

Codes and Standards Title 24 Energy-Efficient Local Ordinances

Title: San Mateo County Green Building Ordinance Energy Cost-Effectiveness Study

Prepared for:

County of San Mateo

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Last Modified: December 31, 2009



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1.0 Executive Summary

This report presents the results of Gabel Associates' research and review of the feasibility and energy cost-effectiveness of building permit applicants exceeding the 2008 Building Energy Efficiency Standards to meet the minimum energy-efficiency requirements of a proposed San Mateo County-wide ordinance for local energy efficiency standards. The proposed ordinance states that residential new construction projects must meet the overall requirements summarized in the Resolution printed on the following pages.

The study contained in this report shall be included in any application to the California Energy Commission (CEC) by any local government in San Mateo County which must meet the requirements specified in Section 10-106 of the California Code of Regulations, Title 24, Part 1, **LOCALLY ADOPTED ENERGY STANDARDS**. Any local ordinance shall be enforceable only after the CEC has reviewed and approved the local energy standards as meeting all requirements of Section 10-106; and the ordinance has been adopted by the local jurisdiction and filed with the Building Standards Commission.

The 2008 Building Energy Efficiency Standards, effective January 1, 2010, are the baseline used to calculate the cost-effectiveness of the proposed Ordinance.

2.0 Impacts of the New Ordinance

The energy performance impacts of a proposed green building ordinance have been evaluated in Climate Zone 3 using several prototypical designs which collectively reflect a broad range of building types, including:

- Single family house: 2-story 1,582 sf
- Single family house: 2-story 2,025 sf
- Low-rise Multi-family building, 8 dwelling units: 2-story 8,442 sf
- High-rise Multi-family building, 40 dwelling units: 4-story 36,800 sf
- Nonresidential office building: 2-story, 21,160 sf
- Nonresidential office building: 5-story, 52,900 sf

The methodology used in the case studies is based on a design process for buildings that meet or exceed the energy standards, and includes the following:

- (a) Each prototype building design is tested for compliance with the 2008 Standards, and the mix of energy measures are adjusted using common construction options so the building first just meets the Standards. The set of energy measures chosen represent a reasonable combination which reflects how designers, builders and developers are likely to achieve a specified level of performance using a relatively low first incremental (additional) cost
- (b) Starting with that set of measures which is minimally compliant with the 2008 Standards, various energy measures are upgraded so that the building just meets the minimum energy performance required by the proposed Ordinance (e.g., 15% better than 2008 Title 24). The design choices by the consultant 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 design energy efficiency measures. Note that lowest simple payback with respect to building site energy is not always the primary focus of selecting measures; but rather the requisite reduction of Title 24 Time Dependent Valuation(TDV) energy at a reasonably low incremental cost consistent with other non-monetary but important design considerations.
- (c) A minimum and maximum range of incremental costs of added energy efficiency measures is established by a variety of research means. A construction cost estimator, Building Advisory LLC, was contracted to conduct research to obtain current measure cost information for many energy measures; and Gabel Associates performed its own additional research to establish first cost data. Site energy in kWh and therms, is calculated from the Title 24 simulation results to establish the annual energy savings, energy cost savings and CO₂-equivalent reductions in greenhouse gases.

2.1 Single Family Homes

The following energy design descriptions of single family building prototypes just meet the 2008 Title 24 Building Energy Efficiency Standards in **Climate Zone 3**:

CZ3: Single Family House 1,582 square feet, 2-story, 14.3% glazing/floor area ratio

Energy Efficiency Measures to Meet Title 24
R-38 Roof w/ Radiant Barrier
R-13 Walls
R-19 Raised Floor
Low E2 Vinyl Windows, U=0.36, SHGC=0.30; no overhangs
Furnace: 80% AFUE; No Cooling
R-6 Attic Ducts
50 gallon Gas DHW: EF=0.58; no extra pipe insulation

CZ3: Single Family House 2,025 square feet, 2-story, 20.2% glazing/floor area ratio

