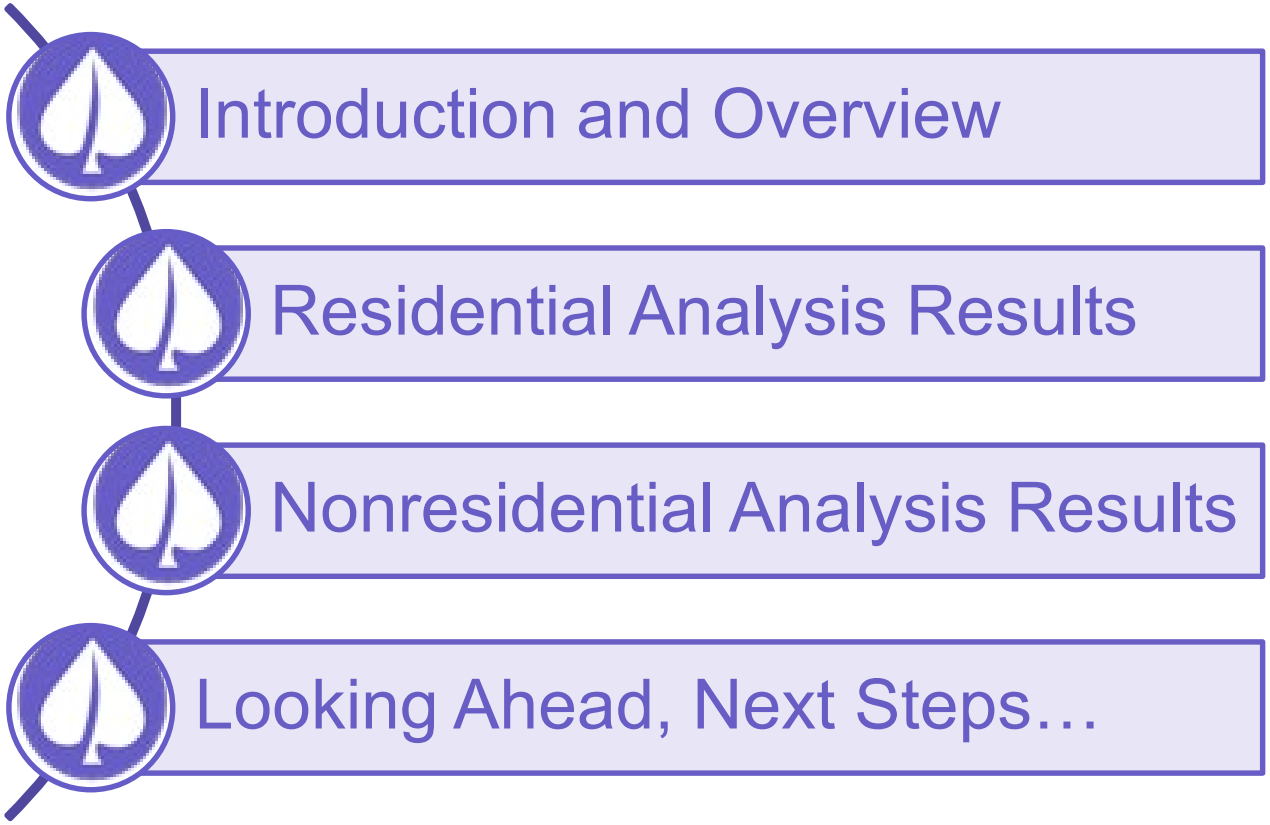
2019 New Construction Cost-effectiveness Studies

Review of Technical Results in Public Review Draft Documents

April 2, 2019

Misti Bruceri

Agenda


Introduction and Overview
Residential Analysis Results
Nonresidential Analysis Results
Looking Ahead, Next Steps…

IOU Codes and Standards Reach Codes Program

Helping cities meet their climate action goals

- Technical Analysis: Cost-effectiveness Report
- Coordination and collaboration
- Model Ordinance Language
- Ad-hoc support

Visit www.localenergycodes.com for more information

2019 Title 24, Part 6 Building Energy Efficiency Standards

Standards design is a performance-based structure

- Sets the minimum requirement and project designers have many different options to meet it.

Analysis Scope: New construction only

- Low-rise residential (single family and low-rise multifamily)
- Nonresidential (office, retail, hotel/motel)

Local energy ordinances (reach codes) must be cost-effective and may not preempt federal appliance regulations

