ATTACHMENT

Codes and Standards
Title 24 Energy-Efficient Local Ordinances

Title:
Climate Zone 6
Energy Cost-Effectiveness Study

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1.0 Executive Summary

This report presents the results of Gabel Associates' research, analysis and review of the feasibility and energy cost-effectiveness of building permit applicants exceeding the 2008 Building Energy Efficiency Standards by 15% in Climate Zone 6 in several case studies which reflect a variety of building types.

The study contained in this report may be useful in several ways to local governments who are considering adoption of green building ordinances. First, as a source of information to better understand and discuss the energy cost-effectiveness of exceeding the state's energy standards within a local ordinance; and second, as the cost-effectiveness study that may be included in an application to the California Energy Commission (CEC) by a local government seeking to meet the requirements specified in Section 10-106 of the California Code of Regulations, Title 24, Part 1, Locally Adopted Energy Standards.

The energy requirements of a local green building ordinance are not legally enforceable until the CEC has reviewed and approved the local energy standards as fulfilling all requirements of Section 10-106, the Ordinance has been adopted by the local jurisdiction and has filed with the Building Standards Commission.

The 2008 Building Energy Efficiency Standards, effective January 1, 2010, have been used as the baseline used in calculating the energy performance of efficiency measures summarized in this study.

2.0 Impacts of Exceeding the 2008 Title 24 Standards

The energy performance impacts of exceeding the performance requirements of the 2008 Title 24 Building Energy Efficiency Standards have been evaluated in Climate Zone 6 using several prototypical designs which collectively reflect a broad range of building types, including:

- Single family house: 2-story 2,025 sf
- Single family house: 2-story 4,500 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: 1-story, 10,580 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 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.

(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 6:

CZ6: 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-30 Raised Floor over Garage/Open at 2nd Floor
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: None
R-8 Attic Ducts
50 Gallon Gas Water Heater: EF=0.62

CZ6: Single Family House 4,500 square feet, 2-story, 22.0% glazing/floor area ratio

Energy Efficiency Measures
R-19 Roof w/o Radiant Barrier
R-13 Walls
R-19 Raised Floor
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(2) Furnaces: 80% AFUE
Air Conditioner: None
R-4.2 Attic Ducts
(2) Instantaneous Gas Water Heater: RE=0.80

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: 2,025 SF, Option 1 **2025 sf** **Climate Zone 6**

