

Memorandum



To Association of Bay Area Governments Bay Area Regional Energy Network (BayREN) Date April 29, 2015

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Subject Cost Effectiveness Analysis: Title 24 2013 Reach Code: Single Family Residential Additions and Alterations

Summary

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

The purpose of this analysis is to demonstrate cost-effectiveness for additions and alterations to single-family low-rise residential building permit applicants to exceed a performance level equivalent to the 2013 California Building Energy Efficiency Standards. This analysis builds from and should be used in conjunction with a previous analyses for new construction, dated 20 December 2014, available through BayREN.

The results presented represent an analysis for low-rise residential single-family homes. The results are presented for equivalency to CALGreen voluntary tiers for residential additions and alterations.

Table 1: Summary Reach Cost-Effective Targets for Single-Family Homes

Climate Zone	Maximum Cost-Effective Reach Performance Target			Maximum Recommended Reach Performance Target
	Additions	Alterations	Alterations	
	0*	1*	2*	CALGreen Tier
2	6.8%	10.6%	13.4%	1
3	5.8%	10.7%	14.1%	1
4	12.0%	5.9%	8.9%	0
12	13.0%	13.1%	15.4%	2

* Numbers shown are number of mechanical system measures assumed in analysis to develop performance targets. CALGreen voluntary tiers are distinguished by number of mechanical systems altered or added (heating, cooling, domestic water heating). See Section A4.204 of CALGreen.

Memorandum

Results

Table 2 through Table 5 show the cost-effective and feasible energy savings measures beyond code that could be implemented for performance compliance in a prototypical single-family residence in Bay Area climate zones. The table also lists select rejected measures that were not found to be cost-effective or applicable for performance compliance under the stated assumptions.

Additions and alterations demonstrate different performance targets. This is because measures and assumptions differ between additions and alterations. See Table 6: Measure Data References for details.

Table 2: Climate Zone 2 Results

Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	Reach TDV kbtu / sq. ft.	Reach TDV %	Reach TDV \$ / sq. ft.	\$ / sq. ft.	
Additions					
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6	1.2	1.6%	\$0.21	\$0.19	1.1
QII (Quality Insulation Inspection) Applied to wall insulation	0.8	1.1%	\$0.13	\$0.35	0.4
Reduced Infiltration: 5 ACH50 to 3 ACH50	3.0	4.1%	\$0.52	\$0.32	1.6
Total Savings for Energy Budget Compliance	5.0	6.8%	\$0.86	\$0.85	1.0
Alterations					
DHW Heater Tankless 40 gal Gas Storage to 2 gal Gas Tankless Instantaneous	2.1	2.8%	\$0.32	\$0.29	1.1
HVAC Technology Changeout Federal Minimum PTAC to Heat Pump	3.9	5.3%	\$1.18	\$0.57	2.1
Reduced Infiltration: 5 ACH50 to 3 ACH50 Applied to entire home	3.0	4.1%	\$0.52	\$0.32	1.6
Ceiling Insulation From R-30 to R-38 blown-in insulation Applied to entire home	0.7	1.0%	\$0.13	\$0.39	0.3
QII (Quality Insulation Inspection) applied to Ceiling Insulation	0.1	0.2%	\$0.02	\$0.35	0.1
Total Savings for Energy Budget Compliance	10	13.4%	\$2.17	\$1.91	1.1
Rejected Measures					
Improved Wall Insulation From R-13 w/no ci on 2x4, to R-17 w/no ci on 2x4, both 16" OC	2.3	3.1%	\$0.40	\$1.13	0.4
Ducts in conditioned space	0.9	1.2%	\$0.15	\$0.46	0.3
Ducts from R-6 to R-8 Insulation	0.8	1.1%	\$0.14	\$0.16	0.9
Solar Water Heating Solar Savings Fraction 50%	5.0	6.9%	\$0.87	\$2.81	0.3