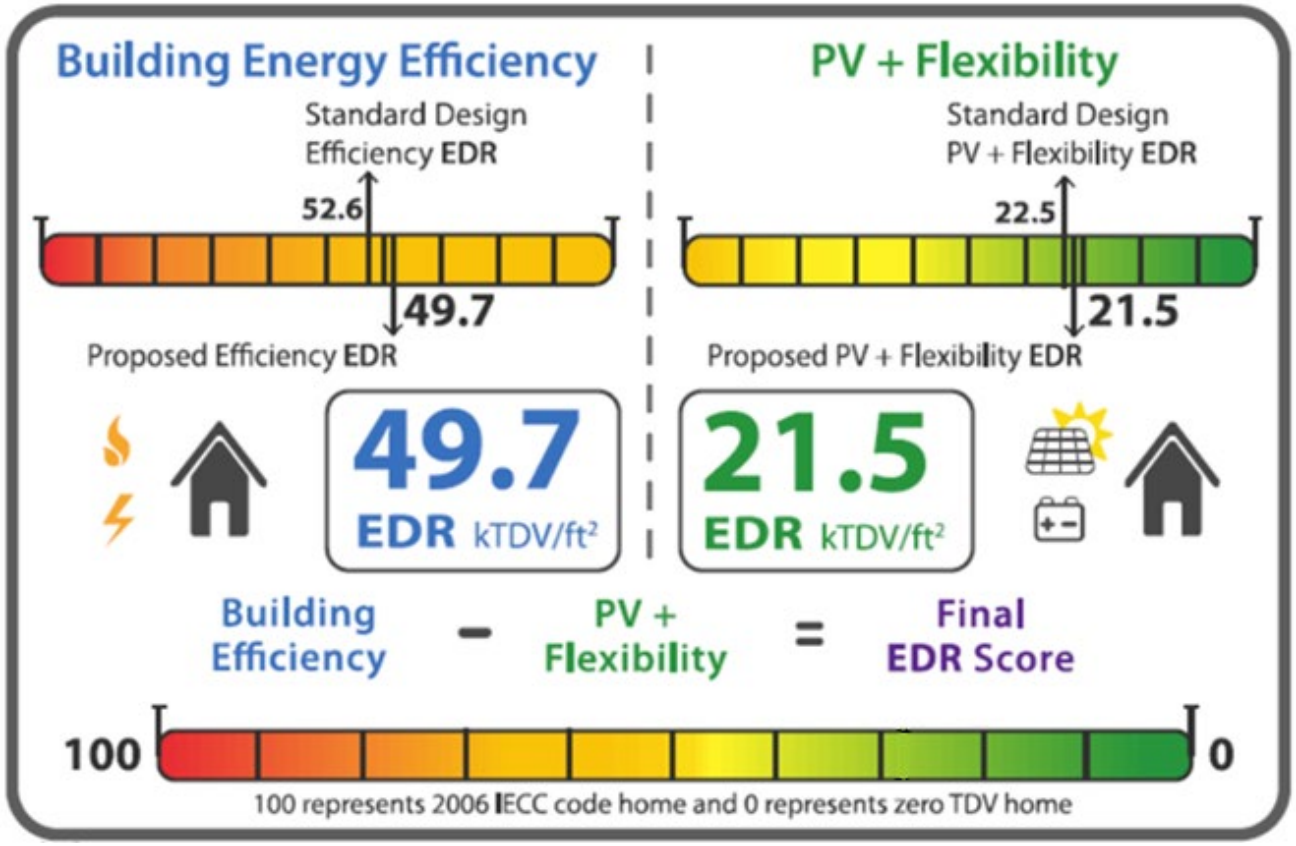
Avoiding Preemption: High Efficiency Appliances and Equipment

- State and local governments may not “preempt” federal appliance standards (includes HVAC and water heaters)
- State and local building codes must meet seven conditions to avoid preemption (US Code 42, Section 6297)
- If the code includes one or more options to meet the objective:
  - for every option which includes a high-efficiency appliance or equipment, at least one option shall include the same equipment which is ≤ 5% more efficient than the minimum, and
  - at least one option which meets but does not exceed the minimum requirement.

2019 Cost-effectiveness Studies: DRAFT Analysis

- Objective: Identify cost-effective, non-preempted measure packages
- The study is NOT:
  - An example of best design practices,
  - A list of measures required to meet the ordinance.
- Analyzed two cost-effectiveness metrics:
  TDV and On-Bill
- Mixed-fuel and all-electric models
- All climate zones
- Consulted with utilities regarding rates and infrastructure costs
- Assumptions and methodologies consistent with Title 24, Part 6

2019 Residential Compliance: Energy Design Rating



- Must meet Efficiency **AND** Final EDR scores
- May increase efficiency to reduce PV requirement
- May NOT reduce efficiency and make up with additional PV
- Study results presented as "Delta EDR" (a reduction in the EDR score)

Image courtesy of Energy Code Ace

Looking Ahead…

- Download studies from the 2019 page of LocalEnergyCodes.com
- Submit comments and questions by April 26, 2019 to info@localenergycodes.com

Thank you!

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2019 Residential New Construction

Cost-effectiveness Study
DRAFT Results

April 2, 2019

Bill Dakin, Alea German – Frontier Energy

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SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company

Residential Assumptions and Methodology

- Single family, low-rise multifamily new construction
  - Mixed-fuel and all-electric cases
  - All-electric vs. mixed fuel comparison
- CBECC-Res 2019.0.11 Alpha (1242)
- Energy Design Rating (EDR)
  - Metric for 2019 Residential code compliance
  - EDR reduction used instead of absolute values
- Cost effectiveness metrics (30 years)
  - Time Dependent Valuation (TDV) per CEC methodology
  - Customer based: On-Bill. TOU utility rates.
    - Reflect rate schedules for 2020
- GHG impacts per CBECC-Res

Residential Building Prototypes

- **Single Family (SF)**: Blended 2,430 ft^2,
  - 45% 1-story / 2100 ft^2, 55% 2-story 2700 ft^2

- **Low-rise Multifamily (MF)**: 3 habitable stories or less
  - 6,960, 2-story, 8-unit, exterior loaded

- Equipment efficiencies consistent with Federal appliance standards
  - Ducted HVAC systems w/ ducts in attic (SF) or in conditioned space (MF)
  - Heat pump technologies for all-electric prototype
  - UEF = 2.0 for HPWH w/ compact WH distribution design

- **PV Standard**: Sized to offset electricity use of loads typically electric in a mixed fuel home, excluding space heating, water heating, clothes drying, and cooking.

