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CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Title 24, Parts 6 and 11
Local Energy Efficiency Ordinances

2019 Cost-effectiveness Study: Low-Rise Residential New Construction Addendum – CPAU Analysis

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1 Introduction

This addendum presents results from analysis conducted in response to a request from City of Palo Alto Utilities (CPAU) to more accurately reflect anticipated local energy costs. This report documents cost-effective combinations of measures within CPAU territory that exceed the minimum state requirements, the 2019 Building Energy Efficiency Standards, which become effective January 1, 2020, for new single family and low-rise (one- to three-story) multifamily residential construction. The analysis includes evaluation of both mixed fuel and all-electric homes, documenting that the performance requirements can be met by either type of building design. Compliance package options and cost-effectiveness analysis are presented for California Climate Zone 4 (Palo Alto). All proposed package options include a combination of efficiency measures and on-site renewable energy.

This analysis builds upon the results of the Draft 2019 Cost-effectiveness Study: Low-Rise Residential (Statewide Reach Codes Team, 2019) conducted for the California Statewide Codes and Standards Program and last modified March 15, 2019, which evaluated compliance packages across all sixteen California climate zones.

2 Methodology and Assumptions

The same methodology used in the statewide analysis was applied to this analysis with two exceptions, as described below.

1. CPAU E-1 (for electricity delivered to the customer from CPAU) and E-EEC-1 (for electricity received by CPAU from the customer) electricity rate schedules were applied in place of PG&E electricity rate schedules.
2. CPAU G-1 rate schedule was applied in place of PG&E gas rates. The monthly total gas rate in $/therm was applied on a monthly basis for the 12-month period ending March 2019. Appendix A summarizes the utility rate schedules used for this study.
3. Revised assumptions for escalation of utility fuel rates over the 30-year analysis period to reflect recent General Rate Case filings in the near term and historical escalation rates for the long term. The escalation rates are provided in Table 1 and were provided by Energy & Environmental Economics (E3) in March 2019.

Table 1: Utility Escalation Rates

Year	Natural Gas Real Escalation (%/yr)	Electricity Real Escalation (%/yr)	Year	Natural Gas Real Escalation (%/yr)	Electricity Real Escalation (%/yr)
2021	2.0%	2.0%	2036	1.0%	1.0%
2022	2.0%	2.0%	2037	1.0%	1.0%
2023	4.0%	2.0%	2038	1.0%	1.0%
2024	4.0%	2.0%	2039	1.0%	1.0%
2025	4.0%	2.0%	2040	1.0%	1.0%
2026	1.0%	1.0%	2041	1.0%	1.0%
2027	1.0%	1.0%	2042	1.0%	1.0%
2028	1.0%	1.0%	2043	1.0%	1.0%
2029	1.0%	1.0%	2044	1.0%	1.0%
2030	1.0%	1.0%	2045	1.0%	1.0%
2031	1.0%	1.0%	2046	1.0%	1.0%
2032	1.0%	1.0%	2047	1.0%	1.0%
2033	1.0%	1.0%	2048	1.0%	1.0%
2034	1.0%	1.0%	2049	1.0%	1.0%
2035	1.0%	1.0%	2050	1.0%	1.0%

Refer to the Draft 2019 Cost-effectiveness Study: Low-Rise Residential (Statewide Reach Codes Team, 2019) for further details. Key components of the methodology are repeated below.

Cost-effectiveness

This analysis uses two different metrics to assess cost-effectiveness. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with energy efficiency measures as compared to the prescriptive Title 24 requirements. The main difference between the methodologies is the manner in which they value energy and thus the cost savings of reduced or avoided energy use.

- **Utility Bill Impacts (On-Bill)**: Customer-based Lifecycle Cost (LCC) approach that values energy based upon estimated site energy usage and customer on-bill savings using electricity and natural gas utility rate schedules over a 30-year duration accounting for discount rate and energy inflation.
- **Time Dependent Valuation (TDV)**: Energy Commission LCC methodology, which is intended to capture the "societal value or cost" of energy use including long-term projected costs such as the cost of providing energy during peak periods of demand and other societal costs such as projected costs for carbon emissions, as well as grid transmission and distribution impacts. This metric values energy use differently depending on the fuel source (gas, electricity, and propane), time of day, and season. Electricity used (or saved) during peak periods has a much higher value than electricity used (or saved) during off-peak periods (Horii et al, 2014). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in Title 24, Part 6.