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 @ $0.45 to $0.70/sf	Upgrade	$ 1,148	$ 1,785	$ 1,466
R-0 Slab on Grade	-	$ -	$ -	$ -
R-19 Raised Floor over Garage/Open at 2nd Floor (from R-30): 448 sf @ $0.25 to $0.35/sf	Downgrade	$ (157)	$ (112)	$ (134)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: None	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 300	$ 600	$ 450
50 Gallon Gas Water Heater: EF=0.62	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,291**	**$ 2,273**	**$ 1,782**
Total Incremental Cost per Square Foot:		**$ 0.64**	**$ 1.12**	**$ 0.88**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 2,025 SF, Option 2 **2025 sf** **Climate Zone 6**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Roof w/ Radiant Barrier (from R-38 w/Radiant Barrier): 1,443 sf @ 0.30 to 0.45/sf	Downgrade	$ (649)	$ (433)	$ (541)
R-19 Walls (from R-13): 2,550 sf @ $0.31 to $0.54/sf	Upgrade	$ 791	$ 1,377	$ 1,084
R-0 Slab on Grade	-	$ -	$ -	$ -
R-19 Raised Floor over Garage/Open at 2nd Floor (from R-30): 448 sf @ $0.25 to $0.35/sf	Downgrade	$ (157)	$ (112)	$ (134)
Quality Insulation Installation (HERS)	Upgrade	$ 450	$ 600	$ 525
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: None	-	$ -	$ -	$ -
R-6 Attic Ducts (from R-8)	Downgrade	$ (325)	$ (225)	$ (275)
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 300	$ 600	$ 450
50 Gallon Gas Water Heater: EF=0.62	-	$ -	$ -	$ -
Pipe Insulation	Upgrade	$ 150	$ 200	$ 175
Total Incremental Cost of Energy Efficiency Measures:		**$ 559**	**$ 2,007**	**$ 1,283**
Total Incremental Cost per Square Foot:		**$ 0.28**	**$ 0.99**	**$ 0.63**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Option 1 **4500 sf** **Climate Zone 6**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier (from R-19 w/o Radiant Barrier): 2,700 sf @ 0.50 to 0.65/sf	Upgrade	$ 1,350	$ 1,755	$ 1,553
R-13 Walls	-	$ -	$ -	$ -
R-19 Raised Floor	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: None	-	$ -	$ -	$ -
R-6 Attic Ducts (from R-4.2)	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 600	$ 1,200	$ 900
(2) Instantaneous Gas Water Heater: RE=0.80	-	$ -	$ -	$ -
Pipe Insulation (1705 sf house)	Upgrade	$ 300	$ 400	$ 350
Total Incremental Cost of Energy Efficiency Measures:		**$ 2,250**	**$ 3,355**	**$ 2,803**
Total Incremental Cost per Square Foot:		**$ 0.50**	**$ 0.75**	**$ 0.62**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Option 2 **4500 sf** **Climate Zone 6**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier (from R-19 w/o Radiant Barrier): 2,700 sf @ 0.50 to 0.65/sf	Upgrade	$ 1,350	$ 1,755	$ 1,553
R-15 Walls (from R-13): 2,518 sf @ $0.14 to $0.18/sf	Upgrade	$ 353	$ 453	$ 403
R-19 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	Upgrade	$ 450	$ 600	$ 525
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: None	-	$ -	$ -	$ -
R-4.2 Attic Ducts	-	$ -	$ -	$ -
(2) Instantaneous Gas Water Heater: RE=0.80	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 2,153**	**$ 2,808**	**$ 2,480**
Total Incremental Cost per Square Foot:		**$ 0.48**	**$ 0.62**	**$ 0.55**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Option 3 **4500 sf** **Climate Zone 6**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Roof w/ Radiant Barrier (from R-19 w/o Radiant Barrier): 2,700 sf @ 0.25 to 0.30/sf	Upgrade	$ 675	$ 810	$ 743
R-21 Walls (from R-13): 2,518 sf @ $0.45 to $0.50/sf	Upgrade	$ 1,133	$ 1,259	$ 1,196
R-19 Raised Floor	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: None	-	$ -	$ -	$ -
R-4.2 Attic Ducts	-	$ -	$ -	$ -
(2) Instantaneous Gas Water Heater: RE=0.82 (from 0.80)	Upgrade	$ 400	$ 600	$ 500
Total Incremental Cost of Energy Efficiency Measures:		**$ 2,208**	**$ 2,669**	**$ 2,439**
Total Incremental Cost per Square Foot:		**$ 0.49**	**$ 0.59**	**$ 0.54**

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:

CZ6: Low-rise Multi-family: 2-story 8,442 square feet, 8 units, 12.5% glazing

Energy Efficiency Measures
R-19 Roof w/ Radiant Barrier
R-13 Walls
R-0 Slab on Grade
Low E Vinyl Windows, U=0.40, SHGC=0.36
(8) Furnaces: 80% AFUE
Air Conditioners: None
R-4.2 Attic Ducts
(8) 40 Gallon Gas Water Heaters: EF=0.60

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**.

Climate Zone 6 Energy Measures Needed to Meet the Ordinance

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 8,442 SF, Option 1 **8442 sf** **Climate Zone 6**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier (from R-19 w/Radiant Barrier): 4,221 sf @ 0.25 to 0.35/sf	Upgrade	$ 1,055	$ 1,477	$ 1,266
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	-	$ -	$ -	$ -
Low E Vinyl Windows, U=0.40, SHGC=0.36	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
Air Conditioners: None	-	$ -	$ -	$ -
R-8 Attic Ducts (from R-4.2)	Upgrade	$ 2,000	$ 3,000	$ 2,500
(8) 40 Gallon Gas Water Heaters: EF=0.63 (from EF=0.60)	Upgrade	$ 800	$ 2,000	$ 1,400
Total Incremental Cost of Energy Efficiency Measures:		**$ 8,421**	**$ 13,580**	**$ 11,000**
Total Incremental Cost per Square Foot:		**$ 1.00**	**$ 1.61**	**$ 1.30**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 8,442 SF, Option 2 **8442 sf** **Climate Zone 6**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-13 Walls	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Dual Clear Vinyl Windows, U=0.50, SHGC=0.60 (from Low E, U=0.40, SHGC=0.36): 1,055 sf @ $1.40 - $1.75 / sf	Downgrade	$ (1,846)	$ (1,477)	$ (1,662)
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
Air Conditioners: None	-	$ -	$ -	$ -
R-4.2 Attic Ducts	-	$ -	$ -	$ -
(8) Instantaneous Gas Water Heaters: EF=0.79 (from (8) 40 Gallon Gas, 0.60 EF)	Upgrade	$ 7,600	$ 13,600	$ 10,600
Total Incremental Cost of Energy Efficiency Measures:		**$ 5,754**	**$ 12,123**	**$ 8,938**
Total Incremental Cost per Square Foot:		**$ 0.68**	**$ 1.44**	**$ 1.06**

