

Association of Bay Area
Governments: Bay Area Regional
Energy Network

Cost Effectiveness Analysis
Title 24 2013 Reach Code
Multi Family Low-Rise Residential
Climate Zone 2, 3, 4, and 12

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This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Arup North America Ltd
560 Mission Street
Suite 700
San Francisco 94105
United States of America
www.arup.com

ARUP

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1 Summary

This report presents the results of a supporting energy savings and cost-effectiveness analysis conducted for low-rise multi-family residential buildings in the San Francisco Bay Area, Climate Zone 2, 3, 4, and 12, under the Bay Area Regional Energy Network (BayREN) Codes and Standards Program.

The purpose of this analysis is to demonstrate cost-effectiveness for multi-family low-rise residential building permit applicants to exceed a performance level equivalent to the 2013 California Building Energy Efficiency Standards, also known as Title 24 Part 6 (“Title 24 2013”).

This report is for new construction only and is not applicable to additions and alterations building renovation projects.

The result of this analysis is a list of energy savings and energy generation measures that can be implemented on a performance basis to achieve a savings performance target. This list is not an endorsement of any particular energy efficiency measure, nor is it necessary that the list be followed prescriptively to achieve energy savings against the baseline.

2 Costs and Savings Analysis

2.1 Base Building Models

We performed a comparative analysis of energy savings and costs using a representative multi-family low-rise building energy prototype. The baseline prototype is compliant with Title 24 Part 6 2013. Values from this analysis are found in Table 1 through Table 4 under the section titled “Measures Analyzed for Code Compliance.” Key building characteristics are described in Appendix A1.

2.2 Methods and Assumptions

Energy savings data was developed using energy modeling with an adapted meta-analysis version of EnergyPlus, the IOU “ZNE Tool”, and the results in the report *The Technical Feasibility of Zero Net Energy Buildings in California* (the “ZNE Report”). ZNE Tool and Report results were cross-verified against results from Codes and Standards Enhancement (CASE) research done for the 2013 and 2016 code cycles. Energy savings were estimated for a set of sample measures for each model, in both real energy terms and in terms of the CEC approved 2013 Reach Time Dependent Value energy (Reach TDV)¹. Where energy savings results differed significantly between these sources, the lower result was chosen in order to provide a conservative approach; where results did not differ significantly the average

¹ Reach TDV are a set of TDV scalars intended for use in reach code analysis specifically. Used as defined in http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/general_cec_documents/Title24_2013_TDV_Methodology_Report_23Feb2011.pdf

results is reported. All energy and cost savings were scaled to a per-square-foot basis.

Incremental first cost data was developed from existing CASE reports done for the 2013 and 2016 code cycles, and from RS Means where CASE data was not available. Cost data was scaled to a per-square-foot basis.

Detailed measure descriptions, and source energy savings and cost data, are described in Appendix A2.

Key notes and assumptions are as follows:

- The following measures were either not analyzed or not totaled towards savings as they do not apply towards compliance under the Title 24 performance compliance path. They are presented in Table 1 through Table 4 (titled “Additional Measures Analyzed”) as possible prescriptive measures that can be implemented under a reach code path.
 - Plug load or electrical equipment measure upgrades, and water use upgrades, were analyzed but are not counted towards the performance compliance rating, as they are not regulated by the Title 24 performance compliance method (Alternative Calculation Method “ACM”) at this time.
 - Lighting upgrades were analyzed but are not counted towards the performance compliance rating, as they are not regulated by the Title 24 residential performance compliance method (ACM) at this time.
 - High efficacy lighting was analyzed in consideration of CALGreen Section A4.203.1.1.3 provision.
 - HVAC equipment rated efficiency improvements (for furnaces, packaged and split AC units, chillers, boilers, water heaters) were not analyzed, as they are regulated by the U.S. Department of Energy and Title 20 and preempted from local regulation.
- Reach Time-dependent valuation of savings (Reach TDV) provided using the CEC approved 2013 Reach TDV numbers. All percent savings targets are based on Reach TDV.
- The cost-benefit calculation evaluated energy savings against incremental first costs of measures. Replacement costs and maintenance costs not considered.
- The IOU ZNE Tool and Report only include energy savings data for climate zones 3 and 12. In order to estimate the savings for climate zone 2 and 4 where appropriate, the results for climate zone 3 and 12 were scaled using the ratio of cooling degree days (CDD) and/or heating degree days (HDD) dependent on the measure, according to the HDD and CDD values which are as defined by the Energy Commission. See Appendix A2.
- Savings provided in terms of standard TDV kBtu were translated to Reach TDV kBtu and reach TDV dollars (\$) via standard multipliers provided as a part of the TDV development. See Appendix A2.

