COUNTY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

"To Enrich Lives Through Effective and Caring Service"

GAIL FARBER, Director

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ADDRESS ALL CORRESPONDENCE TO:
P.O. BOX 1460
ALHAMBRA, CALIFORNIA 91802-1460

IN REPLY PLEASE
REFER TO FILE:

September 4, 2012

The Honorable Board of Supervisors
County of Los Angeles
383 Kenneth Hahn Hall of Administration
500 West Temple Street
Los Angeles, CA 90012

Dear Supervisors:

PROPOSED AMENDMENTS TO THE 2011
LOS ANGELES COUNTY GREEN BUILDING STANDARDS CODE
(ALL SUPERVISORIAL DISTRICTS)
(3 VOTES)

SUBJECT

This action is to set a public hearing to consider a proposed ordinance to modify the Green Building Standards Code known as Title 31 of the Los Angeles County Code.

IT IS RECOMMENDED THAT YOUR BOARD:

Introduce, waive reading, and schedule a public hearing regarding an ordinance amending Title 31 – Green Building Standards Code, of the Los Angeles County Code, which incorporates by reference the 2010 California Green Building Standards Code.

AFTER THE PUBLIC HEARING, IT IS RECOMMENDED THAT YOUR BOARD:

1. Find that the proposed changes and modifications to building standards contained in the 2010 California Green Building Standards Code are reasonably necessary because of local climatic, geological, and/or topographical conditions, as detailed in the ordinance.

2. Approve the cost analysis and effectiveness study regarding the proposed energy standards included in the ordinance and find that these proposed energy standards will require buildings to be designed to consume no more energy than permitted by the California Energy Code.

3. Find that the proposed ordinance is exempt from the provisions of the California Environmental Quality Act pursuant to State Guidelines Section 15061(b)(3).

4. Adopt the ordinance amending Title 31 – Green Building Standards Code.

5. Direct the County of Los Angeles Department of Public Works to file the adopted ordinance containing your Board of Supervisors' findings with the California Building Standards Commission and the California Energy Commission.

PURPOSE/JUSTIFICATION OF RECOMMENDED ACTION

The enclosed ordinance, when adopted, will amend the County's Green Building Standards Code (Title 31) to mandate updated green building, drought-tolerant landscaping, and energy requirements for new construction within the unincorporated areas of the County.

Implementation of Strategic Plan Goals

The Countywide Strategic Plan directs the provisions of Operational Effectiveness (Goal 1) and Integrated Service Delivery (Goal 3) as it provides services to the public that have a wide-reaching positive effect on the entire community. The adoption of the County's Green Building Standards Code provides minimum green building design and construction standards and encourages sustainable construction practices that promote the health and welfare of the general public throughout the unincorporated area of Los Angeles County. By mandating updated green building, drought-tolerant landscaping, and energy requirements, the County will be able to ensure that its Strategic Goals are fully addressed.

FISCAL IMPACT/FINANCING

There will be no impact to the County General Fund. There will be minimal impact on expenditures for the Department of Public Works for training its personnel. All associated costs including these training costs and the printing of the new codes will be reimbursed by funds from fees for services.

FACTS AND PROVISIONS/LEGAL REQUIREMENTS

On November 23, 2010, your Board adopted an ordinance adding Title 31 – Green Building Standards Code and incorporated, by reference, the building standards contained in the 2010 California Green Building Standards Code together with critical and necessary County amendments.

The enclosed ordinance further amends the provisions of the 2010 California Green Building Standards Code to update green building requirements for newly constructed residential buildings of seven stories or more, and non-residential buildings of any height, with a gross floor area of 10,000 square feet or more. The enclosed ordinance also adopts energy standards and drought-tolerant landscaping requirements for all newly constructed buildings.

The California Health and Safety Code requires that the County adopt an ordinance that imposes the same building standards as are contained in the 2010 California Green Building Standards Code, with the exception that the County may make amendments to these building standards that are more restrictive and that are reasonably necessary because of local climatic, geological, and/or topographical conditions.

The enclosed ordinance incorporates, by reference, the building standards contained in the 2010 California Green Building Standards Code together with critical and necessary County amendments. In accordance with Sections 17958.5 and 17958.7 of the Health and Safety Code, your Board must determine and expressly find that the amendments to the State standards are necessary because of local climatic, geological, and/or topographical conditions.

The applicable finding(s) for each proposed amendment to the State's building standards are clearly delineated in a chart which is set forth in the proposed ordinance.

The enclosed ordinance establishes additional energy conservation measures and more stringent energy budgets than the standards contained in the California Energy Code. Section 25402.1 of the Public Resources Code requires that your Board find that the County's proposed energy standards are cost effective and require buildings to be designed to consume no more energy than permitted by the California Energy Code. The enclosed Energy Cost-Effectiveness studies contain supporting analysis of energy savings and a basis for cost effectiveness.

Following the adoption of the ordinance by your Board, four copies of the enclosed application, the ordinance, and cost-effectiveness studies must be submitted to the Executive Director of the California Energy Commission for approval. The energy standards contained in the ordinance cannot become operative until they have been approved by the California Energy Commission. Accordingly, it is recommended that your Board set an operative date of the amendments to be contingent upon approval of the energy standards by the California Energy Commission. The proposed amendments contained in the ordinance will then become operative upon filing with the State of California Building Standards Commission.

In accordance with the requirements of Government Code Section 50022.3, your Board must schedule a public hearing after the first reading of the title of the adopting ordinance. Notice of the hearing is required to be published pursuant to Government Code 6066. A copy of the California Green Building Standards Code must be on file with the Executive Office at least 15 days preceding the hearing and made available for public inspection.

A sample combined notice is submitted herewith.

ENVIRONMENTAL DOCUMENTATION

Adoption of these ordinances is exempt from the California Environmental Quality Act (CEQA) in that it can be seen with certainty that there is no possibility that the ordinance will have a significant effect on the environment pursuant to State CEQA Guidelines Section 15061(b)(3). The adoption of the proposed ordinance is covered by the general rule that CEQA applies only to projects that have the potential for causing a significant effect on the environment. The adoption of the proposed ordinance does not have such potential.

IMPACT ON CURRENT SERVICES (OR PROJECTS)

Other departments embarking on construction projects will be required to comply with the provisions of this ordinance if applications for permits to begin construction are submitted on or after the operative date of this ordinance.

CONCLUSION

Upon approval of the enclosed ordinance, please return one adopted copy of this letter and one adopted copy of the ordinance to the Department of Public Works, Building and Safety Division.

Respectfully submitted,

Gail Farber

GAIL FARBER
Director of Public Works

WTF:GF:RP:ll

Enclosures

c: Chief Executive Office (Rita Robinson)
County Counsel
Executive Office

COUNTY OF LOS ANGELES
OFFICE OF THE COUNTY COUNSEL

648 KENNETH HAHN HALL OF ADMINISTRATION
500 WEST TEMPLE STREET
LOS ANGELES, CALIFORNIA 90012-2713

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JOHN F. KRATTLI
Acting County Counsel

March 22, 2012

Gail Farber, Director
Department of Public Works
900 South Fremont Avenue
Alhambra, California 91803

Attention: Richard Clinton, Building & Safety

Re: Ordinance Amending Title 31 - Green Building Standards Code of the Los Angeles County Code

Dear Ms. Farber:

As requested, this office has prepared an ordinance amending Title 31 – Green Building Standards Code of the Los Angeles County Code to supplement the green building requirements of the Code, to enhance energy standards for newly constructed buildings, and to supplement drought tolerant landscaping requirements.

The ordinance and its analysis are enclosed and may be submitted to the Board of Supervisors for its consideration.

Very truly yours,

JOHN F. KRATTLI
Acting County Counsel

By Carole B. Suzuki
CAROLE B. SUZUKI
Deputy County Counsel
Public Works Division

APPROVED AND RELEASED:

JOHN F. KRATTLI
Acting County Counsel

CBS:gjv
Enclosure

HOA.856900.1

ANALYSIS

This ordinance amends Title 31 – Green Building Standards Code of the Los Angeles County Code, as follows:

- Clarifies that the definition of a "low-rise residential building" includes accessory buildings and parking structures;
- Adds supplemental green building requirements for the construction of residential buildings of seven stories or more, and non-residential buildings of any height, with a gross floor area of 10,000 square feet or more;
- Adopts stricter energy standards for all newly constructed buildings; and
- Adds supplemental drought-tolerant landscaping requirements.

JOHN F. KRATTLI
Acting County Counsel

By Carole B. Suzuki
CAROLE B. SUZUKI
Deputy County Counsel
Public Works Division

CBS:gjv

Requested: 08/08/11
Revised: 03/14/12

HOA.856934.1

ORDINANCE NO. _____

An ordinance amending Title 31 – Green Building Standards Code of the Los Angeles County Code, to impose revised green building requirements, energy standards and drought-tolerant landscaping requirements.

The Board of Supervisors of the County of Los Angeles ordains as follows:

SECTION 1. Section 202 is hereby amended to read as follows:

. . .

LOW-RISE RESIDENTIAL BUILDING. A building that is of Occupancy Group R and is six stories or less, or that is a one- or two-family dwelling, or townhouse, or any Occupancy Group U building or parking structure entirely associated with a Group R Occupancy.

. . .

SECTION 2. Section 301.2.2.1 is hereby amended to read as follows:

301.2.2.1 Buildings Equal to or gGreater tThan ~~or eEqual to 25,000~~Ten Thousand (10,000) sSquare ~~f~~Feet and Less Than Twenty-Five Thousand (25,000) Square Feet.

In addition to the requirements of Section 301.2.2, any newly constructed ~~project~~ building equal to or greater than ~~or equal to 25,000~~ten thousand (10,000) square feet and less than twenty-five thousand (25,000) square feet shall comply with the measures described in Section A5.601.2.~~4~~ (CALGreen Tier 1). ~~Compliance with Section A5.601.2.3 shall be voluntary.~~

SECTION 3. Section 301.2.2.2 is hereby added to read as follows:

301.2.2.2 Buildings Equal to or Greater Than Twenty-Five Thousand (25,000) Square Feet.

In addition to the requirements of Section 301.2.2, any newly constructed building equal to or greater than twenty-five thousand (25,000) square feet shall comply with the measures described in Section A5.601.3 (CALGreen Tier 2). Compliance with Section A5.601.3.3 shall be voluntary.

SECTION 4. Section 4.106.5 is hereby amended to read as follows:

4.106.5 Landscape ~~d~~Design.

Post construction landscape designs that are not required to obtain a landscape permit or develop a water budget under the California Department of Water Resources Model Water-Efficient Landscape Ordinance shall comply with all of the following:

1. Turf areas shall be water efficient and not exceed ~~25~~twenty-five percent (25%) of the total landscaped area.

2. Non-~~i~~invasive drought-tolerant plant and tree species appropriate for the climate zone region shall be utilized in at least ~~75~~seventy-five percent (75%) of the total landscaped area.

3. Hydrozoning irrigation techniques shall be incorporated into the landscape design.

SECTION 5. Section 4.201.1.1 is hereby added to read as follows:

4.201.1.1 Energy Performance.

Newly constructed buildings shall use an Alternative Calculation Method ("ACM") approved by the California Energy Commission to calculate the annual Time Dependent Valuation ("TDV") energy usage of each building, and achieve at least a fifteen percent (15%) reduction in energy usage when compared to the State's mandatory energy efficiency standards.

SECTION 6. Section 5.201.1.1 is hereby added to read as follows:

5.201.1.1 Energy Performance.

Newly constructed buildings shall use an Alternative Calculation Method ("ACM") approved by the California Energy Commission to calculate the annual Time Dependent Valuation ("TDV") energy usage of each building, and achieve at least a fifteen percent (15%) reduction in energy usage when compared to the State's mandatory energy efficiency standards.

SECTION 7. Section 5.304.1 is hereby amended to read as follows:

5.304.1 Water ~~b~~Budget.

. . .

1. Turf areas shall be water-efficient and shall not exceed ~~25~~twenty-five percent (25%) of the total landscaped area.

2. Non-invasive drought-tolerant plant and tree species appropriate for the climate zone region shall be utilized in at least ~~75~~seventy-five percent (75%) of the total landscaped area.

. . .

SECTION 8. The provisions of this ordinance contain various changes or modifications to requirements contained in the building standards published in the California Green Building Standards Code.

Pursuant to California Health and Safety Code sections 17958.5, 17958.7, and 18941.5, the Board of Supervisors hereby expressly finds that all of the changes and modifications to requirements contained in the building standards published in the California Green Building Standards Code, contained in this ordinance, are reasonably necessary because of local climatic, geological, or topographical conditions in the County of Los Angeles as more particularly described in the table set forth below:

GREEN BUILDING STANDARDS CODE AMENDMENTS		
CODE SECTION	**CONDITION**	**EXPLANATION**
301.2.2.1	Climatic, Topographic	Environmental resources in the County of Los Angeles are scarce due to varying and occasionally immoderate temperature and weather conditions. Expanding the scope of the mandatory requirements of this Code for buildings not defined as low-rise residential that are equal to or greater than ten thousand (10,000) square feet and less than twenty-five thousand (25,000) square feet in floor area will achieve a greater reduction in greenhouse gases, higher efficiencies of energy, water, material usage, and improved environmental air quality.

GREEN BUILDING STANDARDS CODE AMENDMENTS		
CODE SECTION	**CONDITION**	**EXPLANATION**
301.2.2.2	Climatic, Topographic	Environmental resources in the County of Los Angeles are scarce due to varying and occasionally immoderate temperature and weather conditions. Expanding the scope of the mandatory requirements of this Code for buildings not defined as low-rise residential that are equal to or greater than twenty-five thousand (25,000) square feet in floor area will achieve a greater reduction in greenhouse gases, higher efficiencies of energy, water, material usage, and improved environmental air quality.
4.106.5	Climatic	The County of Los Angeles is a densely populated area having residential buildings constructed within a region where water is scarce. The proposed landscape design measures will allow greater efficiencies of outdoor water use.
4.201.1.1	Climatic	Resources in the County of Los Angeles are scarce due to varying and occasionally immoderate temperatures and weather conditions. Expanding the scope of the mandatory measures to require all residential buildings to achieve a reduction in energy usage of at least 15 percent (15%) will reduce greenhouse gases and promote greater efficiencies in energy usage.
5.201.1.1	Climatic	Resources in the County of Los Angeles are scarce due to varying and occasionally immoderate temperatures and weather conditions. Expanding the scope of the mandatory measures to require all non-residential buildings to achieve a reduction in energy usage of at least 15 percent (15%) will reduce greenhouse gases and promote greater efficiencies in energy usage.

GREEN BUILDING STANDARDS CODE AMENDMENTS		
CODE SECTION	**CONDITION**	**EXPLANATION**
5.304.1	Climatic	The County of Los Angeles is a densely populated area having non-residential buildings constructed within a region where water is scarce. The proposed landscape design measures will allow greater efficiencies of outdoor water use.

SECTION 9. The provisions of this ordinance require compliance with energy standards that are different from and more stringent than the energy standards contained in the California Energy Code.

The Board of Supervisors hereby expressly finds that the energy standards adopted in this ordinance will require buildings to be designed to consume no more energy than permitted by the California Energy Code.

SECTION 10. This ordinance shall become operative upon the approval of the energy standards contained in the ordinance by the California Energy Commission.

[22522100MYCC]

Energy Cost-Effectiveness of Cool Roof for the Los Angeles County Green Building Ordinance

March 29, 2012

Report prepared for:
Richard C. Clinton, P.E.
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Mechanical/Green Building
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Table of Contents

1.0 Executive Summary

Gabel Associates has researched and reviewed the energy cost-effectiveness of the ordinance (the "Ordinance") amending Title 31 Green Building Standards Code of the Los Angeles County Code. The Ordinance shall become operative upon its approval by the California Energy Commission.

The Ordinance requires that new nonresidential and high-rise residential buildings between 10,000 square feet and 25,000 square feet of conditioned space meet CALGreen Tier 1 cool roof values; and buildings greater than 25,000 square feet of conditioned space meet CALGreen Tier 2 cool roof values as defined in the 7/1/12 Supplement, CALGreen Table A5.106.11.2.2. Tier 1 cool roof values are a prescriptive requirement in the 2008 (current) Building Energy Efficiency Standards, and they have been shown to be cost-effective through studies previously conducted by the California Energy Commission in support of the standards. This study considers the cost-effectiveness of the Tier 2 cool roof values as mandatory in the Los Angeles County ordinance which also requires that the covered types of new construction exceed the Title 24 Part 6 energy performance standards by 15%. Tier 2 cool roof values are as follows:

- **≤ 2:12 pitch ("Low-Slope") roofs** in climate zones 6, 8, 9 and 14: an Aged Solar Reflectance = 0.65, Thermal Emittance = 0.85 and SRI = 78.
- **> 2:12 pitch ("Steep-Slope") lightweight roofs** in climate zones 6, 8, 9, 14 and 16: an Aged Solar Reflectance = 0.23, Thermal Emittance = 0.85 and SRI = 20.
- **> 2:12 pitch ("Steep Slope") heavyweight roofs** in climate zones 6, 8, 9, 14 and 16: an Aged Solar Reflectance = 0.30, Thermal Emittance = 0.85 and SRI = 30.

Key data included in this evaluation include:

- Summary of a cost-effectiveness analysis using TDV energy prepared by Architectural Energy Corporation and presented at the 6/10/11 California Energy Commission Staff Workshop on the 2013 Building Energy Efficiency Standards (see *Appendix A, Nonresidential Cool Roof Proposal*).
- Original analysis using state-approved compliance software, Energy Pro v5.1, to evaluate annual site energy savings, site energy cost savings and cost-effectiveness of Tier 2 values in prototype Retail, Office and High-rise Residential buildings (see *Appendix B*). The analysis aims at assessing implementing Tier 2 cool roof requirements in the five California Climate Zones within Los Angeles County (CZ6, CZ8, CZ9, CZ14 and CZ16) under the conservative assumption that the cool roof has not already been specified to meet the overall energy performance requirement of 15% better than state code.

Omitted from the study are:

- Any effort to quantify and include the impact on mitigation of the urban heat island effect using cool roof surfaces with a high Solar Reflective Index (SRI), the stated green building goal in CALGreen ("*Section A5.106.11 Heat island effect. Reduce ... roof heat islands ..* ").
- External costs of climate change – either mitigation or adaptation -- associated with increase in CO2-e emissions.
- Predictions of summer temperature increases in the Western United States in the next several decades according to climate change computer models. Rising temperatures would have the general effect of increasing the effectiveness of cool roof surfaces in cooling climates.

2.0 Cool Roof Cost-Effectiveness Within the Context of the Los Angeles County Green Building Ordinance

This report summarizes a study of Tier 2 cool roof requirements from two different perspectives within the context of how building permit applicants are required to meet all energy performance aspects of the Ordinance. The first approach uses the societal value of "Time Dependent Valuation (TDV) Energy", the basis for the 2008 and the 2013 Building Energy Efficiency Standards and also referenced in CALGreen code in Title 24 Part 11. The second approach is based on an analysis conducted by Gabel Associates to consider site energy use and cost savings of cool roof based on local utility rates.

2.1 TDV Energy Cost-Effectiveness of Cool Roofs in the 2013 Energy Standards

The state's Building Energy Efficiency Standards contained in Title 24 Part 6 use a building energy performance metric called *Time Dependent Valuation (TDV) Energy* which is defined as "*.. the time varying energy caused to be used by the building to provide space conditioning and water heating, and for specified buildings, lighting. TDV energy accounts for the energy used at the building site and consumed in producing and in delivering energy to a site, including, but not limited to, power generation, transmission and distribution losses.*"

The societal value of energy varies as a function of several factors including fuel type (i.e., electricity, natural gas or propane), day of the year, hour of the day and California Climate Zone. As a result, On-Peak electricity during a summer afternoon has a much higher valuation than winter Off-Peak electricity. As summarized in a February 2011 report by E3 and Architectural Energy Corporation on the California Energy Commission web site ("*Time Dependent Valuation of Energy for Developing Building Efficiency Standards*"):

"The *concept behind TDV is that energy efficiency measure savings should be valued differently depending on which hours of the year the savings occur, to better reflect the actual costs of energy to consumers, to the utility system, and to society. The TDV method encourages building designers to design buildings that perform better during periods of high energy cost.*

Energy measures have been evaluated for inclusion in the new 2013 energy standards based on a cost-effectiveness methodology defined in a CEC report titled "*Life-Cycle Cost Methodology, 2013 California Building Energy Efficiency Standards*", 1/14/2011, prepared by Architectural Energy Corporation (AEC). Based on that general methodology, and with the support of the California Utilities Statewide Codes and Standards Team, AEC researched the cost-effectiveness of cool roofs and has prepared a CASE report ("*Nonresidential Cool Roofs*", October 2011) available from the CEC and included as *Appendix A* in this document. The work associated with that report, plus industry input, led Energy Commission staff to include the current CALGreen Tier 2 Low-Slope Cool Roof Aged Solar Reflectance value (0.65) in the 2013 Standards 45-Day language which was released 2/24/12. The proposed 2013 Steep-Slope Aged Solar Reflectance value of 0.20 is only somewhat less than the Tier 2 Low-Slope Roof values of 0.23 for Lightweight roofs and 0.30 for Heavyweight roofs.

Using the Present Worth of TDV energy, the *Nonresidential Cool Roofs* report calculates and contends that the above cool roof solar reflectance values are, on balance, cost-effective throughout Climate Zones 2 through 15. Also of interest in Appendix A is Table 5 data taken from a U.S. Department of Energy (DOE) 2010 paper on cool roofs which provides a summary of incremental costs going from a standard, dark roof with no cool roof coating to the "Cool Alternative".

Within the specific context of the Los Angeles County Ordinance, it is important to consider that buildings must also exceed the energy performance standards by at least 15% in addition to a specific measure such as cool roof. Exceeding Title 24 Part 6 by 15%, especially in cooling dominated climate zones, means that, in practice, building designers typically specify cool roof as part of the overall package of energy efficiency measures needed to reach that performance level.

An informal survey by Gabel Associates of four experienced Nonresidential Certified Energy Analysts (CEAs) who routinely model nonresidential and high-rise residential buildings suggests that perhaps 60% to 75% of nonresidential and high-rise residential buildings in cooling climates typically have cool roof specified as part of the combination of all energy features selected to exceed Title 24 by 15%. The implication is that only a minority of building projects will have to add a cool roof specification not already specified to meet the ordinance's overall energy performance requirement.