Results for both methodologies are presented as a benefit-to-cost (B/C) ratio, which is a net present value (NPV) metric which represents the cost-effectiveness of a measure over a 30-year lifetime. A value of one indicates the NPV of the savings over the life of the measure is equivalent to the NPV of the lifetime incremental cost of that measure. A value greater than one represents a positive return on investment.

Package Development

Three to four packages were evaluated for each prototype, as described below.

1) **Efficiency – Non-Preempted**: This package uses only efficiency measures that don't trigger federal preemption issues including envelope, and water heating and duct distribution efficiency measures.
2) **Efficiency – Equipment, Preempted**: This package shows an alternative design that applies HVAC and water heating equipment that are more efficient than federal standards.
3) **Efficiency & PV**: Using the Efficiency – Non-Preempted Package as a starting point, additional PV capacity is added to offset most of the estimated electricity use. This only applies to the all-electric case, since for the mixed fuel cases, 100% of the projected electricity use is already being offset in the efficiency only packages as required by 2019 Title 24, Part 6.
4) **Efficiency & PV/Battery**: Using the Efficiency & PV Package as a starting point, additional PV capacity is added as well as a battery system.

Electrification Scenarios

In comparing mixed fuel and all-electric cases, two scenarios were evaluated for each prototype:

1. **2019 Code Compliant**: Compares a 2019 code compliant all-electric home with a 2019 code compliant mixed fuel home.
2. **Efficiency & PV Package**: Compares an all-electric home with efficiency and PV sized to 90% of the annual electricity use to a 2019 code compliant mixed fuel home. The first cost savings in the code compliant all-electric house is invested in above code efficiency and PV reflective of the Efficiency & PV packages described above.

3 Results & Discussion

The analysis found cost-effective, non-preempted packages for both single family and low-rise multifamily buildings, under both mixed fuel and all-electric cases. The results of this analysis can be used by local jurisdictions to support the adoption of reach codes.

For the efficiency-only packages, measures were refined to ensure that the non-preempted package was cost-effective based on one of the two metrics applied in this study, TDV or On-Bill. The preempted equipment package is what the Reach Code Team considers to be a package of upgrades most reflective of what builders commonly apply to exceed code requirements. The packages presented are representative examples of designs and measures that can be used to meet the requirements. In practice, a builder can use any combination of non-preempted or preempted compliant measures to meet the requirements.

Table 2 summarizes the target EDR reductions by case. Table 3 and Table 4 present details of the analysis results for single family and low-rise multifamily homes, respectively. Results are presented as EDR reduction instead of compliance margin, as EDR is the metric used to determine code compliance for residential buildings in the 2019 cycle. Target EDR reduction is based on taking the calculated EDR reduction for the case and rounding down to the next half of a whole number. Target EDR reduction for the Efficiency Package are defined based on the lower of the EDR reduction of the non-preempted package and the equipment, preempted package. For example, for single family homes the all-electric non-preempted package has an EDR reduction of 3.0 and the preempted package an EDR reduction of 3.5, the Target EDR reduction is set at 3.0 in this case.

Table 2: Summary of Target EDR Reductions

Climate Zone	Mixed Fuel		All-Electric		
	Efficiency	**Efficiency & PV/Battery**	**Efficiency**	**Efficiency & PV**	**Efficiency & PV/Battery**
Single Family	2.5	10	3.0	17.0	28.5
Multifamily	1.0	11.0	1.5	15.0	29.5

All packages are cost effective based on the TDV approach. However, most packages are not cost effective using the On-Bill approach, with the exception of the all-electric single family efficiency packages and the mixed fuel single family Efficiency – Equipment Package. All electrification scenarios are cost effective under both methodologies. An all-electric design reduces GHG emissions 46% for single family and 40% for multifamily relative to a comparable mixed fuel design.