Four Measure Packages

- **Efficiency – Non-Preempted**: Efficiency measures that don't trigger federal preemption including envelope, and water heating and duct distribution efficiency.
- **Efficiency – Equipment, Preempted**: HVAC and water heating equipment that are more efficient than federal standards.
- **Efficiency & PV**: (All-Electric case only)
  - Using the Efficiency – Non-Preempted package as a starting point, add PV to offset most of the estimated electricity use.
  - In mixed-fuel cases, 100% of projected electricity use is already offset in efficiency only packages.
- **Efficiency & PV/Battery** : Using the Efficiency – Non-Preempted package as a starting point, add PV and a battery system. TOU battery strategy

PV System Sizing Options in CBECC-Res

- **Standard Design PV**: Same PV capacity as is required for the Standard Design case.
- **Maximum PV for Compliance Credit**: PV system sized to offset 100% of the estimated electricity use of the Proposed Case.
- **Specify PV System Scaling**: PV system sized to offset a specified percentage of the estimated electricity use of the Proposed Case

Package	Mixed Fuel	All-Electric
Efficiency (Envelope & Equipment)	Max PV	Std Design PV
Efficiency & PV	n/a	PV Scaled @ 90%
Efficiency & PV/Battery	PV Scaled @ 100% 5 kWh battery / SF 2.75kWh battery / MF apt TOU battery control	

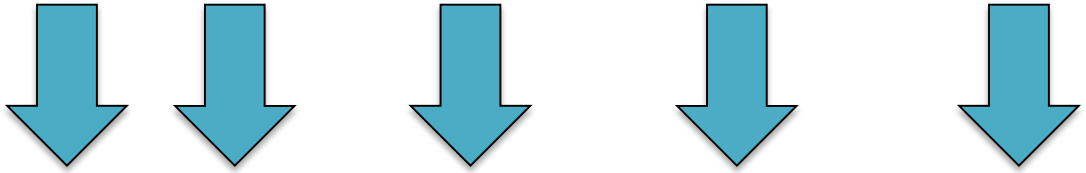
Self-Utilization Credit taken with batteries

All-Electric Compared to Mixed Fuel Home

- **Lifetime Incremental Costs:**
  - SF: ~$5,000 lower cost for all-electric
  - MF: ~$2,000 lower cost / apt for all-electric
  - Lifetime costs (includes fuel escalation, and equipment replacement)
- **Cases:**
  - **2019 Code Compliant**: Code compliant mixed fuel vs code compliant all-electric
  - **Efficiency & PV**: Code compliant mixed fuel vs. all-electric package w/ efficiency and PV to offset 90% estimated electricity use.

Results

Single Family Climate Zone 3 Results



Relative to mixed fuel code compliant home

Relative to all-electric code compliant home

Relative to mixed fuel code compliant home

		EDR Red.	PV Size Change (kW)	CO2-Equivalent Emissions (lbs/sf)		Incremental Cost ($)	Benefit to Cost Ratio (B/C)	
				Total	Red.		On-Bill	TDV
	Efficiency-Non-Preempted	2.5	(0.0)	1.6	0.3	$1,448	1.4	1.3
	t	4.0	(0.0)	1.5	0.4	$1,358	2.1	2.0
	ery	10.0	0.1	1.5	0.4	$4,612	0.6	1.5
c	Efficiency-Non-Preempted	4.5	0.0	0.8	0.2	$1,417	2.4	2.4
	t	4.0	0.0	0.9	0.1	$1,996	1.5	1.6
		18.5	1.8	0.5	0.5	$7,940	2.0	1.7
	ery	29.5	2.4	0.2	0.8	$12,959	1.4	1.6
Mixed Fuel to All-Electric	Code Compliant	0.0	0.0	1.0	0.9	($5,349)	0.8	1.5
	Efficiency & PV	18.5	1.8	0.5	1.4	$3,101	3.4	>1

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Single Family Climate Zone 3 Results

