Attachment B

Codes and Standards
Title 24 Energy-Efficient Local Ordinances

Title:
Climate Zone 12
Energy Cost-Effectiveness Study

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Last Modified: February 1, 2010

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February 1, 2010

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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 local energy efficiency standards covering Climate Zone 12. A local government may use this report as a basis for demonstrating energy cost-effectiveness of a proposed green building or energy ordinance. The study assumes that such an ordinance requires, for the building categories covered, that building energy performance exceeds the 2008 TDV energy standard budget by at least 15%.

The study is also contained in the local government's application to the California Energy Commission (CEC) which 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. An ordinance shall be legally enforceable (a) after the CEC has reviewed and approved the local energy standards as meeting all requirements of Section 10-106; and (b) the ordinance has been adopted by the local government and filed with the Building Standards Commission.

The 2008 Building Energy Efficiency Standards, which took effect on January 1, 2010, are the baseline used to calculate the cost-effectiveness data.

2.0 Methodology and Assumptions

The energy performance impacts of exceeding the performance requirements of the 2008 Title 24 Building Energy Efficiency Standards (2008 Standards) have been evaluated in Climate Zone 12 using the following residential and nonresidential prototypical building types:

Small Single Family House 2-story 2,025 sf	**Large Single Family House** 2-story 4,500 sf
Low-rise Multi-family Apartments 8 dwelling units/2-story 8,442 sf	**High-rise Multi-family Apartments** 40 dwelling units/4-story 36,800 sf
Low-rise Office Building 1-story 10,580 sf	**High-rise Office Building** 5-story 52,900 sf

Methodology

The methodology used in the case studies is based on a design process for each of the proposed prototypical building types that first meets the minimum requirements and then exceeds the 2008 Standards by 15%. The process includes the following major stages:

Stage 1: Minimum Compliance with 2008 Standards:

Each prototype building design is tested for minimum 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.

Stage 2: Incremental Cost for Exceeding 2008 Standards by 15%:

Starting with that set of measures which is minimally compliant with the 2008 Standards, various energy measures are upgraded so that the building just exceeds the 2008 Standards by 15%. 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 the primary focus of selecting measures; but rather the requisite reduction of Title 24 Time Dependent Valuation(TDV) energy at a reasonable incremental cost consistent with other non-monetary but important design considerations. 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.

Stage 3: Cost Effectiveness Determination:

Energy savings in kWh and therms is calculated from the Title 24 simulation results to establish the annual energy cost savings and CO_2-equivalent reductions in greenhouse gases. A simple payback analysis in years is calculated by dividing the incremental cost for exceeding the 2008 Standards by the estimated annual energy cost savings.

Assumptions

Annual Energy Cost Savings

1. Annual site electricity (kWh) and natural gas (therms) saved are calculated using Micropas 8, state-approved energy compliance software for the 2008 Building Energy Efficiency Standards.

2. Average residential utility rates of $0.18/kWh for electricity and $1.20/therm for natural gas in current constant dollars; nonresidential rates are time-of-use rate schedules modeled explicitly in the DOE-2.1E computer simulation: PG&E E-19-P schedule for electricity and PG&E G-NR1 schedule for natural gas.

3. No change (i.e., no inflation or deflation) of utility rates in constant dollars

4. No increase in summer temperatures from global climate change

Simple Payback Analysis

1. No external cost of global climate change -- and corresponding value of additional investment in energy efficiency and CO_2 reduction – is included

2. The cost of money (e.g., opportunity cost) invested in the incremental cost of energy efficiency measures is not included.

3.0 Minimum Compliance with 2008 Standards

The following energy design descriptions of the following building prototypes just meet the 2008 Standards in Climate Zone 12.

Small Single Family House

- 2,025 square feet
- 2-story
- 20.2% glazing/floor area ratio

Energy Efficiency Measures
R-30 Roof w/ Radiant Barrier
R-13 Walls
R-19 Raised Floor over Garage/Open at 2nd Floor
R-0 Slab on Grade
Quality Insulation Installation (HERS)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER, 11 EER (HERS)
Air Conditioner: Refrig. Charge (HERS)
R-6 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
50 Gallon Gas Water Heater: EF=0.62