Energy Efficiency Measures to Meet Title 24
R-38 Roof w/ Radiant Barrier
R-13 Walls
R-19 Raised Floor
Low E2 Vinyl Windows, U=0.40, SHGC=0.40; no overhangs
Furnace: 80% AFUE; No Cooling
R-6 Attic Ducts
50 gallon Gas DHW: EF=0.62; no extra pipe insulation

Climate Zone 3 Energy Efficiency Measures Needed to Meet the Ordinance

The following tables list the energy features and/or equipment included in the Title 24 base design, the efficient measure options, and an estimate of the incremental cost for each measure included **to improve the building performance to use 15% less TDV energy than the corresponding Title 24 base case design.**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 1,582 SF, Option 1

Climate Zone 3

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
Furnace: 92% AFUE	Upgrade	\$ 500	\$ 1,200	\$ 850
Reduced Duct Leakage/Testing (HERS)	Upgrade	\$ 300	\$ 600	\$ 450
House wrap: 1,116 sf @ \$0.08 to \$0.12/sf	Upgrade	\$ 90	\$ 135	\$ 113
R-49 roof insulation: 1,582 sf \$0.19 to \$0.22/sf	Upgrade	\$ 300	\$ 350	\$ 325
50 gallon DHW: EF=0.62 (from EF=0.58)	Upgrade	\$ 100	\$ 200	\$ 150
R-15 Wall Insulation: 1,116 sf @ \$0.06 to \$0.08/sf	-	\$ -	\$ -	\$ -
All DHW Pipe Insulation	-	\$ -	\$ -	\$ -
Total Incremental Cost of Energy Efficiency Measures:		\$ 1,290	\$ 2,485	\$ 1,888
Total Incremental Cost per Square Foot:		\$ 0.82	\$ 1.57	\$ 1.19

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Option 1

Climate Zone 3

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
Furnace: 92% AFUE	Upgrade	\$ 500	\$ 1,200	\$ 850
Reduced Duct Leakage/Testing (HERS)	Upgrade	\$ 300	\$ 600	\$ 450
House wrap: 1,116 sf @ \$0.08 to \$0.12/sf	Upgrade	\$ 205	\$ 305	\$ 255
R-49 roof insulation: 1,443 sf \$0.19 to \$0.22/sf	-	\$ -	\$ -	\$ -
50 gallon DHW: EF=0.62 (from EF=0.58)	-	\$ -	\$ -	\$ -
R-15 Wall Insulation: 2,550 sf @ \$0.06 to \$0.08/sf	-	\$ -	\$ -	\$ -
All DHW Pipe Insulation	-	\$ -	\$ -	\$ -
Total Incremental Cost of Energy Efficiency Measures:		\$ 1,005	\$ 2,105	\$ 1,555
Total Incremental Cost per Square Foot:		\$ 0.50	\$ 1.04	\$ 0.77

2.2 Low-rise Multi-family Residential Building

The following is the energy design description of the low-rise multifamily building prototype which just meets the 2008 Title 24 Building Energy Efficiency Standards:

CZ3: Low-rise Multi-family: 2-story 8,442 square feet, 8 units, 12.5% glazing

Energy Efficiency Measures to Meet Title 24
R-38 Roof w/ Radiant Barrier
R-13 Walls
Slab-on-grade 1st floor
Low E2 Vinyl Windows, U=0.39, SHGC=0.33; no overhangs
Furnace: 80% AFUE; No Cooling
R-6 Attic Ducts
50 gallon Gas DHW: EF=0.575; no extra pipe insulation

Climate Zone 3 Energy Measures Needed to Meet the Ordinance

Incremental Cost Estimate to Exceed Title 24 by 15%
Multifamily Prototype: 8,442 SF, Option 1