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:

Title 24 Base Case Design for Options 1 & 2

Energy Efficiency Measures to Meet Title 24
R-26 (4") 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
Metal Windows, NFRC U=0.66, SHGC=0.39
PTC 1-ton units: COP=3, EER=11.1
Central DHW boiler: 95% AFUE and recirculating system w/ timer-temperature controls

Title 24 Base Case Design for Option 3

Energy Efficiency Measures to Meet Title 24
R-26 (4") rigid insulation; No Cool Roof
R-19 in Metal Frame Walls
R-2 (5/8") Raised Slab over parking garage
Default Dual Metal Windows, U=0.79, SHGC=0.70
2-pipe fan coil, 80% AFUE boiler, no cooling
Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls

CZ6: High-rise Residential: 4-story 36,800 sf, 40 units, Window Wall Ratio=35.2%

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%
High-rise Residential Prototype: 36,800 SF, Option 1 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-26 (4") rigid insulation; No Cool Roof, 9,200 sf @$0.30 - $0.40 sf	Downgrade	$ (3,174)	$ (4,232)	$ (3,703)
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-	$ -	$ -	$ -
Metal Windows, NFRC U=0.71, SHGCc=0.27; 6,240 sf @ $0.10 to $0.35/sf	Upgrade	$ 920	$ 3,220	$ 2,070
PTC 1-ton units: COP=3, EER=11.1	-	$ -	$ -	$ -
Central DHW boiler: 95% AFUE and recirculating system w/ timer-temperature controls	-	$ -	$ -	$ -
Solar Hot Water System, 30% Net Solar Fraction	Upgrade	$ 40,000	$ 55,000	$ 47,500
Total Incremental Cost of Energy Efficiency Measures:		**$ 37,746**	**$ 53,988**	**$ 45,867**
Total Incremental Cost per Square Foot:		**$ 1.03**	**$ 1.47**	**$ 1.25**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 2 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-26 (4") rigid insulation; Cool Roof Refl=0.55, Emitt=0.75 9,200 sf @$0.15 - $0.20 sf	Upgrade	$ 1,380	$ 1,840	$ 1,610
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-6 (2" K-13 spray-on) Raised Slab over parking garage 9,200 sf @0.70 to $1.00 sf	Upgrade	$ 6,440	$ 9,200	$ 7,820
Vinyl Super Low-E, NFRC U=0.39, SHGCc=0.23; 6,240 sf @ $1.40 to $1.60/sf	Upgrade	$ 8,736	$ 9,984	$ 9,360
PTC 1-ton units: COP=3, EER=11.1	-	$ -	$ -	$ -
Central DHW boiler: 95% AFUE and recirculating system w/ timer-temperature controls	-	$ -	$ -	$ -
Solar Hot Water System, 5% Net Solar Fraction	Upgrade	$ 8,000	$ 10,000	$ 9,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 24,556**	**$ 31,024**	**$ 27,790**
Total Incremental Cost per Square Foot:		**$ 0.67**	**$ 0.84**	**$ 0.76**

Incremental Cost Estimate to Exceed Title 24 by 15%

High-rise Residential Prototype: 36,800 SF, Option 3 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-26 (4") rigid insulation; No Cool Roof	-	$ -	$ -	$ -
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-6 (2" K-13 spray-on) Raised Slab over parking garage 9,200 sf @0.70 to $1.00 sf	-	$ -	$ -	$ -
Metal Low-E, NFRC U=0.66, SHGC=0.39; 6,240 sf @ $5.00 to $8.00/sf	Upgrade	$ 31,200	$ 49,920	$ 40,560
PTC 1-ton units: COP=3, EER=11.1	-	$ -	$ -	$ -
Central DHW boiler: 95% AFUE and recirculating system w/ timer-temperature controls	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 31,200**	**$ 49,920**	**$ 40,560**
Total Incremental Cost per Square Foot:		**$ 0.85**	**$ 1.36**	**$ 1.10**

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 6:

CZ6: Nonresidential 1-story office building: 10,580 sf, Window Wall Ratio= 37.1%

Title 24 Base Case Design, Options 1 and 2

Energy Efficiency Measures to Meet Title 24
R-19 on Metal Span Deck, Cool Roof Refl.=0.69, Emitt=0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Dual metal glazing U=0.71 and SHGCc=0.52, 3' overhangs
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, mandatory (on/off) ocupancy sensors; (40) 18w recessed CFLs. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.
(4) 10-ton Packaged DX units EER=11.0, 4,000 cfm; 80% AFUE furnaces; all standard efficiency fan motors
R-8 duct insulation w/ ducts on the roof
Standard 50 gallon gas water heater, EF=0.58

Title 24 Base Case Design, Option 3

Energy Efficiency Measures to Meet Title 24
R-19 on Metal Span Deck, Cool Roof Refl.=0.69, Emitt=0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Dual metal glazing U=0.71 and SHGCc=0.52, 3' overhangs
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, mandatory (on/off) ocupancy sensors; (40) 18w recessed CFLs. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.
(8) 5-ton Packaged DX units SEER=13.0, 2,000 cfm; 93% AFUE furnaces; all standard efficiency fan motors
R-8 duct insulation w/ ducts on the roof
Standard 50 gallon gas water heater, EF=0.58

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%

Nonresidential Prototype: 10,580 SF, Option 1 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 on Metal Span Deck, Cool Roof Refl.=0.69, Emitt=0.75	-	$ -	$ -	$ -
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Dual metal glazing U=0.71 and SHGCc=0.27, 3' overhangs 3,200 sf @ $2.50 to $3.50/sf	Upgrade	$ 8,000	$ 11,200	$ 9,600
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, mandatory (on/off) ocupancy sensors; (40) 18w recessed CFLs. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.	-	$ -	$ -	$ -
(4) 10-ton Packaged DX units EER=11.0, 4,000 cfm; 80% AFUE furnaces; all standard efficiency fan motors	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts on roof: sealed w/ HERS testing	Upgrade	$ 2,000	$ 3,000	$ 2,500
Standard 50 gallon gas water heater, EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 10,000**	**$ 14,200**	**$ 12,100**
Total Incremental Cost per Square Foot:		**$ 0.95**	**$ 1.34**	**$ 1.14**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 2 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-24 on Metal Span Deck, Cool Roof Refl.=0.69, Emitt=0.75	-	$ -	$ -	$ -
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Dual metal glazing U=0.71 and SHGCc=0.27, 3' overhangs 3,200 sf @ $2.50 to $3.50/sf	Upgrade	$ 8,000	$ 11,200	$ 9,600
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
(4) 10-ton Packaged DX units EER=11.0, 4,000 cfm; 80% AFUE furnaces; all standard efficiency fan motors	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts on the roof	-	$ -	$ -	$ -
Standard 50 gallon gas water heater, EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 10,100**	**$ 14,000**	**$ 12,050**
Total Incremental Cost per Square Foot:		**$ 0.95**	**$ 1.32**	**$ 1.14**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 3 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-24 on Metal Span Deck, Cool Roof Refl.=0.69, Emitt=0.75	-	$ -	$ -	$ -
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Dual metal glazing U=0.71 and SHGCc=0.40, 3' overhangs 3,200 sf @ $1.50 to $2.50/sf	Upgrade	$ 4,800	$ 8,000	$ 6,400
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, mandatory (on/off) ocupancy sensors; (40) 18w recessed CFLs. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.	-	$ -	$ -	$ -
(8) 5-ton Packaged DX units SEER=13.0, 2,000 cfm; 93% AFUE furnaces; fixed-temp integrated air-economizers	-	$ 3,600	$ 4,800	$ 4,200
R-8 duct insulation w/ ducts on roof: sealed w/ HERS testing	Upgrade	$ 2,000	$ 3,000	$ 2,500
Standard 50 gallon gas water heater, EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 10,400**	**$ 15,800**	**$ 13,100**
Total Incremental Cost per Square Foot:		**$ 0.98**	**$ 1.49**	**$ 1.24**

CZ6: Nonresidential 5-story office building: 52,900 sf, Window Wall Ratio= 29.1%

Title 24 Base Case Design, Option 1

Energy Efficiency Measures to Meet Title 24
R-19 on Metal Deck; cool roof Reflect=0.55, Emittance=0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
NFRC glazing U=0.57, SHGC=0.407 (COG SHGC=0.38)
Lighting = 0.802 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs. Small Offices: (280) 2-lamp T8 fixtures, (140) multi-level ocupancy sensors on T8s; (200) 18w recessed CFLs. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no controls.
(5) 40-ton Packaged VAV units EER=9.5; 78% TE furnaces; standard efficiency fan motors; 20% VAV boxes w/ electric reheat; DDC controls; differential temp. integrated air economizers
R-8 duct insulation w/ ducts in conditioned
(5) Instantaneous Electric Water Heaters EF=0.92