Large Single Family House

- 4,500 square feet
- 2-story
- 22.0% glazing/floor area ratio

Energy Efficiency Measures
R-30 Roof w/ Radiant Barrier
R-13 Walls
R-30 Raised Floor
Quality Insulation Installation (HERS)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(2) Furnaces: 80% AFUE
(2) Air Conditioner: 13 SEER, 11 EER (HERS)
(2) Air Conditioners: Refrig. Charge (HERS)
R-8 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
(2) Instantaneous Gas Water Heater: RE=0.80

Low-rise Multi-family Apartments

- 8,442 square feet
- 8 units/2-story
- 12.5% glazing/floor area ratio

Energy Efficiency Measures
R-38 Roof w/ Radiant Barrier
R-13 Walls
R-0 Slab on Grade
Quality Insulation Installation (HERS)
Super Low E Vinyl Windows, U=0.36, SHGC=0.23
(8) Furnaces: 80% AFUE
(8) Air Conditioners: 13 SEER, 11 EER (HERS)
R-6 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
(8) 40 Gallon Gas Water Heaters: EF=0.63

High-rise Multifamily Apartments

- 36,800 sf,
- 40 units
- 4-story
- Window to Wall Ratio = 35.2%

Energy Efficiency Measures to Meet Title 24
R-19 Metal Roof w/ R-10 (2") rigid insulation; Cool Roof Reflectance=0.30, Emittance=0.75
R-19 in Metal Frame Walls
R-4 (1.25") Raised Slab over parking garage
Dual Metal Windows: default U-factor=0.79, COG SHGC=0.65
4-pipe fan coil, 80% AFUE boiler, 80-ton scroll air cooled chiller 0.79 KW/ton
Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls

Low-rise Office Building for all these, please capitalize "W" (for watt)

- Single Story
- 10,580 sf,
- Window to Wall Ratio = 37.1%

Energy Efficiency Measures to Meet Title 24
R-30 under Metal Deck + R-7.5 (1.5" rigid); no cool roof
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Metal windows: Default glazing U=0.71, COG SHGC=0.54
Lighting = 0.858 w/sf: Open Office Areas: (60) 2-lamp T8 fixtures @58w each; (24) 18w recessed CFLs no lighting controls. Small Offices: (48) 2-lamp T8 fixtures; (40) 18w recessed CFLs, no controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.
(3) 10-ton DX units EER=11.0; 80% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage
(1) 50 gallon or less tank Gas Water Heaters EF=0.575

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 34.5%

Energy Efficiency Measures to Meet Title 24
R-19 under Metal/Conc. Deck, no cool roof
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Metal windows: COG U=0.30, COG SHGC=0.38
Lighting = 0.753 w/sf: Open Office Areas: (160) HO 2-lamp T8 fixtures @74w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.
(5) 35-ton Packaged VAV EER=10.0; 81% TE furnaces; standard efficiency variable speed fan motors; differential temp. integrated air economizers; 20% VAV boxes, reheat on perimeter zones with hot water
R-8 duct insulation w/ ducts in conditioned
Standard Tank Gas Water Heaters EF=0.58

4.0 Incremental Cost to Exceed 2008 Standards by 15%

The following tables list the energy features and/or equipment included in the 2008 Standards 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**.

Small Single Family House

- 2,025 square feet
- 2-story
- 20.2% glazing/floor area ratio

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Option 1 **2025 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-21 Walls (from R-13): 2,550 sf @ $0.45 to $0.70/sf	Upgrade	$ 1,148	$ 1,785	$ 1,466
R-30 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.25 to $0.35/sf	Upgrade	$ 112	$ 157	$ 134
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
Air Conditioner: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,260**	**$ 1,942**	**$ 1,601**
Total Incremental Cost per Square Foot:		**$ 0.62**	**$ 0.96**	**$ 0.79**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Option 2 **2025 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-13): 2,550 sf @ $0.31 to $0.54/sf	Upgrade	$ 791	$ 1,377	$ 1,084
R-30 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.25 to $0.35/sf	Upgrade	$ 110	$ 157	$ 133
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23 (from Low E2, U=0.36, SHGC=0.30): 409 sf @ $1.40 - $1.75 / sf	Upgrade	$ 573	$ 716	$ 644
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
Air Conditioner: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,473**	**$ 2,250**	**$ 1,861**
Total Incremental Cost per Square Foot:		**$ 0.73**	**$ 1.11**	**$ 0.92**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Option 3 **2025 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-21 Walls (from R-13): 2,550 sf @ $0.45 to $0.70/sf	Upgrade	$ 1,148	$ 1,785	$ 1,466
R-19 Raised Floor over Garage/Open at 2nd Floor	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Eliminate Quality Insulation Installation (HERS)	Downgrade	$ (600)	$ (450)	$ (525)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 92% AFUE (from 80% AFUE)	Upgrade	$ 500	$ 1,200	$ 850
Air Conditioner: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
Air Conditioner: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts (from R-6)	Upgrade	$ 225	$ 325	$ 275
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,273**	**$ 2,860**	**$ 2,066**
Total Incremental Cost per Square Foot:		**$ 0.63**	**$ 1.41**	**$ 1.02**