Climate Zone 3

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
Furnace: (8) @ 92% AFUE	Upgrade	\$ 4,000	\$ 9,600	\$ 6,800
Reduced Duct Leakage/Testing (HERS)	Upgrade	\$ 2,000	\$ 4,000	\$ 3,000
House wrap: 9,266 sf @ \$0.08 to \$0.12/sf	Upgrade	\$ 745	\$ 1,115	\$ 930
R-49 roof insulation: 2,880 sf \$0.19 to \$0.22/sf	Upgrade	\$ 550	\$ 635	\$ 593
50 gallon DHW: EF=0.62 (from EF=0.58)	-	\$ -	\$ -	\$ -
R-15 Wall Insulation: 9,266 sf @ \$0.06 to \$0.08/sf	Upgrade	\$ 560	\$ 745	\$ 653
All DHW Pipe Insulation	-	\$ -	\$ -	\$ -
Total Incremental Cost of Energy Efficiency Measures:		\$ 7,855	\$ 16,095	\$ 11,975
Total Incremental Cost per Square Foot:		\$ 0.93	\$ 1.91	\$ 1.42

2.3 High-rise Multifamily Building

The following is the energy design description of the high-rise multifamily building prototype which just meets the 2008 Title 24 Building Energy Efficiency Standards:

CZ3: High-rise Residential: 4-story 36,800 sf, 40 units, Window Wall Ratio=35.2%

Energy Efficiency Measures to Meet Title 24
R-30 Attic w/ Cool Roof Reflectance=0.30, Emittance=0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) raised slab over parking garage
Low E2 Vinyl Windows, U=0.33, SHGC=0.30 (see Note 1)
Split heat pumps: HSPF=7.2, EER=10.2
Central domestic DHW boiler: 82.7% AFUE and recirculating system w/ timer-temperature controls & VSD hot water pump

Note 1: Includes a small amount of fixed overhangs above first floor front fenestration

CZ 3: Energy Measures Needed to Meet the County's Ordinance

See Section 2.1 for the description of the approach used to establish which energy measures are used to meet the proposed Ordinance for this prototype building design.

Incremental Cost Estimate to Exceed Title 24 by 15% High-rise Residential Prototype: 36,800 SF, Option 1

Climate Zone 3

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Attic; Cool Roof Reflectance=0.30, Emittance=0.75	-	\$ -	\$ -	\$ -
R-19 in Metal Frame Walls	-	\$ -	\$ -	\$ -
R-3 (1" K-13 spray-on) Raised Slab over parking garage 9,200 sf @ \$1.20 to \$1.50/sf	Upgrade	\$ 11,040	\$ 13,800	\$ 12,420
Vinyl Windows, NFRC U=0.33, SHGC=0.23; 6,240 sf @ \$1.40 to \$1.60/sf	Upgrade	\$ 8,425	\$ 9,360	\$ 8,893
(80) Room Heat Pumps: HSPF=7.84, eer=11.2 (No Ducts) @ \$150 to \$250/unit	Upgrade	\$ 12,000	\$ 20,000	\$ 16,000
(2) 94% AFUE DHW boilers @ \$1500 to \$2500 each	Upgrade	\$ 3,000	\$ 5,000	\$ 4,000
Total Incremental Cost of Energy Efficiency Measures:		\$ 34,465	\$ 48,160	\$ 41,313
Total Incremental Cost per Square Foot:		\$ 0.94	\$ 1.31	\$ 1.12

2.4 Nonresidential Buildings

The following energy design descriptions of nonresidential building prototypes just meet the 2008 Title 24 Building Energy Efficiency Standards in **Climate Zone 3**:

CZ3: Nonresidential 2-story office building: 21,160 sf, Window Wall Ratio= 37.1%

Energy Efficiency Measures to Meet Title 24

R-38 Attic w/ No Cool Roof
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Windows NFRC U=0.50 and SHGCc=0.38, no exterior shading
(248) 2-lamp 4' T8 fixtures, 62w each; and (104) 26w CFLs
@ 26w each; no lighting controls (beyond mandatory)
(4) 10-ton Packaged DX units EER=11.0, 4,000 cfm; and
(4) 7.5-ton Packaged DX units EER=11.0, 3,000 cfm;
all standard efficiency fan motors
R-4.2 duct insulation w/ ducts in conditioned space
Standard 50 gallon gas water heater, EF=0.575