3 Results

3.1 Multi-Family Low Rise Residence

Table 1 through Table 4 show energy savings measures beyond code applicable for performance compliance in the multi-family low-rise residence prototype in Climate Zones 2, 3, 4, and 12.

No measures applicable for code compliance in these climate zones were found to be cost-effective under this analysis.

The tables also list additional measures analyzed that are uncovered under performance code compliance. Such measures could be implemented under a prescriptive reach code.

Percent savings are based off of a building code compliance baseline energy consumption. The code compliance baseline excludes plug load and lighting energy, as these are not covered by performance compliance in the residential code. Baseline energy consumption is reported for the building prototypes developed by the IOU ZNE Tool and presented in the report “The Technical Feasibility of Zero Net Energy Buildings in California”.

Table 1: Climate Zone 2 Multifamily Measure Results

Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	Reach TDV kbtu	Reach TDV %	Reach TDV \$ / sq. ft.	\$ / sq. ft.	
Measures Analyzed for Code Compliance					
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6	3,725	0.3%	\$0.04	\$0.09	0.5
Ceiling Insulation R-30 to R-38 blown-in insulation w/RHT	2,102	0.2%	\$0.02	\$0.19	0.1
QII (Quality Insulation Inspection)	2,155	0.2%	\$0.03	\$0.18	0.1
Reduced Infiltration: 5 ACH50 to 3 ACH50	692	0.1%	\$0.01	\$0.32	0.0
Solar Water Heating: Solar Savings Fraction (SSF) 0.7	69,721	5.8%	\$0.82	\$1.95	0.4
Total Savings for Title 24 Part 6 Energy Budget Compliance	78,395	6.5%	\$0.92	\$2.73	0.3
Code Compliance Baseline	1,196,976		\$14.10	\$4.46	
Additional Measures Analyzed					
Showerheads 2.5 to 2.0 GPM	33,672	-	\$0.40	\$0.03	13.1
Kitchen Sinks 2.2 to 1.8 GPM	10,025	-	\$0.12	\$0.02	5.5
Domestic Hot Water Heat Recovery	20,569	-	\$0.24	\$0.49	0.5
All Building LED High-Efficacy Lighting Equivalent to upgrade from 55 lm/W to 75 lm/W	19,264	-	\$0.23	\$0.48	0.5
Plug Load Controls Equivalency of 10% reduction in plug loads	46,714	-	\$0.55	\$0.46	1.2
Whole Building Savings	208,639	-	\$2.46	\$4.21	0.6
Whole Building Baseline	2,666,968	-	\$31.42	-	-

Table 2: Climate Zone 3 Multifamily Measure Results

Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	Reach TDV kbtu	Reach TDV %	Reach TDV \$ / sq. ft.	\$ / sq. ft.	
Measures Analyzed for Code Compliance					
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6	3,158	0.3%	\$0.04	\$0.09	0.4
Ceiling Insulation R-30 to R-38 blown-in insulation w/RHT	1,782	0.2%	\$0.02	\$0.18	0.1
QII (Quality Insulation Inspection)	1,679	0.2%	\$0.02	\$0.18	0.1
Reduced Infiltration: 5 ACH50 to 3 ACH50	587	0.1%	\$0.01	\$0.32	0.0
Solar Water Heating: Solar Savings Fraction (SSF) 0.7	81,341	8.5%	\$0.96	\$2.12	0.5
Total Savings for Title 24 Part 6 Energy Budget Compliance	88,547	9.3%	\$1.04	\$2.90	0.4
Code Compliance Baseline	953,701	-	\$11.24	-	-
Additional Measures Analyzed					
Showerheads 2.5 to 2.0 GPM	33,672	-	\$0.40	\$0.03	13.1
Kitchen Sinks 2.2 to 1.8 GPM	10,025	-	\$0.12	\$0.02	5.5
Domestic Hot Water Heat Recovery	20,569	-	\$0.24	\$0.49	0.5
All Building LED High-Efficacy Lighting Equivalent to upgrade from 55 lm/W to 75 lm/W	19,264	-	\$0.23	\$0.48	0.5
Plug Load Controls Equivalency of 10% reduction in plug loads	46,714	-	\$0.55	\$0.46	1.2
Whole Building Savings	218,790	-	\$2.58	\$4.38	0.6
Whole Building Baseline	2,423,693	-	\$28.55	-	-