The CPAU E-1 rate is a tiered with no time-of-use impact and usage rates lower than PG&E rates[1]. Electricity generation delivered to CPAU from the customer is compensated under the E-EEC-1 rate at $0.07485/kWh, which differs from PG&E's net energy metering tariff which values delivered electricity at the retail rate. The CPAU G-1 rate has usage rates lower than PG&E rates, but there is a ~$11 monthly service charge. These differences result in similar annual gas costs using both CPAU's and PG&E's tariffs.

Before taking into account the utility fuel escalation rates applied in this analysis, on-bill cost effectiveness using CPAU's rates is lower than with PG&E rates in Climate Zone 4 for both the mixed fuel and all-electric packages. On-bill cost-effectiveness is more favorable using CPAU rates for the electrification scenarios. Changes in escalation rates, which are on average higher for electricity and lower for natural gas than what was applied in the draft statewide study, improves cost effectiveness for the all-electric packages and decreases it for the mixed fuel packages and the electrification scenarios.

[1] PG&E's E-TOU Option B which was applied in the statewide study for Climate Zone 12 (Statewide Reach Codes Team, 2019).

Table 3: Single Family CPAU Climate Zone 4 Results Summary

Climate Zone 4 CPAU Single Family		EDR Red.	PV Size Change (kW)[4]	CO_2-Equivalent Emissions (lb/sqft)		Inc. Cost ($)	First Year Utility Savings		Benefit to Cost Ratio (B/C)	
				Total	Red.		Elec	Gas	On-Bill	TDV
Mixed Fuel[1]	Efficiency-Non-Preempted	2.5	(0.0)	1.7	0.2	$1,451	$2	$46	0.8	1.2
	Efficiency-Equipment	2.5	(0.0)	1.6	0.3	$716	$1	$56	1.9	2.7
	Efficiency & PV/Battery	10.0	0.1	1.5	0.3	$4,608	$57	$46	0.5	1.6
All-Electric[2]	Efficiency-Non-Preempted	3.0	0.0	0.9	0.1	$1,417	$110	$0	1.7	1.9
	Efficiency-Equipment	3.5	0.0	0.9	0.1	$1,996	$111	$0	1.2	1.4
	Efficiency & PV	17.0	1.8	0.5	0.5	$8,251	$371	$0	1.0	1.6
	Efficiency & PV/Battery	28.5	2.4	0.3	0.8	$13,289	$544	$0	0.9	1.7
Mixed Fuel to All-Electric[3]	Code Compliant	0.0	0.0	1.0	0.9	($5,349)	($697)	$487	1.2	1.5
	Efficiency & PV	17.0	1.8	0.5	1.3	$3,431	($326)	$487	2.8	>1

Table 4: Multifamily CPAU Climate Zone 4 Results Summary – Results Per Unit

Climate Zone 4 CPAU Multifamily		EDR Red.	PV Size Change Per Unit (kW)[4]	CO_2-Equivalent Emissions (lb/sqft)		Inc. Cost Per Unit ($)	First Year Utility Savings Per Unit		Benefit to Cost Ratio (B/C)	
				Total	Red.		Elec	Gas	On-Bill	TDV
Mixed Fuel[1]	Efficiency-Non-Preempted	1.0	(0.1)	2.1	0.1	$306	$1	$7	0.6	1.2
	Efficiency-Equipment	2.0	(0.1)	2.0	0.2	$471	$1	$14	0.7	1.4
	Efficiency & PV/Battery	11.0	0.4	1.9	0.3	$2,012	$27	$7	0.4	1.8
All-Electric[2]	Efficiency-Non-Preempted	1.5	0.0	1.2	0.0	$336	$14	$0	0.9	1.6
	Efficiency-Equipment	2.5	0.0	1.2	0.1	$753	$25	$0	0.7	1.2
	Efficiency & PV	15.0	6.6	0.7	0.6	$2,940	$124	$0	0.9	1.8
	Efficiency & PV/Battery	29.5	9.2	0.4	0.9	$5,530	$198	$0	0.8	1.9
Mixed Fuel to All-Electric[3]	Code Compliant	0.0	0.0	1.3	0.9	($2,337)	($218)	$262	>1	1.6
	Efficiency & PV	15.0	6.6	0.7	1.4	$786	($94)	$262	7.8	>1

[1]All reductions and incremental costs relative to the mixed fuel code compliant home.
[2]All reductions and incremental costs relative to the all-electric code compliant home.
[3]All reductions and incremental costs relative to the mixed fuel code compliant home except the EDR reductions are relative to the Standard Design for each case which is the all-electric code compliant home.
[4]Positive values indicate an increase in PV capacity relative to the Standard Design.