Climate Zone 3 Single Family		EDR Red.	PV Size Change (kW)	CO2-Equivalent Emissions (lbs/sf)		Incremental Cost ($)	Benefit to Cost Ratio (B/C)	
				Total	Red.		On-Bill	TDV
Mixed Fuel	Efficiency-Non-Preempted	2.5	(0.0)	1.6	0.3	$1,448	1.4	1.3
	Efficiency-Equipment	4.0	(0.0)	1.5	0.4	$1,358	2.1	2.0
	Efficiency & PV/Battery	10.0	0.1	1.5	0.4	$4,612	0.6	1.5
All-Electric	Efficiency-Non-Preempted	4.5	0.0	0.8	0.2	$1,417	2.4	2.4
	Efficiency-Equipment	4.0	0.0	0.9	0.1	$1,996	1.5	1.6
	Efficiency & PV	18.5	1.8	0.5	0.5	$7,940	2.0	1.7
	Efficiency & PV/Battery	29.5	2.4	0.2	0.8	$12,959	1.4	1.6
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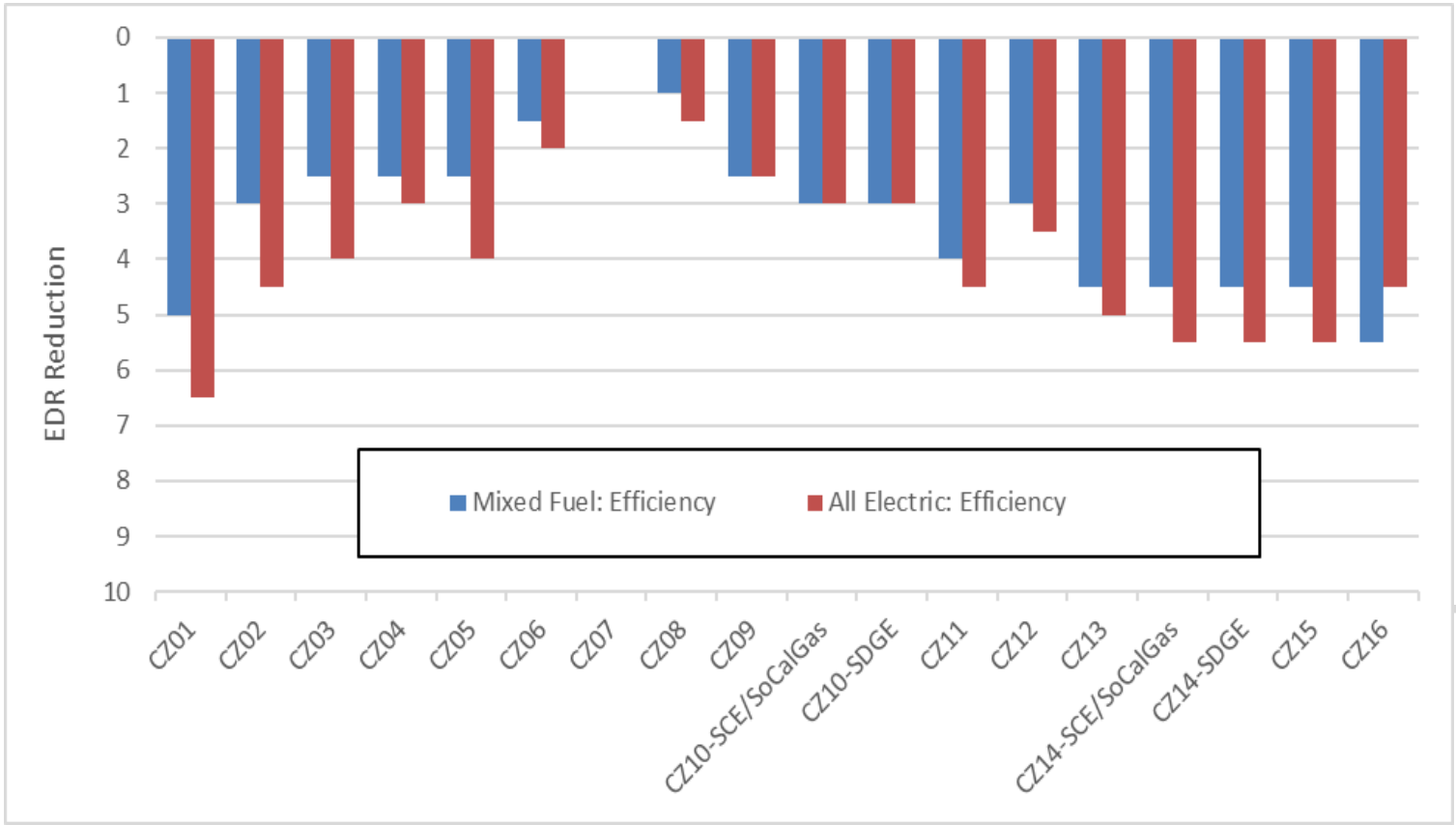
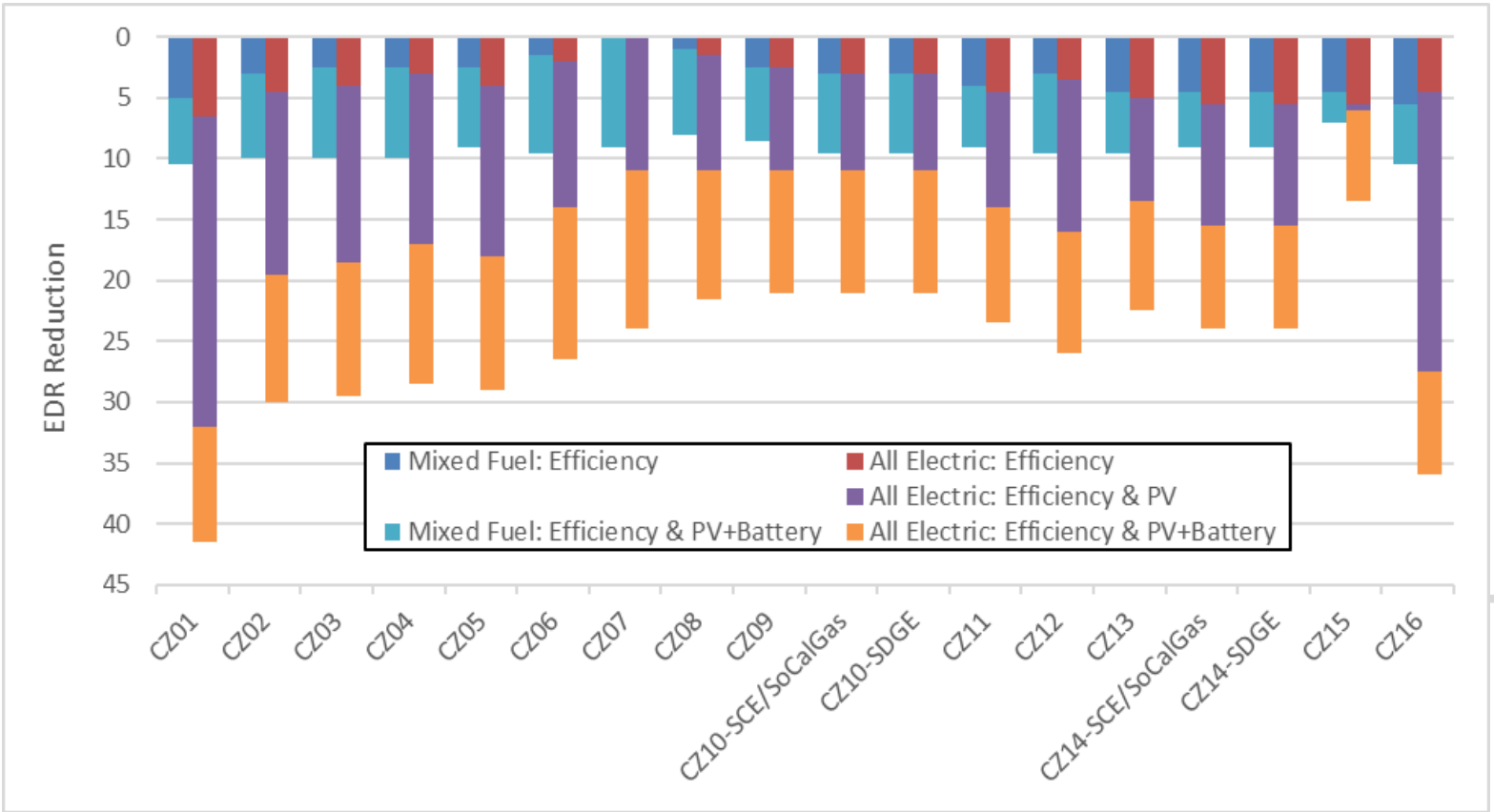
High Level Results