Large Single Family House

- 4,500 square feet
- 2-story
- 22.0% glazing/floor area ratio

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 4,500 SF, Option 1 **4500 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-13): 2,518 sf @ $0.31 to $0.54/sf	Upgrade	$ 781	$ 1,360	$ 1,070
R-30 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23 (from Low E2, U=0.36, SHGC=0.30): 990 sf @ $1.40 - $1.75 / sf	Upgrade	$ 1,386	$ 1,733	$ 1,559
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(2) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) Instantaneous Gas Water Heater: RE=0.80	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 2,167**	**$ 3,092**	**$ 2,629**
Total Incremental Cost per Square Foot:		**$ 0.48**	**$ 0.69**	**$ 0.58**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 4,500 SF, Option 2 **4500 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/ Radiant Barrier): 2,700 sf @ 0.15 to 0.20/sf	Upgrade	$ 405	$ 540	$ 473
R-21 Walls (from R-13): 2,518 sf @ $0.45 to $0.70/sf	Upgrade	$ 1,133	$ 1,763	$ 1,448
R-30 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 92% AFUE (from 80% AFUE)	Upgrade	$ 1,000	$ 2,400	$ 1,700
(2) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(2) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) Instantaneous Gas Water Heater: RE=0.80	-	$ -	$ -	$ -
Pipe Insulation	Upgrade	$ 300	$ 400	$ 350
Total Incremental Cost of Energy Efficiency Measures:		**$ 2,838**	**$ 5,103**	**$ 3,970**
Total Incremental Cost per Square Foot:		**$ 0.63**	**$ 1.13**	**$ 0.88**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 4,500 SF, Option 3 **4500 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/ Radiant Barrier): 2,700 sf @ 0.15 to 0.20/sf	Upgrade	$ 405	$ 540	$ 473
R-19 Walls (from R-13): 2,518 sf @ $0.31 to $0.54/sf	Upgrade	$ 781	$ 1,360	$ 1,070
R-38 Raised Floor (from R-30): 2,700 sf @ $0.05 to $0.10/sf	Upgrade	$ 135	$ 270	$ 203
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23 (from Low E2, U=0.36, SHGC=0.30): 990 sf @ $1.40 - $1.75 / sf	Upgrade	$ 1,386	$ 1,733	$ 1,559
(2) Furnaces: 92% AFUE (from 80% AFUE)	Upgrade	$ 1,000	$ 2,400	$ 1,700
(2) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(2) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) 50 Gallon Gas Water Heater: EF=0.62 (from (2) Instantaneous Gas: RE=0.80)	Downgrade	$ (3,000)	$ (1,800)	$ (2,400)
Total Incremental Cost of Energy Efficiency Measures:		**$ 707**	**$ 4,502**	**$ 2,604**
Total Incremental Cost per Square Foot:		**$ 0.16**	**$ 1.00**	**$ 0.58**

Low-rise Multi-family Apartments

- 8,442 square feet
- 8 units/2-story
- 12.5% glazing/floor area ratio

Incremental Cost Estimate to Exceed Title 24 by 15%
Multi-Family Prototype: 8,442 SF, Option 1 **8442 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier (from R-38 w/Radiant Barrier): 4,221 sf @ 0.15 to 0.20/sf	Downgrade	$ (844)	$ (633)	$ (739)
R-21 Walls (from R-13): 10,146 sf @ $0.45 to $0.70/sf	Upgrade	$ 4,566	$ 7,102	$ 5,834
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(8) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(8) Air Conditioners: Refrig. Charge (HERS)	Upgrade	$ 1,200	$ 1,600	$ 1,400
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 4,922**	**$ 8,069**	**$ 6,495**
Total Incremental Cost per Square Foot:		**$ 0.58**	**$ 0.96**	**$ 0.77**