2.2 Site Energy Cost-Effectiveness of Cool Roofs in L.A. County Climate Zones

Another approach to establishing Tier 2 cool roof energy cost-effectiveness is to consider the site impacts on prototypical buildings covered by the ordinance. Gabel Associates has performed an analysis detailed in *Appendix B, Analysis of Cool Roof Site Energy Savings and Cost-Effectiveness in Five Los Angeles County Climate Zones* which uses current state-approved compliance software to determine annual energy savings and energy cost savings associated with cool roofs for three building types:

(1) 25,000 square feet 1-story retail building
(2) 52,900 square feet 5-story office building
(3) 64,400 square feet 70-unit, high-rise residential building

For each building, and in each of the five Los Angeles County Climate Zones, a base case energy design is run in which there is no cool roof specified, but the building exceeds the current Standards by at least 15%. Then, in accordance with the various Tier 2 values listed previously, the same exact same building is re-run -- the only change being the required cool roof values for aged solar reflectance and thermal emittance. The hour-by-hour simulation of the building's energy performance *includes current time-of-use utility rates* that typically apply to these buildings. The energy modeling analysis provides, in each instance, (a) the change in annual electricity and natural gas use; and, (b) the change in annual energy cost from the addition of the Tier 2 cool roof.

From the DOE Table 5 data contained in the *Appendix A* report, typical ranges of incremental cost for cool roof are used to develop a simple payback for the cool roof type and effectiveness applied to the prototype building modeled. For the sake of this analysis, the following incremental first costs were used:

Building Description	Tier 2 Solar Reflect.	Typical Low Cost ($/SF)	Typical High Cost ($/SF)	Average Typical Cost ($/SF)
1-Story Retail: Low-Slope, Any Weight	0.65	$0.48	$1.20	$0.84
1-Story Retail: Steep-Slope, Lightweight	0.23	$0.10	$0.50	$0.30
1-Story Retail: Steep-Slope, Heavyweight	0.30	$0.00	$0.05	$0.03

Results

As noted in Section 2.1, the following results assume that a cool roof has not already been specified in the building energy design and is not contributing to the overall energy performance to achieve 15% better than Title 24. In that sense, these results are worst case scenarios. If Tier 2 cool roof values are mandatory, the cool roof energy credit will automatically be included in the energy model to demonstrate compliance with the overall energy performance requirement.

CLIMATE ZONE 6 Building Description	Low Simple Payback (years)	High Simple Payback (years)	Average Simple Payback (years)
1-Story Retail: Low-Slope, Any Weight	9.4	23.4	16.4
1-Story Retail: Steep-Slope, Lightweight	6.8	34.1	20.4
1-Story Retail: Steep-Slope, Heavyweight	0.0	2.4	1.2
5-Story Office: Low-Slope, Any Weight	No Payback	No Payback	No Payback
5-Story Office: Steep-Slope, Lightweight	No Payback	No Payback	No Payback
5-Story Office: Steep-Slope, Heavyweight	No Payback	No Payback	No Payback
7-Story HR Res: Low-Slope, Any Weight	28.5	> 50	49.9
7-Story HR Res: Steep-Slope, Lightweight	36.8	> 50	> 50
7-Story HR Res: Steep-Slope, Heavyweight	0.0	9.6	4.8

CLIMATE ZONE 8 Building Description	Low Simple Payback (years)	High Simple Payback (years)	Average Simple Payback (years)
1-Story Retail: Low-Slope, Any Weight	8.0	20.1	14.0
1-Story Retail: Steep-Slope, Lightweight	5.3	26.7	16.0
1-Story Retail: Steep-Slope, Heavyweight	0.0	1.9	1.0
5-Story Office: Low-Slope, Any Weight	11.7	29.3	20.5
5-Story Office: Steep-Slope, Lightweight	6.6	32.9	19.7
5-Story Office: Steep-Slope, Heavyweight	0.0	2.5	1.3
7-Story HR Res: Low-Slope, Any Weight	28.5	> 50	49.9
7-Story HR Res: Steep-Slope, Lightweight	31.7	> 50	> 50
7-Story HR Res: Steep-Slope, Heavyweight	0.0	7.0	3.5

CLIMATE ZONE 9 Building Description	Low Simple Payback (years)	High Simple Payback (years)	Average Simple Payback (years)
1-Story Retail: Low-Slope, Any Weight	7.5	18.8	13.1
1-Story Retail: Steep-Slope, Lightweight	4.9	24.4	14.6
1-Story Retail: Steep-Slope, Heavyweight	0.0	1.8	0.9
5-Story Office: Low-Slope, Any Weight	8.6	21.4	15.0
5-Story Office: Steep-Slope, Lightweight	5.5	27.6	16.5
5-Story Office: Steep-Slope, Heavyweight	0.0	1.9	1.0
7-Story HR Res: Low-Slope, Any Weight	20.1	> 50	35.1
7-Story HR Res: Steep-Slope, Lightweight	29.7	> 50	> 50
7-Story HR Res: Steep-Slope, Heavyweight	0.0	7.2	3.6

CLIMATE ZONE 14 Building Description	Low Simple Payback (years)	High Simple Payback (years)	Average Simple Payback (years)
1-Story Retail: Low-Slope, Any Weight	5.3	13.2	9.3
1-Story Retail: Steep-Slope, Lightweight	3.6	18.1	10.9
1-Story Retail: Steep-Slope, Heavyweight	0.0	1.3	0.6
5-Story Office: Low-Slope, Any Weight	9.0	22.4	15.7
5-Story Office: Steep-Slope, Lightweight	6.4	31.9	19.1
5-Story Office: Steep-Slope, Heavyweight	0.0	2.3	1.2
7-Story HR Res: Low-Slope, Any Weight	24.9	> 50	43.7
7-Story HR Res: Steep-Slope, Lightweight	> 50	> 50	> 50
7-Story HR Res: Steep-Slope, Heavyweight	0.0	15.9	7.9

CLIMATE ZONE 16 Building Description	Low Simple Payback (years)	High Simple Payback (years)	Average Simple Payback (years)
1-Story Retail: Low-Slope, Any Weight	7.1	17.7	12.4
1-Story Retail: Steep-Slope, Lightweight	7.0	35.0	21.0
1-Story Retail: Steep-Slope, Heavyweight	0.0	2.4	1.2
5-Story Office: Low-Slope, Any Weight	24.5	> 50	42.9
5-Story Office: Steep-Slope, Lightweight	17.3	> 50	> 50
5-Story Office: Steep-Slope, Heavyweight	0.0	6.0	3.0
7-Story HR Res: Low-Slope, Any Weight	38.7	> 50	> 50
7-Story HR Res: Steep-Slope, Lightweight	> 50	> 50	> 50
7-Story HR Res: Steep-Slope, Heavyweight	0.0	13.9	7.0

In the mildest heating climate, CZ6, the reduction in electricity cost for cooling in the 5-story office building is more than offset by an increase in natural gas cost for heating. Those instances of "No Payback" indicate no net energy cost savings from cool roof.

The steep slope heavy roof is assumed to be ceramic/concrete tile which apparently has a very small incremental cost for a cool roof coating. Because of the low cost, a cool roof coating for that roof type appears to be consistently cost-effective. Cool roof in most roof types in most climate zones studied are relatively cost-effective in the 1-story retail building. The Tier 2 lightweight roof surfaces (low-slope or steep-slope) in the five- and seven-story buildings do not appear cost-effective in the climate zones studied using this analytic method.

3.0 Conclusions

Utility rate structures do not pass along to utility customers the actual instantaneous costs of meeting the highest summer electricity demands which may involve bringing on line older and less efficient power plants only for peak events on the statewide grid. The TDV energy cost-effectiveness study in Appendix A focuses on the societal present worth of energy and electricity savings in accounting for statewide hourly energy costs. From this perspective, the Tier 2 cool roof values are cost-effective, even ignoring the reduction of the heat island effect and assuming that external costs of climate change are zero.

The evaluation of cost-effectiveness using the sole focus of on-site building energy savings and energy cost savings from the Tier 2 cool roofs is a bit more complicated. As stated earlier, many -- if not most -- buildings required to meet all Ordinance requirements will already have cool roofs specified to help buildings exceed the Title 24 energy performance budget by at least 15%. In those buildings, there is either no extra cost or only a small incremental cost in reaching the mandatory Tier 2 levels if cool roof is a credit in the energy model. However, if a cool roof is not initially an energy measure that a designer has specified to achieve the 15% better energy performance, then adding the Tier 2 requirement may or may not be cost-effective even though Title 24 TDV energy credit will still accrue in the energy performance calculation.

Appendix A:

Nonresidential Cool Roofs CASE (Codes and Standards Enhancement Initiative) Report on the 2013 California Building Energy Efficiency Standards

October, 2011

CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Nonresidential Cool Roofs

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team October 2011

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1. Purpose

The proposed revision to the Title 24 cool roof reflectance prescriptive standards for low-sloped nonresidential roofs will bring California's standards up to date with the current state of the market for available cool roofs. This measure proposal seeks to move the prescriptive standard to R_{aged} = 0.67 across all climate zones for most nonresidential buildings. High-rise residential, hotel, and motel building in climate zones 1 and 16 will continue to not have a reflectance standard.
The increase in the prescriptive reflectance level is projected to produce energy savings over the 15 year projected life of a cool roof of between $0.40/ft^2 and $1.35/ft^2, depending on the climate zone, for standard nonresidential buildings.

2. Overview

<table>
<tr><td>a. Measure Title</td><td>Nonresidential Cool Roof Reflectance Standard</td></tr>
<tr><td>b. Description</td><td>This proposal would raise the prescriptive reflectance requirement for nonresidential low-sloped cool roofs from R_{aged} = 0.55 to R_{aged} = 0.67. Climate zones 1 and 16 would now have a reflectance standard, also at R_{aged} = 0.67 in climate zones 2-15.
For high-rise residential, hotel, and motel occupancies, the reflectance standard would be set at R_{aged} = 0.67 as well; those occupancies would continue to not have a reflectance standard in climate zones 1 and 16.
There will be no change to the existing exceptions to the reflectance standards or to the conditions under which the reflectance standard must be complied with for roofing alterations and additions. The reflectance standard for steep-sloped roofs will be changed as well to match the new reflectance standard for residential structures.</td></tr>
<tr><td>c. Type of Change</td><td>The proposed code change is a prescriptive code measure. The change will be implemented primarily through the prescriptive levels set forth in Tables 143-A and 143-B and associated text in Sections 143 and 149.</td></tr>
<tr><td>d. Energy Benefits</td><td>The energy benefits below reflect savings based on the prototype building as described in the Methodology section, where more detail is provided. Briefly, the prototype building is a 130' X 130', single-floor energy model, with Title 24-2008 minimally-compliant walls, roof insulation, and HVAC. Internal loads and schedules were taken from the Title 24-2008 ACM for nonresidential and high-rise residential occupancies. Energy use was modeled with roofing reflectance levels ranging from 0.08 to 0.87, including models at 0.55 and 0.67. All models used an emittance of 0.85, in accordance with the default assumptions of the NACM. The model used updated weather and TDV files.
<table>
<tr><th>CZ1</th><th>Electricity Savings (kWh/yr)</th><th>Demand Savings (kW)</th><th>Natural Gas Savings (Therm/yr)</th><th>TDV Savings</th></tr>
<tr><td>Per Unit Measure</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>Per Prototype Building</td><td>12,496</td><td>1.66</td><td>-78.4</td><td>255,014.9</td></tr>
<tr><td>Savings per square foot</td><td>0.74</td><td>9.8E-05</td><td>-4.6E-03</td><td>15.1</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><th>CZ2</th><th>Electricity Savings (kWh/yr)</th><th>Demand Savings (kW)</th><th>Natural Gas Savings (Therm/yr)</th><th>TDV Savings</th></tr>
<tr><td>Per Unit Measure</td><td>NA</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>Per Prototype Building</td><td>3,832</td><td>0.87</td><td>-8.4</td><td>90,279.6</td></tr>
<tr><td>Savings per square foot</td><td>0.23</td><td>5.1E-05</td><td>-5.0E-04</td><td>5.3</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
</table>

CZ3	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	3,319	0.68	-3.3	75,778.0
Savings per square foot	0.20	4.0E-05	-2.0E-04	4.5
CZ4	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	3,866	0.85	-2.3	91,009.4
Savings per square foot	0.23	5.0E-05	-1.3E-04	5.4
CZ5	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	4,599	1.05	-5.8	108,913.7
Savings per square foot	0.27	6.2E-05	-3.4E-04	6.4
CZ6	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	7,948	1.95	-3.7	195,781.1
Savings per square foot	0.47	1.2E-04	-2.2E-04	11.6
CZ7	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,693	1.56	-0.5	164,323.0
Savings per square foot	0.40	9.2E-05	-2.8E-05	9.7

CZ8	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	7,523	1.81	-1.0	183,923.9
Savings per square foot	0.45	1.1E-04	-6.2E-05	10.9

CZ9	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	3,582	0.91	-0.2	87,711.0
Savings per square foot	0.21	5.4E-05	-1.1E-05	5.2

CZ10	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	4,382	0.93	-0.9	102,212.6
Savings per square foot	0.26	5.5E-05	-5.6E-05	6.0

CZ11	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	3,893	0.88	-11.7	91,824.5
Savings per square foot	0.23	5.2E-05	-6.9E-04	5.4

CZ12	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	3,871	0.90	-10.0	92,014.1
Savings per square foot	0.23	5.3E-05	-5.9E-04	5.4

CZ13	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	4,093	0.92	-12.0	95,615.8
Savings per square foot	0.24	5.4E-05	-7.1E-04	5.7
CZ14	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	4,627	1.00	-10.3	107,643.6
Savings per square foot	0.27	5.9E-05	-6.1E-04	6.4
CZ15	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	5,157	0.97	-0.3	117,595.7
Savings per square foot	0.31	5.7E-05	-1.7E-05	7.0
CZ16	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	15,061	3.26	-142.7	328,191.1
Savings per square foot	0.89	1.9E-04	-8.4E-03	19.4
CZ2 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,049	1.99	-340.3	104,308.8
Savings per square foot	0.36	1.2E-04	-2.0E-02	6.2

CZ3 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,813	2.46	-385.7	123,761.2
Savings per square foot	0.40	1.5E-04	-2.3E-02	7.3

CZ4 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,527	1.78	-248.5	122,723.3
Savings per square foot	0.39	1.1E-04	-1.5E-02	7.3

CZ5 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,766	2.39	-419.6	111,755.5
Savings per square foot	0.40	1.4E-04	-2.5E-02	6.6

CZ6 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	9,982	2.87	-165.6	226,861.6
Savings per square foot	0.59	1.7E-04	-9.8E-03	13.4

CZ7 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	9,238	2.62	-91.7	224,514.1
Savings per square foot	0.55	1.6E-04	-5.4E-03	13.3

CZ8 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,884	1.67	-100.8	152,614.3
Savings per square foot	0.41	9.9E-05	-6.0E-03	9.0
CZ9 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	7,661	1.90	-144.3	163,495.3
Savings per square foot	0.45	1.1E-04	-8.5E-03	9.7
CZ10 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,027	0.52	-56.3	40,244.3
Savings per square foot	0.12	3.1E-05	-3.3E-03	2.4
CZ11 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,158	0.48	-86.0	36,557.3
Savings per square foot	0.13	2.8E-05	-5.1E-03	2.2
CZ12 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	7,162	1.78	-296.9	125,618.9
Savings per square foot	0.42	1.1E-04	-1.8E-02	7.4

CZ13 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,327	0.48	-79.3	40,234.8
Savings per square foot	0.14	2.8E-05	-4.7E-03	2.4

CZ14 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,263	0.50	-100.6	35,514.7
Savings per square foot	0.13	3.0E-05	-6.0E-03	2.1

CZ15 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,669	0.49	-24.7	55,750.6
Savings per square foot	0.16	2.9E-05	-1.5E-03	3.3

Statewide Savings Estimates

The savings from this/these measures results in the following statewide first year energy savings. The present value savings of the measure over the 15 year life-cycle is also shown.

1. Non-Residential, New Construction

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	0.354	0.26	-1.63	$924,517
2	3.383	0.78	-1.69	$3,102,017
3	13.869	2.77	-2.77	$10,797,098
4	8.374	1.93	-1.09	$7,822,881
5	1.626	0.44	-0.55	$1,800,195
6	13.027	6.12	-2.87	$26,142,997

7	16.973	6.79	-0.48	$28,481,558
8	15.490	6.97	-0.96	$29,210,229
9	30.579	6.42	-0.34	$27,508,549
10	9.012	2.34	-0.50	$9,354,791
11	4.684	1.08	-3.23	$4,375,557
12	23.988	5.52	-14.15	$22,409,517
13	10.720	2.57	-7.61	$10,570,819
14	1.975	0.53	-1.21	$2,187,182
15	0.858	0.27	-0.01	$1,038,930
16	2.506	2.23	-21.05	$8,411,461
Total	157.418	47.02	-60.15	$194,138,300

2. High-Rise Residential (incl. hotels and motels), new construction

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	0.034	0.00	0.00	0
2	0.290	0.10	-5.79	$310,747
3	0.791	0.32	-18.20	$999,204
4	0.769	0.30	-11.54	$971,695
5	0.149	0.06	-3.73	$170,576
6	0.500	0.30	-4.90	$1,159,957
7	0.672	0.37	-3.63	$1,545,852
8	0.943	0.39	-5.66	$1,468,303
9	2.191	0.99	-18.62	$3,676,683
10	0.330	0.04	-1.09	$137,187
11	0.166	0.02	-0.84	$63,023
12	1.337	0.56	-24.07	$1,712,250
13	0.493	0.07	-2.32	$204,859
14	0.190	0.02	-1.14	$68,867
15	0.044	0.01	-0.07	$24,912
16	0.198	0.00	0.00	$0
Total	9.098	3.54	-101.61	$12,514,113

3. Total New Construction Statewide Impact

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	0.034	0.26	-1.63	$924,517
2	0.290	0.88	-7.49	$3,412,764
3	0.791	3.09	-20.97	$11,796,302
4	0.769	2.23	-12.63	$8,794,576
5	0.149	0.50	-4.29	$1,970,771
6	0.500	6.42	-7.77	$27,302,954
7	0.672	7.16	-4.10	$30,027,410
8	0.943	7.36	-6.62	$30,678,532
9	2.191	7.41	-18.96	$31,185,232
10	0.330	2.38	-1.60	$9,491,978
11	0.166	1.10	-4.08	$4,438,580
12	1.337	6.08	-38.23	$24,121,767
13	0.493	2.64	-9.93	$10,775,679
14	0.190	0.56	-2.34	$2,256,049
15	0.044	0.27	-0.08	$1,063,842
16	0.198	2.23	-21.05	$8,411,461
Total	9.098	50.56	-161.76	$206,652,413

4. Alterations (Re-Roofs) Nonresidential Statewide Impact

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	1.069	0.79	-4.92	$2,793,833
2	9.721	2.24	-4.86	$8,913,507
3	45.454	9.09	-9.09	$35,386,225
4	22.967	5.28	-2.99	$21,455,630
5	4.459	1.20	-1.52	$4,937,353
6	44.457	20.90	-9.78	$89,217,293
7	23.793	9.52	-0.67	$39,926,441
8	58.880	26.50	-3.65	$111,030,016

9	51.917	10.90	-0.57	$46,704,437
10	40.560	10.55	-2.27	$42,100,944
11	8.789	2.02	-6.06	$8,210,642
12	47.512	10.93	-28.03	$44,385,369
13	17.912	4.30	-12.72	$17,663,162
14	7.514	2.03	-4.58	$8,320,026
15	6.728	2.09	-0.11	$8,147,285
16	6.215	5.53	-52.21	$20,859,100
Total	397.948	123.85	-144.03	$510,051,264

Table 5: Alterations, High-Rise Residential (incl. hotels, motels)

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	0.078	0.00	0.00	0
2	0.606	0.22	-12.12	$649,968
3	2.827	1.13	-65.02	$3,570,404
4	1.397	0.54	-20.95	$1,763,804
5	0.271	0.11	-6.78	$309,626
6	1.961	1.16	-19.22	$4,546,195
7	1.862	1.02	-10.05	$4,284,169
8	2.562	1.05	-15.37	$3,989,712
9	2.232	1.00	-18.97	$3,745,468
10	1.904	0.23	-6.28	$790,336
11	0.339	0.04	-1.73	$129,185
12	2.215	0.93	-39.87	$2,835,304
13	0.695	0.10	-3.27	$288,712
14	0.306	0.04	-1.84	$111,176
15	0.339	0.05	-0.51	$193,459
16	0.261	0.00	0.00	$0
Total	19.855	7.63	-221.98	$27,207,518

6. Total Impact, Alterations

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	1.147	0.79	-4.92	$2,793,833
2	10.327	2.45	-16.98	$9,563,474
3	48.282	10.22	-74.12	$38,956,629
4	24.363	5.83	-23.94	$23,219,434
5	4.730	1.31	-8.30	$5,246,979
6	46.419	22.05	-29.00	$93,763,488
7	25.655	10.54	-10.72	$44,210,610
8	61.442	27.55	-19.03	$115,019,728
9	54.149	11.91	-19.54	$50,449,906
10	42.463	10.77	-8.55	$42,891,280
11	9.128	2.07	-7.80	$8,339,827
12	49.726	11.86	-67.90	$47,220,673
13	18.607	4.40	-15.99	$17,951,874
14	7.820	2.07	-6.42	$8,431,202
15	7.067	2.14	-0.62	$8,340,744
16	6.476	5.53	-52.21	$20,859,100
Total	417.804	131.49	-366.01	$537,258,781

7. Total Statewide Impact, New Construction and Alterations

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	1.536	1.053	-6.548	$3,718,349
2	14.000	3.336	-24.466	$12,976,238
3	62.942	13.312	-95.087	$50,752,931
4	33.507	8.053	-36.565	$32,014,010
5	6.506	1.811	-12.583	$7,217,750
6	59.946	28.470	-36.769	$121,066,442
7	43.299	17.700	-14.824	$74,238,020
8	77.876	34.904	-25.644	$145,698,260
9	86.918	19.314	-38.503	$81,635,138
10	51.806	13.157	-10.148	$52,383,257

	11	13.978	3.164	-11.872	$12,778,407	
	12	75.052	17.937	-106.125	$71,342,440	
	13	29.821	7.038	-25.916	$28,727,552	
	14	9.985	2.627	-8.762	$10,687,251	
	15	7.968	2.413	-0.703	$9,404,587	
	16	9.180	7.762	-73.259	$29,270,561	
	Total	584.320	182.052	-527.772	$743,911,194	
e. Non-Energy Benefits	Increasing the use of cool roofs will help to reduce the heat island effect by absorbing less heat on roof surfaces.					

f. Environmental Impact

There are no known significant environmental impacts associated with the proposed code change.