- Cost-effective packages statewide, SF & LRMF buildings
  - Packages are c/e under either On-Bill or TDV, not always both
  - No c/e ***Efficiency*** package:
    - SF CZ7, mixed fuel & all-electric
    - LRMF CZ3 & 5, all-electric

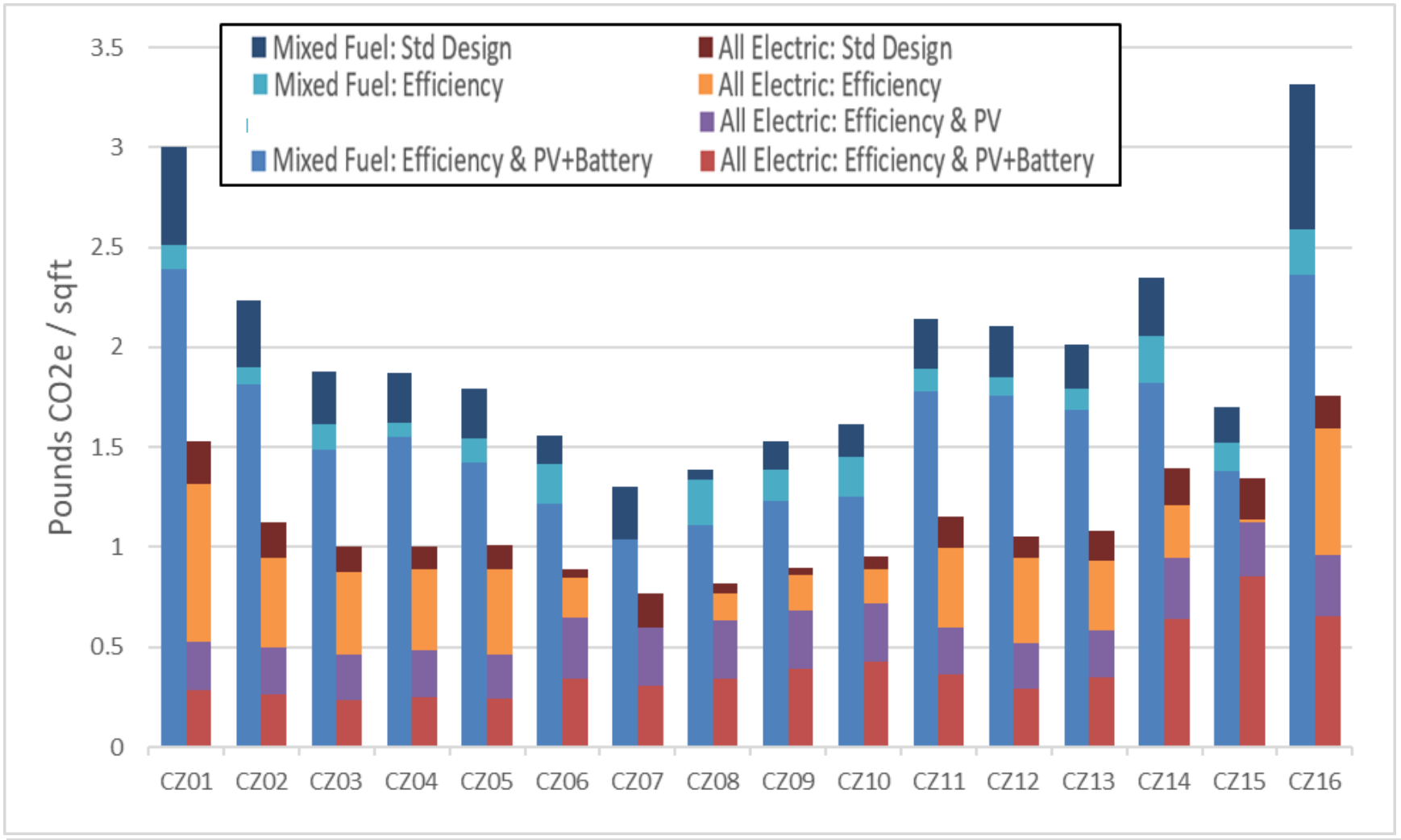


High Level Results – Single Family

- Efficiency + PV package for all-electric case only
  - Additional EDR reduction possible with larger PV system to offset additional electricity loads (avg. +11 EDR Reduction)
- Efficiency+PV+Battery: Avg EDR reduction +7 mixed fuel. +10 electric



Single Family GHG Comparison



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High Level Results – All Electric vs. Mixed Fuel

- All-electric design reduces GHG emissions 40-50% in most cases relative to a comparable mixed fuel design
  - Code compliance all-electric home
    - On-Bill: Cost effective in ~half of CZs
    - TDV: Cost effective in all CZs except 1 & 16
  - Efficiency & PV all-electric home
    - Cost effective across the state based on On-Bill & TDV

Thank you.