CZ3: Nonresidential 5-story office building: 52,900 sf, Window Wall Ratio= 29.1%

Energy Efficiency Measures to Meet Title 24

R-30 Attic w/ No Cool Roof
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Windows NFRC U=0.50 and SHGCc=0.38, no exterior shading
(720) 2-lamp 4' T8 fixtures w/ high efficiency instant start ballasts
& premium lamps, 50w; and (260) 26w CFLs @ 26w
each; no lighting controls (beyond mandatory)
(5) 30-ton Packaged VAV units EER=10.4, 10,000 cfm; 20% VAV
boxes w/ reheat; all standard efficiency fan motors
R-4.2 duct insulation w/ ducts in conditioned space
Standard hot water boiler, AFUE=80%

CZ3: Nonresidential 2-story office building: 21,160 sf, Window Wall Ratio= 37.1%

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 21,160 SF, Option 1

Climate Zone 3

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Attic + R-10 rigid insulation w/ Cool Roof Reflectance = 0.70, Emittance = 0.75; 10,580 sf @ \$1.75 to \$2.35/sf	Upgrade	\$ 18,515	\$ 24,865	\$ 21,690
R-19 in Metal Frame Walls	-	\$ -	\$ -	\$ -
R-0 (un-insulated) slab-on-grade 1st floor				
Windows, NFRC U=0.50, SHGC=0.31; 5,160 sf @ \$2.00 to \$3.00/sf	Upgrade	\$ 10,320	\$ 15,480	\$ 12,900
(248) 2-lamp 4' T8 fixtures w/ high efficiency instant start ballasts & premium lamps, 50w @ \$25.00 - \$30.00 each	Upgrade	\$ 6,200	\$ 7,440	\$ 6,820
(64) [26% of] 2-lamp 4' T8 fixtures on (32) multi-level occupant sensors in small offices @ \$65.00 to \$85.00 each	Upgrade	\$ 2,080	\$ 2,720	\$ 2,400
(24) additional recessed CFL fixtures w/ all CFLs 18w lamps @ \$175 to \$250 each	Upgrade	\$ 4,200	\$ 6,000	\$ 5,100
(4) 10-ton Packaged DX units EER=11.0, 4,000 cfm; (4) 7.5-ton Packaged DX units EER=11.0, 3,000 cfm; and (8) Premium Efficiency fan motors @ \$100 to \$200 each	Upgrade	\$ 800	\$ 1,600	\$ 1,200
R-4.2 duct insulation w/ ducts in conditioned space	-	\$ -	\$ -	\$ -
Standard 50 gallon gas water heater, EF=0.575	-	\$ -	\$ -	\$ -
Total Incremental Cost of Energy Efficiency Measures:		\$ 42,115	\$ 58,105	\$ 50,110
Total Incremental Cost per Square Foot:		\$ 1.99	\$ 2.75	\$ 2.37

CZ3: Nonresidential 5-story office building: 52,900 sf, Window Wall Ratio= 29.1%

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 1

Climate Zone 3

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Attic w/ No Cool Roof	-	\$ -	\$ -	\$ -
R-19 in Metal Frame Walls	-	\$ -	\$ -	\$ -
R-0 (un-insulated) slab-on-grade 1st floor				
Windows NFRC U=0.50 and SHGC=0.38, no exterior shading	-	\$ -	\$ -	\$ -
(720) 2-lamp 4' T8 fixtures w/ high efficiency instant start ballasts & premium lamps, 50w @ \$25.00 - \$30.00 each	Upgrade	\$ 18,000	\$ 21,600	\$ 19,800
(240) 33% of] 2-lamp 4' T8 fixtures on (120) multi-level occupant sensors in small offices @ \$65.00 to \$85.00 each	Upgrade	\$ 7,800	\$ 10,200	\$ 9,000
(40) additional recessed CFL fixtures w/ all CFLs 18w lamps @ \$175 to \$250 each	Upgrade	\$ 7,000	\$ 10,000	\$ 8,500
(5) 10-ton Packaged DX units, EER= 11.0 w/ Premium fan motors @ \$10,800 to \$15,600 ea,	Upgrade	\$ 54,000	\$ 78,000	\$ 66,000
R-4.2 duct insulation w/ ducts in conditioned space	-	\$ -	\$ -	\$ -
Standard hot water boiler, AFUE=80%	-	\$ -	\$ -	\$ -
Total Incremental Cost of Energy Efficiency Measures:		\$ 86,800	\$ 119,800	\$ 103,300
Total Incremental Cost per Square Foot:		\$ 1.64	\$ 2.26	\$ 1.95