Material Increase (I), Decrease (D), or No Change (NC): (All units are lbs/year)

	Mercury	Lead	Copper	Steel	Plastic	Others (Titanium dioxide)
Per Unit Measure[1]	NC	NC	NC	NC	NA	0.0072 lb / ft2
Per Prototype Building[2]	NC	NC	NC	NC	NA	121.7 lb

The titanium dioxide estimate assumes an increase of up to 6% in TiO_2 by weight, from a standard product formulation of 5% to 10% TiO_2 by weight. This assumes a product coverage of 12 lb/100ft^2 (approximately 1 gallon/100ft^2). Crude titanium dioxide is first converted to titanium tetrachloride and re-oxidized under very high temperatures.

Water Consumption:

	On-Site (Not at the Powerplant) Water Savings (or Increase) (Gallons/Year)
Per Unit Measure[1]	NC
Per Prototype Building[2]	NC

Water Quality Impacts:

	Mineralization (calcium, boron, and salts	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	NC	NC	NC	NC
Reasons	NC	NC	NC	NC

g. Technology Measures	If the measure requires or encourages a particular technology, address the following, otherwise skip this section. **Measure Availability:** Approximately half of all field applied coatings (134 of 248) and single-ply thermoplastic membranes (22 of 57) that currently meet the nonresidential low-sloped standard of $R_{aged} = 0.55$ will meet the new standard of $R_{aged} = 0.67$. Of the products currently meeting the low slope reflectance standard of $R_{aged} = 0.55$, the average R_{aged} for field applied coatings in 0.67 and the average R_{aged} for single-ply thermoplastics is 0.67. $R_{aged} = 0.67$ is readily available in the market. Carlisle Syntec, Cooley, Dow Roofing, Firestone, Johns Manville, Mule-Hide, Tremco, Versico and other manufacturers have single-ply membrane products with an aged reflectance of 0.67. **Useful Life, Persistence, and Maintenance:** Most cool roof products are projected to have a useful life of 10-15 years, although some can last longer. The performance of a high reflectance cool roof will be improved through regular washing to remove dirt accumulation that can darken the surface. Some cool roof coatings may need recoating after 7 to 8 years of operation.
h. Performance Verification of the Proposed Measure	There are no changes proposed to the existing performance verification process using CRRC ratings. Three-year aged reflectance as measured by CRRC procedures is used for performance verification.

i. Cost Effectiveness

a	b	c		e		f	g
Measure Name	Measure Life (Years)	Additional Costs[1]– Current Measure Costs (Relative to Basecase) ($)		PV of Additional[3] Maintenance Costs (Savings) (Relative to Basecase) (PV$)		PV of[4] Energy Cost Savings – Per Proto Building (PV$)	LCC Per Prototype Building ($)
		Per Unit	Per Proto Building	Per Unit	Per Proto Building		(c+e)-f Based on Current Costs
CZ1	15	$0.50	$8,450.00	NA	NA	$22,696	($14,246)
CZ2	15	$0.00	$0.00	NA	NA	$9,946	($9,946)
CZ3	15	$0.00	$0.00	NA	NA	$6,744	($6,744)
CZ4	15	$0.00	$0.00	NA	NA	$8,100	($8,100)
CZ5	15	$0.00	$0.00	NA	NA	$9,693	($9,693)
CZ6	15	$0.00	$0.00	NA	NA	$17,424	($17,424)
CZ7	15	$0.00	$0.00	NA	NA	$14,624	($14,624)
CZ8	15	$0.00	$0.00	NA	NA	$16,369	($16,369)
CZ9	15	$0.00	$0.00	NA	NA	$7,806	($7,806)
CZ10	15	$0.00	$0.00	NA	NA	$9,097	($9,097)
CZ11	15	$0.00	$0.00	NA	NA	$8,172	($8,172)
CZ12	15	$0.00	$0.00	NA	NA	$8,189	($8,189)
CZ13	15	$0.00	$0.00	NA	NA	$8,509	($8,509)
CZ14	15	$0.00	$0.00	NA	NA	$9,580	($9,580)
CZ15	15	$0.00	$0.00	NA	NA	$10,466	($10,466)
CZ16	15	$0.50	$8,450.00	NA	NA	$29,208	($20,758)
CZ1 - HRR	15	$0.50	$8,450.00	NA	NA	($1,700)	$10,150
CZ2 - HRR	15	$0.50	$8,450.00	NA	NA	$9,283	($833)
CZ3 - HRR	15	$0.50	$8,450.00	NA	NA	$11,014	($2,564)
CZ4 - HRR	15	$0.50	$8,450.00	NA	NA	$10,922	($2,472)
CZ5 - HRR	15	$0.50	$8,450.00	NA	NA	$9,946	($1,496)
CZ6 - HRR	15	$0.50	$8,450.00	NA	NA	$20,190	($11,740)
CZ7 - HRR	15	$0.50	$8,450.00	NA	NA	$19,981	($11,531)
CZ8 - HRR	15	$0.50	$8,450.00	NA	NA	$13,582	($5,132)
CZ9 - HRR	15	$0.50	$8,450.00	NA	NA	$14,551	($6,101)
CZ10 - HRR	15	$0.00	$0.00	NA	NA	$3,582	($3,582)
CZ11 - HRR	15	$0.00	$0.00	NA	NA	$3,253	($3,253)
CZ12 - HRR	15	$0.50	$8,450.00	NA	NA	$11,180	($2,730)
CZ13 - HRR	15	$0.00	$0.00	NA	NA	$3,581	($3,581)
CZ14 - HRR	15	$0.00	$0.00	NA	NA	$3,161	($3,161)
CZ15 - HRR	15	$0.00	$0.00	NA	NA	$4,962	($4,962)
CZ16 - HRR	15	$0.50	$8,450.00	NA	NA	$6,902	$1,548

a	b	c	d	e	f	g
Measure Name	Measure Life (Years)	Additional Costs[1]– Current Measure Costs	Additional Cost[2]– Post-Adoption Measure Costs	PV of Additional[3] Maintenance Costs (Savings)	PV of[4] Energy Cost	LCC Per Prototype Building ($)

j. Analysis Tools	No changes are needed to the performance analysis tools other than to update the Table 143-A and Table 143-B reflectance values for the reference design.
k. Relationship to Other Measures	This measure will interact, by way of available tradeoffs, with the new mandatory minimum reflectance levels being proposed by the California Energy Commission.

3. Methodology

The revised reflectance levels for low-sloped nonresidential cool roofs were developed by looking at a combination of factors, focused on market availability, potential energy savings, and product costs. The Cool Roof Rating Council website was used to assess product availability, followed by calls to roofing supply distributors throughout California to determine what roofing products were currently available for sale and at what price per square foot. Our research indicated that with a significant number of products now on the market with aged CRRC ratings, the market is ready to move to a standard of $R_{aged} = 0.67$ by 2014.

For those building types in climate zones that do not presently have a low-sloped cool roof standard, existing studies and RS Means were used to assess the likely price premium of moving from a dark roof to a cool roof. Those studies include:

Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements, by Lawrence Berkeley National Lab for Pacific Gas & Electric for the 2005 Title 24 code update process

Guidelines for Selecting Cool Roofs, Department of Energy, 2010

Building Construction Cost Data, RS Means, 2010

A single story, 16,900 ft^2 office building was modeled using EnergyPlus and the new Title 24 2013 TDV and weather files. Roof reflectance levels from .08 to 0.87 were modeled, including models at reflectance levels of 0.55 and 0.67. The buildings used standard assumptions from the NACM and code minimum attributes for HVAC and insulation, varying the values by climate zone as set forth by Title 24. Two major categories of buildings were analyzed, a standard office occupancy and a high-rise residential occupancy.

	Occupancy Type (Residential, Retail, Office, etc)	Area (Square Feet)	Number of Stories	Other Notes
Prototype 1	Office	16,900	1	
Prototype 2	High-rise res	16,900	1	

Figure 1. Prototype Key Characteristics

3.1 Statewide Savings Estimates

The statewide energy savings associated with the proposed measures will be calculated by multiplying the energy savings per square foot with the statewide estimate of new construction in 2014. Details on the method and data source of the nonresidential construction forecast are in section 7.2.

4. Analysis and Results

4.1 Product Availability

Looking first to the question of product availability, the research showed that there are a sufficient number of products on the market at or near the $R_{aged} = 0.67$ level to support the adoption of that standard for enforcement starting in 2014. There are over 200 products listed on the CRRC database that meet the proposed $R_{aged} = 0.67$ standard. More products are likely coming on the market before the proposed standard would take effect in 2014.

Analyzing the availability of single-ply thermoplastics (TPO and PVC) as well as field applied coatings using the CRRC database, the following availability information summarizes the state of the market. For those two product types, cool roofs over $R_{aged} = 0.55$ are converging on an average R_{aged} of 0.67.

	Average R_{aged} of products with $R_{aged} \geq 0.55$	Products with $R_{aged} \geq 0.67$	Products with $R_{aged} \geq 0.55$
Field-applied coatings	0.70	134	of 248
Single-ply Thermoplastics	0.67	22	of 57

Figure 2: Product Availability Summary

Stakeholders raised concerns after the June 2011 workshop that the requirement of an aged reflectance of 0.67 would eliminate over a third of the products on the market. They expressed particular concern over the impact the proposed change would have on built-up roofing products that are widely used for low-sloped roofing. In particular, re-roofing, which by some estimates accounts for approximately 70% of the roofing market, allows for less flexibility in selecting roofing products. Only a couple of BUR products meet the current 0.55 aged reflectance standard, and none would meet the proposed standard.

To address this issue, AEC developed a simplified insulation tradeoff procedure for re-roofing and alterations.

4.2 Cool Roof Product Costs, $R_{aged} = 0.55$ to $R_{aged} = 0.67$

With commercial low-sloped cool roofs products moving toward average R_{aged} values of 0.67, this proposed measure actually has a measure cost that is less expensive than the historical standard. Within the cool roof market, many of the products with R_{aged} values close to 0.55 are actually tinted versions of the more conventional white versions of the same product. The products with the darker reflectance can, therefore, actually have a higher initial cost while also driving higher energy costs. For field-applied coatings, costs are flat in relation to reflectance throughout the range from $R_{aged} = 0.67$ to $R_{aged} = 0.80$. Below the level of $R_{aged} = 0.67$ prices appear to actually increase.

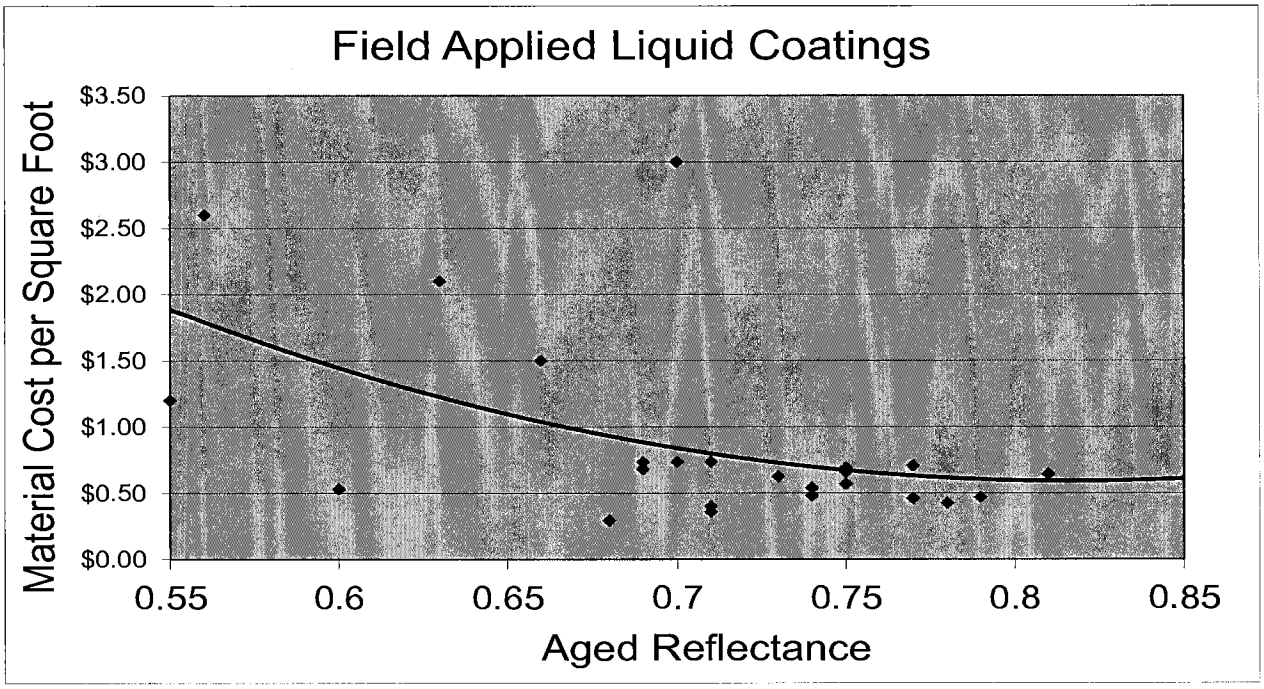

Figure 3. Cost of Field Applied Coatings

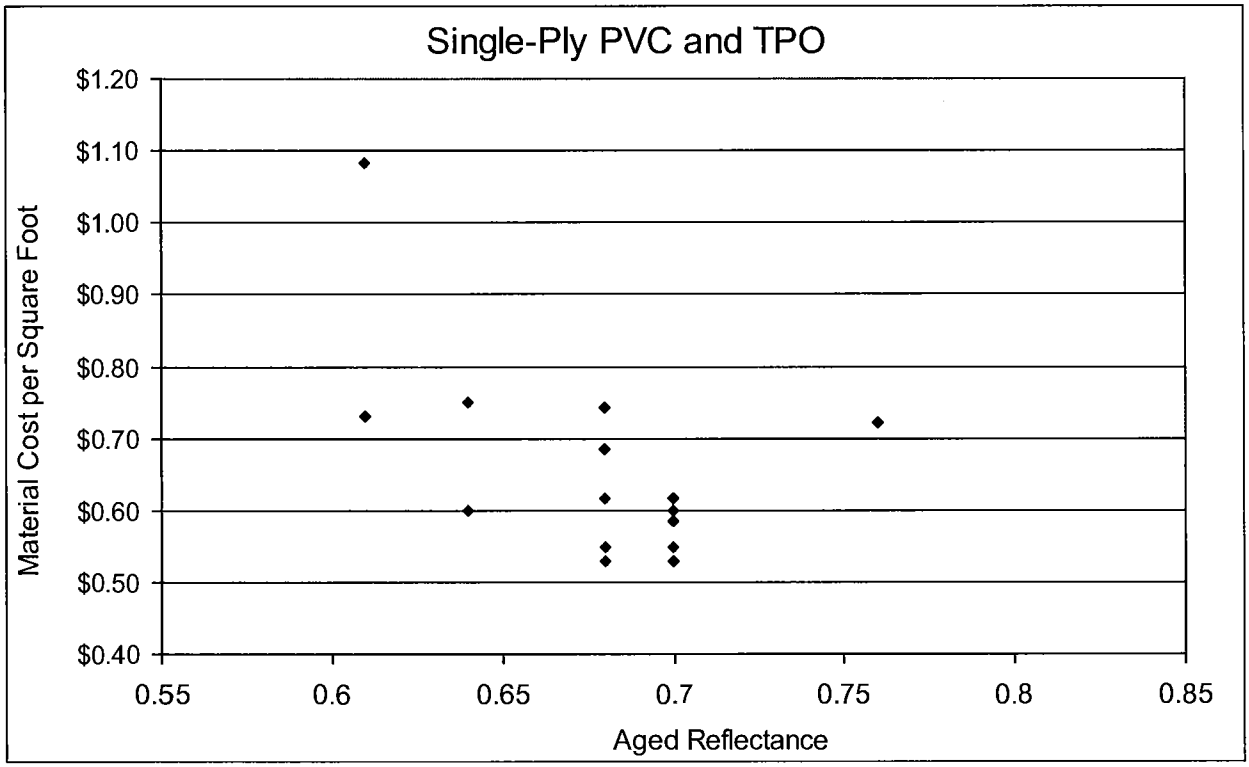

Figure 4. Material Cost of Single-Ply Membranes

For single-ply membranes, the lowest cost products appear to be in the R_{aged} = 0.67 range.

An additional comparison is to compare the installed cost of a built-up roof with a cool cap sheet that meets the 2008 Title 24 cool roof requirements (ρ=0.55) with the installed cost of a single-ply roof that meets the new proposed requirement (ρ=0.67). This incremental installed costs, from cost surveys, is estimated at $\$0.30/ft^2$. This number will be used as a conservative estimate for the incremental cost.

4.3 Cool Roof Product Costs, from No Standard to R_{aged} = 0.67

For standard nonresidential buildings in climate zones 1 and 16 and high-rise residential, hotel, motel buildings in climate zones 1-9, 12, and 16 for, there is no existing cool roof standard. For those instances, the baseline against which a shift to an R_{aged} = 0.67 standard should be evaluated is a dark roof.

For this study cost surveys were used to determine product cost for single ply roofing and for field-applied coatings. Additional cost surveys developed with ARMA were performed to determine:

1. Installed cost of built-up roofs (BURs), both cool and non-cool options
2. Installed cost of single-ply roofs
3. Installed cost of modified bitumen roofs
4. Costs of factory-applied and field-applied coatings
5. Costs to recoat
6. Re-roof costs if replaced with a BUR
7. Re-roof costs if replaced with a cool BUR
8. Re-roof costs if replaced with a single ply roof

A cost survey was sent to roofing contractors throughout the state, covering the San Francisco Bay Area, the Sacramento Valley, Los Angeles, San Diego, Fresno and San Bernardino areas. Only a fraction of those contacted agreed to provide feedback on the survey, and only a few survey responses were received.

The incremental cost to make a non-cool roof cool by adding a cool cap sheet to a built-up roof is estimated at $\$0.54/ft^2$. The incremental installed cost of a roofing system with a reflectance that meets the proposed requirement over a roofing system that meets the current roof reflectance requirement of 0.55 is $\$0.30/ft^2$. Therefore, the incremental cost to go from a non-cool roof to a cool roof that meets the new proposed requirement is $\$0.84/ft^2$.

Some survey respondents indicated that installing a single-ply roof on a re-roof can actually be less expensive than a built-up roof with a cool cap sheet. The higher of the incremental costs were used as the cost estimate as a conservative assumption.

4.4 Energy Savings and Cost Effectiveness for Nonresidential Buildings

Using energy models for a standard nonresidential buildings, the proposed measure shows 15 year energy savings of between $\$0.40/ft^2$ and $\$1.03/ft^2$ in climate zones 2 through 15 that presently have a standard of R_{aged} = 0.55. In those climate zones, because the additional cost is $\$0.30/ft^2$, the proposed measure is cost effective.

In climate zones 1 and 16, where there is not presently a cool roof standard, the energy models show projected 15 year energy savings of $\$1.34/ft^2$ and $\$1.73/ft^2$. With an estimated measure cost of $\$0.84/ft^2$ to move from no standard to $R_{aged} = 0.67$, the proposed measure is cost effective in those climate zones as well. Due to product availability, an aged reflectance of 0.67 makes a more appropriate prescriptive standard for this code cycle, the 2013 Standards update.
The cool roof reflectance standard should, therefore, be moved to $R_{aged} = 0.67$ for all climate zones for standard nonresidential buildings.

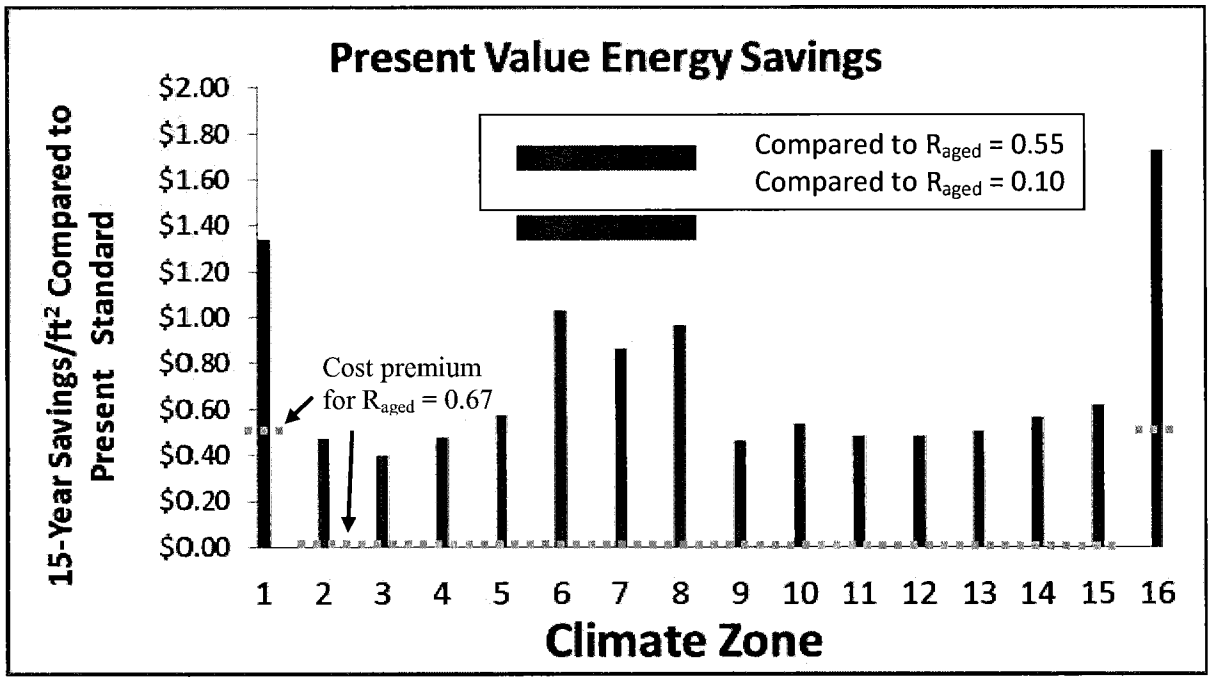

Figure 5. Life-Cycle Energy Savings by Climate Zone, Nonresidential

4.5 Energy Savings and Cost Effectiveness for High-Rise Residential, Hotel, and Motel Buildings

Using energy models for a high-rise residential building, the proposed measure shows 15 year energy savings of between $\$0.19/ft^2$ and $\$0.29/ft^2$ in climate zones 10, 11, 13, 14, and 15 that presently have a standard of $R_{aged} = 0.55$. In those climate zones, because there is no additional cost for the proposed measure, the proposed measure is cost effective.
For the climate zones where there is not presently a cool roof standard, the energy models show projected 15 year energy savings in climate zones 2-9 and 12 for $R_{aged} = 0.67$ that exceed the estimated measure cost of $\$0.50/ft^2$.
The cool roof reflectance standard should, therefore, be moved to $R_{aged} = 0.67$ for climate zones 2-15 for high-rise residential, hotel, and motel buildings.