Incremental Cost Estimate to Exceed Title 24 by 15%
Multi-Family Prototype: 8,442 SF, Option 2 **8442 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-15 Walls (from R-13): 10,146 sf @ $0.14 to $0.18/sf	Upgrade	$ 1,420	$ 1,826	$ 1,623
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(8) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(8) Air Conditioners: Refrig. Charge (HERS)	Upgrade	$ 1,200	$ 1,600	$ 1,400
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) Intantaneous Gas DHW: RE=0.82 (from (8) 40 Gallon Gas Water Heaters: EF=0.63)	Upgrade	$ 7,200	$ 11,600	$ 9,400
Total Incremental Cost of Energy Efficiency Measures:		**$ 9,820**	**$ 15,026**	**$ 12,423**
Total Incremental Cost per Square Foot:		**$ 1.16**	**$ 1.78**	**$ 1.47**

Incremental Cost Estimate to Exceed Title 24 by 15%
Multi-Family Prototype: 8,442 SF, Option 3 **8442 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier (from R-38 w/Radiant Barrier): 4,221 sf @ 0.15 to 0.20/sf	Downgrade	$ (844)	$ (633)	$ (739)
R-21 Walls (from R-15): 10,146 sf @ $0.27 to $0.56/sf	Upgrade	$ 2,739	$ 5,682	$ 4,211
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Housewrap: 10,146 sf @ $0.50 to $0.75/sf	Upgrade	$ 5,073	$ 7,610	$ 6,341
Low E2 Vinyl Windows, U=0.36, SHGC=0.30 (from Super Low E Vinyl, U=0.36, SHGC=0.23): 1055 sf @ $1.40 - $1.75 / sf	Downgrade	$ (1,846)	$ (1,477)	$ (1,662)
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(8) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(8) Air Conditioners: Refrig. Charge (HERS)	Upgrade	$ 1,200	$ 1,600	$ 1,400
R-8 Attic Ducts (from R-6)	Upgrade	$ 1,800	$ 2,600	$ 2,200
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 8,122**	**$ 15,381**	**$ 11,752**
Total Incremental Cost per Square Foot:		**$ 0.96**	**$ 1.82**	**$ 1.39**

Incremental Cost Estimate to Exceed Title 24 by 15%
Multi-Family Prototype: 8,442 SF, Option 4 **8442 sf** **Climate Zone 12**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-13): 10,146 sf @ $0.15 to $0.40/sf	Upgrade	$ 1,522	$ 4,058	$ 2,790
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(8) Furnace: 90% AFUE (from 80% AFUE)	Upgrade	$ 4,000	$ 8,000	$ 6,000
(8) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 5,522**	**$ 12,058**	**$ 8,790**
Total Incremental Cost per Square Foot:		**$ 0.65**	**$ 1.43**	**$ 1.04**