Memorandum

Table 3: Climate Zone 3 Results

Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	Reach TDV kbtu / sq. ft.	Reach TDV %	Reach TDV \$ / sq. ft.	\$ / sq. ft.	
Additions					
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6	1.0	1.7%	\$0.18	\$0.19	0.9
Reduced Infiltration: 5 ACH50 to 3 ACH50	2.5	4.2%	\$0.44	\$0.32	1.4
Total Savings for Energy Budget Compliance	3.6	5.8%	\$0.62	\$0.51	1.2
Alterations					
DHW Heater Tankless 40 gal Gas Storage to 2 gal Gas Tankless Instantaneous	2.0	3.3%	\$0.32	\$0.29	1.1
HVAC Technology Changeout Federal Minimum PTAC to Heat Pump	3.3	5.4%	\$1.00	\$0.57	1.7
Reduced Infiltration: 5 ACH50 to 3 ACH50 Applied to entire home	2.5	4.2%	\$0.44	\$0.32	1.4
Ceiling Insulation From R-30 to R-38 blown-in insulation Applied to entire home	0.7	1.1%	\$0.12	\$0.39	0.3
Total Savings for Energy Budget Compliance	8.6	14.1%	\$1.88	\$1.57	1.2
Rejected Measures					
Improved Wall Insulation From R-13 w/no ci on 2x4, to R-17 w/no ci on 2x4, both 16" OC	1.9	3.0%	\$0.32	\$1.13	0.3
QII (Quality Insulation Inspection) applied to Ceiling and Wall Insulation	0.9	1.5%	\$0.16	\$0.35	0.5
Ducts in conditioned space	0.7	1.2%	\$0.13	\$0.46	0.3
Ducts from R-6 to R-8 Insulation	0.5	0.8%	\$0.08	\$0.16	0.5
Solar Water Heating Solar Savings Fraction 50%	5.0	8.2%	\$0.87	\$2.81	0.3

Memorandum

Table 4: Climate Zone 4 Results

Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	Reach TDV kbtu / sq. ft.	Reach TDV %	Reach TDV \$ / sq. ft.	\$ / sq. ft.	
Additions					
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6	2.2	3.3%	\$0.37	\$0.19	2.0
QII (Quality Insulation Inspection) Applied to wall insulation	1.3	1.9%	\$0.22	\$0.35	0.6
Ducts in conditioned space	3.2	4.9%	\$0.55	\$0.46	1.2
Reduced Infiltration: 5 ACH50 to 3 ACH50	1.3	1.9%	\$0.22	\$0.32	0.7
Total Savings for Energy Budget Compliance	7.9	12.0%	\$1.36	\$1.32	1.0
Alterations					
DHW Heater Tankless 40 gal Gas Storage to 2 gal Gas Tankless Instantaneous	1.9	3.0%	\$0.30	\$0.29	1.0
HVAC Technology Changeout Federal Minimum PTAC to Heat Pump	2.6	4.0%	\$0.75	\$0.57	1.3
Reduced Infiltration: 5 ACH50 to 3 ACH50 Applied to entire home	1.3	1.9%	\$0.22	\$0.32	0.7
Total Savings for Energy Budget Compliance	5.8	8.9%	\$1.27	\$1.18	1.1
Rejected Measures					
Improved Wall Insulation From R-13 w/no ci on 2x4, to R-19 w/no ci on 2x4, both 16" OC	2.1	3.2%	\$0.37	\$1.13	0.3
Ceiling Insulation (R-30 to R-38 blown-in insulation)	0.8	1.2%	\$0.14	\$0.39	0.4
Ducts from R-6 to R-8 Insulation	1.0	1.5%	\$0.17	\$0.16	1.0
Solar Water Heating Solar Savings Fraction 50%	4.6	7.0%	\$0.80	\$2.81	0.3