4 References

Statewide Reach Codes Team. 2019. Draft 2019 Cost-effectiveness Study: Low-Rise Residential. Prepared for Pacific Gas and Electric Company. Prepared by Frontier Energy. March 2019. http://localenergycodes.com/download/602/file_path/fieldList/2019%20ResNewCon%20Cost-Eff-PublicDraft

Appendix A – Utility Tariff Details

Following are the CPAU electricity tariffs applied in this study.

RESIDENTIAL ELECTRIC SERVICE

UTILITY RATE SCHEDULE E-1

A. APPLICABILITY:

This schedule applies to separately metered single-family residential dwellings receiving Electric Service from the City of Palo Alto Utilities.

B. TERRITORY:

This rate schedule applies everywhere the City of Palo Alto provides Electric Service.

C. UNBUNDLED RATES:

Per kilowatt-hour (kWh)	Commodity	Distribution	Public Benefits	Total
Tier 1 usage	$0.07214	$0.05240	$0.00417	$0.12871
Tier 2 usage Any usage over Tier 1	0.11347	0.07515	0.00417	0.19279
Minimum Bill ($/day)				0.3040

D. SPECIAL NOTES:

1. Calculation of Cost Components

The actual bill amount is calculated based on the applicable rates in Section C above and adjusted for any applicable discounts, surcharges and/or taxes. On a Customer's bill statement, the bill amount may be broken down into appropriate components as calculated under Section C.

2. Calculation of Usage Tiers

Tier 1 Electricity usage shall be calculated and billed based upon a level of 11 kWh per day, prorated by Meter reading days of Service. As an example, for a 30-day bill, the Tier 1 level would be 330 kWh. For further discussion of bill calculation and proration, refer to Rule and Regulation 11.

{End}

CITY OF PALO ALTO UTILITIES
Issued by the City Council

Supersedes Sheet No E-1-1 dated 7-1-2017

CITY OF PALO ALTO UTILITIES

Effective 7-1-2018
Sheet No **E-1-1**

Attachment B

EXPORT ELECTRICITY COMPENSATION

UTILITY RATE SCHEDULE E-EEC-1

A. APPLICABILITY:
This schedule applies in conjunction with the otherwise applicable rate schedules for each customer class. This schedule may not apply in conjunction with any time-of-use rate schedule. This schedule applies to Customer-Generators as defined in Rule and Regulation 2 who are either not eligible for Net Energy Metering or who are eligible for Net Energy metering but elect to take service under this rate schedule.

B. TERRITORY:
Applies to locations within the service area of the City of Palo Alto.

C. RATE:
The following buyback rate shall apply to all energy exported to the grid.

	Per kWh
Export electricity compensation rate	$0.07485

D. SPECIAL CONDITIONS

1. Metering equipment: Electricity delivered by CPAU to the Customer-Generator or received by CPAU from the Customer-Generator shall be measured using a meter capable of registering the flow of electricity in two directions (aka "bidirectional meter"). The electrical power measurements will be used for billing the Customer-Generator. CPAU shall furnish, install and own the appropriate meter.

2. Billing:
   a. CPAU shall measure during the billing period, in kilowatt-hours, the energy delivered and received after the Customer-Generator serves its own instantaneous load.
   b. CPAU shall bill the Customer-Generator consumption charges for the energy delivered by CPAU to the Customer-Generator based on the Customer-Generator's applicable rate schedule.
   c. In the event the energy generated exceeds the energy consumed and therefore is received by CPAU, the Customer will receive a credit for all energy received by CPAU at the buyback rate designated in section C above.

