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CA Statewide Codes and Standards Program

Title 24, Part 6
Local Energy Efficiency Ordinances

Climate Zone 12
Energy Cost-Effectiveness Study

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LEGAL NOTICE

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Contents

List of Tables

1.0 Executive Summary

The California building code, Title 24, is maintained and updated approximately every three years by two state agencies, the California Energy Commission (CEC) and Building Standards Commission (BSC). In addition to enforcing the code, local governments have the authority to adopt local energy efficiency ordinances that require certain construction projects to exceed the minimum Title 24, Part 6 (Building Energy Efficiency Standards) requirements. The ordinance must be more stringent than the minimum state requirements, and be cost-effective. In addition, the local government must obtain approval from the CEC and file the ordinance with the BSC for the ordinance to be legally enforceable. The application for approval must meet all requirements specified in Section 10-106 of the California Code of Regulations, Title 24, Part 1, Article 1: Locally Adopted Energy Standards.

This report presents the results from analysis of the feasibility and energy cost-effectiveness of requiring new low-rise residential construction to exceed the 2013 Building Energy Efficiency Standards by at least 15% in Climate Zone 12. The report documents three different cost-effective design packages that meet the 15% performance improvement for each of the building prototypes included in the study, showing the variety of different design options available to permit applicants to meet the requirements. The 2013 Building Energy Efficiency Standards, which took effect on July 1, 2014, are the baseline used to calculate the cost-effectiveness data.

A local government may use this report as a basis for demonstrating energy cost-effectiveness of a proposed green building or energy efficiency ordinance. The study assumes that such an ordinance requires, for the building categories covered, that building energy performance exceeds the minimum Title 24, Part 6 requirements by at least 15%, consistent with the voluntary Tier 1 Performance Standard in Title 24, Part 11 (CALGreen).

2.0 Methodology and Assumptions

The energy performance impacts of exceeding the low-rise residential requirements of the 2013 Title 24 Building Energy Efficiency Standards by 15% were evaluated in Climate Zone 12 (CZ12). The analysis uses the following single and multi-family residential prototype buildings used by the California Energy Commission (CEC) to evaluate the cost-effectiveness of proposed changes to the Title 24 requirements.

Small Single Family House 1-story 2,100 sf	**Large Single Family House** 2-story 2,700 sf
Low-rise Multi-Family Apartments 8 dwelling unit building, 2-story 6,960 sf (870 sf per dwelling unit)	

In looking at the single family cases, the CEC's standard protocol is to weight the simulated energy impacts of various measures by a factor that represents the breakdown of single-story and two-story homes being built statewide. Based on the CEC's assumed breakdown, the single family results assume 55% two-story and 45% single story. Simulation results in this study are therefore characterized based on the ratio of the two prototype homes, which is approximately equivalent to a 2,430 ft^2 house[1].

The CBECC-Res simulation tool (version 2013-4) was used to evaluate energy impacts in CZ12 using 2013 prescriptive standards as the benchmark, as well as 2013 time dependent valuation (TDV) values. TDV, the energy metric used by the CEC to evaluate compliance with the Energy Standards, accounts for the change in the value of energy used based on the time of use and coincident demand on the grid. The methodology used in the analyses for each of the prototypical building types begins with a design that precisely meets the minimum prescriptive requirements. Alternative packages of measures are then developed which exceed the 2013 Standards by 15%. The process includes the following major stages:

Stage 1: Demonstrate Compliance with 2013 Standards

Each prototype building design is tested for minimum compliance with the 2013 Standards, with basic CZ12 prescriptive features shown in Table 1 below. For each of the three building types, these features were simulated using the CBECC-Res software. Results were confirmed to be consistent with the standard design budget.