Memorandum

Table 5: Climate Zone 12 Results

Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	Reach TDV kbtu / sq. ft.	Reach TDV %	Reach TDV \$ / sq. ft.	\$ / sq. ft.	
Additions					
Improved Wall Insulation From R-15 w/R-4ci on 2x4, to R-21 w/R-4ci on 2x6	2.9	3.6%	\$0.50	\$0.19	2.6
Ducts in conditioned space	4.2	5.2%	\$0.73	\$0.46	1.6
QII (Quality Insulation Inspection) Applied to wall insulation	1.7	2.1%	\$0.29	\$0.35	0.8
Reduced Infiltration: 5 ACH50 to 3 ACH50	1.7	2.2%	\$0.30	\$0.32	1.0
Total Savings for Title 24 Part 6 Energy Budget Compliance	11	13.0%	\$1.82	\$1.32	1.4
Alterations					
DHW Heater Tankless 40 gal Gas Storage to 2 gal Gas Tankless Instantaneous	1.9	2.3%	\$0.29	\$0.29	1.0
HVAC Technology Changeout Federal Minimum PTAC to Heat Pump	3.2	3.9%	\$1.66	\$0.57	2.9
Reduced Infiltration: 5 ACH50 to 3 ACH50 Applied to entire home	1.7	2.2%	\$0.30	\$0.32	1.0
Improved Wall Insulation From R-13 w/no ci on 2x4, to R-19 w/no ci on 2x4, both 16" OC	3.0	3.7%	\$0.52	\$1.13	0.5
Ceiling Insulation From R-30 to R-38 blown-in insulation Applied to entire home	1.2	1.4%	\$0.20	\$0.39	0.5
QII (Quality Insulation Inspection) applied to Wall and Ceiling Insulation	1.5	1.8%	\$0.26	\$0.35	0.7
Total Savings for Title 24 Part 6 Energy Budget Compliance	12	15.4%	\$3.24	\$3.05	1.1
Rejected Measures					
Ducts from R-6 to R-8 Insulation	1.4	1.8%	\$0.25	\$0.16	1.5
Solar Water Heating Solar Savings Fraction 50%	4.6	5.7%	\$0.80	\$2.81	0.3

Memorandum

Assumptions

This information is adapted from and should be referenced in conjunction with the previously mentioned BayREN local reach code reports for new construction.

This analysis represents single-family homes only. The new construction analysis also studied low-rise multi-family buildings, however did not find sufficient cost-effective energy savings to justify above-code performance targets; therefore this analysis did not consider low-rise multi-family buildings.

For more information about additions and alterations performance compliance, please see Table 150.2-B of the Energy Efficiency Standards and Table 9-1 of the Standards Residential Compliance Manual.

Additions

- For additions, the only performance compliance path is to model the addition as a standalone component. Therefore, per-square-foot incremental costs and energy savings of new components are assumed in this analysis to be approximately the same for additions as for new construction.
- For this analysis, HVAC equipment measures are considered largely inapplicable for additions alone, as additions are anticipated to typically be conditioned by the existing building HVAC system.

Alterations

- For alterations, the simplest allowed performance compliance path is to model the alteration with the existing building, either with or without verification of existing conditions.
 - The performance compliance path is only allowed when two or more components are altered at the same time. Furthermore, only a subset of component alterations may be modeled as listed in Table 150.2-B of the Standards. If only one measure is implemented, the measure must demonstrate prescriptive compliance.
 - For the purposes of this analysis, measures were assumed to be applied to the entire base building. **If measures are only partially applied to the existing building** (e.g. insulation only applied partially to home), **total savings and costs will be lower than presented here. Care should be taken when setting savings performance targets to consider this fact.**
- Per-square-foot incremental costs and energy savings are anticipated to vary slightly as compared to new construction, particularly for envelope related measures, due to the difference in implementing the measure in an existing building.
- It is possible to model the building with existing conditions if verified in-field. This achieves higher savings if the existing conditions are below code. Therefore, the results shared herein, which compare to a code minimum baseline, represent a conservative use case for alterations.
 - It may be possible to justify more aggressive savings targets in a local reach code if third party verification of existing conditions is mandated for alterations. Per section 150.2(c)2 of the Energy Efficiency Standards, when the third party verification option is specified, all components proposed for alteration must be verified. The Executive Director determines the qualifications required by the third party inspector.
 - Certain measures are only allowed if existing conditions are verified. For example, duct insulation from R-6 to R-8 may only count towards performance compliance if verified.

Memorandum

Additions + Alterations

- For additions and alterations combined, the simplest allowed performance compliance path is to model the existing building with the addition and alteration, with or without verification of existing conditions. This case is considered infrequent and is not evaluated here.

References

The following table contains the measure references and describe how measure results were developed. References and standard assumptions are identical to those referenced in the 20 December 2014 report; a full reference list is presented in that report.

