City and County of San Francisco

2013 San Francisco Green Building Code

Analysis of Cost Effectiveness of Energy Requirements

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Prepared for:

SF Environment
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1 Summary

This report presents the results of an energy savings and cost-effectiveness analysis conducted for the City and County of San Francisco, examining the cost-effectiveness of energy efficiency requirements of the San Francisco Green Building Code (2013). The San Francisco Green Building Code (2013) consists of California Green Building Standards Code Title 24 Part 11 (2013), known as CalGreen, and stricter local requirements established for San Francisco in 2008 and updated in 2010.

This report summarizes the cost-effectiveness of energy efficiency requirements for new low-rise residential buildings in San Francisco (or any community located in "Climate Zone 3" as defined by the California Energy Commission.) It is limited to new low-rise residential because the proposed San Francisco Green Building Code (2013) would continue to require such projects to achieve 75 points in GreenPoint Rated and all GreenPoint Rated prerequisites – including a significant cost-effective compliance margin over California's Title 24 Part 6 Energy Standards consistent with this analysis. Build It Green has confirmed that the prescriptive package of cost-effective measures in this report will be accepted as one cost-effective way to meet the minimum requirements of GreenPoint Rated. In practice, projects would continue to have the option of meeting this requirement through a performance-based energy model prepared in California Energy Commission approved energy modeling software, which allows tradeoffs among measures, provided that the resulting designed will consume at least 10% less energy than a similar building which minimally complies with the code.

This report is a part of the application from City of San Francisco to the California Energy Commission (CEC). It is intended to meet the requirements specified in Section 10-106 of the Title 24, Part 6: Locally Adopted Energy Standards, as follows:

> (a) Requirements. Local governmental agencies may adopt and enforce energy standards for newly constructed buildings, additions, alterations, and repairs to existing buildings provided the Energy Commission finds that the standards will require buildings to be designed to consume no more energy than permitted by Title 24, Part 6.
>
> (b) Documentation Application. Local governmental agencies wishing to enforce locally adopted energy standards shall submit an application with the following materials to the Executive Director:
>
> 1. The proposed energy standards.
>
> 2. The local governmental agency's findings and supporting analyses on the energy savings and cost effectiveness of the proposed energy standards.
>
> 3. A statement or finding by the local governmental agency that the local energy standards will require buildings to be designed to consume no more energy than permitted by Part 6.
>
> 4. Any findings, determinations, declarations or reports, including any negative declaration or environmental impact report, required pursuant to the California Environmental Quality Act, Pub. Resources Code Section 21000 et seq.

This report is also the first part of a broader analysis of the potential for cost effective energy efficiency in new construction in general under the 2013 Energy Standards. SF Environment and the Department of Building Inspection will share results of the broader analysis as they become available, as well as technical analysis of LEED v4, which will be optional until at least July 1, 2015. SF Environment prioritized analysis of energy efficiency opportunities in low-rise residential for two reasons:

1. Energy modeling software approved by the California Energy Commission was not available until September, while it was necessary to finalize the draft code by July 2013 in order for the San Francisco Green Building Code to be effective January 1, 2014. The 2013 California Energy Standards are more than 20% stricter than the prior 2010 Energy Standards – so every

project built to the 2013 Energy Standards will be held to a higher efficiency requirement than projects subject to San Francisco's 2010 green building requirements.

2. The San Francisco Green Building Code as proposed would continue to require LEED for Building Design & Construction (BD&C) v2009 rating system (or LEED Core & Shell, etc.) for any applicable non-residential new construction project.[1] In all cases, all projects applying for building permit on or after January 1, 2014 must meet the 2013 California Title 24 Energy Standards. However, for purposes of additionally meeting San Francisco's green building requirements (which extend to many considerations in addition to energy efficiency), LEED BD&C v2009 continues to allow energy efficiency calculations based on ASHRAE 90.1 (2007) or CA Title 24 (2005).[2] As a result, California's Title 24 (2013) Energy Standards are significantly stricter than the minimum requirements of LEED v2009. However, GreenPoint Rated New Home and LEED for Homes are the two rating systems applicable to new residential buildings of 3 floors or less, and both require energy efficiency beyond code compliance.