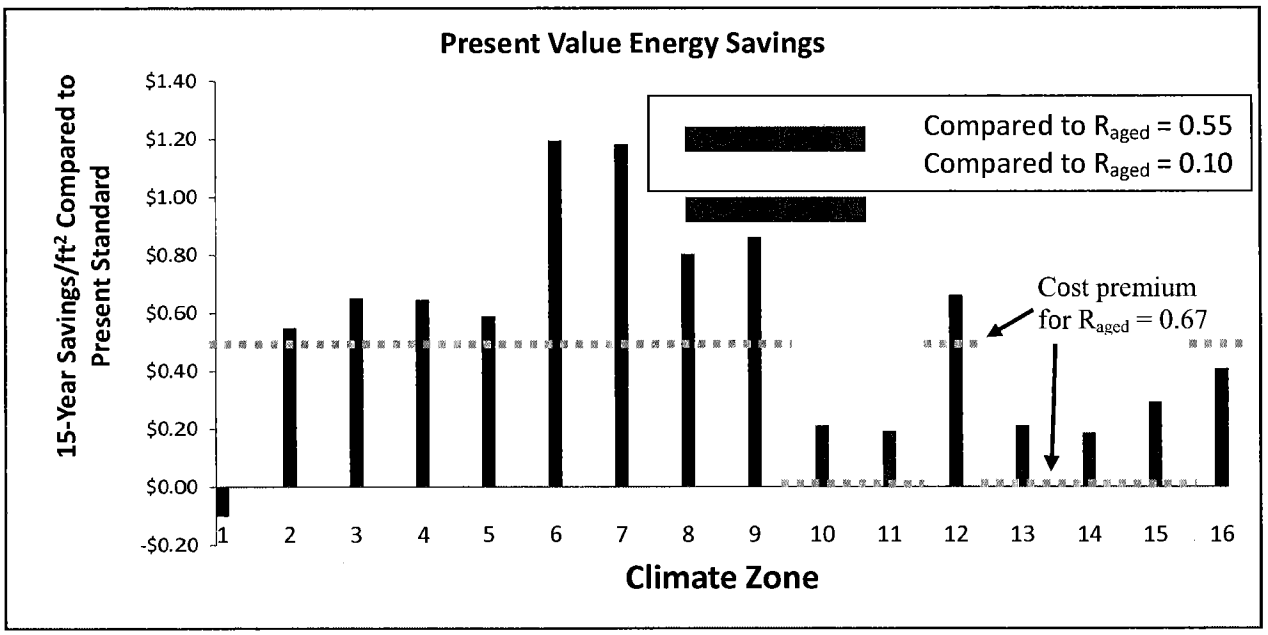

Figure 6. Life-Cycle Energy Savings by Climate Zone, High-Rise Residential

4.6 Insulation Tradeoff for Roof Alterations

The initial proposal would require the replacement of a roof with a roofing system with an aged reflectance of 0.67, matching the prescriptive requirement. After meetings with stakeholders, AEC and CEC staff thought that the limitations of available reflective products for re-roofs created the need for more flexibility in alterations. The proposed requirement of 0.63 aged reflectance applies to alterations.

In response to stakeholders' concerns about the lack of product options that can be used in re-roofing, AEC developed a simplified tradeoff table that can be used with alterations. As the baseline, AEC assumed a lower level of insulation than is required for new construction. The amount of insulation assumed is the values in Section 149 of the 2008 Title 24 Standards, R-8 of continuous insulation (U=0.081) for temperate climates and R-14 of continuous insulation (U=0.055) for inland and mountain climates. Parametric energy simulations were run by varying the roof envelope assembly between over five insulation levels corresponding from 0.01 to 0.081. A linear correlation was developed between TDV energy use and U-factor. For each set of insulation runs, reflectance levels were varied in increments of 0.05 down to a minimum of 0.1. The same set of simulations was performed for the high-rise residential occupancy.

Refl.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	**Avg**
0.67																	
0.6	3.6	3.2	3.3	2.5	3.6	2.8	3.3	2.5	2.2	2.9	2.5	2.7	2.5	2.7	2.2	2.6	**2.8**
0.55	6.2	5.4	5.5	4.2	6.1	4.6	5.4	4.2	3.5	5.0	4.2	4.5	4.1	4.5	3.8	4.4	**4.7**

0.5	8.7	7.5	7.6	5.8	8.4	6.3	7.5	5.8	5.1	6.9	5.8	6.2	5.6	6.2	5.2	6.2	**6.6**
0.45	11.3	9.4	9.6	7.3	10.8	8.2	9.5	7.4	6.5	8.7	7.3	7.9	7.1	7.9	6.5	7.9	**8.3**
0.4	13.8	11.2	11.6	8.8	13.0	9.8	11.4	8.8	7.7	10.4	8.8	9.5	8.5	9.4	7.9	9.6	**10.0**
0.3	18.8	14.6	15.1	11.5	17.1	12.8	15.0	11.3	10.0	13.3	11.6	12.3	11.2	12.3	10.4	12.8	**13.1**
0.2	23.6	17.5	18.4	13.9	20.8	15.5	18.2	13.8	12.2	16.1	14.1	14.9	13.6	15.0	12.6	15.8	**16.0**
0.1	28.1	20.2	21.1	16.1	23.7	18.0	21.1	16.2	14.0	18.5	16.5	17.3	15.9	17.8	14.8	18.6	**18.6**

Figure 7. Insulation Tradeoff Analysis Results, Non-Residential Occupancy

Refl	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	**Avg**
0.67																	
0.6	-0.1	2.0	1.9	2.2	1.9	2.7	3.2	2.7	2.4	2.2	1.8	1.9	1.9	1.8	2.0	1.4	2.0
0.55	0.0	3.3	3.3	3.6	3.1	4.5	5.2	4.4	3.8	3.7	2.9	3.1	3.0	2.9	3.2	2.3	3.3
0.5	0.2	4.5	4.5	5.0	4.3	6.2	7.2	6.0	5.2	5.0	3.9	4.3	4.2	4.0	4.4	3.2	4.5
0.45	0.4	5.6	5.7	6.3	5.5	7.7	9.0	7.5	6.5	6.2	5.0	5.3	5.2	5.1	5.6	4.0	5.7
0.4	0.7	6.7	6.8	7.5	6.6	9.1	10.6	8.9	7.8	7.4	5.9	6.4	6.2	6.0	6.6	4.8	6.8
0.3	1.4	8.7	8.9	9.7	8.6	11.8	13.7	11.5	10.0	9.6	7.7	8.3	8.1	7.9	8.6	6.3	8.8
0.2	2.1	10.5	10.8	11.7	10.5	14.1	16.4	13.8	12.1	11.6	9.4	10.1	9.8	9.6	10.5	7.6	10.7
0.1	2.9	12.1	12.5	13.5	12.1	16.2	18.9	15.8	13.9	13.4	10.9	11.7	11.4	11.1	12.2	8.9	12.3

Figure 8. Insulation Tradeoff Analysis Results for High-Rise Residential Occupancy

To establish an easy-to-use tradeoff, AEC and CEC staff decided to average results from all climates to develop a single required insulation level, regardless of climate. Also, one table was developed that would apply to alterations for both non-residential and high-rise residential occupancies. A lower aged reflectance limit of 0.25 is used to promote products with some level of reflective properties. The results are shown below.

Aged Reflectance Greater Than	Required Continuous Insulation
0.60	R-3
0.55	R-4
0.50	R-6
0.45	R-8
0.40	R-10
0.30	R-13
0.25	R-15

Figure 9. Proposed Insulation Tradeoff Table for Alterations

This tradeoff table would only apply to re-roofs and alterations, as covered under Section 149 of the Title 24 Standards. New construction projects can use the performance approach to demonstrate compliance. As there is no mandatory reflectance requirement, the California Title 24 Part 6 efficiency code does not exclude any roofing products.

4.7 No Changes to the Exceptions for the Cool Roof Requirements

At present, there is no proposal to adjust the exceptions to Section 143(a)1. of the energy code. Even through the reflectance standard is being raised to $R_{aged} = 0.67$from $R_{aged} = 0.55$, a ballasted roof of 25 lbs/ft^2 will still be considered to provide an equivalent amount of energy benefits for the building.

4.8 Statewide Savings Estimates

The total energy savings potential for this measure for new construction for non-residential buildings (157.42 million square feet) is 47.02 GWh, -60,150 therm (net gas increase). Applying the CEC conversions for TDV energy, this amounts to a present value cost savings of $194,138,300 over the 15-year measure life.

The total energy savings potential for this measure for new construction for high-rise residential buildings and hotels (9.1 million square feet) is 3.54 GWh, -101,610 therm (net gas increase). Applying the CEC conversions for TDV energy, this amounts to a present value cost savings of $12,514,113 over the 15-year measure life.

The market for alterations (re-roofs) is approximately 70% of the total roofing market. The total statewide impact, as outlined in the Overview section, is an annual reduction of 182.6 GWh, an increase in heating energy equivalent to -528,000 therm, and a present value savings of $743.9 million over the 15-year measure life.

5. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

5.1 New Construction and Additions

The proposed change in nonresidential low-sloped reflectance standards will be implemented through Section 143 of the code. The low-sloped reflectance standard in Tables 143-A and Table 143-B will be revised as follows for aged reflectance levels:

Climate Zone:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
143-A Nonres	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
143-B High-Rise	NR	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	NR

Section 143(a)1.a.i. shall be amended to read, "Nonresidential buildings with low-sloped roofs ~~in climate zones 2-15~~ shall have a minimum 3-year aged solar reflectance of ~~0.55~~ 0.67 and a minimum thermal emittance of 0.75, or a minimum aged SRI of ~~64~~ 78."

Section 143(a)1.a.iii. shall be amended to read, "High-rise residential buildings and hotels and motels with low-sloped roofs in climate zones ~~10, 11, 13,14, and 15~~ 2-15shall have a minimum 3-year aged solar reflectance of ~~0.55~~ 0.67 and a minimum thermal emittance of 0.75, or a minimum aged SRI of ~~64~~ 78."

Table 143-C, applicable to relocatable school buildings shall also be amended to incorporate an aged reflectance standard of 0.67 for low-sloped roofs.

5.2 Alterations (including reroofing)

With respect to alterations, Section 149(b)1.B.i would be amended to state, "Nonresidential buildings with low-sloped roofs ~~in climate zones 2-15~~ shall have a minimum aged solar reflectance of ~~0.55~~ 0.67 and a minimum thermal emittance of 0.75, or a minimum SRI of ~~64~~ 78."

Similarly, Section 149(b)1.B.iii. would be amended to state, "iii. High-rise residential buildings and hotels and motels with low-sloped roofs in climate zones ~~10, 11, 13,14, and 15~~ 2-15 shall have a minimum aged solar reflectance of ~~0.55~~ 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of ~~64~~ 78." A tradeoff table with insulation will be provided, as shown in this report. The minimum required aged reflectance level for the tradeoff table will be 0.25.

The overall envelope TDV energy approach in Section 143 of the Standards can be removed, since the simplified insulation tradeoff provides an alternative for alterations:

~~(b) **Overall Envelope TDV Energy Approach.**~~

~~The total TDV Energy of the overall envelope of the proposed building, TDV_{prop}, shall be no greater than the total TDV Energy of the overall envelope of a standard building, TDV_{std}, as calculated in Reference Nonresidential Appendix NA5 "Envelope Tradeoff Procedure". In making the calculations, it shall be assumed that the orientation and area of each envelope component of the standard building are the same as in the proposed building. If the proposed building has Window-Wall Ratio greater than 40 percent or Skylight-Roof Ratio greater than 5 percent, the area of walls and windows or roofs and skylights will be adjusted accordingly in the standard building to cap the WWR at 40 percent and SRR at 5 percent.~~

Similarly, Reference Appendix NA5, which documents the Overall Envelope TDV Energy Approach, can be removed.

5.3 Nonresidential Steep-Sloped Roofs and Residential Low-Sloped Roofs

The new residential reflectance standards for steep-sloped roofs, proposed at $R_{aged} = 0.20$ will be applied to the nonresidential steep-sloped standards, likely for the same climate zones as the nonresidential low-sloped standard of $R_{aged} = 0.67$.

The new nonresidential reflectance standards for low-sloped roofs, proposed at Raged = 0.67, will be applied to the residential low-sloped standards, likely for climate zones 2-15 where Raged = 0.67 has been shown to be cost effective for high-rise residential structures.

5.4 ACM Manual

Aside from updating the baseline to match the prescriptive requirement, there are no changes planned to the ACM Manual for this measure.

6. Bibliography and Other Research

Literature:

Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements, by Lawrence Berkeley National Lab for Pacific Gas and Electric for the 2005 Title 24 code update process

Guidelines for Selecting Cool Roofs, Department of Energy, 2010

Building Construction Cost Data, RS Means, 2010

Roofing supply distributors were contacted throughout California to collect cost data on single-ply thermoplastic and liquid-applied coating cool roof materials.

7. Appendices

7.1 Additional Cost Sources

In addition to the cost surveys distributed to manufacturers and to California roof contractors, the following additional cost sources provide informative context. However, these additional sources were not used in cost effectiveness calculations.

The DOE paper on cool roofs from 2010, *Guidelines for Selecting Cool Roof,* provided the following summary information on the cost of moving from a dark roof to a cool alternative:

Table 5: Roof Surfaces, Cool Alternatives, and Approximate Price Premiums*

Roof	Typical Non-Cool Surface	Cool Alternative	Price Premium ($/ft^2)
Built-Up Roof	Mineral aggregate embedded in flood coat	Light-colored aggregate, like marble chips, gray slag	0.00
	Asphaltic emulsion	Field applied coating on top of emulsion	0.80-1.50
	Mineral surfaced cap sheet	White mineral granules	0.50
Metal[3]	Unpainted metal	May already be cool	0.00
		Factory applied white paint	0.20
	Painted metal	Cool-colored paint	0.00-1.00+
Modified Bitumen	Mineral surfaced cap sheet	Factory applied coating, white mineral granules	0.50
	Gravel surface in bitumen	Light colored gravel	0.00
	Metallic foil	May already be cool	0.00
		Field applied coating	0.80-1.50
	Asphalt coating	Field applied coating on top of asphaltic coating	0.80-1.50
Shingles[3]	Mineral granules	White granules	0.00
		Cool-colored granules	0.35-0.75
Sprayed Polyurethane Foam	Liquid applied coating	Most coatings are already cool to protect the foam	0.00
	Aggregate	Light colored aggregate	0.00
Thermoplastic Membranes	White, colored, or dark surface	Choose a white or light colored surface	0.00
Thermoset Membranes	Dark membrane, not ballasted (adhered or mechanically attached)	Cool EPDM formulation	0.10-0.15
		Factory cool ply or coating on dark EPDM	0.50
Tiles[3]	Non-reflective colors	Clay, slate: naturally cool	0.00
		Cool colored coatings	0.00

*Premiums are the extra cost, per square foot of roof area, of installing the cool roof option as compared with the corresponding non-cool option. Premiums are based on achieving the minimum cool roof characteristics described in Table 1. Values are approximate, and are based on discussions with roofing contractors, manufacturers, wholesalers, and RSMeans cost data.

[3]These roofs may be used in steep slope applications where cool roof requirements are less stringent. Uncoated metal roofs normally meet requirements for steep slope, but not for low slope. Premiums for shingles & tiles are based on steep slope requirements. All other premiums are based on low slope requirements.

The LBNL study for the 2005 Title 24 update provided the following summary information on the cost of moving from a dark roof to a cool alternative:

Roofing Product	Cool Variety	Cost Premium ($/ft²)
ballasted BUR	use white gravel	up to 0.05
BUR with smooth asphalt coating	use cementitious or other white coatings	0.10 to 0.20
BUR with aluminum coating	use cementitious or other white coatings	0.10 to 0.20
single-ply membrane (EPDM, TPO, CSPE, PVC)	choose a white color	0.00 to 0.05
modified bitumen (SBS, APP)	use a white coating over the mineral surface	up to 0.05
metal roofing (both painted and unpainted)	use a white or cool color paint	0.00 to 0.05
roof coatings (dark color, asphalt base)	use a white or cool color coating	0.00 to 0.10
concrete tile	use a white or cool color	0.00 to 0.05
cement tile (unpainted)	use a white or cool color	0.05
red clay tile	use cool red tiles	0.10

7.2 Non-Residential Construction Forecast details

7.2.1 Summary

The Non-Residential construction forecast dataset is data that is published by the California Energy Commission's (CEC) demand forecast office. This demand forecast office is charged with calculating the required electricity and natural gas supply centers that need to be built in order to meet the new construction utility loads. Data is sourced from Dodge construction database, the demand forecast office future generation facility planning data, and building permit office data.
All CASE reports should use the statewide construction forecast for 2014. The TDV savings analysis is calculated on a 15 or 30 year net present value, so it is correct to use the 2014 construction forecast as the basis for CASE savings.

7.2.2 Additional Details

The demand generation office publishes this dataset and categorizes the data by demand forecast climate zones (FCZ) as well as building type (based on NAICS codes). The 16 climate zones are organized by the generation facility locations throughout California, and differ from the Title 24 building climate zones (BCZ). HMG has reorganized the demand forecast office data using 2000 Census data (population weighted by zip code) and mapped FCZ and BCZ to a given zip code. The construction forecast data is provided to CASE authors in BCZ in order to calculate Title 24 statewide energy savings impacts. Though the individual climate zone categories differ between the demand forecast published by the CEC and the construction forecast, the total construction estimates are consistent; in other words, HMG has not added to or subtracted from total construction area.
The demand forecast office provides two (2) independent data sets: total construction and additional construction. Total construction is the sum of all existing floor space in a given category (Small office, large office, restaurant, etc.). Additional construction is floor space area constructed in a given year (new construction); this data is derived from the sources mentioned above (Dodge, Demand forecast office, building permits).
Additional construction is an independent dataset from total construction. The difference between two consecutive years of total construction is not necessarily the additional construction for the year because this difference does not take into consideration floor space that was renovated, or repurposed.

In order to further specify the construction forecast for the purpose of statewide energy savings calculation for Title 24 compliance, HMG has provided CASE authors with the ability to aggregate across multiple building types. This tool is useful for measures that apply to a portion of various building types' floor space (e.g. skylight requirements might apply to 20% of offices, 50% of warehouses and 25% of college floor space).
The main purpose of the CEC demand forecast is to estimate electricity and natural gas needs in 2022 (or 10-12 years in the future), and this dataset is much less concerned about the inaccuracy at 12 or 24 month timeframe.
It is appropriate to use the CEC demand forecast construction data as an estimate of future years construction (over the life of the measure). The CEC non-residential construction forecast is the best publicly available data to estimate statewide energy savings.

7.2.3 Alterations Estimate

The Alterations estimate assumes that the average roof has a sixteen year life span, resulting in a 6% applicability of existing floor area for most building types. For schools and restaurants it is assumed that only half of the roof area is a low-sloped roof. These percentages, when used with the HMG construction estimate and forecast, show an alterations market that is approximately 70% of the total roofing market, a number consistent with what has been provided by the roofing industry.

7.2.4 Citation

"NonRes Construction Forecast by BCZ v7"; Developed by Heschong Mahone Group with data sourced August, 2010 from Abrishami, Moshen at the California Energy Commission (CEC)

Appendix B:

Supplemental Information and Results for the Cool Roof Analysis of Site Energy Savings and Cost-Effectiveness in Los Angeles County Climate Zones

March, 2012

Supplemental Data for the L.A. County Cool Roof Analysis

Energy performance impacts of the ordinance have been evaluated using three building prototypes which reflect a range of buildings required to meet Tier 2 values:

- 25,000 square foot 1-story retail building
- 52,900 square foot 5-story office building
- 64,400 square foot 70-unit 7-story high-rise residential building

The software used was the Title 24 Part 6 state-approved program Energy Pro (version 5.1.6). The hourly computer simulation run within the Energy Pro interface is the last publicly supported version of DOE-2.1E developed by the U.S. Department of Energy.

Case Study Method

The methodology used in these case studies is based on the way that buildings are typically designed and evaluated to exceed the 2008 Title 24 Part 6 Building Energy Efficiency Standards by 15%.

(a) A base case for each building design in each climate zone just meets the 15% Tier 1 overall energy performance requirement, but with no cool roof specification (i.e., aged solar reflectance = 0.10, thermal emittance = 0.75, Solar Reflective Index or SRI = approximately zero). The roof assembly is assumed to have between R-20 and R-30 insulation (depending on the climate zone) at the roof deck.

(b) For each building, a series of computer simulations are performed to reflect each of the Tier 2 cool roof conditions:

- **≤ 2:12 pitch ("Low-Slope") roofs** in climate zones 6, 8, 9 and 14: an Aged Solar Reflectance = 0.65, Thermal Emittance = 0.85 and SRI = 78.
- **> 2:12 pitch ("Steep-Slope") lightweight roofs** in climate zones 6, 8, 9, 14 and 16: an Aged Solar Reflectance = 0.23, Thermal Emittance = 0.85 and SRI = 20.
- **> 2:12 pitch ("Steep Slope") heavyweight roofs** in climate zones 6, 8, 9, 14 and 16: an Aged Solar Reflectance = 0.30, Thermal Emittance = 0.85 and SRI = 30.

[Note: SRI values calculated according to aged solar reflectance and thermal emittance using the "SRI Cal 10" spreadsheet by Lawrence Berkeley National Laboratory online at http://HeatIsland.LBL.gov].

(c) A minimum and maximum range of incremental costs of added energy measures is established from the research that was presented at the California Energy Commission on June 10, 2011 in the 2013 Standards public workshops (see Appendix 1). Site energy KWh and Therms is calculated for each computer run to establish the annual energy savings, and energy cost savings as compared with the base case with no cool roof.