High-rise Multifamily Apartments

- 36,800 sf,
- 40 units/4-story
- Window to Wall Ratio = 35.2%

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 1 **Climate Zone 12**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Metal Roof w/ R-10 (2") rigid insulation; Cool Roof Reflectance=0.30, Emittance=0.75; 9,200 sf @ $0.25 - $0.35/sf	Upgrade	$ 2,300	$ 3,220	$ 2,760
R-19 in Metal Frame Walls	-			
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-			
Dual Vinyl Windows, NFRC U=0.40, SHGC=0.30; 6,240 sf @ $4.00 to $6.00/sf	Upgrade	$ 24,960	$ 37,440	$ 31,200
4-pipe fan coil, 80% AFUE boiler, 80-ton scroll air cooled chiller 0.79 KW/ton	-			
Central DHW boiler: 95% AFUE and recirculating system w/ timer-temperature controls	Upgrade	$ 6,000	$ 10,000	$ 8,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 33,260**	**$ 50,660**	**$ 41,960**
Total Incremental Cost per Square Foot:		**$ 0.90**	**$ 1.38**	**$ 1.14**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 2 **Climate Zone 12**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Metal Roof w/ R-10 (2") rigid insulation; Cool Roof Reflectance=0.30, Emittance=0.75; 9,200 sf @ $0.25 - $0.35/sf	Upgrade	$ 2,300	$ 3,220	$ 2,760
R-19 in Metal Frame Walls	-			
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows, NFRC U=0.66, SHGC=0.39 6,240 sf @ $5.50 to $7.50/sf	Upgrade	$ 34,320	$ 46,800	$ 40,560
4-pipe fan coil, 80% AFUE boiler, 80-ton scroll air cooled chiller 0.79 KW/ton	-			
Central DHW boiler: 95% AFUE and recirculating system w/ timer-temperature controls	Upgrade	$ 6,000	$ 10,000	$ 8,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 42,620**	**$ 60,020**	**$ 51,320**
Total Incremental Cost per Square Foot:		**$ 1.16**	**$ 1.63**	**$ 1.39**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 3 **Climate Zone 12**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Metal Roof w/ R-10 (2") rigid insulation; Cool Roof Reflectance=0.30, Emittance=0.75; 9,200 sf @ $0.25 - $0.35/sf	-	$ 2,300	$ 3,220	$ 2,760
R-19 in Metal Frame Walls	-			
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows: default U-factor=0.79, COG SHGC=0.65	Upgrade	$ -	$ -	$ -
4-pipe fan coil, 80% AFUE boiler, 80-ton scroll air cooled chiller 0.79 KW/ton				
Central DHW boiler: 95% AFUE and recirculating system w/ timer-temperature controls	Upgrade	$ 6,000	$ 10,000	$ 8,000
Solar Hot Water System, 30% Net Solar Fraction @ $1,500 to $2,000 per dwelling unit (after tax credits)	Upgrade	$ 60,000	$ 80,000	$ 70,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 68,300**	**$ 93,220**	**$ 80,760**
Total Incremental Cost per Square Foot:		**$ 1.86**	**$ 2.53**	**$ 2.19**

Low-rise Office Building in the offices, perhaps split lighting into two lines (no change, and change) so one can easily see what changed from base case? Gets kinda hard to compare, so many things on one line

- Single Story
- 10,580 sf,
- Window to Wall Ratio = 37.1%

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 10,580 SF, Option 1 **Climate Zone 12**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-30 under Metal Deck + R-19.5 (3" rigid); cool roof Refl=0.45; 10,580 sf @ $1.35 to $1.95/sf	Upgrade	$ 14,283	$ 20,314	$ 17,299
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: COG U=0.30, COG SHGC=0.27; 3,200 sf @ $2.00 to $3.00/sf	Upgrade	$ 6,400	$ 9,600	$ 8,000
Lighting = 0.858 w/sf: Open Office Areas: (60) 2-lamp T8 fixtures @58w each; no lighting controls; (24) 18w recessed CFLs. Small Offices: (56) 2-lamp T8 fixtures, **(28) multi-level ocupancy sensors @ $75 to $100 each;** (40) 18w recessed CFLs. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.	Upgrade	$ 2,100	$ 2,800	$ 2,450
(3) 10-ton DX units EER=11.0; 80% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) 50 gallon or less tank Gas Water Heaters EF=0.575	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 22,783**	**$ 32,714**	**$ 27,749**
Total Incremental Cost per Square Foot:		**$ 2.15**	**$ 3.09**	**$ 2.62**