3. Generation facilities shall adhere to Rule and Regulation 27: Generating Facility Interconnections.

{End}

CITY OF PALO ALTO UTILITIES
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CITY OF PALO ALTO UTILITIES

Effective 7-1-2016
Sheet No. **E-EEC-1**

Following are the CPAU natural gas tariffs applied in this study. The CPAU monthly gas rate in $/therm was applied on a monthly basis for the 12-month period ending January 2018.

RESIDENTIAL GAS SERVICE

UTILITY RATE SCHEDULE G-1

A. APPLICABILITY:

This schedule applies to the following Customers receiving Gas Service from City of Palo Alto Utilities:

1. Separately-metered single-family residential Customers.
2. Separately-metered multi-family residential Customers in multi-family residential facilities.

B. TERRITORY:

This schedule applies anywhere the City of Palo Alto provides Gas Service.

C. UNBUNDLED RATES:

	Per Service
Monthly Service Charge:	$10.94

Tier 1 Rates:	Per Therm
Supply Charges:	
1. Commodity (Monthly Market Based)	$0.10-$2.00
2. Cap and Trade Compliance Charge	$0.00-$0.25
3. Transportation Charge	$0.00-$0.15
4. Carbon Offset Charge	$0.00-$0.10
Distribution Charge:	$0.4239

Tier 2 Rates: (All usage over 100% of Tier 1)	
Supply Charges:	
1. Commodity (Monthly Market Based)	$0.10-2.00
2. Cap and Trade Compliance Charge	$0.00-$0.25
3. Transportation Charge	$0.00-$0.15
4. Carbon Offset Charge	$0.00-$0.10
Distribution Charge:	$0.9948

D. SPECIAL NOTES:

1. Calculation of Cost Components

CITY OF PALO ALTO UTILITIES
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CITY OF PALO ALTO UTILITIES

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Sheet No G-1-1

CITY OF PALO ALTO UTILITIES

Monthly Gas Commodity & Volumetric Rates

Your gas bill includes two charge types: 1) a service charge, and 2) a volumetric charge. The service charge for your gas service can be found on the appropriate rate schedule, which you can find in the following locations: Residential Rate Schedules, and Business Rate Schedules.

The volumetric charge depends on your consumption, and the rate varies monthly based on the current price of gas. The following tables show the volumetric rates ($/therm) for each gas rate schedule. The volumetric rates include a) a Commodity charge, which represents the cost of the gas, b) a Distribution rate, c) a Cap and Trade Compliance charge, a d) Carbon Offset Charge and e) a Transportation Charge. The Cap and Trade charge covers the cost of acquiring compliance instruments in California's Cap and Trade program, and will change in response to market conditions, sales volumes, and the quantity of allowances required. The Transportation Charge is based on the current PG&E G-WSL rate for Palo Alto, accounting for delivery losses to the Customer's Meter. Prior to November 1, 2016, it was included within the Distribution rate.

On September 15, 2014, Council adopted Resolution #9451 authorizing the City's participation in a natural gas purchase from Municipal Gas Acquisition and Supply Corporation (MuniGas) for the City's entire retail gas load for a period of at least 10 years. The MuniGas transaction includes a mechanism for municipal utilities to utilize their tax exempt status to achieve a discount on the market price of gas. As of November 1, 2018, gas will begin flowing under this program, reducing the City's gas commodity cost by about $1 Million per year and saving gas customers approximately $0.03 per therm on the commodity portion of their bills.

These charges are shown on the left-hand side of the table below for information purposes, while the total volumetric rate (Commodity+ Distribution+ Cap and Trade Compliance+ Carbon Offset+ Transportation) is shown on the right-hand side of the table. To calculate your variable gas costs, apply the total rate to your consumption for each month. If you are a resident, note that your gas rate varies based on how much you consume (Tier 1 and Tier 2). For information on consumption tiers please refer to the G-1 Residential Gas Service Rate Schedule.

If you have questions on your bill, please call the City of Palo Alto Utilities Customer Service Center at 650-329-2161.

