CA Statewide Codes and Standards Program
Title 24 Local Energy Efficiency Ordinances

Title:
Climate Zone 2
Energy Cost-Effectiveness Study

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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 2. 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 2 using the following residential and nonresidential prototypical building types:

Single Family House 2-story 2,025 sf	**Single Family House** 2-story 2,682 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 2-story 21,160 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 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 $0.173 /kWh for electricity and $1.15/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 A-6 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 t he following building prototypes just meet the 2008 Standards in Climate Zone 2.

Single Family House

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

Energy Efficiency Measures
R-38 Roof w/ Radiant Barrier
R-13 Walls
R-0 Slab on Grade
R-19 Raised Floor over Garage/Open at 2nd Floor
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-6 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
50 Gallon Gas Water Heater: EF=0.60

Single Family House

- 2,682 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
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-6 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
50 Gallon Gas Water Heaters: EF=0.60

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-15 Walls
R-0 Slab on Grade
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(8) Furnaces: 80% AFUE
(8) Air Conditioners: 13 SEER
R-8 Attic Ducts
(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-30 Attic; Cool Roof Reflectance=0.70, Emittance=0.75
R-19 in Metal Frame Walls
R-6 (2" K-13 spray-on) Raised Slab over parking garage
Vinyl Windows, NFRC U=0.36, SHGC=0.35
Split Heat Pumps: HSPF=7.2, EER=10.2
Central DHW boiler: 82.7% AFUE and recirculating system w/ timer-temperature controls & VSD hot water pump

Low-rise Office Building

- Two Story
- 21,160 sf,
- Window to 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

High-rise Office Building

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

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=0.31, 2' overhang 1st floor front elevation only (720) 2-lamp 4' T8 fixtures w/ high efficiency instant start ballasts & premium lamps, 50w; and (300) 18w CFLs @ 18w 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%

4.0 Incremental Cost to Exceed 2008 Standards by 15%

The following tables list the energy feat ures and/or equipment included in the 2008 Standards base design, the e fficient 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**.

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 2**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-13): 2,550 sf @ $0.55 to $0.85/sf	Upgrade	$ 1,403	$ 2,168	$ 1,786
R-0 Slab on Grade	-	$ -	$ -	$ -
R-19 Raised Floor over Garage/Open at 2nd Floor	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER, 11 EER (HERS)	Upgrade	$ 25	$ 75	$ 50
Air Conditioner: Refrig. Charge (HERS)	Upgrade	$ 150	$ 200	$ 175
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.60	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,578**	**$ 2,443**	**$ 2,011**
Total Incremental Cost per Square Foot:		**$ 0.78**	**$ 1.21**	**$ 0.99**

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

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-21 Walls (from R-13): 2,550 sf @ $0.70 to $0.95/sf	Upgrade	$ 1,785	$ 2,423	$ 2,104
R-0 Slab on Grade	-	$ -	$ -	$ -
R-19 Raised Floor over Garage/Open at 2nd Floor	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioning: 13 SEER	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.60	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,785**	**$ 2,423**	**$ 2,104**
Total Incremental Cost per Square Foot:		**$ 0.88**	**$ 1.20**	**$ 1.04**

Single Family House

- 2,682 square feet
- 2-story
- 20.2% glazing/floor area ratio

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,682 SF, Option 1 **2682 sf** **Climate Zone 2**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-13): 2,638 sf @ $0.55 to $0.85/sf	Upgrade	$ 1,451	$ 2,242	$ 1,847
R-19 Floor	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER, 11 EER (HERS)	Upgrade	$ 25	$ 75	$ 50
Air Conditioner: Refrig. Charge (HERS)	Upgrade	$ 150	$ 200	$ 175
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.60	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,626**	**$ 2,517**	**$ 2,072**
Total Incremental Cost per Square Foot:		**$ 0.61**	**$ 0.94**	**$ 0.77**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,682 SF, Option 2 **2682 sf** **Climate Zone 2**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30): 1,402sf @ 0.40 to 0.60/sf	Upgrade	$ 561	$ 841	$ 701
R-15 Walls (from R-13): 2,638 sf @ $0.12 to $0.20/sf	Upgrade	$ 317	$ 528	$ 422
R-19 Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	Upgrade	$ 450	$ 600	$ 525
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 90% AFUE (from 80% AFUE)	Upgrade	$ 500	$ 1,000	$ 750
Air Conditioner: 13 SEER	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62 (from EF=0.60)	Upgrade	$ 100	$ 200	$ 150
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,928**	**$ 3,169**	**$ 2,548**
Total Incremental Cost per Square Foot:		**$ 0.72**	**$ 1.18**	**$ 0.95**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,682 SF, Option 3 **2682 sf** **Climate Zone 2**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-21 Walls (from R-13): 2,638 sf @ $0.70 to $0.95/sf	Upgrade	$ 1,847	$ 2,506	$ 2,177
R-19 Floor	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62 (from EF=0.60)	Upgrade	$ 100	$ 200	$ 150
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,947**	**$ 2,706**	**$ 2,327**
Total Incremental Cost per Square Foot:		**$ 0.73**	**$ 1.01**	**$ 0.87**