Table 3: Climate Zone 4 Multifamily Measure Results

Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	Reach TDV kbtu	Reach TDV %	Reach TDV \$ / sq. ft.	\$ / sq. ft.	
Measures Analyzed for Code Compliance					
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6	2,297	0.2%	\$0.03	\$0.09	0.3
Ceiling Insulation R-38 to R-49 blown-in insulation w/RHT	4,935	0.5%	\$0.06	\$0.19	0.3
QII (Quality Insulation Inspection)	2,406	0.2%	\$0.03	\$0.18	0.2
Reduced Infiltration: 5 ACH50 to 3 ACH50	13,224	1.3%	\$0.16	\$0.32	0.5
Solar Water Heating: Solar Savings Fraction (SSF) 0.7	81,341	8.2%	\$0.96	\$1.97	0.5
Total Savings for Title 24 Part 6 Energy Budget Compliance	104,203	10.5%	\$1.23	\$2.75	0.4
Code Compliance Baseline	991,503	-	\$11.68	-	-
Additional Measures Analyzed					
Showerheads 2.5 to 2.0 GPM	27,135	-	\$0.32	\$0.03	10.5
Kitchen Sinks 2.2 to 1.8 GPM	12,204	-	\$0.14	\$0.02	6.7
Domestic Hot Water Heat Recovery	18,874	-	\$0.22	\$0.49	0.5
All Building LED High-Efficacy Lighting Equivalent to upgrade from 55 lm/W to 75 lm/W	18,729	-	\$0.22	\$0.48	0.5
Plug Load Controls Equivalency of 10% reduction in plug loads	46,714	-	\$0.55	\$0.46	1.2
Whole Building Savings	227,860	-	\$2.68	\$4.23	0.6
Whole Building Baseline	2,644,650	-	\$31.16	-	-

Table 4: Climate Zone 12 Multifamily Measure Results

Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	Reach TDV kbtu	Reach TDV %	Reach TDV \$ / sq. ft.	\$ / sq. ft.	
Measures Analyzed for Code Compliance					
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6	3,148	0.2%	\$0.04	\$0.09	0.4
Ceiling Insulation R-38 to R-49 blown-in insulation w/RHT	5,533	0.4%	\$0.07	\$0.23	0.3
QII (Quality Insulation Inspection)	3,303	0.3%	\$0.04	\$0.18	0.2
Reduced Infiltration: 5 ACH50 to 3 ACH50	18,167	1.4%	\$0.21	\$0.32	0.7
Solar Water Heating: Solar Savings Fraction (SSF) 0.7	48,579	3.7%	\$0.57	\$1.37	0.4
Total Savings for Title 24 Part 6 Energy Budget Compliance	78,730	6.1%	\$0.93	\$2.19	0.4
Code Compliance Baseline	1,298,152	-	\$15.29	-	-
Additional Measures Analyzed					
Showerheads 2.5 to 2.0 GPM	27,135	-	\$0.32	\$0.03	10.5
Kitchen Sinks 2.2 to 1.8 GPM	12,204	-	\$0.14	\$0.02	6.7
Domestic Hot Water Heat Recovery	18,874	-	\$0.22	\$0.49	0.5
All Building LED High-Efficacy Lighting Equivalent to upgrade from 55 lm/W to 75 lm/W	18,729	-	\$0.22	\$0.48	0.5
Plug Load Controls Equivalency of 10% reduction in plug loads	46,714	-	\$0.55	\$0.46	1.2
Whole Building Savings	1,579,269	-	\$18.61	\$5.86	3.2
Whole Building Baseline	2,951,300	-	\$34.77	-	-

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A1 Baseline Building Models

Representative Baseline Building for Energy Reach Code Analysis.

Table 5: Prototype Building Characteristics

Representative Single-Family Baseline Building	
Conditioned Floor Area	14,700 sq. ft.
Number of Levels	12
Ceiling	14,700 sq. ft., vented attic CZ 2 & 3: R-30 insulation CZ 4 & 12: R-38 insulation
Walls	2'x 4', 16" o.c., R-15 w/R-4 rigid c.i. U = 0.065
DHW System	Gas Water Heater w/ 40 gal tank serving each individual dwelling unit 0.62 EF
Heating System	Gas-Fired Furnace, 0.80 EF
Cooling System	DX PTAC (11.0 SEER, 9.5 EER, 2.9 COP)
Interior Lighting Power Density (LPD)	High-efficacy lighting mandatory in many spaces per Title 24 Dimming or vacancy sensor mandatory in many spaces per Title24
Exterior Lighting Power Density (LPD)	None
Code Compliance Total EUI (kbtu / sq. ft.) (excl. plug loads & lighting)	CZ 2: 16.8 CZ 3: 13.8 CZ 4: 13.2 CZ 12: 16.7
Total EUI (kbtu / sq. ft.)	CZ 2: 38.7 CZ 3: 35.7 CZ 4: 35.1 CZ 12: 38.6

A2 Measure References and Data

The following tables contain the measure savings and costs references, and notes, to detail how measure results were developed.