Incremental Costs

A California Energy Commission study (6/10/11) presented in support of the 2013 standards development work is included as Appendix A. This presentation includes recent data on the incremental costs of various types of cool roof. The incremental cost cool roof assumptions used are as follows:

Building Description	Tier 2 Solar Reflect.	Typical Low Cost ($/SF)	Typical High Cost ($/SF)	Average Typical Cost ($/SF)
1-Story Retail: Low-Slope, Any Weight	0.65	$0.48	$1.20	$0.84
1-Story Retail: Steep-Slope, Lightweight	0.23	$0.10	$0.50	$0.30
1-Story Retail: Steep-Slope, Heavyweight	0.30	$0.00	$0.05	$0.03

Modeling and other assumptions include:

- All buildings are air conditioned, and cooling energy savings accrue from cool roof coatings as modeled.
- Incremental site electricity (kWh) and natural gas (therms) saved per year as calculated using the most current 2008 Standards version of state-approved software, Energy Pro v.5.1.6.
- Current utility rates for the prototype buildings: Electricity, SCE TOU-8 (2kv – 50kv); Natural Gas, SoCalGas GR-10.
- There is no change (i.e., no inflation or deflation) in utility rates in constant dollars over time.
- There no increase in summer temperatures despite most mainstream scientific studies which predict that climate change will increase temperatures in the Western U.S. which will in turn increase air conditioning energy use.
- Simple Payback includes neither the cost of financing nor any external cost associated with climate change.

Based on California Energy Commission studies, the useful life of lightweight cool roof coatings is assumed to be in range of 10 to 15 years. A built-up-roof or asphalt shingle cool roof with a payback of around 15 years or less could be considered cost-effective. Steep slope heavyweight cool roofs such as ceramic tile may be expected to last up to 30 years. The data summarized here is intended to be illustrative, not comprehensive or definitive, in demonstrating the scale of typical results and the variability of results depending on the selection of a particular cool roof CRRC rating and the actual longevity of the roof coating used.

Climate Zone #6 Cool Roof Energy/Cost Summary

Building Description	Site Electricity Savings (KWh/yr)	Site Gas Savings (therms/yr)	Tier 2 Annual Energy Cost ($)	Base Case Annual Energy Cost ($)	Total Annual Cost Savings ($)	Tier 2 Solar Reflectance
1-Story Retail: Low-Slope, Any Weight	8,922	-1	$50,943	$52,224	$1,281	0.65
1-Story Retail: Steep-Slope, Lightweight	2,552	0	$52,988	$53,355	$367	0.23
1-Story Retail: Steep-Slope, Heavyweight	3,567	0	$52,838	$53,355	$517	0.30
5-Story Office: Low-Slope, Any Weight	-706	-5	$83,285	$83,165	-$120	0.65
5-Story Office: Steep-Slope, Lightweight	273	-1	$83,166	$83,167	$1	0.23
5-Story Office: Steep-Slope, Heavyweight	307	-1	$83,176	$83,167	-$9	0.30
7-Story HR Res: Low-Slope, Any Weight	1,992	-37	$49,445	$49,600	$155	0.65
7-Story HR Res: Steep-Slope, Lightweight	329	-9	$47,919	$47,944	$25	0.23
7-Story HR Res: Steep-Slope, Heavyweight	663	-13	$47,909	$47,957	$48	0.30

Building Description	Cond. Floor Area (SF)	Building Annual CO_2 Reduction (Lbs.)	Building Annual CO_2 Reduction (Tons)	Annual CO_2-e Reduction (Lbs./SF)
1-Story Retail: Low-Slope, Any Weight	25,000	6144	3.07	0.25
1-Story Retail: Steep-Slope, Lightweight	25,000	1761	0.88	0.07
1-Story Retail: Steep-Slope, Heavyweight	25,000	2461	1.23	0.10
5-Story Office: Low-Slope, Any Weight	52,900	-546	-0.27	-0.01
5-Story Office: Steep-Slope, Lightweight	52,900	177	0.09	0.00
5-Story Office: Steep-Slope, Heavyweight	52,900	200	0.10	0.00
7-Story HR Res: Low-Slope, Any Weight	64,400	942	0.47	0.01
7-Story HR Res: Steep-Slope, Lightweight	64,400	122	0.06	0.00
7-Story HR Res: Steep-Slope, Heavyweight	64,400	306	0.15	0.00

Climate Zone #8 Cool Roof Energy/Cost Summary

Building Description	Site Electricity Savings (KWh/yr)	Site Gas Savings (therms/yr)	Tier 2 Annual Energy Cost ($)	Base Case Annual Energy Cost ($)	Total Annual Cost Savings ($)	Tier 2 Solar Reflectance
1-Story Retail: Low-Slope, Any Weight	10,690	0	$54,254	$55,749	$1,495	0.65
1-Story Retail: Steep-Slope, Lightweight	3,614	0	$56,533	$57,002	$469	0.23
1-Story Retail: Steep-Slope, Heavyweight	4,985	0	$56,818	$57,466	$648	0.30
5-Story Office: Low-Slope, Any Weight	2,293	-5	$85,975	$86,409	$434	0.65
5-Story Office: Steep-Slope, Lightweight	998	-2	$86,634	$86,795	$161	0.23
5-Story Office: Steep-Slope, Heavyweight	1,276	-3	$86,584	$86,795	$211	0.30
7-Story HR Res: Low-Slope, Any Weight	1,981	-37	$49,051	$49,206	$155	0.65
7-Story HR Res: Steep-Slope, Lightweight	360	-8	$50,551	$50,580	$29	0.23
7-Story HR Res: Steep-Slope, Heavyweight	904	-17	$50,562	$50,628	$66	0.30

Building Description	Cond. Floor Area (SF)	Building Annual CO_2 Reduction (Lbs.)	Building Annual CO_2 Reduction (Tons)	Annual CO_2-e Reduction (Lbs./SF)
1-Story Retail: Low-Slope, Any Weight	25,000	7376	3.69	0.30
1-Story Retail: Steep-Slope, Lightweight	25,000	2494	1.25	0.10
1-Story Retail: Steep-Slope, Heavyweight	25,000	3440	1.72	0.14
5-Story Office: Low-Slope, Any Weight	52,900	1524	0.76	0.03
5-Story Office: Steep-Slope, Lightweight	52,900	665	0.33	0.01
5-Story Office: Steep-Slope, Heavyweight	52,900	845	0.42	0.02
7-Story HR Res: Low-Slope, Any Weight	64,400	934	0.47	0.01
7-Story HR Res: Steep-Slope, Lightweight	64,400	155	0.08	0.00
7-Story HR Res: Steep-Slope, Heavyweight	64,400	425	0.21	0.01

Climate Zone #9 Cool Roof Energy/Cost Summary

Building Description	Site Electricity Savings (KWh/yr)	Site Gas Savings (therms/yr)	Tier 2 Annual Energy Cost ($)	Base Case Annual Energy Cost ($)	Total Annual Cost Savings ($)	Tier 2 Solar Reflectance
1-Story Retail: Low-Slope, Any Weight	10,875	0	$55,530	$57,130	$1,600	0.65
1-Story Retail: Steep-Slope, Lightweight	3,754	-1	$58,411	$58,923	$512	0.23
1-Story Retail: Steep-Slope, Heavyweight	5,231	-1	$58,209	$58,923	$714	0.30
5-Story Office: Low-Slope, Any Weight	3,098	-6	$86,707	$87,300	$593	0.65
5-Story Office: Steep-Slope, Lightweight	1,114	-2	$87,511	$87,703	$192	0.23
5-Story Office: Steep-Slope, Heavyweight	1,655	-3	$87,427	$87,703	$276	0.30
7-Story HR Res: Low-Slope, Any Weight	2,778	-46	$51,532	$51,752	$220	0.65
7-Story HR Res: Steep-Slope, Lightweight	364	-8	$51,227	$51,258	$31	0.23
7-Story HR Res: Steep-Slope, Heavyweight	806	-17	$51,238	$51,302	$64	0.30

Building Description	Cond. Floor Area (SF)	Building Annual CO_2 Reduction (Lbs.)	Building Annual CO_2 Reduction (Tons)	Annual CO_2-e Reduction (Lbs./SF)
1-Story Retail: Low-Slope, Any Weight	25,000	7504	3.75	0.30
1-Story Retail: Steep-Slope, Lightweight	25,000	2579	1.29	0.10
1-Story Retail: Steep-Slope, Heavyweight	25,000	3598	1.80	0.14
5-Story Office: Low-Slope, Any Weight	52,900	2067	1.03	0.04
5-Story Office: Steep-Slope, Lightweight	52,900	745	0.37	0.01
5-Story Office: Steep-Slope, Heavyweight	52,900	1107	0.55	0.02
7-Story HR Res: Low-Slope, Any Weight	64,400	1379	0.69	0.02
7-Story HR Res: Steep-Slope, Lightweight	64,400	158	0.08	0.00
7-Story HR Res: Steep-Slope, Heavyweight	64,400	357	0.18	0.01

Climate Zone #14 Cool Roof Energy/Cost Summary

Building Description	Site Electricity Savings (KWh/yr)	Site Gas Savings (therms/yr)	Tier 2 Annual Energy Cost ($)	Base Case Annual Energy Cost ($)	Total Annual Cost Savings ($)	Tier 2 Solar Reflectance
1-Story Retail: Low-Slope, Any Weight	17,989	-19	$54,759	$57,027	$2,268	0.65
1-Story Retail: Steep-Slope, Lightweight	5,519	-5	$58,041	$58,731	$690	0.23
1-Story Retail: Steep-Slope, Heavyweight	7,759	-7	$58,089	$59,056	$967	0.30
5-Story Office: Low-Slope, Any Weight	3,281	-43	$83,993	$84,560	$567	0.65
5-Story Office: Steep-Slope, Lightweight	968	-11	$84,786	$84,952	$166	0.23
5-Story Office: Steep-Slope, Heavyweight	1,358	-15	$84,722	$84,952	$230	0.30
7-Story HR Res: Low-Slope, Any Weight	2,958	-158	$53,261	$53,438	$177	0.65
7-Story HR Res: Steep-Slope, Lightweight	396	-37	$53,447	$53,465	$18	0.23
7-Story HR Res: Steep-Slope, Heavyweight	646	-59	$53,460	$53,489	$29	0.30

Building Description	Cond. Floor Area (SF)	Building Annual CO_2 Reduction (Lbs.)	Building Annual CO_2 Reduction (Tons)	Annual CO_2-e Reduction (Lbs./SF)
1-Story Retail: Low-Slope, Any Weight	25,000	12190	6.10	0.49
1-Story Retail: Steep-Slope, Lightweight	25,000	3750	1.87	0.15
1-Story Retail: Steep-Slope, Heavyweight	25,000	5272	2.64	0.21
5-Story Office: Low-Slope, Any Weight	52,900	1761	0.88	0.03
5-Story Office: Steep-Slope, Lightweight	52,900	539	0.27	0.01
5-Story Office: Steep-Slope, Heavyweight	52,900	762	0.38	0.01
7-Story HR Res: Low-Slope, Any Weight	64,400	194	0.10	0.00
7-Story HR Res: Steep-Slope, Lightweight	64,400	-159	-0.08	0.00
7-Story HR Res: Steep-Slope, Heavyweight	64,400	-244	-0.12	0.00

Climate Zone #16 Cool Roof Energy/Cost Summary

Building Description	Site Electricity Savings (KWh/yr)	Site Gas Savings (therms/yr)	Tier 2 Annual Energy Cost ($)	Base Case Annual Energy Cost ($)	Total Annual Cost Savings ($)	Tier 2 Solar Reflectance
1-Story Retail: Low-Slope, Any Weight	13,000	-48	$49,182	$50,881	$1,699	0.65
1-Story Retail: Steep-Slope, Lightweight	2,647	-11	$50,187	$50,544	$357	0.23
1-Story Retail: Steep-Slope, Heavyweight	3,981	-14	$50,169	$50,695	$526	0.30
5-Story Office: Low-Slope, Any Weight	486	-53	$82,750	$82,957	$207	0.65
5-Story Office: Steep-Slope, Lightweight	134	-12	$82,422	$82,483	$61	0.23
5-Story Office: Steep-Slope, Heavyweight	217	-19	$82,524	$82,612	$88	0.30
7-Story HR Res: Low-Slope, Any Weight	2,228	-159	$53,959	$54,073	$114	0.65
7-Story HR Res: Steep-Slope, Lightweight	283	-37	$53,684	$53,693	$9	0.23
7-Story HR Res: Steep-Slope, Heavyweight	594	-57	$53,615	$53,648	$33	0.30

Building Description	Cond. Floor Area (SF)	Building Annual CO_2 Reduction (Lbs.)	Building Annual CO_2 Reduction (Tons)	Annual CO_2-e Reduction (Lbs./SF)
1-Story Retail: Low-Slope, Any Weight	25,000	8409	4.20	0.34
1-Story Retail: Steep-Slope, Lightweight	25,000	1698	0.85	0.07
1-Story Retail: Steep-Slope, Heavyweight	25,000	2583	1.29	0.10
5-Story Office: Low-Slope, Any Weight	52,900	-284	-0.14	-0.01
5-Story Office: Steep-Slope, Lightweight	52,900	-48	-0.02	0.00
5-Story Office: Steep-Slope, Heavyweight	52,900	-72	-0.04	0.00
7-Story HR Res: Low-Slope, Any Weight	64,400	-321	-0.16	0.00
7-Story HR Res: Steep-Slope, Lightweight	64,400	-237	-0.12	0.00
7-Story HR Res: Steep-Slope, Heavyweight	64,400	-256	-0.13	0.00

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

Title:
Climate Zone 6
Energy Cost-Effectiveness Study

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Table of Contents

1.0 Executive Summary

Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards (Standards) establish a process which allows local adoption of energy standards that are more stringent than the statewide Standards. This process allows local governments to adopt and enforce energy standards before the statewide Standards effective date, require additional energy conservation measures, and/or set more stringent energy budgets. Because these energy standards "reach" beyond the minimum requirements of Title 24, Part 6 of the California Building Code, they are commonly referred to as Reach Codes when adopted as a collective set by a local jurisdiction.

The process for adopting a Reach Code requires that local governments apply to the California Energy Commission (CEC) for approval. The applicant jurisdiction must document the supporting analysis for determining that the proposed Reach Code Standards will save more energy than the current statewide Standards. The applicant jurisdiction must also prepare a **Cost Effectiveness Study** that provides the basis of the local government's determination that the proposed Reach Code Standards are cost-effective. Once the CEC staff has verified that the local Reach Code Standards will require buildings to use no more energy than the current statewide Standards and that the documentation requirements in Section 10-106 are met, the application is brought before the full California Energy Commission for approval.

This Cost Effectiveness Study was prepared for Climate Zone 6 which encompasses all or a portion of 60 incorporated coastal cities located within Santa Barbara, Ventura, Los Angeles, and Orange counties (see Appendix "A" for list of cities). 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 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 6 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 CO2-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 a beta version of the state-approved energy compliance software for the 2008 Building Energy Efficiency Standards, Micropas 8.

2. 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.

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 6.

Small Single Family House

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

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

Large Single Family House

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

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

Low-rise Multi-family Apartments

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

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

High-rise Multifamily Apartments

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

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

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

Low-rise Office Building

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

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

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

High-rise Office Building

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

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 29.1%

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

3.0 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 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**

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 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**

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%
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**

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 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**

Low-rise Office Building

- 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 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) occupancy 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**

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 29.1%

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**

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)	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

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)	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

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)	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

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)	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

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)	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

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)	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

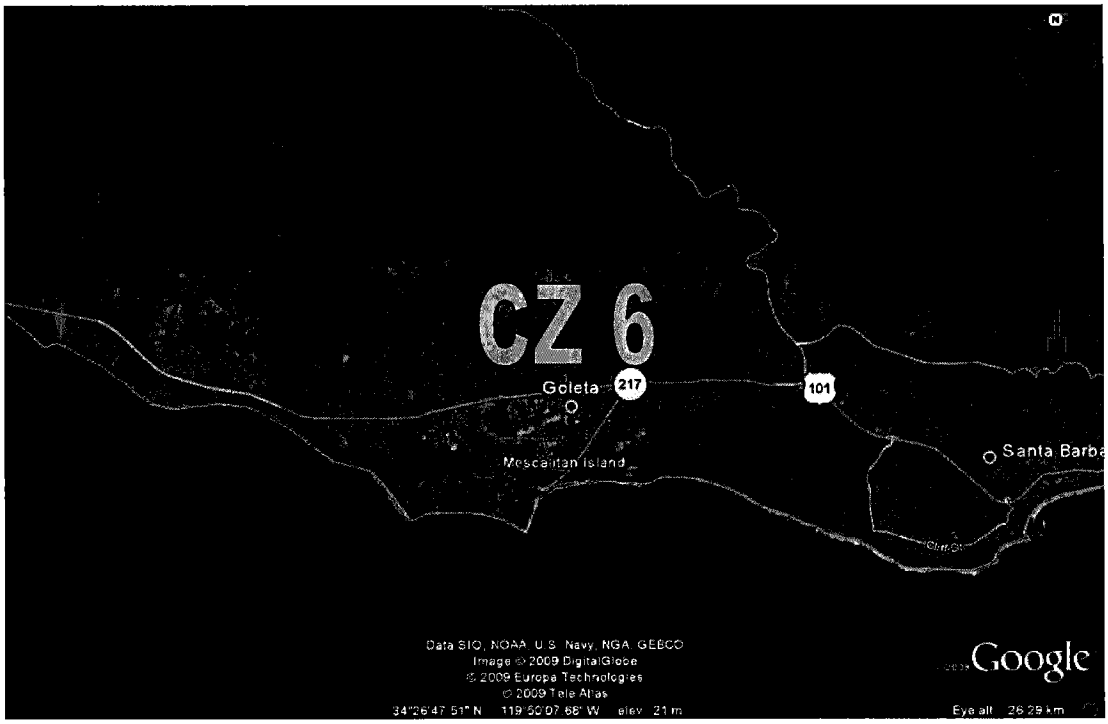
Annual Reduction in CO2-equivalent: ***5,964 lb./building-year***
0.11 lb./sq.ft.-year

Appendix "A"

Climate Zone 6 Cities

1	Agoura Hills	31	Malibu
2	Aliso Viejo	32	Manhattan Beach
3	Calabasas	33	Marina del Rey
4	Camarillo	34	Mission Viejo
5	Capistrano Beach	35	Moorpark
6	Carpinteria	36	Newport Beach
7	Carson	37	Ojai
8	Corona del Mar	38	Oxnard
9	Costa Mesa	39	Pacific Palisades
10	Culver City	40	Palos Verdes Peninsula
11	Dana Point	41	Port Hueneme
12	El Segundo	42	Rancho Palos Verdes
13	Fountain Valley	43	Redondo Beach
14	Garden Grove	44	San Clemente
15	Gardena	45	San Juan Capistrano
16	Goleta	46	Santa Ana
17	Hawthorne	47	Santa Barbara
18	Hermosa Beach	48	Santa Monica
19	Huntington Beach	49	Santa Paula
20	Inglewood	50	Seal Beach
21	Irvine	51	Signal Hill
22	Laguna Beach	52	Somis
23	Laguna Hills	53	Stanton
24	Laguna Niguel	54	Summerland
25	Laguna Woods	55	Sunset Beach
26	Lawndale	56	Surfside
27	Lomita	57	Torrance
28	Lompoc	58	Ventura
29	Long Beach	59	Westlake Village
30	Los Alamitos	60	Westminster

☐ *Only a portion located within Climate Zone 6*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101
Mescalitan Island
Santa Barba
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2009 DigitalGlobe
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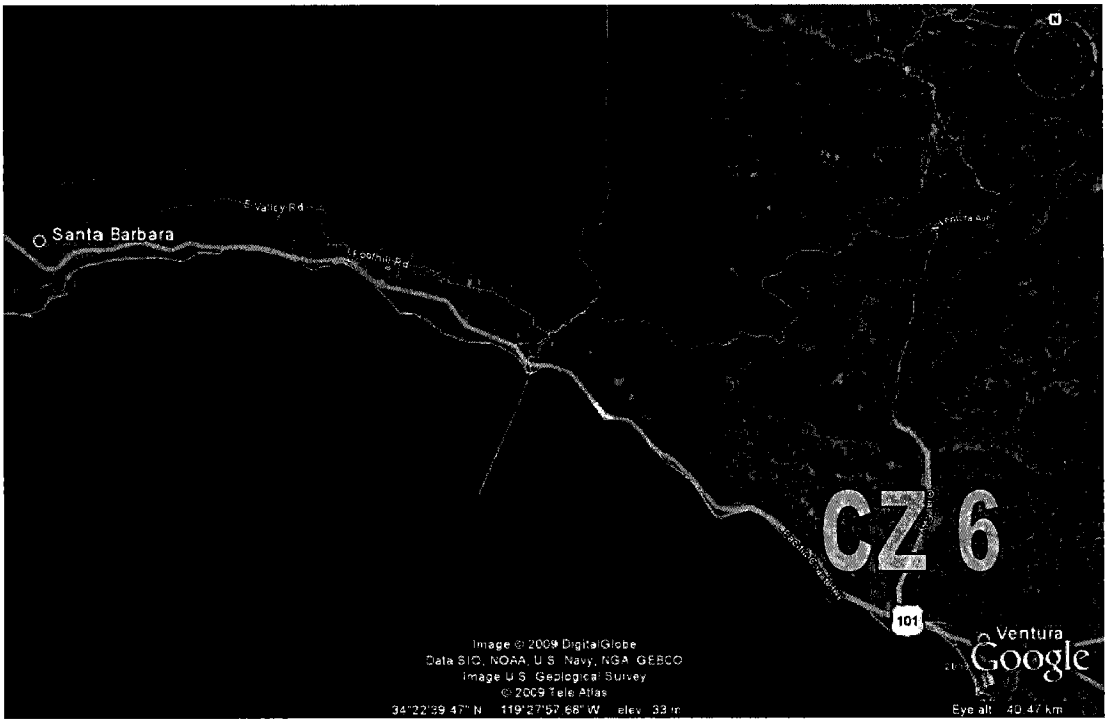
© 2009 Tele Atlas
34°26'47.51" N 119°50'07.68" W elev 21 m
Google
Eye alt 26.29 km