Bill Dakin – Frontier Energy

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2019 Nonresidential New Construction

Cost Effectiveness Study
DRAFT Results

April 2, 2019

Farhad Farahmand

TRC Advanced Energy

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Overview

- Methodology
  - Measure packages
  - Prototype descriptions

(pause for questions)

- Results
  - Initial focus on Climate Zone 3
  - Statewide

- More Questions

Nonresidential Methodology

- Measure definition and research
  - Efficiency packages
  - Solar PV + battery
  - All-electric space and water heating, including utility infrastructure
  - Contractors and designers for system configuration and costs

- Ran building simulations
  - EnergySoft collaboration, developers of EnergyPro
  - Engine based on CBECC-Com 2019 0.4 (January)
  - GHG emissions factors built-in

- Cost effectiveness metrics
  - Time Dependent Valuation (TDV) per Energy Commission methodology
  - On-bill with Time of Use Rates

Efficiency Measure Packages

Package		Fuel Type		Energy Efficiency Measures	Solar PV & Battery	High Efficiency Appliances
		Mixed Fuel	All-Electric			
Mixed-Fuel Code Minimum (Baseline for all other packages)		X				
Mixed-Fuel	**+ EE**	X		X		
	+ EE + PV	X		X	X	
	+ HE	X				X
All-Electric	**Fed Code Min**		X			
	+ EE		X	X		
	+ EE + PV		X	X	X	
	+ HE		X			X

EE = Energy Efficiency
PV = Solar PV + Battery
HE = High Efficiency / Preemptive

Nonresidential Building Prototypes

		Medium Office	Medium Retail	Small Hotel
Conditioned Floor Area (ft)		53,628	24,691	42,552
Num. of Stories		3	1	4
Num. of Guest Rooms		0	0	78
HVAC System	**Baseline**	Packaged DX + VAV with HW reheat. Central **gas** boilers.	Single zone packaged DX with **gas** furnaces	NonRes: Packaged DX + VAV with HW reheat. Central **gas** boilers. Res: Single zone DX AC unit with **gas** furnaces
	Proposed All-Electric	Packaged DX + VAV with electric **resistance** reheat.	Single zone packaged **heat pumps**	NonRes: Packaged DX + VAV with electric **resistance** reheat Res: Single zone **heat pumps**
DHW System	**Baseline**	Electric **resistance** with storage	Electric **resistance** with storage	NonRes: **Electric** resistance storage Res: Central **gas** storage with recirculation
	Proposed All-Electric	Electric **resistance** with storage	Electric **resistance** with storage	NonRes: Electric **resistance** storage Res: Individual **heat pumps**

Nonresidential Building Prototypes

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Measure Descriptions and Applications to Each Prototype

Package	Measure	Office	Retail	Hotel
EE	**ENVELOPE**			
	Lower SHGC Fenestration	X	X	
	Fenestration as a Function of Orientation	X		
	DHW/HVAC			
	Drain Water Heat Recovery			X
	VAV Box Minimum Flow	X		X
	Economizers on Small Capacity Systems		X	
	LIGHTING			
	Interior Lighting Reduced LPD	X	X	X
	Institutional Tuning	X	X	X
	Daylight Dimming Plus Off	X		
	Occupant Sensing in Open Plan Offices	X		
PV	Solar PV	135 kW	80 kW	90 kW
	50 kWh Battery	X	X	X
HE	Preemptive efficiencies	X	X	X

Questions on Methodology?

Key Considerations While Viewing Results

- Local reach codes must both
  - Have >0% compliance margin
  - Be cost effective

- Solar PV or batteries do not earn compliance credit

- Standard Design HVAC or DHW remain mixed-fuel when Proposed Design is electric

- Findings are specific to these scenarios, methodology, assumptions.

Construction Costs Breakdown for Medium Office in Climate Zone 3

Prototype	Cost Component	Mixed Fuel Baseline	All Electric System	Incremental cost for All-Electric
Office	HVAC	$1,200,172	$1,113,989	$(91,183)
	Electrical Infrastructure	$0	$27,802	$27,802
	Natural Gas Infrastructure	$18,949	$0	$(18,949)
	Efficiency Measures	$66,649		$0
	Solar PV + Battery	$306,493		$0
	Total	**$1,290,770**	**$1,208,440**	**($82,330)**