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 10,580 SF, Option 2 **Climate Zone 12**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-30 under Metal Deck + R-7.5 (1.5" rigid); cool roof Refl=0.45; 10,580 sf @ $0.40 to $0.50/sf	Upgrade	$ 4,232	$ 5,290	$ 4,761
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: COG U=0.30, COG SHGC=0.27; 3,200 sf @ $2.00 to $3.00/sf	Upgrade	$ 6,400	$ 9,600	$ 8,000
Lighting = 0.696 w/sf: Open Office Areas: **(32) HO 2-lamp T8 fixtures @74w each**; no lighting controls; (24) 18w recessed CFLs. Small Offices: (56) 2-lamp T8 fixtures, **(28) multi-level ocupancy sensors on T8s @ $75 to $100 each;**; (40) 18w recessed CFLs. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls. **Net saving of $36 to $40 per new fixture in open offices because of a total reduction of 46% of T8 fixtures**	Upgrade	$ (1,152)	$ (1,280)	$ (1,216)
(3) 10-ton DX units EER=11.0; 80% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) 50 gallon or less tank Gas Water Heaters EF=0.575	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 9,480**	**$ 13,610**	**$ 11,545**
Total Incremental Cost per Square Foot:		**$ 0.90**	**$ 1.29**	**$ 1.09**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 3 **Climate Zone 12**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 under Metal Deck + R-7.5 (1.5" rigid); no cool roof	-			
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: Default glazing U=0.71, COG SHGC=0.54	-	$ -	$ -	$ -
Lighting = 0.858 w/sf: Open Office Areas: (60) 2-lamp T8 fixtures @58w each; (24) 18w recessed CFLs no lighting controls. Small Offices: (48) 2-lamp T8 fixtures; (40) 18w recessed CFLs, no controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.	-	$ -	$ -	$ -
(1) 30-ton Packaged VAV unit EER=9.5; 78% TE furnaces; standard efficiency variable speed fan motors; 30% VAV boxes w/ no reheat; fixed temp. integrated air economizers; @ $1.50 to $2.00/sf	Upgrade	$ 15,870	$ 21,160	$ 18,515
R-8 duct insulation w/ ducts on roof, **No HERS test required**	Downgrade	$ (1,200)	$ (2,700)	$ (1,950)
(1) 50 gallon or less tank Gas Water Heaters EF=0.575	-			
Total Incremental Cost of Energy Efficiency Measures:		**$ 14,670**	**$ 18,460**	**$ 16,565**
Total Incremental Cost per Square Foot:		**$ 1.39**	**$ 1.74**	**$ 1.57**

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 34.5%

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 52,900 SF, Option 1 **Climate Zone 12**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 under Metal/Conc. Deck with R-10 rigid on top: cool roof Reflect=0.55, Emittance=0.75; 10,580 sf @ $1.50 to $2.65/sf	Upgrade	$ 15,870	$ 28,037	$ 21,954
R-19 in Metal Frame Walls with 1" R-6.5 rigid (no framing) exterior; 22,780 sf @ $5.00 to $7.00/sf	Upgrade	$ 113,900	$ 159,460	$ 136,680
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: COG U=0.30, COG SHGC=0.27; 12,000 sf @ $1.00 to $1.50/sf	Upgrade	$ 12,000	$ 18,000	$ 15,000
Lighting = 0.678 w/sf: Open Office Areas: (160) HO 2-lamp T8 fixtures @74w each; no lighting controls; (120) 18w recessed CFLs no lighting controls;. Small Offices: **(280) 2-lamp T8 fixtures with 140 multi-level sensors; @ $75 to $100 each**; (200) 18w recessed CFLs, with multi-level sensors. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no lighting controls	Upgrade	$ 10,500	$ 14,000	$ 12,250
(5) Packaged 35-ton Packaged VAV EER=10.0; 81% TE furnaces; premium efficiency variable speed fan motors; differential temp. integrated air economizers; 20% VAV boxes, reheat on perimeter zones with hot water; cycle on at night	Upgrade	$ 1,000	$ 1,500	$ 1,250
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
(5) Instanteous Gas Water Heaters EF=0.82	Upgrade	$ 5,000	$ 8,000	$ 6,500
Total Incremental Cost of Energy Efficiency Measures:		**$ 158,270**	**$ 228,997**	**$ 193,634**
Total Incremental Cost per Square Foot:		**$ 2.99**	**$ 4.33**	**$ 3.66**

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 52,900 SF, Option 2 **Climate Zone 12**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 under Metal/Conc. Deck: cool roof Reflect=0.55, Emittance=0.75; 10,580 sf @ $0.35 to $0.50/sf	Upgrade	$ 3,703	$ 5,290	$ 4,497
R-19 in Metal Frame Walls with 1" R-5 rigid (no framing) exterior; 22,780 sf @ $4.00 to $6.00/sf	Upgrade	$ 91,120	$136,680	$ 113,900
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: COG U=0.30, COG SHGC=0.27 1st floor; thermally broken COG U=0.30, COG SHGC=.27 2nd - 5th; 3,000 sf @ $1.00 to $1.50/sf; 9,000 sf @ $3.00 to $3.50/sf	Upgrade	$ 30,000	$ 36,000	$ 33,000
Lighting = 0.678 w/sf: Open Office Areas: (160) HO 2-lamp T8 fixtures @74w each; no lighting controls; (120) 18w recessed CFLs no lighting controls;. Small Offices: **(280) 2-lamp T8 fixtures with 140 multi-level sensors; @ $75 to $100 each;** (200) 18w recessed CFLs, with multi-level sensors. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no	Upgrade	$ 10,500	$ 14,000	$ 12,250
(5) Packaged 35-ton Packaged VAV EER=10.0; 81% TE furnaces; premium efficiency variable speed fan motors; differential temp. integrated air economizers; 20% VAV boxes, reheat on perimeter zones with hot water; cycle on at night	Upgrade	$ 1,000	$ 1,500	$ 1,250
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
(5) Instanteous Gas Water Heaters EF=0.82	Upgrade	$ 5,000	$ 8,000	$ 6,500
Total Incremental Cost of Energy Efficiency Measures:		**$ 141,323**	**$201,470**	**$ 171,397**
Total Incremental Cost per Square Foot:		**$ 2.67**	**$ 3.81**	**$ 3.24**