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%
Low-rise Multifamily Prototype: 8,442 SF, Option 1 **8442 sf** **Climate Zone 2**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-21 Walls (from R-15): 10,146 sf @ $0.50 to $0.75/sf	Upgrade	$ 5,073	$ 7,510	$ 6,292
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(8) Air Conditioner: 13 SEER, 11 EER (HERS)	Upgrade	$ 200	$ 600	$ 400
(8) Air Conditioner: Refrig. Charge (HERS)	Upgrade	$ 1,200	$ 1,600	$ 1,400
R-8 Attic Ducts	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 6,473**	**$ 9,710**	**$ 8,092**
Total Incremental Cost per Square Foot:		**$ 0.77**	**$ 1.15**	**$ 0.96**

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

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-15): 10,146 sf @ $0.45 to $0.75/sf	Upgrade	$ 4,566	$ 7,610	$ 6,088
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(8) Air Conditioners: 13 SEER	-	$ -	$ -	$ -
R-4.2 Attic Ducts (from R-8)	Downgrade	$ (3,000)	$ (2,000)	$ (2,500)
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 2,000	$ 4,000	$ 3,000
(8) 40 Gallon Gas Water Heaters: EF=0.62 (from 0.63 EF)	Downgrade	$ -	$ (400)	$ (200)
Total Incremental Cost of Energy Efficiency Measures:		**$ 3,566**	**$ 9,210**	**$ 6,388**
Total Incremental Cost per Square Foot:		**$ 0.42**	**$ 1.09**	**$ 0.76**

High-rise Multifamily Apartments

- 36,800 sf,
- 40 units/4-story
- Window to Wall Ratio = 31.6%

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 1 **Climate Zone 2**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Attic; Cool Roof Reflectance=0.70, Emittance=0.75	-	$ -	$ -	$ -
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-8 (2.5" K-13 spray-on) Raised Slab over parking garage	Upgrade	$ 3,680	$ 5,520	$ 4,600
Vinyl Windows, NFRC U=0.33, SHGC=0.25; 6,240 sf @ $1.40 to $1.60/sf	Upgrade	$ 8,736	$ 9,984	$ 9,360
(80) Room Heat Pumps: HSPF=7.84, eer=11.2 (No Ducts) @ $150 to $250/unit	Upgrade	$ 12,000	$ 20,000	$ 16,000
Premium Efficiency DHW Hot Water Pump	Upgrade	$ 150	$ 250	$ 200
Total Incremental Cost of Energy Efficiency Measures:		**$ 24,566**	**$ 35,754**	**$ 30,160**
Total Incremental Cost per Square Foot:		**$ 0.67**	**$ 0.97**	**$ 0.82**

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

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Attic; Cool Roof Reflectance=0.70, Emittance=0.75	-	$ -	$ -	$ -
R-19 in Metal Frame Walls + R-5 exterior rigid insulation 11,472 sf @ $5.00 to $8.00/sf	Upgrade	$ 57,360	$ 91,776	$ 74,568
R-6 (2" K-13 spray-on) Raised Slab over parking garage	-	$ -	$ -	$ -
Vinyl Windows, NFRC U=0.33, SHGC=0.25; 6,240 sf @ $1.40 to $1.60/sf	Upgrade	$ 8,736	$ 9,984	$ 9,360
Split Heat Pumps: HSPF=7.2, EER=10.2	-	$ -	$ -	$ -
(2) 94% AFUE DHW boilers @ $1500 to$2500 each	Upgrade	$ 3,000	$ 5,000	$ 4,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 69,096**	**$106,760**	**$ 87,928**
Total Incremental Cost per Square Foot:		**$ 1.88**	**$ 2.90**	**$ 2.39**

Low-rise Office Building

- Two Story
- 21,160 sf,
- Window to Wall Ratio = 37.1%

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 21,160 SF, Option 1 **Climate Zone 2**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
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, 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	$ 6,000	$ 7,200	$ 6,600
(4) 10-ton Packaged DX units, EER= 13.4 @ $2300 - $2600 ea,	Upgrade	$ 16,000	$ 24,000	$ 20,000
(4) 7.5-ton Packaged DX units, EER= 13.4 @ $1950 - $2450 ea,	Upgrade	$ 12,000	$ 18,800	$ 15,400
(8) Premium Efficiency supply fans @ $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:		**$ 45,120**	**$ 67,080**	**$ 56,100**
Total Incremental Cost per Square Foot:		**$ 2.13**	**$ 3.17**	**$ 2.65**