2 Costs and Savings Analysis

2.1 Base Building Models

Arup is performing a comparative analysis of energy savings and costs using four representative building energy models. Four key building types – single family residential, multifamily, large high-rise office, and low-rise retail – were chosen as representative of anticipated new construction in San Francisco. The baseline models have critical attributes consistent with Title 24 2013, which will become effective on January 1, 2014. Key building characteristics are described in Table 2 in Appendix 0.

2.2 Methods and Assumptions

Energy savings data was developed from energy modeling using an adapted version of EnergyPlus customized for the *Technical Feasibility of Zero Net Energy Buildings in California* Study (ZNE Tool), and cross-verified against results from Codes and Standards Enhancement (CASE) research done for Title 24 2013 development. Energy savings were estimated for a set of sample measures for each model in terms of the CEC approved 2013 Time Dependent Value energy (TDV). Energy and cost savings were scaled to a per-square-foot basis.

Incremental cost data was developed from existing CASE research, from RS Means, and from other sources where CASE data was not available. Cost data was scaled to a per-square-foot basis. Measures such as LED lighting, with long useful lives, were compared against the initial purchase price and eventual replacement cost of comparable equipment (such as a compact fluorescent lamp).

3 Results

3.1 Single Family and Multi-Family Residence

Table 1 shows the feasible energy savings measures beyond code that could be implemented in a low-rise residential building in San Francisco (CZ3). The analysis looked at both single family and multi-

[1] In the case of new high-rise residential, the San Francisco Green Building Code as proposed would continue to allow LEED BD&C v2009 or GreenPoint Rated as compliance options. For the reasons stated, projects that opt for LEED BD&C v2009 would not have mandatory energy efficiency requirements beyond Title 24 (2013) at this time.
[2] LEED v4 references ASHRAE 90.1 (2010), a substantially higher energy efficiency standard.

family prototypes. Percent savings are based off of a housing unit baseline energy consumption of 185,346 TDV kbtu. The group of measures is cost effective.

Table 1: Low-Rise Residence Energy Results

Prescriptive Measure List Description	Lifecycle Savings			First Costs	Lifecycle Benefit : Cost Ratio
	TDV kbtu	TDV Percent %	TDV $/sq ft.	$/sq. ft.	
Wall Insulation R-19 w/R-4ci, 2x6	2,321	1.3%	$0.19	$0.41	0.5
Showerheads 2.0 to 1.8 GPM	1,483	0.8%	$0.12	$0.02	5.1
Kitchen Sinks 1.5 to 1.4 GPM	556	0.3%	$0.05	$0.02	1.9
All Building LED High-Efficacy Lighting	4,887	2.6%	$0.40	$0.05	8.0
Natural Ventilation	3,707	2.0%	$0.30	$0.00	Large
Ducts in conditioned space*	1,199	0.6%	$0.10	$0.40	0.2
Reduced infiltration: 5 ACH50 to 3 ACH50*	4,032	2.2%	$0.33	$0.52	0.6
DHW Heat Recovery**	5,321	2.9%	$0.87	$0.22	4.1
Total Savings	23,506	13%	$2.36	$1.43	1.7

* Single Family Residential focused measures
** Multi-Family Residential focused measures

The package of measures in Table 1 represents one cost-effective path to attaining a substantial compliance margin over 2013 Title 24 Part 6 Energy Standards. Plumbing fitting flow rates, whole building LED high efficacy lighting, and natural ventilation are each anticipated to be afforded prescriptive credit toward the compliance margin due to limitations of commonly available compliance software.[3] In practice, projects may meet the requirement via other design solutions, which could for example include improved efficiency of mechanical equipment, on-site renewable energy generation,[4] or envelope improvements to Passive House standards.

3.2 High-Rise Office

High-Rise Office analysis is underway. Preliminary results indicate an energy efficiency compliance margin in excess of 10% is cost-effective. High rise residential will also be considered in this analysis.

3.3 Small Retail

Small retail analysis is underway. Preliminary results indicate an energy efficiency compliance margin in excess of 10% is cost-effective.

[3] Prescriptive compliance credit would solely be applicable to the required compliance margin, not to minimum compliance with Title 24 2013 Energy Standards.
[4] Photovoltaics and solar hot water heating have been recognized methods to meet San Francisco's supplemental energy performance requirements under the Green Building Ordinance since 2008.