3.0 Cost Effectiveness

The summary of results in this section are based upon the following assumptions:

- Annual site electricity (kWh) and natural gas (therms) saved are calculated using a beta version of the state-approved energy compliance software for the 2008 Building Energy Efficiency Standards, Micropas 8.
- Average utility rates of \$0.173/kWh for electricity and \$1.15/therm for natural gas in current constant dollars
- No change (i.e., no inflation or deflation) of utility rates in constant dollars
- No increase in summer temperatures from global climate change

The Simple Payback data includes a cost-effectiveness analysis of the Ordinance with respect to each case study building design and assumes:

- No external cost of global climate change -- and corresponding value of additional investment in energy efficiency and CO2 reduction – is included
- The cost of money (e.g, opportunity cost) invested in the incremental cost of energy efficiency measures is not included.

3.1 New Single Family Houses

Climate Zone 3: 15% Better Than Title 24 Single Family

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost (\$)	Annual Energy Cost Savings (\$)	Simple Payback (Years)
1,582 sf (Option 1)	63	67	\$1,888	\$88	21.5

Annual Reduction in CO2-equivalent: *808 lb./building-year*
0.51 lb./sq.ft.-year

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost (\$)	Annual Energy Cost Savings (\$)	Simple Payback (Years)
2,025 sf (Option 1)	81	88	\$1,555	\$115	13.5

Annual Reduction in CO2-equivalent: *1,061 lb./building-year*
0.52 lb./sq.ft.-year

3.2 Low-rise Multi-family Building

Climate Zone 3: 15% Better Than Title 24

Low-rise Apartments

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost (\$)	Annual Energy Cost Savings (\$)	Simple Payback (Years)
8,442 sf (Option 1)	363	318	\$11,975	\$428	27.9

*Annual Reduction in CO2-equivalent: 3,865 lb./building-year
0.46 lb./sq.ft.-year*

3.3 High-rise Multi-family Building

Climate Zone 3: 15% Better Than Title 24

High-rise Apartments

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost (\$)	Annual Energy Cost Savings (\$)	Simple Payback (Years)
36,800 sf (Option 1)	10032	179	\$40,513	\$1,941	20.9

*Annual Reduction in CO2-equivalent: 6,598 lb./building-year
0.18 lb./sq.ft.-year*

3.4 Nonresidential Buildings

Climate Zone 3: 15% Better Than Title 24

2-Story Office Building

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost (\$)	Annual Energy Cost Savings (\$)	Simple Payback (Years)
21,160 sf (Option 1)	19294	-75	\$49,670	\$3,252	15.3

*Annual Reduction in CO2-equivalent: 7,809 lb./building-year
0.37 lb./sq.ft.-year*

Climate Zone 3: 15% Better Than Title 24

5-Story Office Building

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost (\$)	Annual Energy Cost Savings (\$)	Simple Payback (Years)
52,900 sf (Option 1)	47039	1450	\$92,300	\$9,805	9.4

*Annual Reduction in CO2-equivalent: 38,046 lb./building-year
0.72 lb./sq.ft.-year*

Conclusions

Regardless of the building design, occupancy profile and number of stories, the incremental improvement in overall annual energy performance of buildings under green building ordinances within San Mateo County and the 2008 Title 24 Building Energy Efficiency Standards appears cost-effective. However, each building's overall design, occupancy type and specific design choices may allow for a large range of incremental first cost and payback. As with simply meeting the requirements of the Title 24 energy standards, a permit applicant complying with the energy requirements of a green building ordinance within San Mateo County should carefully analyze building energy performance to reduce incremental first cost and the payback for the required additional energy efficiency measures.