Table 1: CZ12 Prescriptive Assumptions for Key Measures

Measure	Single Family	Multi-Family
Attic Insulation	R-38	
2x4 Exterior Wall Insulation	R-15 + R-4 exterior	
Window Area as % of Floor Area	20%, equally distributed	15%, equally distributed
Glazing Properties (U-factor / SHGC)	0.32 / 0.25	
Duct R-value and Maximum Leakage	R-6 insulated ducts, 6% leakage	
Envelope Leakage	5.0 air changes per hour (ACH50)	
Water Heating*	0.60 EF atmospheric gas storage water heater	

*Assumes individual water heater serves each dwelling unit in both single and multi-family cases

[1] 2,430 = 0.45 x 2,100 + 0.55 x 2,700

Stage 2: Identify Prospective Measures and Typical Incremental Costs

Using the 2013 baseline as the starting point, prospective energy efficiency measures were identified and modeled in each of the prototypes to determine the projected energy (therm and kWh) and TDV (compliance) impacts. The goal of this effort was to identify measures that packaged together exceed the minimum code performance level by 15%. The design choices by the consultants authoring this study are based on many years of experience with architects, builders, mechanical engineers; and general knowledge of the relative acceptance and preferences of many measures, as well as their incremental costs. This approach tends to reflect how building energy performance is typically evaluated for code compliance and how it's used to select energy efficiency measures. Using the relative weighting of one and two-story new homes (45% one-story, 55% two-story), resulted in a "typical" savings estimate and TDV impact for each measure.

Table 2 below summarizes the measures modeled, including three measures that were deemed cost effective as part of the 2016 Title 24 Standards process and therefore constitute a cost effective 2013 solution. The three measures include:

1. Non-condensing gas tankless water heater (0.82 Energy Factor)
2. High Performance Attic (HPA)- HPA is a package of attic measures that minimizes the temperature difference between a traditional vented attic and the conditioned air in ducts. HPA includes adding R-13 insulation below the roof deck, raising the duct insulation level from R-6 to R-8, and lowering the total duct leakage rate from 6% to 5% of rated air handler airflow.
3. High Performance Walls (HPW)- This measure improves the performance of the residential envelope by increasing both the amount of wall cavity and exterior insulation in wall systems. The 2016 Standards prescribe a U-of 0.051 Btu/hr-ft^2-°F, which can be met with a 2x6 wall with R-21 batt insulation and R-4 exterior rigid insulation, or with other combinations of cavity and exterior insulation that result in the same or better U-factor.

Table 2: Summary of Measures Modeled

Measure	Estimated Cost	
	Single Family	Multi-Family (per dwelling unit)
Improved glazing (U-factor = 0.30 / SHCG = 0.23)	$73	$25 based on $0.15/ft^2 estimate. (Varies by vendor, but incremental cost is small as this level of performance has become standard.)
Quality insulation inspection (QII)	$659	Estimate $350 for multi-family unit; includes added labor + inspection costs.
5% duct leakage	$0. Results from CALCerts database indicate 5% is being regularly achieved.	$0. Results from CALCerts database indicate 5% is being regularly achieved.

Reduced envelope leakage (3.5 ACH50)	$377 includes added labor + inspection costs	Not applicable to multi-family
0.82 EF gas tankless water heater[2]	$725 (from 2016 CASE study)	$725 (from 2016 CASE-study)
High Performance Attic (HPA)[3]	$753 (from 2016 CASE study.)	$226/unit, based on relative roof area calculation between single and multi-family prototypes.
High Performance Walls (HPW)[4]	$967 (from 2016 CASE study)	$569/unit, based on relative exterior wall area calculation between single and multi-family prototypes.

[2] http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-21_workshop/final_case_reports/2016_Title_24_Final_CASE_Report_Res_IWH-Sep2014.pdf

[3] http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-21_workshop/final_case_reports/2016_Title_24_Final_CASE_Report_HPA-DCS-Oct2014.pdf

[4] http://www.energy.ca.gov/title24/2016standards/prerulemaking/documents/2014-07-21_workshop/final_case_reports/2016_T24_CASE_Report-High_Perf_Walls-Sep2014.pdf

Stage 3: Develop Packages Exceeding 2013 Standards by 15%

Starting with the 2013 prescriptive standard as the reference level, selected energy efficiency measures were modeled to assess the improvement in the compliance margin (percent savings) of each measure individually. Measures were then packaged to achieve a 15% beyond code performance level. Three packages were developed for both the single and multi-family building types. For each, the 2016 prescriptive Standard (HPA + HPW + 0.82 EF gas tankless water heater was one of the cases, since the rigorous 2016 Standards process indicated that this package was cost effective. Two additional packages were then developed, one of which included the 0.82 EF gas tankless water heater, and one that did not.