Effective Date	Commodity Rate	Cap and Trade Compliance Charge	Transportation Charge	Carbon Offset Charge	Total Volumetric Rate			
					G-1 (Residential)		G-2 (Master Metered Multi-Family and Small Commercial)	G-3 (Large Commercial)
					Tier 1	Tier 2		
	per therm	per therm	per therm	per therm	per therm	per therm	per therm	per therm
3/1/19	0.4071	0.033	0.11607	0.040	1.0207	1.59097	1.21447	1.20597
2/1/19	0.3406	0.033	0.11607	0.040	0.95357	1.52447	1.14797	1.13947
1/1/19	0.4337	0.033	0.11607	0.040	1.04667	1.61757	1.24107	1.23257
12/1/18	0.6255	0.033	0.12554	0.040	1.24794	1.81884	1.44224	1.43384
11/1/18	0.3831	0.026	0.12554	0.040	0.99854	1.56944	1.19294	1.18444
10/1/18	0.3360	0.026	0.12554	0.040	0.95144	1.52234	1.14584	1.13734
9/1/18	0.3258	0.026	0.12554	0.040	0.94124	1.51214	1.13564	1.12714
8/1/18	0.3145	0.026	0.12554	0.040	0.92994	1.50084	1.12434	1.11584
7/1/18	0.3043	0.026	0.15000	0.040	0.94420	1.51510	1.13860	1.13010
6/1/18	0.3166	0.026	0.12431	0.040	0.90021	1.43881	1.08361	1.07561
5/1/18	0.2706	0.026	0.12431	0.040	0.85421	1.39281	1.03761	1.02961
4/1/18	0.2644	0.026	0.12431	0.040	0.84801	1.38661	1.03141	1.02341

Appendix B –Detailed Results

Table 5: Efficiency Package Cost-Effectiveness Results

Climate Zone	BASECASE					Non-Preempted								Equipment - Preempted							
	Final EDR	Efficiency EDR	CALGreen Tier 1 EDR Target	lbs CO2 per sqft	PV kW	Final EDR	Efficiency EDR	EDR Red.	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio	Final EDR	Efficiency EDR	EDR Red,	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio
Mixed Fuel SF	22.9	44.4	8	1.9	2.7	20.6	41.9	2.5	14.2%	1.7	2.7	0.8	1.2	20.3	41.8	2.6	15.1%	1.6	2.7	1.9	2.7
All-Electric SF	31.6	53.2	12	1.0	2.7	28.2	49.8	3.4	15.7%	0.9	2.7	1.7	1.9	28.0	49.6	3.6	16.4%	0.9	2.7	1.2	1.4
Mixed Fuel MF	25.4	56.4	8	2.2	13.6	24.3	55.1	1.3	7.6%	2.1	13.5	0.6	1.2	23.4	54.2	2.2	12.5%	2.0	13.5	0.7	1.4
All-Electric MF	34.1	64.4	12	1.3	13.6	32.6	62.9	1.5	7.9%	1.2	13.6	0.9	1.6	31.6	61.9	2.5	12.9%	1.2	13.6	0.7	1.2

">1" = indicates cases where there is both first cost savings and annual utility bill savings.
EDR Red. = EDR Reduction.

Table 6: Efficiency & PV-PV/Battery Package Cost-Effectiveness Results

Climate Zone	BASECASE				Efficiency & PV							Efficiency & PV/Battery						
	Final EDR	CALGreen Tier 1 EDR Target	PV kW	lbs CO2 per sqft	Final EDR	EDR Red.	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio	Final EDR	EDR Red.	% Comp Margin	lbs CO2 per sqft	PV kW	On-Bill B/C Ratio	TDV B/C Ratio
Mixed Fuel SF	22.9	8	1.9	2.7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	12.8	10.1	25.2%	1.5	2.8	0.5	1.6
All-Electric SF	31.6	12	1.0	2.7	14.4	17.2	15.7%	0.5	4.5	1.0	1.6	2.9	28.7	26.7%	0.3	5.15	0.9	1.7
Mixed Fuel MF	25.4	8	2.2	13.6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	14.3	11.1	14.6%	1.9	13.9	0.4	1.8
All-Electric MF	34.1	12	1.3	13.6	18.8	15.3	7.9%	0.7	20.2	0.9	1.8	4.5	29.6	14.9%	0.4	22.8	0.8	1.9

">1" = indicates cases where there is both first cost savings and annual utility bill savings.
EDR Red. = EDR Reduction.