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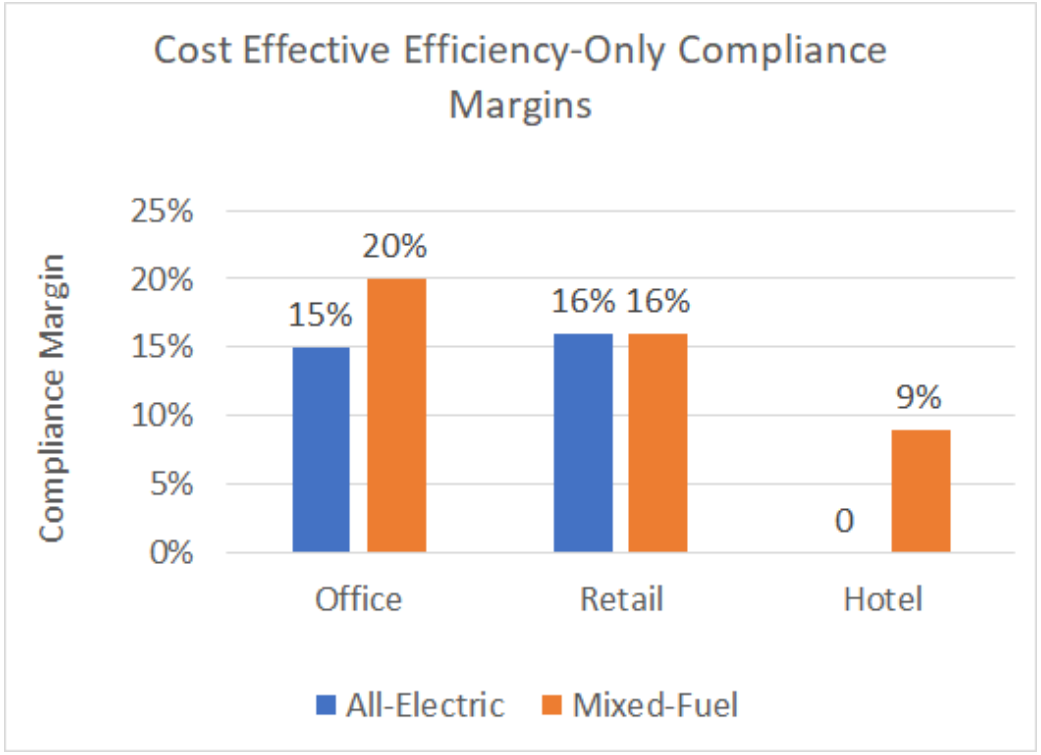
Cost Effective Compliance Margins in Climate Zone 3

- **Office:** All-electric compliance lower than mixed-fuel due to TDV penalty associated with electric resistance VAV

- **Retail:** Equivalent all-electric compliance due to daytime heat pump operation

- **Hotel:** No all-electric positive compliance margin due to heat pump water heater modeling

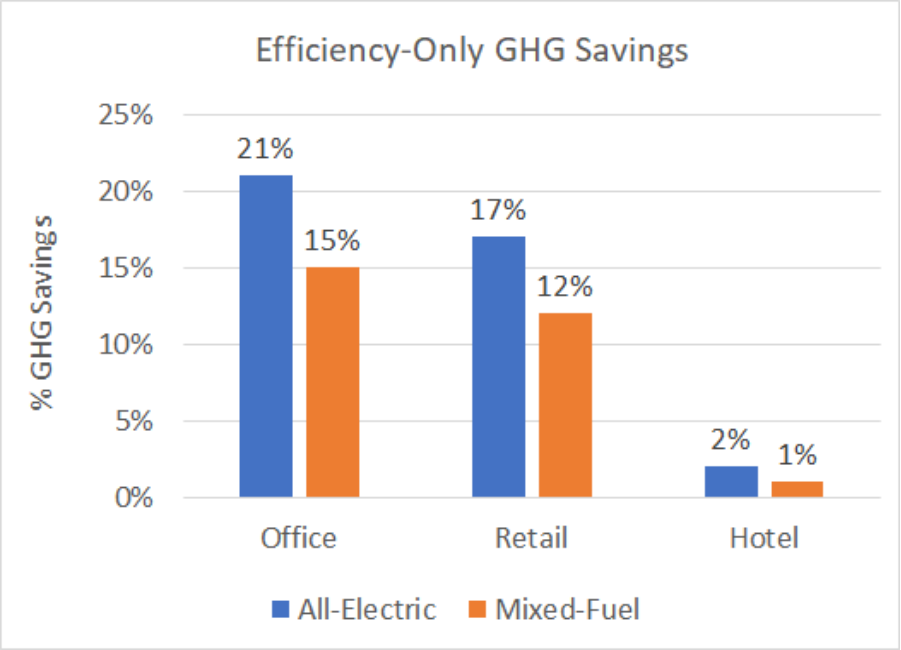


Climate Zone 3 – Solar PV + Batteries, GHGs

- Solar PV + Batteries: Benefit-to-cost ratio lower than efficiency measures, but Net Present Value is higher.

Mixed Fuel Building in CZ 3	Benefit/ Cost Ratio (On-bill)	Net Present Value (On-Bill)
Efficiency Only	2.3	$88,045
Solar PV + Battery	2.2	$444,788

- All-electric buildings save more GHG emissions



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MEDIUM OFFICE – Compliance Margins & Cost Effectiveness

CZ	Utility	Mixed Fuel Compliance Margin			All Electric Compliance Margin			
		EE	EE + PV	HE	Fed Code	EE	EE + PV	HE
CZ1	PG&E	17%	17%	3%	-18%	5%	5%	-18%
CZ2	PG&E	17%	17%	4%	-8%	10%	10%	-5%
CZ3	PG&E	20%	20%	3%	-9%	15%	15%	-8%
CZ4	PG&E	14%	14%	5%	-6%	9%	9%	-3%
CZ5	PG&E	18%	18%	4%	-9%	11%	11%	-7%
CZ6	SCE/SCG	20%	20%	3%	-5%	18%	18%	-3%
CZ7	SDG&E	20%	20%	4%	-2%	20%	20%	1%
CZ8	SCE/SCG	18%	18%	4%	-2%	18%	18%	1%
CZ9	SCE/SCG	16%	16%	4%	-2%	14%	14%	1%
CZ10	SCE/SCG	17%	17%	4%	-4%	13%	13%	-1%
CZ10-2	SDG&E	17%	17%	4%	-4%	13%	13%	-1%
CZ11	PG&E	13%	13%	5%	-5%	9%	9%	-1%
CZ12	PG&E	14%	14%	5%	-5%	9%	9%	-2%
CZ13	PG&E	13%	13%	5%	-5%	9%	9%	-1%
CZ14	SCE/SCG	18%	18%	10%	0%	14%	14%	4%
CZ14-2	SDG&E	13%	13%	5%	-5%	9%	9%	-1%
CZ15	SCE/SCG	12%	12%	5%	-2%	11%	11%	3%
CZ16	PG&E	14%	14%	4%	-27%	-13%	-13%	-25%
Avg GHG Savings		**15%**	**44%**	**3%**	**2%**	**18%**	**47%**	**3%**