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 21,160 SF, Option 2 **Climate Zone 2**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Attic w/ No Cool Roof	-	$ -	$ -	$ -
R-19 in Metal Frame Walls + R-6.5 (1") rigid insulation 8,752 sf @ $3.00 to $4.00/sf	-	$ 26,256	$ 35,008	$ 30,632
R-0 (un-insulated) slab-on-grade 1st floor				
Windows, NFRC U=0.50, SHGC=0.28; 5,160 sf @ $3.50 to $4.50/sf	Upgrade	$ 18,060	$ 23,220	$ 20,640
(72) [30% of] 2-lamp 4' T8 fixtures on (36) multi-level occupant sensors in small offices @ $65.00 to $85.00 each	Upgrade	$ 2,340	$ 3,060	$ 2,700
(248) 2-lamp 4' T8 fixtures w/ high efficiency instant start ballasts & premium lamps, 50w @ $25.00 - $30.00 each	Upgrade	$ 6,000	$ 7,200	$ 6,600
(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	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 52,656**	**$ 68,488**	**$ 60,572**
Total Incremental Cost per Square Foot:		**$ 2.49**	**$ 3.24**	**$ 2.86**

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 2**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Attic w/ Cool Roof Reflectance=0.70, Emittance=0.75 10,580 sf @ $0.40 to $0.60/sf	Upgrade	$ 4,235	$ 6,348	$ 5,292
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	-	$ -	$ -	$ -
(180) [25% of] 2-lamp 4' T8 fixtures on (90) multi-level occupant sensors in small offices @ $65.00 to $85.00 each	Upgrade	$ 5,850	$ 7,650	$ 6,750
(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:		**$ 59,850**	**$ 85,650**	**$ 72,750**
Total Incremental Cost per Square Foot:		**$ 1.13**	**$ 1.62**	**$ 1.38**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 2 **Climate Zone 2**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Attic w/ Cool Roof Reflectance=0.70, Emittance=0.75 10,580 sf @ $0.40 to $0.60/sf	Upgrade	$ 4,235	$ 6,348	$ 5,292
R-19 in Metal Frame Walls + R-6.5 (1") rigid insulation 8,752 sf @ $3.00 to $4.00/sf	Upgrade	$ 26,256	$ 35,008	$ 30,632
R-0 (un-insulated) slab-on-grade 1st floor				
Windows, NFRC U=0.50, SHGC=0.28; 8,500 sf @ $2.00 to $3.00/sf	Upgrade	$ 17,000	$ 25,500	$ 21,250
(180) [25% of] 2-lamp 4' T8 fixtures on (90) multi-level occupant sensors in small offices @ $65.00 to $85.00 each	Upgrade	$ 5,850	$ 7,650	$ 6,750
(248) 2-lamp 4' T8 fixtures w/ high efficiency instant start ballasts & premium lamps, 50w @ $25.00 - $30.00 each	Upgrade	$ 6,000	$ 7,200	$ 6,600
(5) 30-ton Packaged VAV units EER=10.4, 10,000 cfm; 20% VAV boxes w/ reheat; (10) Premium Effiiciency fan motors	Upgrade	$ 1,000	$ 1,500	$ 1,250
R-4.2 duct insulation w/ ducts in conditioned space	-	$ -	$ -	$ -
Standard hot water boiler, AFUE=80%	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 56,106**	**$ 76,858**	**$ 66,482**
Total Incremental Cost per Square Foot:		**$ 1.06**	**$ 1.45**	**$ 1.26**

5.0 Cost -Effectiveness Determination

Regardless of the building design, occ upancy 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-effe ctive. 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: 2,025 sf

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)	399	69	$2,011	$148	13.5
2,025 sf (Option 2)	348	81	$2,104	$153	13.7
Averages:	374	75	$2,057	$151	13.6

Annual Reduction in CO2-equivalent: ***1,041 lb./building-year***
0.51 lb./sq.ft.-year

Small Single Family: 2,682 sf

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (Years)
2,682 sf (Option 1)	524	71	$2,072	$172	12.0
2,682 sf (Option 2)	338	111	$2,549	$186	13.7
2,682 sf (Option 3)	427	92	$2,327	$180	12.9
Averages:	430	91	$2,316	$179	12.9

Annual Reduction in CO2-equivalent: ***1,256 lb./building-year***
0.47 lb./sq.ft.-year

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)
8,442 sf (Option 1)	1575	261	$8,089	$573	14.1
8,442 sf (Option 2)	1468	284	$6,388	$581	11.0
Averages:	1522	273	$7,238	$577	12.6

Annual Reduction in CO2-equivalent: ***3,857 lb./building-year***
0.10 lb./sq.ft.-year

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)	14292	0	$30,160	$2,473	12.2
36,800 sf (Option 2)	9590	268	$87,428	$1,967	44.4
Averages:	11941	134	$58,794	$2,220	28.3

Annual Reduction in CO2-equivalent: ***6,933 lb./building-year***
0.19 lb./sq.ft.-year

Low-rise 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)	19085	-95	$56,100	$3,192	17.6
21,160 sf (Option 2)	15862	90	$60,572	$2,848	21.3
Averages:	17474	-3	$58,336	$3,020	19.4

Annual Reduction in CO2-equivalent: ***7,834 lb./building-year***
0.37 lb./sq.ft.-year

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)	40514	-506	$72,750	$6,427	11.3
52,900 sf (Option 2)	35774	-653	$66,482	$5,438	12.2
Averages:	38144	-580	$69,616	$5,932	11.8

Annual Reduction in CO2-equivalent: ***10,419 lb./building-year***
0.20 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 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.