Table 3 provides a summary of the improvement beyond the standard budget (compliance margin) for each package, as well as the projected electricity and natural gas savings for CZ12. Note that multi-family results are shown for the eight unit prototype building, meaning that per unit impacts would be 1/8 of that shown in the table.

Table 3: CBECC-Res Projected Package Performance (CZ12)

Package	Description	Compliance Margin	Annual Projected Savings		Projected % Savings *	
		%	kWh	Therms	kWh	Therms
Single Family Prototype Building						
2016	HPW + HPA + 5% Duct Leakage + 0.82 EF Gas Tankless	24.2%	205	95.4	3.6%	19.2%
Water Heating	QII + 0.82 EF Gas Tankless	15.5%	75	90.5	1.3%	18.2%

Table 3: CBECC-Res Projected Package Performance (CZ12)						
Package	Description	Compliance Margin	Annual Projected Savings		Projected % Savings *	
		%	kWh	Therms	kWh	Therms
Envelope (no equipment upgrade)	0.30/0.23 Glazing + 5% Duct Leakage + QII + 3.5 ACH50	15.1%	159	51.1	2.8%	10.3%
Multi-Family Prototype Building						
2016	HPW + HPA + 5% Duct Leakage + 0.82 EF Gas Tankless	24.4%	530	497.4	2.0%	28.3%
Water Heating	QII + 0.82 EF Gas Tankless	15.4%	0	433.4	0.0%	24.7%
Envelope (no equipment upgrade)	0.30/0.23 Glazing + 5% Duct Leakage + QII + 3.5 ACH50	15.5%	824	143.0	3.2%	8.1%

*** Percent savings relative to regulated energy use (does not include lighting, plugs, & miscellaneous use)**

Stage 4: Cost Effectiveness Determination

Average PG&E residential utility rates are needed to complete a simple payback calculation for the proposed packages. Current PG&E electric rate schedules[2] as of November 3, 2015 were used to estimate a representative average electric rate of $0.176/kWh. (The average rate was determined by assuming that each month the household consumes 130% of the baseline usage level.) Gas rates were determined by looking at historical and forecast residential gas rates in PG&E territory[3]. For 2014, the average rate was $1.34 per therm, for 2015 a rate of $1.41 is projected, and for 2016 a rate of $1.58. The 2016 gas rate was used in this evaluation.

Table 4 summarizes the incremental cost for each package of measures and the energy bill savings per dwelling unit. Simple payback is calculated based on the incremental first cost divided by the annual bill savings to determine the number of years it will take for the measures to "pay for themselves". The 2016 package is the most costly, but generates the greatest percentage improvement beyond Title 24 and the greatest projected bill savings. The water heating package is the most cost effective, with multi-family showing slightly improved paybacks relative to single family since QII is not required to achieve the 15% performance level. The envelope package is less cost effective than the water heating package, especially in the multi-family case where water heating is the primary load and envelope improvements offer reduced savings potential.

[2] http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_E-1.pdf

[3] http://www.pge.com/nots/rates/tariffs/rateinfo.shtml#GRF

Table 4: Projected per unit Costs, Utility Bill Savings, and Simple Payback (years)			
Package	**Incremental First Cost ($)**	**Bill Savings ($/year)**	**Simple Payback (years)**
	Single Family		
2016 Package	$3,104	$187	16.6
Water Heating Package	$1,384	$156	8.9
Envelope Package	$1,109	$109	10.2
	Multi-Family (per dwelling unit)		
2016 Package	$1,520	$110	13.8
Water Heating Package	$725	$86	8.5
Envelope Package	$1,168	$46	25.1

3.0 Conclusion

For the standard prototypical designs evaluated here, the incremental improvement in overall annual energy performance of low-rise residential buildings which exceed the 2013 Title 24 Building Energy Efficiency Standards by 15% meets the CEC cost-effectiveness criteria. However, each building's overall design, operating conditions, and specific design choices may result some variability in incremental costs and the time required for payback. As with simply meeting the requirements of the Title 24 energy standards, a permit applicant complying with the energy requirements of a local energy efficiency or green building ordinance should carefully analyze the specific characteristics of the project to achieve the desired balance of building energy performance, incremental first cost and payback time for the required additional energy efficiency measures.