City and County of San Francisco

2013 San Francisco Green Building Code

Analysis of Cost Effectiveness of Energy Requirements

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Arup North America Ltd
560 Mission Street
Suite 700
San Francisco 94105
United States of America

Prepared for:

SF Environment
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Contents

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 residential and commercial buildings in San Francisco (or any community located in "Climate Zone 3" as defined by the California Energy Commission.) The proposed San Francisco Green Building Code (2013) would continue to require such projects to achieve 75 points in the GreenPoint Rated standard and all GreenPoint Rated prerequisites. GreenPoint Rated v12 requires projects in Climate Zone 3 to attain at least a 10% energy efficiency compliance margin over Title 24 Part 6 (2013).

For residential buildings, this report presents a prescriptive list of cost-effective measures that together represent one cost-effective way to achieve this target. In practice, projects would continue to have the option of meeting this requirement through a performance-based energy model in standard California Energy Commission approved energy modeling software, which allows tradeoffs among measures, provided that the result is designed to consume at least 10% less energy than a similar building which minimally complies with the code.

For commercial buildings, this report describes measures that can be implemented using standard Title 24 performance compliance methods.

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 limited to the minimum requirements of the San Francisco Green Building Code that will be effective January 1, 2014. When available, SF Environment and the Department of Building Inspection will share a follow-up technical analysis of LEED v4, which will be optional until 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, 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 even projects in San Francisco under the 2010 GBO.

2. The San Francisco Green Building Code as proposed would continue to require[1] LEED for Building Design & Construction (BD&C) v2009 rating system (or LEED Core & Shell, etc.) for any applicable non-residential new construction project. LEED BD&C v2009 energy efficiency requirements are based on ASHRAE 90.1 (2007) or CA Title 24 (2005), and the Title 24 (2013) Energy Standards are significantly stricter in all cases 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 – a single-family residence, high-rise multifamily building, large high-rise office building, 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 4 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).

Discount rates used in the analysis are those embedded in the TDV values, or 3%. Consistent with the CEC cost-effectiveness calculation methodologies, residential measures and commercial envelope measures were analyzed using 30 year measure lives, and other measures were analyzed using 15 year measure lives. Exceptions were taken to these general rules where appropriate.

[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).

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-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 Residential 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

3.1.1 High-Rise Residential

High-rise residential buildings generally need to comply with the nonresidential provisions of Title 24 Part 6. This requirement is driven by the types of envelope and HVAC systems in high-rise residential buildings, which tend to be similar to those in commercial buildings. As such, the performance targets for such buildings are outlined below, as specified for nonresidential buildings.

3.2 High-Rise Office

Table 2 shows the feasible energy savings measures beyond code that could be implemented in a high-rise office building in San Francisco. Percent savings are based off of a complete building energy consumption of 147,288,390 TDV kbtu. The group of measures is cost effective.

Table 2: High-Rise Office Energy

ResultsPrescriptive Measure List Description	Lifecycle Savings TDV kbtu	TDV Percent %	TDV $/sq ft.	First Costs $/sq. ft.	Lifecycle Benefit : Cost Ratio
High Efficiency Cooling Towers (80 gpm/hp)	2,240,980	2%	$0.40	$0.31	1.3
25% reduction in General LPDs	16,011,813	11%	$1.43	$2.00	0.7
Prescriptive Window-Wall-Ratio Decrease to 35%	3,305,445	2%	$1.18	NA	Large
Total Savings	**21,558,238**	**15%**	**$3.01**	**$2.31**	**1.3**

3.3 Small Retail

Table 3 shows the feasible energy savings measures beyond code that could be implemented in a retail building in San Francisco (CZ3). Percent savings are based on a whole building energy consumption level of 10,964,721 TDV kbtu. The group of measures is cost effective.

Table 3: Small Retail Energy Results

Prescriptive Measure List Description	Lifecycle Savings TDV kbtu	TDV Percent %	TDV $/sq ft.	First Costs $/sq. ft.	Lifecycle Benefit : Cost Ratio
40% reduction in Retail LPDs;	1,388,076	13%	$4.75	$4.00	1.2
Low-Slope Cool Roofs (R=0.67)	69,132	1%	$0.47	$0.50	0.9
Total Savings	**1,457,208**	**13%**	**$5.22**	**$4.50**	**1.2**

A1 References

Arup. The Technical Feasibility of Zero Net Energy Buildings in California. Prepared for Pacific Gas and Electric Company. December 31, 2012. http://www.energydataweb.com/cpucFiles/pdaDocs/904/California_ZNE_Technical_Feasibility_Report_Final.pdf

Codes and Standards Enhancement Initiative (CASE). Indoor Lighting – Retail: 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/Nonresidential/Lighting_Controls_Bldg_Power/2013_CASE_NR_Retail_Tailored_Lighting_Oct_2011.pdf

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DOE Commercial Prototype Building Models. U.S. Department of Energy (DOE). Accessed October 2013. http://www.energycodes.gov/development/commercial/90.1_models

DOE Solid-State Lighting Research and Development Multi-Year Program Plan. April 2013. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2013_web.pdf

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
Lavatory: 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
Commercial LED Lighting	DOE Solid-State Lighting Research and Development Multi-Year Program Plan. April 2013	http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2013_web.pdf
High Efficiency Cooling Towers	Draft Measure Information Template – Cooling Tower Efficiency and Turndown	http://www.h-m-g.com/T24/ASHRAE/2013_CASE_CoolingTowerEfficiency_042611_v2.pdf
Commercial Cool Roof	Nonresidential Cool Roofs	Draft Measure Information Template – Cooling Tower Efficiency and Turndown

A2 Baseline Building Models

Table 4: Representative Baseline Buildings for Energy Reach Code Analysis

	Single-Family Residence	High-Rise 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