LEGEND

>0% Compliance

and both

TDV Cost Effective
and
On-Bill Cost Effective

>0% Compliance

and either

TDV Cost Effective
or
On-Bill Cost Effective

<0% Compliance

or

not cost effective

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MEDIUM RETAIL – Compliance Margins & Cost Effectiveness

CZ	Utility	Mixed Fuel Compliance Margin			All Electric Compliance Margin			
		EE	EE + PV	HE	Fed Code	EE	EE + PV	HE
CZ1	PG&E	18%	18%	2%	-4.1%	15%	15%	-2%
CZ2	PG&E	14%	14%	3%	-1.1%	15%	15%	2%
CZ3	PG&E	16%	16%	2%	-0.4%	16%	16%	2%
CZ4	PG&E	15%	15%	3%	-0.1%	15%	15%	3%
CZ5	PG&E	16%	16%	1%	-1.2%	15%	15%	0%
CZ6	SCE/SCG	10%	10%	3%	0.5%	11%	11%	3%
CZ7	SDG&E	13%	13%	2%	0.3%	13%	13%	3%
CZ8	SCE/SCG	10%	10%	3%	0.4%	10%	10%	4%
CZ9	SCE/SCG	9%	9%	4%	0.4%	10%	10%	4%
CZ10	SCE/SCG	12%	12%	4%	0.1%	12%	12%	4%
CZ10-2	SDG&E	12%	12%	4%	0.1%	12%	12%	4%
CZ11	PG&E	13%	13%	4%	0.5%	12%	12%	5%
CZ12	PG&E	13%	13%	4%	-0.1%	13%	13%	4%
CZ13	PG&E	12%	12%	4%	-0.4%	12%	12%	4%
CZ14	SCE/SCG	12%	12%	5%	0.5%	12%	12%	5%
CZ14-2	SDG&E	12%	12%	5%	0.5%	12%	12%	5%
CZ15	SCE/SCG	11%	11%	5%	0.9%	10%	10%	6%
CZ16	PG&E	13%	13%	3%	-12%	3%	3%	-8%
Avg GHG Savings		**11%**	**68%**	**2%**	**6%**	**14%**	**71%**	**8%**

LEGEND

>0% Compliance

and both

TDV Cost Effective
and
On-Bill Cost Effective

>0% Compliance

and either

TDV Cost Effective
or
On-Bill Cost Effective

<0% Compliance

or

not cost effective

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SMALL HOTEL – Compliance Margins & Cost Effectiveness

CZ	Utility	Mixed Fuel Compliance Margin			All Electric Compliance Margin			
		EE	EE + PV	HE	Fed Code	EE	EE + PV	HE
CZ1	PG&E	7%	7%	2%	-68%	-51%	-51%	-38%
CZ2	PG&E	7%	7%	2%	-52%	-39%	-39%	-25%
CZ3	PG&E	9%	9%	1%	-58%	-41%	-41%	-28%
CZ4	PG&E	7%	7%	1%	-54%	-42%	-42%	-27%
CZ5	PG&E	9%	9%	1%	-60%	-42%	-42%	-29%
CZ6	SCE/SCG	8%	8%	1%	-50%	-37%	-37%	-22%
CZ7	SDG&E	9%	9%	1%	-50%	-36%	-36%	-21%
CZ8	SCE/SCG	7%	7%	2%	-49%	-41%	-41%	-20%
CZ9	SCE/SCG	6%	6%	2%	-44%	-37%	-37%	-17%
CZ10	SCE/SCG	5%	5%	3%	-40%	-34%	-34%	-16%
CZ10-2	SDG&E	5%	5%	3%	-40%	-34%	-34%	-16%
CZ11	PG&E	4%	4%	3%	-42%	-35%	-35%	-19%
CZ12	PG&E	5%	5%	3%	-47%	-38%	-38%	-21%
CZ13	PG&E	4%	4%	3%	-41%	-35%	-35%	-18%
CZ14	SCE/SCG	4%	4%	3%	-41%	-34%	-34%	-18%
CZ14-2	SDG&E	4%	4%	3%	-41%	-34%	-34%	-18%
CZ15	SCE/SCG	3%	3%	5%	-27%	-24%	-24%	-8%
CZ16	PG&E	5%	5%	2%	-78%	-59%	-59%	-56%
Avg GHG Savings		1%	20%	2%	-7%	-6%	13%	9%

LEGEND

>0% Compliance

and both

TDV Cost Effective
and
On-Bill Cost Effective

>0% Compliance

and either

TDV Cost Effective
or
On-Bill Cost Effective

<0% Compliance

or

not cost effective

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Summary and Conclusions

1. Study identified higher compliance margins and solar PV + battery scenarios that are cost effective for both mixed-fuel and all-electric buildings.

2. Medium Office and Retail mixed-fuel scenarios achieve higher compliance margins, but all-electric scenarios achieve higher GHG savings reductions.

3. Small Hotel is challenging to show cost-effectively exceeding the state's budget, and uncertain precision given modeling limitations.

4. High efficiency appliances must be integrated into design, but are not as effective as efficiency packages.

5. ACM updates regarding HVAC and DHW baselines, and treatment of solar PV, would change results.

Reach Code Measure Considerations

- Develop policies accounting for various building types and/or building systems.
  - Groceries, labs, spas… have very different energy demands

- Lower GHG emissions by encouraging
  - All-electric design
  - Higher compliance margins for mixed-fuel buildings
  - Increased solar PV and battery penetration

Thank you!

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