Title 24 Base Case Design, Option 2

Energy Efficiency Measures to Meet Title 24
R-19 on Metal Deck; cool roof Reflect=0.55, Emittance=0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
NFRC glazing U=0.57, SHGC=0.407 (COG SHGC=0.38)
Lighting = 0.802 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs. Small Offices: (280) 2-lamp T8 fixtures, (140) multi-level ocupancy sensors on T8s; (200) 18w recessed CFLs. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no controls.
(5) 40-ton Packaged VAV units EER=9.5; 78% TE furnaces; standard efficiency fan motors; 20% VAV boxes w/ hot water reheat; DDC controls; differential temp. integrated air economizers
R-8 duct insulation w/ ducts in conditioned
(5) Instantaneous Electric Water Heaters EF=0.92

Title 24 Base Case Design, Option 3

Energy Efficiency Measures to Meet Title 24
R-26 on Metal Deck, no cool roof
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
NFRC glazing U=0.57, SHGC=0.544 (COG SHGC=0.54)
Lighting = 0.802 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs. Small Offices: (280) 2-lamp T8 fixtures, mandatory (on/off) ocupancy sensors on T8s; (200) 18w recessed CFLs. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no controls.
Built-up VAV system, 80% boiler, 180-ton screw chiller 1.2 kw/ton, one AHU per floor, standard efficiency VSD fan motors; 20% VAV boxes w/ hot water reheat; DDC controls; differential temp. integrated air economizers
R-8 duct insulation w/ ducts in conditioned
(5) Instantaneous Electric Water Heaters EF=0.92

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 1 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-26 on Metal Deck; cool roof Reflect=0.70, Emittance=0.75 10,580 sf @ $0.90 to $1.60/sf	Upgrade	$ 9,522	$ 16,928	$ 13,225
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
NFRC glazing U=0.573, SHGC=0.312 (COG SHGC=0.27) 16,000 sf @ $1.00 to $2.00/sf	Upgrade	$ 16,000	$ 32,000	$ 24,000
Lighting = 0.696 w/sf: Open Office Areas: (160) HO 2-lamp T8 fixtures @74w each; no lighting controls; (120) 18w recessed CFLs. Small Offices: (280) 2-lamp T8 fixtures, (140) multi-level ocupancy sensors on T8s; (200) 18w recessed CFLs. Support Areas: (160) 18w recessed CFLs; (240) 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 in these areas	Upgrade	$ (5,760)	$ (6,400)	$ (6,080)
(5) 40-ton Packaged VAV units EER=9.5; 78% TE furnaces; Premium efficiency fan motors; 20% VAV boxes w/ hot water reheat; DDC controls; differential temp. integrated air economizers	Upgrade	$ 54,400	$ 81,350	$ 67,875
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
92% RE boiler for service hot water	Upgrade	$ 8,000	$ 12,000	$ 10,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 82,162**	**$ 135,878**	**$ 109,020**
Total Incremental Cost per Square Foot:		**$ 1.55**	**$ 2.57**	**$ 2.06**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 2 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-26 on Metal Deck; cool roof Reflect=0.72, Emittance=0.75 10,580 sf @ $0.90 to $1.60/sf	Upgrade	$ 9,522	$ 16,928	$ 13,225
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
NFRC glazing U=0.54, SHGC=0.30 (COG SHGC=0.27) 16,000 sf @ $3.00 to $4.00/sf	Upgrade	$ 48,000	$ 64,000	$ 56,000
Lighting = 0.696 w/sf: Open Office Areas: (160) HO 2-lamp T8 fixtures @74w each; no lighting controls; (120) 18w recessed CFLs. Small Offices: (280) 2-lamp T8 fixtures, (140) multi-level occupancy sensors on T8s; (200) 18w recessed CFLs. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no controls. Net saving of $38 to $42 per new fixture in open offices because of a total reduction of 46% of T8 fixtures in these areas	Upgrade	$ (5,760)	$ (6,400)	$ (6,080)
(5) 40-ton Packaged VAV units EER=9.5; 78% TE furnaces; Premium efficiency fan motors; 20% VAV boxes w/ hot water reheat; DDC controls; differential temp. integrated air economizers	Upgrade	$ 1,500	$ 2,500	$ 2,000
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
92% RE boiler for service hot water	Upgrade	$ 8,000	$ 12,000	$ 10,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 61,262**	**$ 89,028**	**$ 75,145**
Total Incremental Cost per Square Foot:		**$ 1.16**	**$ 1.68**	**$ 1.42**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 3 **Climate Zone 6**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-26 on Metal Deck, no cool roof	-	$ -	$ -	$ -
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
NFRC glazing U=0.57, SHGC=0.312 (COG SHGC=0.27) 16,000 sf @ $1.50 to $2.50/sf	Upgrade	$ 24,000	$ 40,000	$ 32,000
Lighting = 0.797 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs. Small Offices: (280) 2-lamp T8 fixtures, (140) multi-level occupancy sensors on T8s @ $75 to $100 each; (200) 18w recessed CFLs. Support Areas: (160) 18w recessed CFLs; (240) 13w CFL wall sconces; no controls.	Upgrade	$ 10,500	$ 14,000	$ 12,250
Built-up VAV system, 80% boiler, 180-ton screw chiller 1.2 kw/ton, one AHU per floor, standard efficiency VSD fan motors; 20% VAV boxes w/ hot water reheat; DDC controls; differential temp. integrated air economizers	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
DHW from 80% RE boiler used for space heating	Upgrade	$ 6,000	$ 10,000	$ 8,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 40,500**	**$ 64,000**	**$ 52,250**
Total Incremental Cost per Square Foot:		**$ 0.77**	**$ 1.21**	**$ 0.99**