Table 6: Measure Data References

Measure	Data Sources
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6 (w/o QII: 70% of maximum savings)	<ul style="list-style-type: none"> Savings developed from the ZNE Report Costs developed from the CASE report for <i>Residential High Performance Walls and QII</i> (scaled to match wall insulation area of the multi-family prototype building)

<p>Ceiling Insulation R-30 to R-38 (CZ 2 & 3) and R-38 to R-49 (CZ 4 & 12) blown-in insulation w/Raised Heel Trusses (w/o QII: $(96-0.347 \cdot R)$% of maximum savings)</p>	<ul style="list-style-type: none"> • Savings developed from the ZNE Report, (and from the CASE report for <i>Residential Roof Envelope Measures</i> for CZ 4 & 12) • Costs developed from the CASE report for <i>Residential Roof Envelope Measures</i>, in conjunction with RS Means Online
<p>QII (Quality Insulation Inspection) Brings savings from wall and ceiling insulation up to 100%</p>	<ul style="list-style-type: none"> • Savings developed from the IOU ZNE Tool • Costs developed from the CASE report for <i>Residential High Performance Walls and QII</i> (scaled to match wall and ceiling insulation area of the multi-family prototype building)
<p>Reduced Infiltration: 5 ACH50 to 3 ACH50</p>	<ul style="list-style-type: none"> • Savings developed from the ZNE Report • Costs developed from NREL's National Residential Efficiency Measures Database
<p>Solar Water Heating: SSF 50%</p>	<ul style="list-style-type: none"> • Savings developed from the IOU ZNE Tool (CASE report Solar Water Heating – Residential and Specialty Commercial reviewed but not used due to CASE analysis use of electric water heat for analysis baseline) • Costs developed from RS Means Online and CASE report
<p>Showerheads 2.5 to 1.8 GPM</p>	<ul style="list-style-type: none"> • Savings developed from the IOU ZNE Tool, and the CASE report for <i>Multi-Head Showers and Lower-Flow Shower Heads</i> (linear interpolation between GPMs provided from annual energy consumption data) • Costs developed from the DEER database
<p>Kitchen Sinks 2.2 to 1.8 GPM</p>	<ul style="list-style-type: none"> • Savings developed from the IOU ZNE Tool, and the CASE report for <i>Multi-Head Showers and Lower-Flow Shower Heads</i> (linear interpolation between GPMs provided from annual energy consumption data, assuming half the usage time of showerheads) • Costs developed from the DEER database
<p>Domestic Hot Water Heat Recovery 40% Heat Recovery Effectiveness</p>	<ul style="list-style-type: none"> • Savings developed from ZNE Report, and checked against exceptional calculations (assuming 1 shower and 2 sinks, with a total DHW usage of 32 gal/day/unit) • Costs developed from literature review and review of retail prices
<p>All Building LED High-Efficacy Lighting Equivalent to upgrade from 55 lm/W to 75 lm/W</p>	<ul style="list-style-type: none"> • Savings from the IOU ZNE Tool, and calculated from the CASE report for <i>Residential Lighting</i> (CASE report reliant calculations developed based on CASE reported average daily hours of use, average room type quantities, average permanently installed Watts per room type, and typical lamp and fixture types and rated efficacies) • Costs developed from the same CASE report (assuming Pin-base CFL downlight as baseline and LED downlight as proposed lamp type)

<p>Plug Load Controls One major home circuit on a timer to shut off major standby/vampire loads midnight-6am and 10am-1pm, on weekdays, in each dwelling unit</p>	<ul style="list-style-type: none"> • Savings developed from the IOU ZNE Tool, and the CASE report for <i>Residential Plug-load Controls</i> (“average savings scenario”) • Costs developed from the same CASE report
<p>Solar Water Heating: SSF 70%</p>	<ul style="list-style-type: none"> • Savings from the IOU ZNE Tool, and from CASE report <i>Multifamily Central DHW and Solar Water Heating</i>. • Costs directly from the same CASE report and checked against RS Means Online

Table 7: Heating and cooling degree days for the studied climate zones.

Climate Zone	HDD	CDD
CZ 2	3194	239
CZ 3	2708	142
CZ 4	2033	717
CZ 12	2496	985

Table 8: TDV PV Adjustment Factors

	(2013 \$/TDVkBtu)	(2008 \$/TDVkBtu)
Non-Res (15-yr)	\$ 0.089	\$ 0.084
Non-Res (30-yr)	\$0.154	\$ 0.146
Res (30-yr)	\$ 0.173	\$ 0.164

Convert TDV kBtu to TDV \$.

Table 9: Average TDV Scalars

	2013 Reach	2013	2008
TDV kbtu/therm	203.09	159.51	148.12
TDV kbtu/kWh	27.3	21.26	13.95

Approximately convert standard therms and kWh to TDV kBtu; averages of the annual 8760 scalar values.

Table 10: Reach TDV Multipliers

	Electricity	Gas	Propane
Non-Res (15-yr)	1.253	1.375	1.197
Non-Res (30-yr)	1.27	1.354	1.182
Res (30-yr)	1.259	1.331	1.152

Convert standard TDV to reach TDV.