Santa Barbara
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101
Ventura
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Image U.S. Geological Survey
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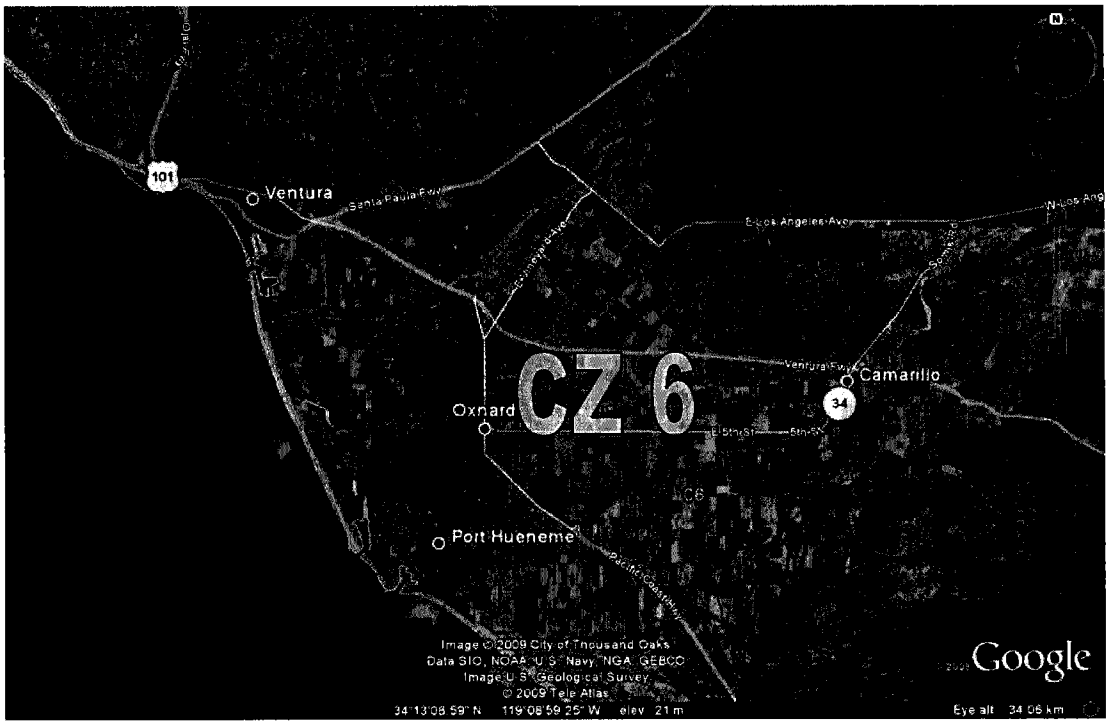
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Oxnard
CZ 6
Camarillo
Port Hueneme
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Image U.S. Geological Survey
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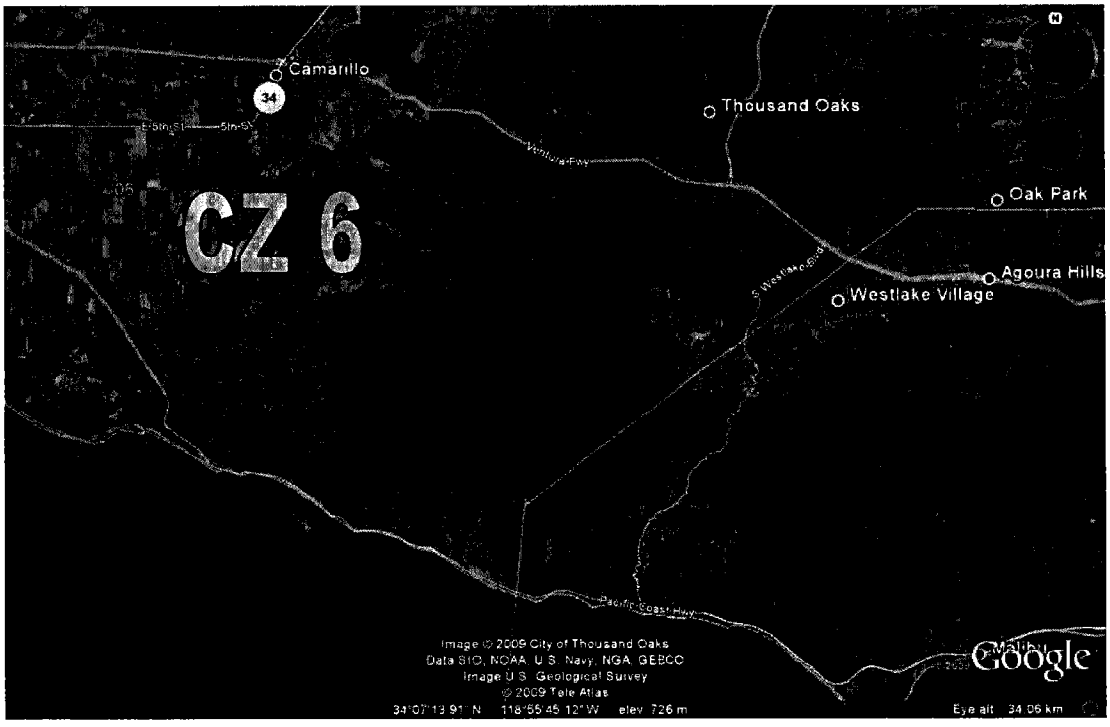
Google
Eye alt 34.06 km


Camarillo
Thousand Oaks
CZ 6
Oak Park
Agoura Hills
Westlake Village
Image © 2009 City of Thousand Oaks
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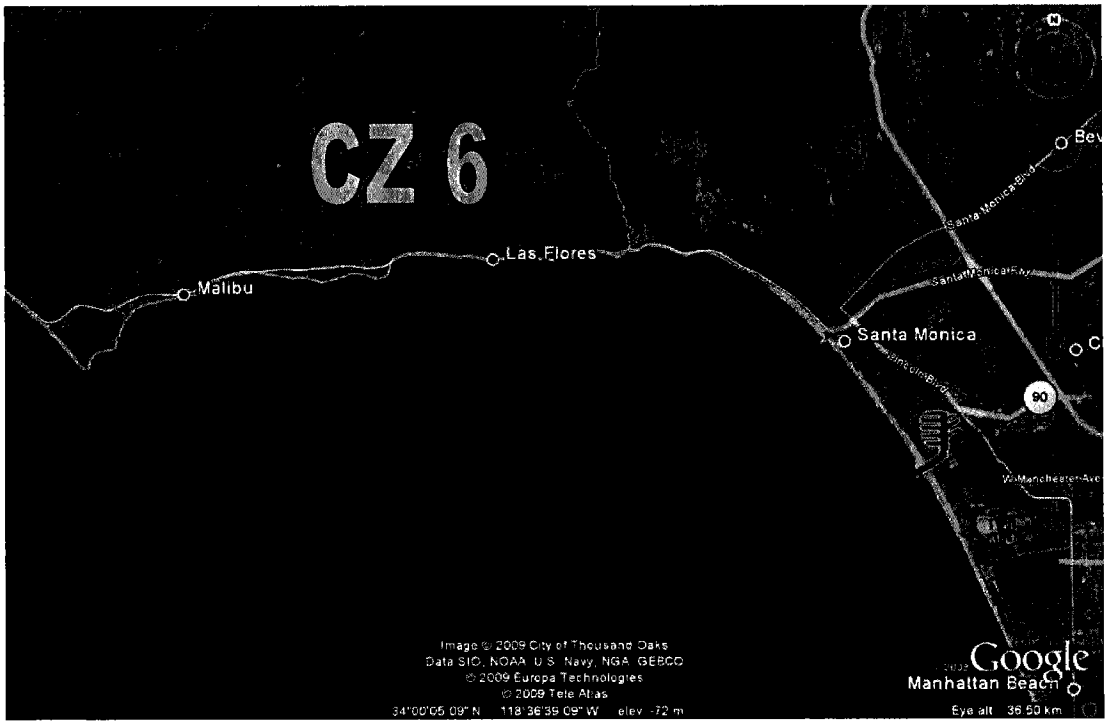
© 2009 Tele Atlas
Google
Eye alt 34.06 km


CZ 6
Las Flores
Malibu
Santa Monica
Manhattan Beach
Image © 2009 City of Thousand Oaks
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© 2009 Europa Technologies
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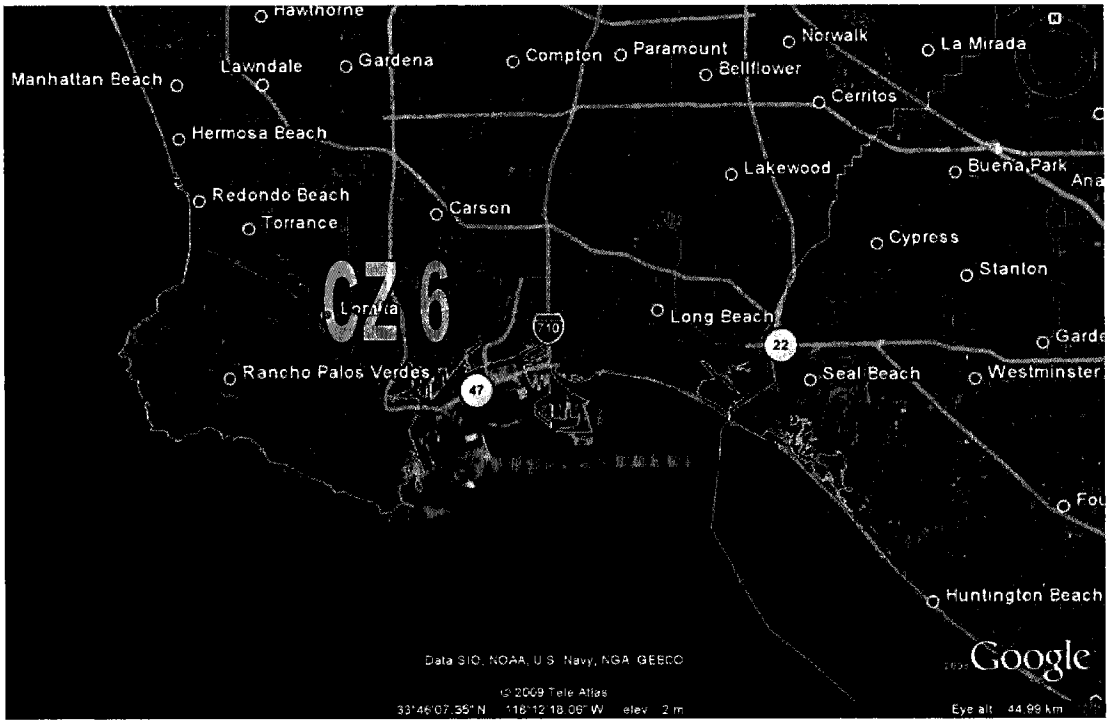
Hawthorne
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Lawndale
Gardena
Compton
Paramount
Norwalk
La Mirada
Bellflower
Cerritos
Hermosa Beach
Lakewood
Buena Park
Redondo Beach
Torrance
Carson
Cypress
Stanton
CZ 6
Long Beach
Rancho Palos Verdes
Seal Beach
Westminster
Huntington Beach
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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33°46'07.35" N 118°12'18.06" W elev 2 m
Google
Eye alt 44.99 km


Fountain Valley
55
Orange
133
Irvine
Huntington Beach
Costa Mesa
CZ 6
Lake Forest
Mission Viejo
Rancho
Newport Beach
Laguna Hills
Aliso Viejo
Laguna Beach
Laguna Niguel
San Juan Capistra
Dana Point
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2009 Tele Atlas
33°34'47.81" N 117°59'35.63" W elev 68 m
Eye alt 44.99 km
Google

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

Title:
Climate Zone 8
Energy Cost-Effectiveness Study

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Table of Contents

1.0 Executive Summary

Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards (Standards) establish a process which allows local adoption of energy standards that are more stringent than the statewide Standards. This process allows local governments to adopt and enforce energy standards before the statewide Standards effective date, require additional energy conservation measures, and/or set more stringent energy budgets. Because these energy standards "reach" beyond the minimum requirements of Title 24, Part 6 of the California Building Code, they are commonly referred to as Reach Codes when adopted as a collective set by a local jurisdiction.

The process for adopting a Reach Code requires that local governments apply to the California Energy Commission (CEC) for approval. The applicant jurisdiction must document the supporting analysis for determining that the proposed Reach Code Standards will save more energy than the current statewide Standards. The applicant jurisdiction must also prepare a **Cost Effectiveness Study** that provides the basis of the local government's determination that the proposed Reach Code Standards are cost-effective. Once the CEC staff has verified that the local Reach Code Standards will require buildings to use no more energy than the current statewide Standards and that the documentation requirements in Section 10-106 are met, the application is brought before the full California Energy Commission for approval.

This Cost Effectiveness Study was prepared for Climate Zone 8 which encompasses over 100 cities and towns within Imperial, San Diego, Riverside and San Bernardino counties (see Appendix "A" for list of local jurisdictions). 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 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 8 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 several 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 CO2-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 for low-rise residential buildings are calculated using the state-approved energy compliance software for the 2008 Building Energy Efficiency Standards, Micropas 8; and for high-rise residential and nonresidential buildings using the state-approved 2008 energy compliance software EnergyPro v5.0.

2. 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.

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 8.

Small Single Family House

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

Energy Efficiency Measures
R-19 Roof w/ Radiant Barrier
R-13 Walls
R-19 Raised Floor over Garage/Open at 2nd Floor
R-0 Slab on Grade
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-4.2 Attic Ducts
50 Gallon Gas Water Heater: EF=0.60

Large Single Family House

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

Energy Efficiency Measures
R-38 Roof w/ Radiant Barrier
R-15 Walls
R-19 Raised Floor
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(2) Furnaces: 80% AFUE
(2) Air Conditioners: 13 SEER, 11 EER (HERS)
(2) Air Conditioners: Refrig. Charge (HERS)
R-6 Attic Ducts
(2) 50 Gallon Gas Water Heaters: EF=0.63
Pipe Insulation

Low-rise Multi-family Apartments

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

Energy Efficiency Measures
R-30 Roof w/ Radiant Barrier
R-13 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-6 Attic Ducts
(8) 40 Gallon Gas Water Heaters: EF=0.60

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-5 (1") rigid insulation; cool roof Reflectance = 0.55 Emittance = 0.75
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, default SHGC=.70
2 ton 4-pipe fan coil, 80% AFUE boiler, 70-ton scroll air cooled chiller 0.72 KW/ton
Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls with variable speed pump

Low-rise Office Building

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

Energy Efficiency Measures to Meet Title 24
R-19 under Metal Deck with 2" rigid (R-10) above
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; on/off lighting controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.
(3) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers
R-4.2 duct insulation w/ducts on roof, HERS verified duct leakage
(1) Tank Gas Water Heaters EF=0.58

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 39.4%

Design "A" for Options 1, 2 and 3

Energy Efficiency Measures to Meet Title 24
R-19 under Metal Deck, Cool Roof Reflectance = 0.55, Emittance = 0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Metal windows: Default glazing U=0.71, SHGC = .73
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 58w fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.
(3) 60 ton Packaged VAV system 10 EER/80% TE, standard efficiency variable speed fan motors; 25% VAV boxes, hot water reheat on perimeter zones with 80% AFUE boiler, fixed temp. economizer
R-4.2 duct insulation w/ ducts in conditioned
(1) Tank Gas Water Heaters EF=0.58

Design "B" for Option 4

Energy Efficiency Measures to Meet Title 24
R-19 under Metal Deck with 2" (R-10) rigid insualtion, Cool Roof Reflectance = 0.55, Emittance = 0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Metal windows: Default glazing U=0.71, SHGC = .73
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 58w fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.
(3) 60 ton Packaged VAV system 10 EER/80% TE, standard efficiency variable speed fan motors; 20% VAV boxes, hot water reheat on perimeter zones with 92% AFUE boiler, fixed temp. economizer
R-4.2 duct insulation w/ ducts in conditioned
(1) Gas fired boiler = 92% AFUE

3.0 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 8**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier (from R-19 w/Radiant Barrier): 1,443 sf @ 0.25 to 0.35/sf	Upgrade	$ 361	$ 505	$ 433
R-13 Walls	-	$ -	$ -	$ -
R-19 Raised Floor over Garage/Open at 2nd Floor	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
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 (from R-4.2)	Upgrade	$ 225	$ 325	$ 275
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 300	$ 600	$ 450
50 Gallon Gas Water Heater: EF=0.62 (from EF=0.60)	Upgrade	$ 100	$ 200	$ 150
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,161**	**$ 1,905**	**$ 1,533**
Total Incremental Cost per Square Foot:		**$ 0.57**	**$ 0.94**	**$ 0.76**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Option 2 **2025 sf** **Climate Zone 8**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 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	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER	-	$ -	$ -	$ -
R-4.2 Attic Ducts	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62 (from EF=0.60)	Upgrade	$ 100	$ 200	$ 150
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,248**	**$ 1,985**	**$ 1,616**
Total Incremental Cost per Square Foot:		**$ 0.62**	**$ 0.98**	**$ 0.80**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 2,025 SF, Option 3 **2025 sf** **Climate Zone 8**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 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)	Upgrade	$ 450	$ 600	$ 525
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-4.2 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 300	$ 600	$ 450
50 Gallon Gas Water Heater: EF=0.60	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 925**	**$ 1,475**	**$ 1,200**
Total Incremental Cost per Square Foot:		**$ 0.46**	**$ 0.73**	**$ 0.59**

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 8**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier (from R-38 w/ Radiant Barrier): 2,700 sf @ 0.15 to 0.20/sf	Downgrade	$ (540)	$ (405)	$ (473)
R-21 Walls (from R-15): 2,518 sf @ $0.27 to $0.56/sf	Upgrade	$ 680	$ 1,410	$ 1,045
R-30 Raised Floor (from R-19): 2,700 sf @ $0.25 to $0.35/sf	Upgrade	$ 675	$ 945	$ 810
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioner: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(2) Air Conditioner: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 600	$ 1,200	$ 900
(2) 50 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Pipe Insulation	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,415**	**$ 3,150**	**$ 2,282**
Total Incremental Cost per Square Foot:		**$ 0.31**	**$ 0.70**	**$ 0.51**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Option 2 **4500 sf** **Climate Zone 8**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-13 Walls (from R-15): 2,518 sf @ $0.14 to $0.18/sf	Downgrade	$ (453)	$ (353)	$ (403)
R-19 Raised Floor	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioner: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(2) Air Conditioner: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 600	$ 1,200	$ 900
(2) Instantaneous Gas Water Heaters: RE=0.80 (from (2) 50 Gal Gas: EF=0.63)	Upgrade	$ 1,800	$ 2,900	$ 2,350
No Pipe Insulation	Downgrade	$ (400)	$ (200)	$ (300)
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,547**	**$ 3,547**	**$ 2,547**
Total Incremental Cost per Square Foot:		**$ 0.34**	**$ 0.79**	**$ 0.57**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Option 3 **4500 sf** **Climate Zone 8**

Energy Efficiency Measures	Change	Incremental Cost Estimate		
R-30 Roof w/ Radiant Barrier (from R-38 w/ Radiant Barrier): 2,700 sf @ 0.15 to 0.20/sf	Downgrade	$ (540)	$ (405)	$ (473)
R-19 Walls (from R-15): 2,518 sf @ $0.15 to $0.40/sf	Upgrade	$ 378	$ 1,007	$ 692
R-19 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	Upgrade	$ 900	$ 1,200	$ 1,050
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioner: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(2) Air Conditioner: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 600	$ 1,200	$ 900
(2) 50 Gallon Gas Water Heaters: EF=0.62 (from EF=0.63)	Downgrade	$ (100)	$ -	$ (50)
No Pipe Insulation	Downgrade	$ (400)	$ (200)	$ (300)
Total Incremental Cost of Energy Efficiency Measures:		**$ 838**	**$ 2,802**	**$ 1,820**
Total Incremental Cost per Square Foot:		**$ 0.19**	**$ 0.62**	**$ 0.40**

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 8**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
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 E2 Vinyl, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(6) Air Conditioners: 13 SEER	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
(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:		**$ 5,366**	**$ 9,102**	**$ 7,234**
Total Incremental Cost per Square Foot:		**$ 0.64**	**$ 1.08**	**$ 0.86**

Incremental Cost Estimate to Exceed Title 24 by 15%

Multi-Family Prototype: 8,442 SF, Option 2 **8442 sf** **Climate Zone 8**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/Radiant Barrier): 4,221 sf @ 0.15 to 0.20/sf	Upgrade	$ 633	$ 844	$ 739
R-19 Walls (from R-13): 10,146 sf @ $0.31 to $0.54/sf	Upgrade	$ 3,145	$ 5,479	$ 4,312
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl, 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-6 Attic Ducts	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.62 (from EF=0.60)	Upgrade	$ 800	$ 1,600	$ 1,200
Total Incremental Cost of Energy Efficiency Measures:		**$ 5,978**	**$ 10,123**	**$ 8,051**
Total Incremental Cost per Square Foot:		**$ 0.71**	**$ 1.20**	**$ 0.95**

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

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-13 Walls	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(8) Air Conditioners: 13 SEER	-	$ -	$ -	$ -
R-4.2 Attic Ducts (from R-6)	Downgrade	$ (1,500)	$ (1,000)	$ (1,250)
(8) Instantaneous Gas Water Heater: RE=0.80 (from 40 Gal Gas: EF=0.60)	Upgrade	$ 8,000	$ 13,600	$ 10,800
Total Incremental Cost of Energy Efficiency Measures:		**$ 6,500**	**$ 12,600**	**$ 9,550**
Total Incremental Cost per Square Foot:		**$ 0.77**	**$ 1.49**	**$ 1.13**

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 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Metal Roof w/ R-5 (1") rigid insulation; cool roof Reflectance = 0.55 Emittance = 0.75	-			
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=.79, **COG SHGC=0.38** 6,240 sf @ $2.00 to $3.50/sf	Upgrade	$ 15,600	$ 24,960	$ 20,280
2 ton 4-pipe fan coil, 80% AFUE boiler, 70-ton scroll air cooled chiller 0.72 KW/ton	-			
Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls with variable speed pump	-			
Total Incremental Cost of Energy Efficiency Measures:		**$ 15,600**	**$ 24,960**	**$ 20,280**
Total Incremental Cost per Square Foot:		**$ 0.42**	**$ 0.68**	**$ 0.55**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 2 **Climate Zone 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Metal Roof w/ **R-10 (2") rigid insulation**; cool roof Reflectance = 0.55 Emittance = 0.75	Upgrade			
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=.79, **COG SHGC=0.54** 6,240 sf @ $2.00 to $3.50/sf	Upgrade	$ 15,600	$ 24,960	$ 20,280
2 ton 4-pipe fan coil, **98% AFUE boiler,** 70-ton scroll air cooled chiller 0.72 KW/ton	Upgrade	$ 1,750	$ 3,000	$ 2,375
Central DHW boiler: **98% AFUE** and recirculating system w/ timer-temperature controls with variable speed pump	Upgrade	$ 1,750	$ 3,000	$ 2,375
Total Incremental Cost of Energy Efficiency Measures:		**$ 19,100**	**$ 30,960**	**$ 25,030**
Total Incremental Cost per Square Foot:		**$ 0.52**	**$ 0.84**	**$ 0.68**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 3 **Climate Zone 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Metal Roof; cool roof Reflectance = 0.55 Emittance = 0.75	Downgrade			
R-19 in Metal Frame Walls	-			
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows: COG U-factor=.30, **COG SHGC=0.31** 6,240 sf @ $3.00 to $4.50/sf	Upgrade	$ 18,720	$ 28,080	$ 23,400
2 ton 4-pipe fan coil, 80% AFUE boiler, 70-ton scroll air cooled chiller 0.72 KW/ton	-			
Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls **with one-speed pump**	Downgrade			
Total Incremental Cost of Energy Efficiency Measures:		**$ 18,720**	**$ 28,080**	**$ 23,400**
Total Incremental Cost per Square Foot:		**$ 0.51**	**$ 0.76**	**$ 0.64**