5.0 Cost -Effectiveness Determination

Regardless of the building design, occupancy profile and number of stories, the incremental improvement in overall annual energy performance of buildings in exceeding the 2008 Standards is determined to be cost-effective. However, each building's overall design, occupancy type and specific design choices may allow for a large range of incremental costs for exceeding 2008 Standards, estimated annual energy cost savings, and subsequent payback period.

Small Single Family

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)	388	70	$1,601	$154	10.4
2,025 sf (Option 2)	501	43	$1,862	$142	13.1
2,025 sf (Option 3)	281	86	$2,067	$154	13.4
Averages:	390	66	$1,843	$150	12.3

Annual Reduction in CO2-equivalent: 0.30 lb./sq.ft.-year, 618 lb./building-year
Increased Cost / lb. CO2-e reduction: $1.91

Large Single Family

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (Years)
4,500 sf (Option 1)	1095	12	$2,630	$212	12.4
4,500 sf (Option 2)	505	132	$3,971	$249	15.9
4,500 sf (Option 3)	1182	-7	$2,605	$204	12.7
Averages:	927	46	$3,068	$222	13.7

Annual Reduction in CO2-equivalent: 0.21 lb./sq.ft.-year, 949 lb./building-year
Increased Cost / lb. CO2-e reduction: $3.23

Low-rise Multi-family Apartments

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (Years)
8-Unit, 8,442 sf (Option 1)	1724	232	$6,496	$589	11.0
8-Unit, 8,442 sf (Option 2)	693	449	$12,423	$664	18.7
8-Unit, 8,442 sf (Option 3)	1254	336	$11,752	$629	18.7
8-Unit, 8,442 sf (Option 4)	1312	303	$8,790	$600	14.7
Averages:	1246	330	$9,865	$620	15.8

Annual Reduction in CO2-equivalent: 0.52 lb./sq.ft.-year, 4,402 lb./building-year
Increased Cost / lb. CO2-e reduction: $2.24

High-rise Multi-family 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)	16796	666	$41,960	$3,822	11.0
36,800 sf (Option 2)	14813	1191	$51,320	$4,096	12.5
36,800 sf (Option 3)	950	3082	$80,760	$3,869	20.9
Averages:	10853	1646	$58,013	$3,929	14.8

Annual Reduction in CO2-equivalent: 0.65 lb./sq.ft.-year, 24,047 lb./building-year
Increased Cost / lb. CO2-e reduction: $2.41

Low-rise Office Building

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (Years)
10,580 sf (Option 1)	16575	95	$29,349	$2,284	12.8
10,580 sf (Option 2)	19167	-216	$11,545	$2,453	4.7
10,580 sf (Option 3)	29518	343	$16,565	$3,877	4.3
Averages:	21753	74	$19,153	$2,871	7.3

Annual Reduction in CO2-equivalent: 1.01 lb./sq.ft.-year, 10,650 lb./building-year
Increased Cost / lb. CO2-e reduction: $1.92

High-rise 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)	11729	-292	$193,634	$16,620	11.7
52,900 sf (Option 2)	9870	267	$171,397	$17,073	10.0
Averages:	10800	-13	$182,515	$16,847	10.8

Annual Reduction in CO2-equivalent: 0.09 lb./sq.ft.-year, 3,143 lb./building-year
Increased Cost / lb. CO2-e reduction: $38.72

Conclusions

Regardless of the building design, occupancy profile and number of stories, the incremental improvement in overall annual energy performance of buildings which exceed the 2008 Title 24 Building Energy Efficiency Standards by 15% 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 should carefully analyze building energy performance to reduce incremental first cost and the payback for the required additional energy efficiency measures.