A1 References

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National Renewable Energy Laboratory (NREL). National Residential Efficiency Measures Database. Accessed October 2013. http://www.nrel.gov/ap/retrofits/measures.cfm

RS Means Online. Accessed October 2013. www.meanscostworks.com

Measure Description	Data Source	URL
Wall Insulation: R-19 w/R-4ci, 2x6	Residential Increased Wall Insulation: 2013 California Building Energy Efficiency Standards California Utilities Statewide Codes and Standards Team. October 2011.	http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Envelope/2013_CASE_R_Increased_Wall_Insulation_Oct_2011.pdf
Showerhead: 2.0 to 1.8 GPM	Multi-Head Showers and Lower-Flow Shower Heads: 2013 California Building Energy Efficiency Standards California Utilities Statewide Codes and Standards Team. October 2011.	http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Water_Heating/2013_CASE_R_Shower_Heads_Sept_2011.pdf
Kitchen faucet: 1.5 to 1.4 GPM	Original calculation.	
Ducts in conditioned space	Davis Energy Group research: SFD-Residential EEM Cost_v2.xlsx	
Improve indoor lighting from 50 lm/W to 100 lm/W	Measure Information Template – Residential Lighting, California Building Energy Efficiency Standards California Utilities Statewide Codes and Standards Team. March 2011.	http://www.h-m-g.com/T24/Lighting/draft%20presentations%202011.03.11/Residential%20Lighting%20%20Draft%20CASE%20Report.pdf
Natural Ventilation	Remove cooling load.	
Reduced infiltration: 1.8 SLA / 3.15 ACH50	National Renewable Energy Laboratory (NREL). National Residential Efficiency Measures Database. Accessed October 2013.	http://www.nrel.gov/ap/retrofits/measures.cfm
Drain water heat recovery added	Are potential savings going down the drain? – Clean Energy Resource Team. July 2013.	http://s3.amazonaws.com/zanran_storage/www.duluthenergydesign.com/ContentPages/2489554523.pdf http://www.cleanenergyresourceteams.org/blog/are-potential-savings-going-down-drain

A2 Baseline Building Models

Table 2: Representative Baseline Buildings for Energy Reach Code Analysis

	Single-Family Residence	Multifamily	High-Rise Office	Small Retail
Area (sq. ft.)	2,116	84,360	498,600	22,500
Dimensions	46 ft x 46 ft	152 ft x 56 ft	240 ft x 160 ft	300 ft x 75 ft
Number of Levels	1	10	10 + 2 basement	1
Walls	2'x4', 16" o.c., R-15 w/R-4 rigid c.i. U = 0.065	R-13.0 + R-7.5 c.i. U = 0.064	R-13.0 + R-3.8 c.i. U = 0.084	R-13.0 + R-3.8 c.i. U = 0.084
Window to Wall Ratio (%)	25%	14.9%	40% above-grade	10.5% over all 26% south-facing
Window	U = 0.32 SHGC = 0.25	U = 0.65 SHGC = 0.25	U = 0.65 SHGC = 0.25	U = 0.65 SHGC = 0.25
Skylight	None	None	None	None
Roof	R-30 U = 0.031	R-20.0 c.i. U = 0.048	R-20.0 c.i. U = 0.048	R-20.0 c.i. U = 0.048
Heating System	Gas Furnace	WSHP with CAV	Boiler Hot Water VAV	Gas Furnace
Cooling System	DX PTAC	WHSP with CAV	Water-Cooled Chiller Chilled Water VAV	Packaged SZ CAV DX RTU
Interior Lighting Power Density (LPD)	NA High-efficacy lighting mandatory in many spaces Dimming or vacancy sensor mandatory in many spaces	Apartment: 0.35 W/sf Corridors: 0.55 W/sf Weighted: 0.38 W/sf	1.0 W/sf	High Retail: 2.28 W/sf Mid Retail: 1.7 W/sf Low Retail: 1.3 W/sf Weighted: 1.64 W/sf
Interior Plug Load Density (EPD)	NA	Weighted: 0.80 w/sf	Office: 0.75 W/sf Weighted: 0.727 W/sf	1.0 W/sf
Exterior Lighting Power Density (LPD)	None	13.58 kW installed	60.216 kW installed	9.153 kW installed
Base Total EUI (kbtu / sq. ft.)	24.9	30.4	26.8	45.0