Low-rise Office Building

- 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 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Metal Roof w/ R-10 (2") rigid insulation; **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	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: default U=0.71, **COG SHGC=0.38;** 3,200 sf @ $1.00 to $1.50/sf	Upgrade	$ 3,200	$ 4,800	$ 4,000
Lighting = 0.783 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 on T8s @ $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) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-4.2 duct insulation w/ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 9,003**	**$ 12,890**	**$ 10,947**
Total Incremental Cost per Square Foot:		**$ 0.85**	**$ 1.22**	**$ 1.03**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 2 **Climate Zone 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 under Metal Deck with 2" rigid (R-10) above; **with Cool Roof Reflectance = 0.55, Emittance = 0.75**	Upgrade	$ 3,703	$ 5,290	$ 4,497
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: default U=0.71, **COG SHGC=0.27;** 3,200 sf @ $2.00 to $2.50/sf	Upgrade	$ 6,400	$ 8,000	$ 7,200
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, on/off lighting controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.	-	$ -	$ -	$ -
(3) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-4.2 duct insulation w/ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 10,103**	**$ 13,290**	**$ 11,697**
Total Incremental Cost per Square Foot:		**$ 0.95**	**$ 1.26**	**$ 1.11**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 3 **Climate Zone 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Metal Roof w/ **R-15 (3") rigid insulation; cool roof Reflect = 0.55 Emittance = 0.75**; 10,580 sf @ $1.10 to $1.50/sf	Upgrade	$ 11,638	$ 15,870	$ 13,754
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: default U=0.71, **COG SHGC=0.38;** 3,200 sf @ $1.00 to $1.50/sf	Upgrade	$ 3,200	$ 4,800	$ 4,000
Lighting = 0.678 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 in these areas	Upgrade	$ 820	$ 1,648	$ 1,234
(3) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-6 duct insulation w/ducts on roof; **no HERS verified duct leakage**	Downgrade	$ (1,000)	$ (1,500)	$ (1,250)
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 14,658**	**$ 20,818**	**$ 17,738**
Total Incremental Cost per Square Foot:		**$ 1.39**	**$ 1.97**	**$ 1.68**

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 39.4%

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 52,900 SF, Option 1 **Climate Zone 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 under Metal Deck, Cool Roof Reflectance = 0.55, Emittance = 0.75	-			
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**; 16,000 sf @ $3.00 to $4.00/sf	Upgrade	$ 48,000	$ 64,000	$ 56,000
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 58w fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.	-			
(3) 60 ton Packaged VAV system 10 EER/80% TE, standard efficiency variable speed fan motors; 25% VAV boxes, hot water reheat on perimeter zones with 80% AFUE boiler, fixed temp. economizer	-			
R-4.2 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 48,000**	**$ 64,000**	**$ 56,000**
Total Incremental Cost per Square Foot:		**$ 0.91**	**$ 1.21**	**$ 1.06**

Nonresidential Prototype: 52,900 SF, Option 2 **Climate Zone 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 under Metal Deck + **R-15 (3" rigid);** Cool Roof Reflectance = 0.55, Emittance = 0.75; 10,580 sf @ $2.25 to $3.00/sf	Upgrade	$ 23,805	$ 31,740	$ 27,773
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: **COG U=0.30, COG SHGC=0.54**; 16,000 sf @ $2.50 to $3.50/sf	Upgrade	$ 40,000	$ 56,000	$ 48,000
Lighting = 0.783 w/sf; Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 58w fixtures (140) **multi-level ocupancy sensors on T8s @ $75 to $100 each**; (200) 18w recessed CFLs no lighting on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.	Upgrade	$ 10,500	$ 14,000	$ 12,250
(3) 60 ton Packaged VAV system 10 EER/80% TE, standard efficiency variable speed fan motors; 25% VAV boxes, hot water reheat on perimeter zones with 80% AFUE boiler, **Differential Temp. economizer, Cycle on at night**	Upgrade	$ 2,000	$ 4,000	$ 3,000
R-4.2 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
(1) Tank Gas Water Heater **EF=0.62**	Upgrade	$ 150	$ 250	$ 200
Total Incremental Cost of Energy Efficiency Measures:		**$ 76,455**	**$105,990**	**$ 91,223**
Total Incremental Cost per Square Foot:		**$ 1.45**	**$ 2.00**	**$ 1.72**

Nonresidential Prototype: 52,900 SF, Option 3 **Climate Zone 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 under Metal Deck, Cool Roof Reflectance = 0.55, Emittance = 0.75	-			
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: default U=0.71, **COG SHGC=0.38**; 16,000 sf @ $3.00 to $4.00/sf	Upgrade	$ 48,000	$ 64,000	$ 56,000
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 58w fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.	-			
(3) 60 ton Packaged VAV system 10 EER/80% TE, standard efficiency variable speed fan motors; **20% VAV boxes,** hot water reheat on perimeter zones with 80% AFUE boiler, fixed temp. economizer	Upgrade	$ 10,580	$ 15,870	$ 13,225
R-4.2 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 58,580**	**$ 79,870**	**$ 69,225**
Total Incremental Cost per Square Foot:		**$ 1.11**	**$ 1.51**	**$ 1.31**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 4 **Climate Zone 8**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 under Metal Deck, Cool Roof Reflectance = 0.55, Emittance = 0.75	-			
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: **COG U=0.30, COG SHGC=0.54**; 16,000 sf @ $2.50 to $3.50/sf	Upgrade	$ 40,000	$ 56,000	$ 48,000
Lighting = 0.650 W/sf: Open Office Areas: **(140) 2-lamp T8 fixtures @74W each;** no lighting controls; (120) 18W recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 58W fixtures **multi-level occupancy sensors on (140) T8 fixtures @ $75 to $100 each**; (200) 18W recessed CFLs no lighting on/off lighting controls. Support Areas: (160) 18W recessed CFLs no lighting controls; (240) 13W CFL wall sconces; no lighting controls. Net added cost of $105 to $120 each for open office T8 fixtures.	Upgrade	$ 25,200	$ 30,800	$ 28,000
(3) 60 ton Packaged VAV system 10 EER/80% TE, standard efficiency variable speed fan motors; 25% VAV boxes, hot water reheat on perimeter zones with 80% AFUE boiler, **Differential Temp. economizer, Cycle on at night**	Upgrade	$ 2,000	$ 4,000	$ 3,000
R-4.2 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 67,200**	**$ 90,800**	**$ 79,000**
Total Incremental Cost per Square Foot:		**$ 1.27**	**$ 1.72**	**$ 1.49**

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)	255	37	$1,533	$75	20.4
2,025 sf (Option 2)	253	44	$1,617	$82	19.8
2,025 sf (Option 3)	269	36	$1,200	$77	15.7
Averages:	259	39	$1,450	$78	18.6

Annual Reduction in CO2-equivalent: ***571 lb./building-year***
0.28 lb./sq.ft.-year

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)	396	58	$2,283	$117	19.4
4,500 sf (Option 2)	154	115	$2,547	$133	19.2
4,500 sf (Option 3)	440	52	$1,820	$119	15.3
Averages:	330	75	$2,217	$123	18.0

Annual Reduction in CO2-equivalent: ***1,022 lb./building-year***
0.23 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-Unit, 8,442 sf (Option 1)	1015	209	$7,234	$358	20.2
8-Unit, 8,442 sf (Option 2)	1155	168	$8,051	$342	23.6
8-Unit, 8,442 sf (Option 3)	-98	448	$9,550	$406	23.5
Averages:	691	275	$8,278	$368	22.4

Annual Reduction in CO2-equivalent: ***3,512 lb./building-year***
0.42 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)	12381	-430	$20,280	$1,564	13.0
36,800 sf (Option 2)	5593	893	$25,030	$1,729	14.5
36,800 sf (Option 3)	26981	-1001	$23,400	$3,348	7.0
Averages:	14985	-179	$22,903	$2,214	11.5

Annual Reduction in CO2-equivalent: *4,656 lb./building-year*
0.13 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)
10,580 sf (Option 1)	11545	-96	$10,947	$2,551	4.3
10,580 sf (Option 2)	10348	-143	$11,697	$2,261	5.2
10,580 sf (Option 3)	11789	-102	$17,738	$2,550	7.0
Averages:	11227	-114	$13,460	$2,454	5.5

Annual Reduction in CO2-equivalent: *3,729 lb./building-year*
0.35 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)	85222	-3	$56,000	$19,152	2.9
52,900 sf (Option 2)	28130	-32	$91,223	$6,073	15.0
52,900 sf (Option 3)	100878	-2	$69,225	$22,491	3.1
52,900 sf (Option 4)	87822	272	$79,000	$19,779	4.0
Averages:	75513	59	$73,862	$16,114	6.3

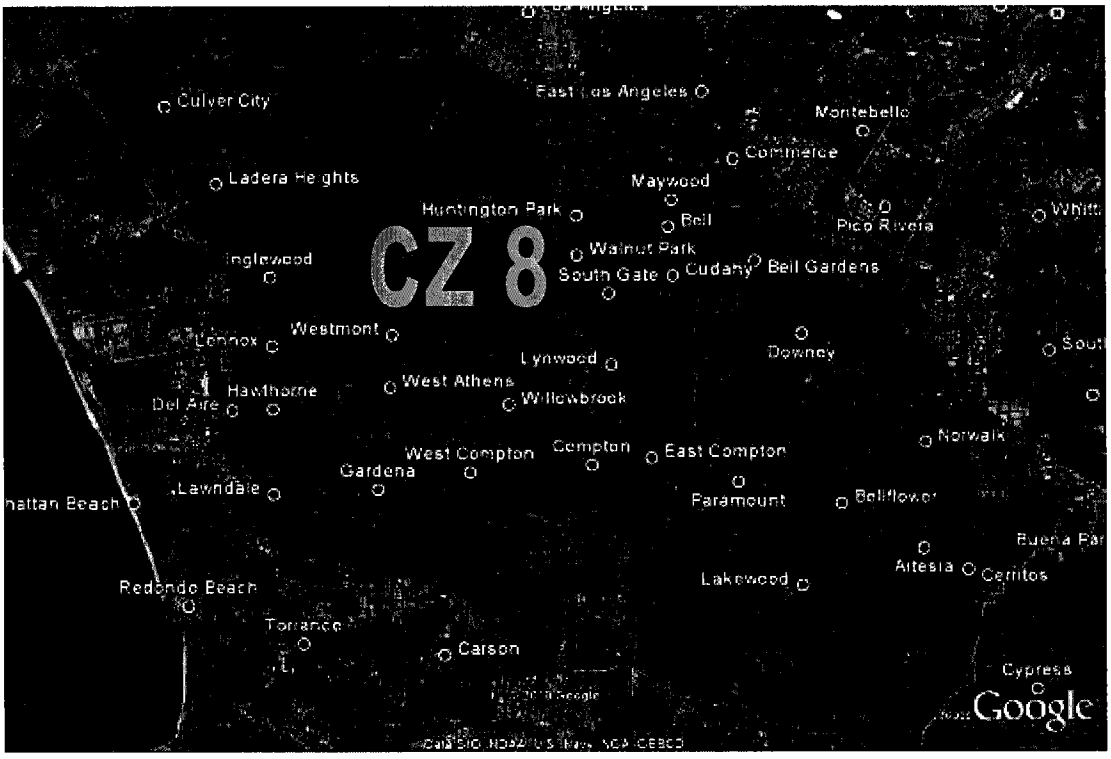
Annual Reduction in CO2-equivalent: *34,665 lb./building-year*
0.66 lb./sq.ft.-year

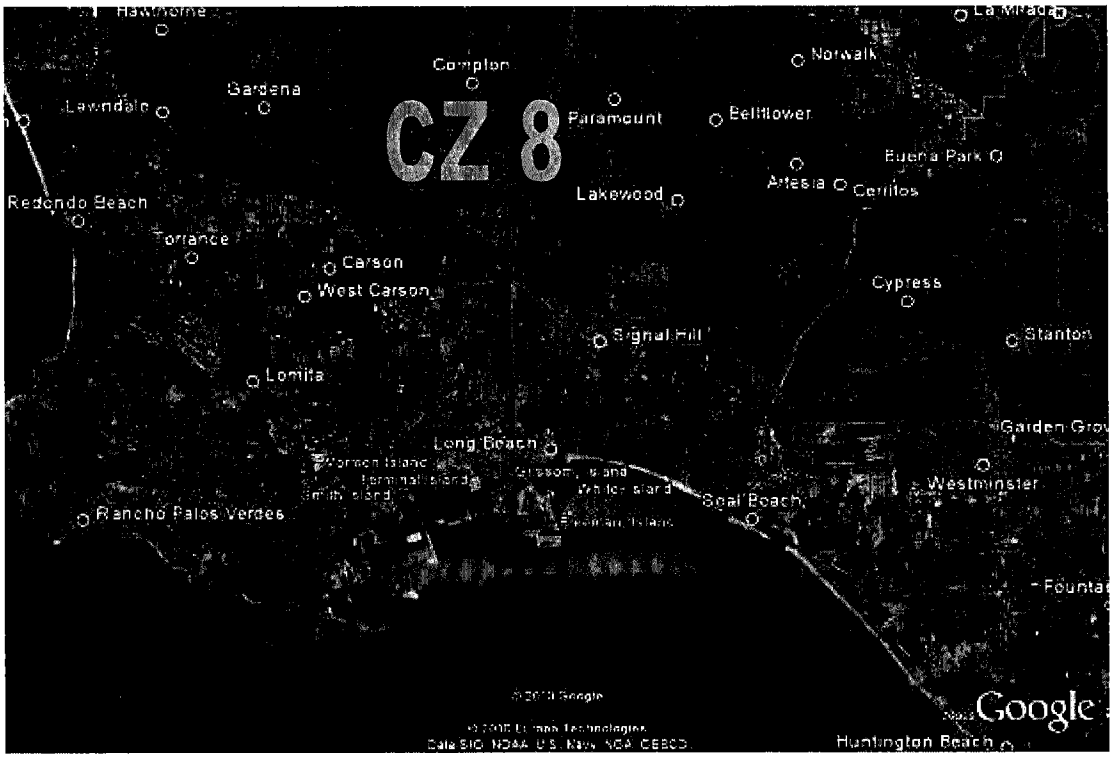
Appendix A
Climate Zone 8 Cities

1	Aliso Viejo	34	Lake Forest
2	Alondra Park	35	Lakewood
3	Anaheim	36	Lawndale
4	Artesia	37	Lennox
5	Bell	38	Long Beach
6	Bell Gardens	39	Los Alamitos
7	Bellflower	40	Los Angeles
8	Brea	41	Lynwood
9	Buena Park	42	Maywood
10	Cerritos	43	Mission Viejo
11	Commerce	44	Modjeska
12	Compton	45	Norwalk
13	Coto De Caza	46	Orange
14	Cudahy	47	Paramount
15	Culver City	48	Placentia
16	Cypress	49	Rancho Santa Margarita
17	Downey	50	Rossmoor
18	East Compton	51	South Gate
19	East Irvine	52	Stanton
20	El Toro	53	Trabuco Canyon
21	Florence	54	Tustin
22	Fullerton	55	Tustin Foothills
23	Garden Grove	56	U.S.M.C. Air Station El Toro
24	Gardena	57	U.S.N. Air Station Los Alamitos
25	Hawaiian Gardens	58	Vernon
26	Hawthorne	59	View Park
27	Huntington Park	60	Villa Park
28	Inglewood	61	Walnut Park
29	Irvine	62	West Athens
30	La Habra	63	West Compton
31	La Habra Heights	64	Willow Brook
32	La Palma	65	Willowbrook
33	Laguna Hills	66	Yorba Linda

Only a portion located within Climate Zone 8


CZ 8
Alhambra
Rancho Cucamonga
Fontana
El Monte
West Covina
Pomona
Ontario
Los Angeles
Santa Monica
East Los Angeles
Chino
Pico Rivera
Whittier
Chino Hills
Riverside
Inglewood
South Gate
Downey
Hawthorne
Compton
Norwalk
Fullerton
Corona
Buena Park
Lakewood
Anaheim
Torrance
Carson
Long Beach
Garden Grove
Orange
Santa Ana
Westminster
Irvine
Huntington Beach
Lake Forest
Costa Mesa
Newport Beach
Mission Viejo
Google


CZ 8
Culver City
East Los Angeles
Montebello
Commerce
Ladera Heights
Maywood
Huntington Park
Bell
Pico Rivera
Walnut Park
Inglewood
South Gate
Cudahy
Bell Gardens
Lennox
Westmont
Lynwood
Downey
West Athens
Hawthorne
Del Aire
Willowbrook
Norwalk
West Compton
Compton
East Compton
Gardena
Lawndale
Paramount
Bellflower
Artesia
Cerritos
Lakewood
Redondo Beach
Torrance
Carson
Cypress
Google


CZ 8
Compton
Norwalk
Gardena
Lawndale
Paramount
Bellflower
Buena Park
Artesia
Cerritos
Redondo Beach
Lakewood
Carson
West Carson
Cypress
Signal Hill
Stanton
Lomita
Long Beach
Seal Beach
Westminster
Rancho Palos Verdes
Huntington Beach
Google


Hacienda Heights
Whittier
Rowland Heights
Chino Hills
Bell Gardens
La Habra Heights
Downey
South Whittier
La Habra
East La Mirada
La Mirada
Brea
Norwalk
Yorba Linda
Bellflower
Fullerton
Placentia
Buena Park
Artesia
Cerritos
CZ 8
Anaheim
Cypress
Villa Park
Stanton
Orange
Garden Grove
Westminster
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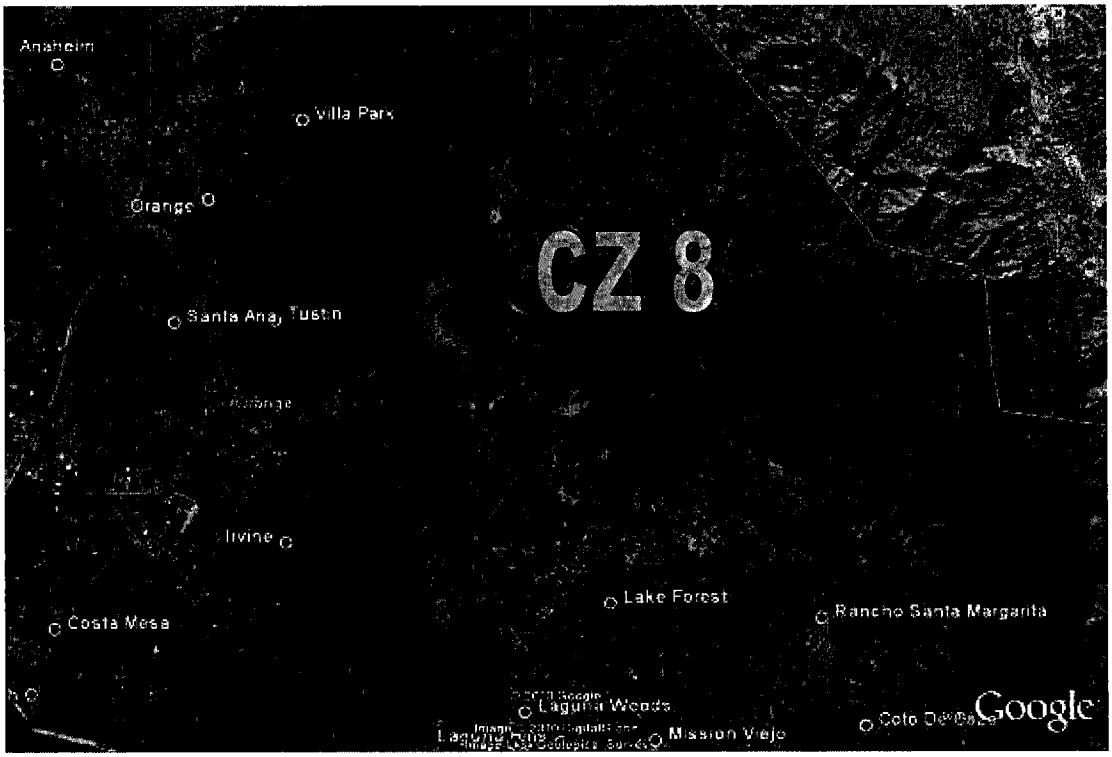
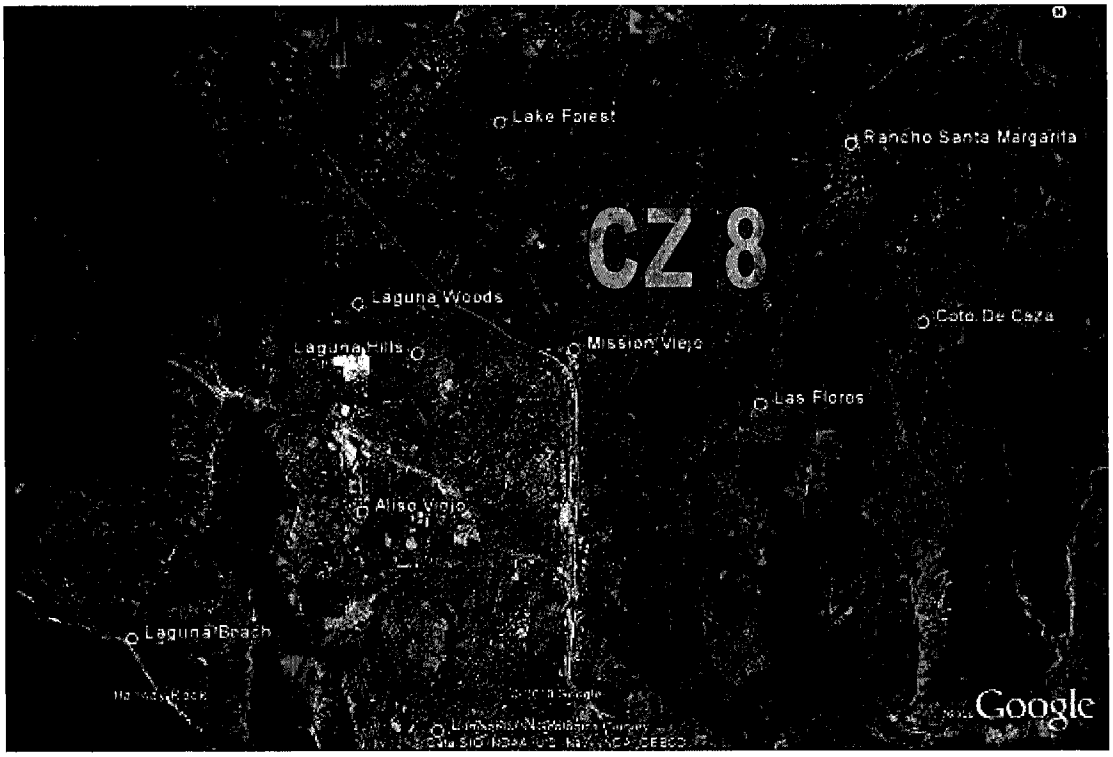

Anaheim
Villa Park
Orange
CZ 8
Santa Ana
Tustin
Irvine
Lake Forest
Rancho Santa Margarita
Costa Mesa
Laguna Woods
Mission Viejo
Google


Lake Forest
Rancho Santa Margarita
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Coto De Caza
Laguna Hills
Mission Viejo
Las Flores
Aliso Viejo
Laguna Beach
Google


Lake Forest
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Laguna Woods
Laguna Hills
Mission Viejo
Coto De Caza
Las Flores
Aliso Viejo
CZ 8
Laguna Beach
Laguna Niguel
San Juan Capistrano
Dana Point
Google

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

Title:
Climate Zone 9
Energy Cost-Effectiveness Study

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Table of Contents

1.0 Executive Summary

Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards (Standards) establish a process which allows local adoption of energy standards that are more stringent than the statewide Standards. This process allows local governments to adopt and enforce energy standards before the statewide Standards effective date, require additional energy conservation measures, and/or set more stringent energy budgets. Because these energy standards "reach" beyond the minimum requirements of Title 24, Part 6 of the California Building Code, they are commonly referred to as Reach Codes when adopted as a collective set by a local jurisdiction.