Table 6: Measure Data References

Measure	Adds	Alts	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)	X		<ul style="list-style-type: none"> • Savings directly from the CASE report for <i>Residential High Performance Walls and QII</i> at http://title24stakeholders.com/wp-content/uploads/2014/10/2016-T24-CASE-Report-High-Perf-Walls-Sep2014.pdf • Costs directly from the same CASE report
Improved Wall Insulation From R-13 w/no ci on 2x4, to R-17 w/no ci on 2x4, both 16" OC		X	<ul style="list-style-type: none"> • Savings directly from CASE report for <i>Residential Roof Envelope Measures</i> at http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Envelope/2013_CASE_R_Roof_Measures_Oct_2011.pdf • Costs directly from the same CASE report
DHW Heater Tankless 40 gal Gas Storage to Gas Tankless Instantaneous (Federal Minimum equivalent of 0.62 EF to 0.74 EF equivalent)		X	<ul style="list-style-type: none"> • Savings from the IOU ZNE Tool, and directly from the CASE report for <i>Residential Instantaneous Water Heaters</i> at http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-21_workshop/case_reports/2016_Title_24_Draft_CASE_Report-Residential_Instantaneous_Water_Heaters.pdf • Costs directly from the same CASE reports
HVAC Technology Change PTAC to Heat Pump (11.0 SEER, 9.5 EER, 2.9 COP)		X	<ul style="list-style-type: none"> • Savings from the IOU ZNE Tool • Costs developed from RS Means Online for 5 ton cooling unit
QII (Quality Insulation Inspection) Brings savings from wall and ceiling insulation up to 100%	X	X	<ul style="list-style-type: none"> • Savings calculated from wall and ceiling insulation savings calculations per Residential ACM method • Costs from the CASE report for <i>Residential High Performance Walls and QII</i> at http://title24stakeholders.com/wp-content/uploads/2014/10/2016-T24-CASE-Report-High-Perf-Walls-Sep2014.pdf

Memorandum

Reduced Infiltration: 5 ACH50 to 3 ACH50	X	X	<ul style="list-style-type: none"> • Savings directly from the ZNE Report • Costs from NREL's National Residential Efficiency Measures Database
Ceiling Insulation From R-30 to R-38 or R-38 to R-49 blown-in insulation w/Raised Heel Trusses (w/o QII: (96-0.347*R)% of maximum savings)	X		<ul style="list-style-type: none"> • Savings directly from the ZNE Report, and directly from the CASE report for <i>Residential Roof Envelope Measures</i> at http://www.energy.ca.gov/title24/2013standards/prulemaking/documents/current/Reports/Residential/Envelope/2013_CASE_R_Roof_Measures_Oct_2011.pdf • Costs directly from the same CASE report, checked against RS Means Online
Ceiling Insulation from R-30 to R-38 blown-in insulation (w/o QII: (96-0.347*R)% of maximum savings)		X	<ul style="list-style-type: none"> • Savings from the CASE report for <i>Residential High Performance Walls and QII</i> at http://title24stakeholders.com/wp-content/uploads/2014/10/2016-T24-CASE-Report-High-Perf-Walls-Sep2014.pdf • Costs directly from the same CASE report
Ducts in conditioned space	X		<ul style="list-style-type: none"> • Savings from the IOU ZNE Tool and from the CASE report for <i>Residential Ducts in Conditioned Space / High Performance Attics</i> at http://www.energy.ca.gov/title24/2016standards/prulemaking/documents/2014-07-21_workshop/case_reports/2016_Title_24_Draft_CASE_Report-Residential_Ducts_in_Conditioned_Space-High_Performance_Attics.pdf • Costs directly from the same CASE report
Ducts from R-6 to R-8 insulation		X	<ul style="list-style-type: none"> • Savings scaled from CASE report for <i>Residential Roof Envelope Measures</i> at http://www.energy.ca.gov/title24/2013standards/prulemaking/documents/current/Reports/Residential/Envelope/2013_CASE_R_Roof_Measures_Oct_2011.pdf • Costs directly from the same CASE report
Solar Water Heating: SSF 50%	X	X	<ul style="list-style-type: none"> • Savings from the IOU ZNE Tool, and the CBEC-Residential 2013 software assuming a standard single-family default model and default gas storage water heater with 60% efficiency. • Costs directly from the same CASE report and checked against RS Means Online