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 residential utility rates of $0.159/kWh for electricity and $0.94/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: Southern California Edison GS-1 schedule for electricity and Southern California Gas GN-10 schedule for natural gas.

- 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 CO_2 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 6: 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)
2,025 sf (Option 1)	87	49	$1,782	$60	29.8
2,025 sf (Option 2)	81	50	$1,283	$60	21.4
Averages:	84	50	$1,533	$60	25.6

Annual Reduction in CO2-equivalent: ***618 lb./building-year***
0.30 lb./sq.ft.-year

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)	194	44	$2,803	$72	38.8
4,500 sf (Option 2)	207	43	$2,481	$73	33.8
4,500 sf (Option 3)	189	45	$2,439	$72	33.7
Averages:	197	44	$2,574	$73	35.4

Annual Reduction in CO2-equivalent: ***601 lb./building-year***
0.13 lb./sq.ft.-year

3.2 Low-rise Multi-family Building

Climate Zone 6: 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-Unit, 8,442 sf (Option 1)	470	227	$11,001	$288	38.2
8-Unit, 8,442 sf (Option 2)	-1221	483	$8,939	$260	34.4
Averages:	-376	355	$9,970	$274	36.3

Annual Reduction in CO2-equivalent: ***3,963 lb./building-year***
0.47 lb./sq.ft.-year

3.3 High-rise Multi-family Building

Climate Zone 6: 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)	1655	1110	$45,867	$1,307	35.1
36,800 sf (Option 2)	4800	555	$27,790	$1,285	21.6
36,800 sf (Option 3)	27657	-658	$40,560	$3,779	10.7
Averages:	11371	336	$38,072	$2,123	22.5

Annual Reduction in CO2-equivalent: ***11143 lb./building-year***
0.30 lb./sq.ft.-year

3.4 Nonresidential Buildings

Climate Zone 6: 15% Better Than Title 24
1-Story 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)	13427	-53	$12,100	$2,957	4.1
10,580 sf (Option 2)	5481	356	$12,050	$1,400	8.6
10,580 sf (Option 3)	12307	17	$13,100	$1,026	12.8
Averages:	10405	107	$12,417	$1,794	8.5

Annual Reduction in CO2-equivalent: ***5,924 lb./building-year***
0.56 lb./sq.ft.-year

Climate Zone 6: 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)	87180	-3439	$109,020	$17,289	6.3
52,900 sf (Option 2)	75234	-2433	$75,145	$15,720	4.8
52,900 sf (Option 3)	99931	-2733	$52,250	$21,244	2.5
Averages:	87448	-2868	$78,805	$18,084	4.5

Annual Reduction in CO2-equivalent: ***5,964 lb./building-year***
0.11 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 in exceeding 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 additional energy requirements of a local green building ordinance should carefully analyze building energy performance to reduce incremental first cost and the payback for the required additional energy efficiency measures.