The process for adopting a Reach Code requires that local governments apply to the California Energy Commission (CEC) for approval. The applicant jurisdiction must document the supporting analysis for determining that the proposed Reach Code Standards will save more energy than the current statewide Standards. The applicant jurisdiction must also prepare a **Cost Effectiveness Study** that provides the basis of the local government's determination that the proposed Reach Code Standards are cost-effective. Once the CEC staff has verified that the local Reach Code Standards will require buildings to use no more energy than the current statewide Standards and that the documentation requirements in Section 10-106 are met, the application is brought before the full California Energy Commission for approval.

This Cost Effectiveness Study was prepared for Climate Zone 9 which encompasses over 100 cities within Los Angeles and Ventura counties (see Appendix "A" for list of cities). 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 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 9 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 CO2-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 a beta version of the state-approved energy compliance software for the 2008 Building Energy Efficiency Standards, Micropas 8.

2. 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.

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 9.

Small Single Family House

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

Energy Efficiency Measures
R-19 Roof w/ Radiant Barrier
R-13 Walls
R-19 Raised Floor over Garage/Open at 2nd Floor
R-0 Slab on Grade
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-4.2 Attic Ducts
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-19 Raised Floor
Quality Insulation Installation (HERS)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(2) Furnaces: 80% AFUE
(2) Air Conditioners: 13 SEER, 11 EER (HERS)
(2) Air Conditioners: Refrigerant Charge (HERS)
R-6 Attic Ducts
(2) 50 Gallon Gas Water Heaters: EF=0.61

Low-rise Multi-family Apartments

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

R-38 Roof w/ Radiant Barrier
R-13 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-4.2 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-19 Metal Roof w/ R-5 (1") rigid insulation; no Cool Roof
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, SHGC=0.79
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

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

Energy Efficiency Measures to Meet Title 24
R-19 under Metal Deck + R-5 (1" rigid); with Cool Roof Reflectance = 0.55, Emittance = 0.75
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, on/off lighting 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-6 duct insulation w/ ducts on roof, HERS verified duct leakage
(1) Tank Gas Water Heaters EF=0.575

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 39.4%

Base Case for Options 1 and 2

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: Default U=0.71, COG SHGC=0.54
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 fixtures on/off occ. sensors; (200) 18w recessed CFLs on/off occ. sensors. 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; Fixed temp. air economizers; 20% VAV boxes, reheat on perimeter zones with hot water using 85% AFUE boiler
R-6 duct insulation w/ ducts in conditioned
Standard Tank Gas Water Heaters EF=0.58

Base Case for Option 3

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: Default glazing U=0.71, SHGC=0.73
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 fixtures on/off occ. sensors; (200) 18w recessed CFLs on/off occ. sensors. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.
(1) Built Up VAV system with (1) 150 ton recipricating chiller 1.2 kW/ton and 80% AFUE boiler, standard efficiency vane axial fan motors; 30% VAV boxes, reheat on perimeter zones with hot water using 80% AFUE boiler
R-6 duct insulation w/ ducts in conditioned
Standard Tank Gas Water Heaters EF=0.58

3.0 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 9**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-19 w/Radiant Barrier): 1,443 sf @ 0.30 to 0.45/sf	Upgrade	$ 433	$ 649	$ 541
R-13 Walls	-	$ -	$ -	$ -
R-19 Raised Floor over Garage/Open at 2nd Floor	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
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-4.2 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:		**$ 908**	**$ 1,524**	**$ 1,216**
Total Incremental Cost per Square Foot:		**$ 0.45**	**$ 0.75**	**$ 0.60**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Option 2 **2025 sf** **Climate Zone 9**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-13): 2,550 sf @ $0.45 to $0.70/sf	Upgrade	$ 1,148	$ 1,785	$ 1,467
R-19 Raised Floor over Garage/Open at 2nd Floor	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER	-	$ -	$ -	$ -
R-6 Attic Ducts (from R-4.2)	Upgrade	$ 225	$ 325	$ 275
50 Gallon Gas Water Heater: EF=0.62	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,373**	**$ 2,110**	**$ 1,742**
Total Incremental Cost per Square Foot:		**$ 0.68**	**$ 1.04**	**$ 0.86**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Option 3 **2025 sf** **Climate Zone 9**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-19 w/Radiant Barrier): 1,443 sf @ 0.30 to 0.45/sf	Upgrade	$ 433	$ 649	$ 541
R-13 Walls	-	$ -	$ -	$ -
R-19 Raised Floor over Garage/Open at 2nd Floor	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	Upgrade	$ 450	$ 600	$ 525
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-4.2 Attic Ducts	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,058**	**$ 1,524**	**$ 1,291**
Total Incremental Cost per Square Foot:		**$ 0.52**	**$ 0.75**	**$ 0.64**

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 9**

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 @ $0.45 to $0.70/sf	Upgrade	$ 1,133	$ 1,763	$ 1,448
R-19 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(2) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 600	$ 1,200	$ 900
(2) 50 Gallon Gas Water Heaters: EF=0.60 (from EF=0.61)	Downgrade	$ (200)	$ (100)	$ (150)
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,533**	**$ 2,863**	**$ 2,198**
Total Incremental Cost per Square Foot:		**$ 0.34**	**$ 0.64**	**$ 0.49**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 4,500 SF, Option 2 **4500 sf** **Climate Zone 9**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-13 Walls	-	$ -	$ -	$ -
R-19 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-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 600	$ 1,200	$ 900
(2) 50 Gallon Gas Water Heaters: EF=0.60 (from EF=0.61)	Downgrade	$ (200)	$ (100)	$ (150)
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,786**	**$ 2,833**	**$ 2,309**
Total Incremental Cost per Square Foot:		**$ 0.40**	**$ 0.63**	**$ 0.51**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Option 3 **4500 sf** **Climate Zone 9**

Energy Efficiency Measures	Change	Incremental Cost Estimate		
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-21 Walls (from R-13): 2,518 sf @ $0.60 to $0.85/sf	Upgrade	$ 1,511	$ 2,140	$ 1,826
R-19 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(2) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-4.2 Attic Ducts (from R-6)	Downgrade	$ (650)	$ (450)	$ (550)
Reduced Duct Leakage/Testing (HERS)	Upgrade	$ 600	$ 1,200	$ 900
(2) 50 Gallon Gas Water Heaters: EF=0.62 (from EF=0.61)	Upgrade	$ 100	$ 200	$ 150
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,561**	**$ 3,090**	**$ 2,326**
Total Incremental Cost per Square Foot:		**$ 0.35**	**$ 0.69**	**$ 0.52**

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 9**

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 @ $0.60 to $0.85/sf	Upgrade	$ 6,088	$ 8,624	$ 7,356
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
R-4.2 Attic Ducts	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 5,444**	**$ 8,591**	**$ 7,017**
Total Incremental Cost per Square Foot:		**$ 0.64**	**$ 1.02**	**$ 0.83**

Incremental Cost Estimate to Exceed Title 24 by 15%
Multi-Family Prototype: 8,442 SF, Option 2 **8442 sf** **Climate Zone 9**

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-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)	Upgrade	$ 1,800	$ 2,400	$ 2,100
Super Low E Vinyl, U=0.36, SHGC=0.23 (from Low E2 Vinyl Windows, U=0.36, SHGC=0.30): 1055 sf @ $1.40 - $1.75 / sf	Upgrade	$ 1,477	$ 1,846	$ 1,662
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(8) Air Conditioner: 13 SEER, 11 EER (HERS)	Upgrade	$ 200	$ 600	$ 400
(8) Air Conditioners: Refrig. Charge (HERS)	Upgrade	$ 1,200	$ 1,600	$ 1,400
R-4.2 Attic Ducts	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 5,253**	**$ 7,639**	**$ 6,446**
Total Incremental Cost per Square Foot:		**$ 0.62**	**$ 0.90**	**$ 0.76**

Incremental Cost Estimate to Exceed Title 24 by 15%
Multi-Family Prototype: 8,442 SF, Option 3 **8442 sf** **Climate Zone 9**

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-19 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 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 Conditioners: Refrig. Charge (HERS)	Upgrade	$ 1,200	$ 1,600	$ 1,400
R-4.2 Attic Ducts	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 5,966**	**$ 9,302**	**$ 7,634**
Total Incremental Cost per Square Foot:		**$ 0.71**	**$ 1.10**	**$ 0.90**

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 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Metal Roof w/ R-5 (1") rigid insulation; no Cool Roof	-	$ -	$ -	$ -
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-	$ -	$ -	$ -
Dual Metal Windows; **COG U-factor=0.3, COG SHGC=0.38;** 6,240 sf @ $2.50 to $4.00/sf	Upgrade	$ 15,600	$ 24,960	$ 20,280
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	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 15,600**	**$ 24,960**	**$ 20,280**
Total Incremental Cost per Square Foot:		**$ 0.42**	**$ 0.68**	**$ 0.55**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 2 — **Climate Zone 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Metal Roof w/ **R-10 (2") rigid insulation; Cool Roof Reflectance=0.30, Emittance=0.75;** 9,200 sf @ $1.10 - $1.50/sf	Upgrade	$ 10,120	$ 13,800	$ 11,960
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-	$ -	$ -	$ -
Dual Metal Windows; **COG U-factor=0.3, COG SHGC=0.54;** 6,240 sf @ $2.00 to $3.50/sf	Upgrade	$ 12,480	$ 17,472	$ 14,976
4-pipe fan coil, **84% AFUE boiler,** 80-ton scroll air cooled chiller 0.79 KW/ton	Upgrade	$ 1,250	$ 2,000	$ 1,625
Central DHW boiler: **84% AFUE** and recirculating system w/ timer-temperature controls	Upgrade	$ 1,250	$ 2,000	$ 1,625
Total Incremental Cost of Energy Efficiency Measures:		**$ 25,100**	**$ 35,272**	**$ 30,186**
Total Incremental Cost per Square Foot:		**$ 0.68**	**$ 0.96**	**$ 0.82**

Incremental Cost Estimate to Exceed Title 24 by 15%

High-rise Residential Prototype: 36,800 SF, Option 3 **Climate Zone 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 Metal Roof w/ **R-10 (2")** rigid insulation; no Cool Roof; 9,200 sf @ $0.75 - $1.00/sf	Upgrade	$ 6,900	$ 9,200	$ 8,050
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-	$ -	$ -	$ -
Dual Non-Metal Windows: default U-factor=0.58, COG SHGC=0.38; 6,240 sf @ $2.00 to $3.50/sf	Upgrade	$ 12,480	$ 17,472	$ 14,976
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	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 19,380**	**$ 26,672**	**$ 23,026**
Total Incremental Cost per Square Foot:		**$ 0.53**	**$ 0.72**	**$ 0.63**

Low-rise Office Building

- 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 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 under Metal Deck + **R-10 (2" rigid)**; Cool Roof Reflectance =0.55, Emittance = 0.75; 10,580 sf @ $1.10 to $1.50/sf	Upgrade	$ 11,638	$ 15,870	$ 13,754
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 @ $2.50 to $4.00/sf	Upgrade	$ 8,000	$ 12,800	$ 10,400
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, on/off lighting 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, **Cycle on at night**	Upgrade	$ 300	$ 600	$ 450
R-6 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Gas Tank Water Heater EF=0.575	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 19,938**	**$ 29,270**	**$ 24,604**
Total Incremental Cost per Square Foot:		**$ 1.88**	**$ 2.77**	**$ 2.33**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 2 **Climate Zone 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 under Metal Deck + **R-10 (2" rigid)**; Cool Roof Reflectance =0.55, Emittance = 0.75; 10,580 sf @ $1.10 to $1.50/sf	Upgrade	$ 11,638	$ 15,870	$ 13,754
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**; 3,200 sf @ $2.00 to $3.50/sf	Upgrade	$ 6,400	$ 11,200	$ 8,800
Lighting = 0.783 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 on T8s @ $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, **Cycle on at night**	Upgrade	$ 300	$ 600	$ 450
R-6 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) **Tankless Gas Water Heater EF=0.85**	Upgrade	$ 1,200	$ 2,500	$ 1,850
Total Incremental Cost of Energy Efficiency Measures:		**$ 21,638**	**$ 32,970**	**$ 27,304**
Total Incremental Cost per Square Foot:		**$ 2.05**	**$ 3.12**	**$ 2.58**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 3 **Climate Zone 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 under Metal Deck + **R-10 (2" rigid)**; Cool Roof Reflectance =0.55, Emittance = 0.75; 10,580 sf @ $1.10 to $1.50/sf	Upgrade	$ 11,638	$ 15,870	$ 13,754
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: Default glazing U=0.71, SHGC=0.73	Downgrade	$ (3,200)	$ (4,800)	$ (4,000)
Lighting = 0.797 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 occupancy sensors on T8s @ $75 to $100 each;**; (40) 18w recessed CFLs on/off lighting controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.	Upgrade	$ 2,100	$ 2,800	$ 2,450
(6) 5-ton Packaged DX units SEER=14.0; 80% AFUE furnaces; premium efficiency variable speed fan motors; fixed temp. integrated air economizers; @ $300/ton to $400/ton for increasing number and changing type of DX units	Upgrade	$ 9,000	$ 12,000	$ 10,500
R-6 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1)Tank Gas Water Heaters EF=0.575	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 19,538**	**$ 25,870**	**$ 22,704**
Total Incremental Cost per Square Foot:		**$ 1.85**	**$ 2.45**	**$ 2.15**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 4 **Climate Zone 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 under Metal Deck + R-5 (1" rigid); with cool roof Aged = .55 TE = .75	-	$ -	$ -	$ -
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, on/off lighting controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.	-	$ -	$ -	$ -
(6) 5-ton Packaged DX units SEER=14.0; 80% AFUE furnaces; premium efficiency variable speed fan motors; fixed temp. integrated air economizers; @ $300/ton to $400/ton for increasing number and changing type of DX units	Upgrade	$ 9,000	$ 12,000	$ 10,500
R-6 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Gas Tank Water Heater EF=0.575	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 9,000**	**$ 12,000**	**$ 10,500**
Total Incremental Cost per Square Foot:		**$ 0.85**	**$ 1.13**	**$ 0.99**

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 39.4%

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 1 **Climate Zone 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 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	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: **COG U=0.30, COG SHGC=0.27**; 16,000 sf @ $2.00 to $2.50/sf	Upgrade	$ 32,000	$ 40,000	$ 36,000
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 fixtures on/off occ. sensors; (200) 18w recessed CFLs on/off occ. sensors. 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; Fixed temp. air economizers; 20% VAV boxes, reheat on perimeter zones with hot water using 85% AFUE boiler	-	$ -	$ -	$ -
R-6 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
Standard Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 35,703**	**$ 45,290**	**$ 40,497**
Total Incremental Cost per Square Foot:		**$ 0.67**	**$ 0.86**	**$ 0.77**

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 52,900 SF, Option 2 **Climate Zone 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 under Metal/Conc. Deck: **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	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: Default U=0.71, COG SHGC=0.38; 16,000 sf @ $1.50 to $2.00/sf	Upgrade	$ 24,000	$ 32,000	$ 28,000
Lighting = 0.692 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: (140) 2-lamp T8 fixtures **multi-level occupancy sensors on T8s @ $75 to $100 each**; (200) 18w recessed CFLs on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting 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	$ 4,740	$ 7,600	$ 6,170
(5) 35-ton Packaged VAV EER=10.0; 81% TE furnaces; **premium** efficiency variable speed fan motors; Fixed temp. air economizers; 20% VAV boxes, reheat on perimeter zones with hot water using **93% AFUE** boiler (cost of boiler below)	Upgrade	$ 1,500	$ 2,500	$ 2,000
R-6 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
(1) Boiler with 93% AFUE for service hot water	Upgrade	$ 5,000	$ 8,000	$ 6,500
Total Incremental Cost of Energy Efficiency Measures:		**$ 51,110**	**$ 78,137**	**$ 64,624**
Total Incremental Cost per Square Foot:		**$ 0.97**	**$ 1.48**	**$ 1.22**

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 52,900 SF, Option 3 **Climate Zone 9**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
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: Default U=0.71, **COG SHGC=0.54**; 16,000 sf @ $2.50 to $4.00/sf	Upgrade	$ 40,000	$ 64,000	$ 52,000
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 fixtures on/off occ. sensors; (200) 18w recessed CFLs on/off occ. sensors. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.	-	$ -	$ -	$ -
(1) Built Up VAV system with (1) 150 ton recipricating chiller 1.2 kW/ton and **93% AFUE boiler**, standard efficiency **variable speed fan motors; 20% VAV boxes**, reheat on perimeter zones (cost of boiler below)	Upgrade	$ 25,000	$ 35,000	$ 30,000
R-6 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
(1) Boiler with 93% AFUE for service hot water	Upgrade	$ 5,000	$ 8,000	$ 6,500
Total Incremental Cost of Energy Efficiency Measures:		**$ 70,000**	**$107,000**	**$ 88,500**
Total Incremental Cost per Square Foot:		**$ 1.32**	**$ 2.02**	**$ 1.67**

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)	400	27	$1,216	$89	13.7
2,025 sf (Option 2)	376	37	$1,742	$95	18.4
2,025 sf (Option 3)	394	30	$1,291	$91	14.2
Averages:	390	31	$1,416	$91	15.4

Annual Reduction in CO2-equivalent: ***540 lb./building-year***
0.27 lb./sq.ft.-year

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)	619	48	$2,198	$144	15.3
4,500 sf (Option 2)	914	-1	$2,310	$144	16.0
4,500 sf (Option 3)	567	61	$2,326	$147	15.8
Averages:	700	36	$2,278	$145	15.7

Annual Reduction in CO2-equivalent: ***734 lb./building-year***
0.16 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-Unit, 8,442 sf (Option 1)	1625	126	$7,018	$377	18.6
8-Unit, 8,442 sf (Option 2)	2037	58	$6,446	$378	17.0
8-Unit, 8,442 sf (Option 3)	1757	107	$7,634	$380	20.1
Averages:	1806	97	$7,033	$378	18.6

Annual Reduction in CO2-equivalent: ***1,942 lb./building-year***
0.23 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)	15503	-361	$20,280	$2,126	9.5
36,800 sf (Option 2)	10998	188	$30,186	$1,925	15.7
36,800 sf (Option 3)	16531	-287	$23,026	$2,359	9.8
Averages:	14344	-153	$24,497	$2,137	11.7

Annual Reduction in CO2-equivalent: 4,670 lb./building-year
0.13 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)
10,580 sf (Option 1)	10509	-30	$30,658	$2,255	13.6
10,580 sf (Option 2)	8333	166	$27,304	$1,876	14.6
10,580 sf (Option 3)	24507	25	$24,161	$5,517	4.4
10,580 sf (Option 4)	26034	-80	$10,500	$5,741	1.8
Averages:	17346	20	$23,156	$3,847	8.6

Annual Reduction in CO2-equivalent: 8,041 lb./building-year
0.76 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)	46359	-1305	$40,497	$10,151	4.0
52,900 sf (Option 2)	65339	91	$64,624	$14,819	4.4
52,900 sf (Option 3)	69159	511	$88,500	$15,874	5.6
Averages:	60286	-234	$64,540	$13,615	4.6

Annual Reduction in CO2-equivalent: 24,401 lb./building-year
0.46 lb./sq.ft.-year

Appendix "A"

Climate Zone 9 Cities

1	Agoura Hills	31	El Monte
2	Agua Dulce	32	Encino
3	Alhambra	33	Fillmore
4	Altadena	34	Glendale
5	Arcadia	35	Glendora
6	Avocado Heights	36	Granada Hills
7	Azusa	37	Hacienda Heights
8	Baldwin Park	38	Hidden Hills
9	Bardsdale	39	Highland Park
10	Bassett	40	Hollywood
11	Beverly Hills	41	Industry
12	Bradbury	42	Irwindale
13	Burbank	43	La Canada Flintridge
14	Calabasas	44	La Crescenta
15	Canoga Park	45	La Mirada
16	Casitas Springs	46	La Puente
17	Castaic	47	La Verne
18	Charter Oak	48	Ladera Heights
19	Chatsworth	49	Lake Casitas
20	City Terrace	50	Los Nietos
21	Claremont	51	Marina del Rey
22	Cornell	52	Mira Canyon
23	Covina	53	Monrovia
24	Diamond Bar	54	Montebello
25	Duarte	55	Monterey Park
26	East La Mirada	56	Montrose
27	East Los Angeles	57	Moorpark
28	East Pasadena	58	Newbury Park
29	East San Gabriel	59	Newhall
30	East Whittier	60	North Hollywood

Climate Zone 9 Cities – con't

61 Northridge
62 Oak Ridge
63 Oak View
64 Ojai
65 Pacoima
66 Panorama City
67 Pasadena
68 Pico Rivera
69 Piru
70 Pomona
71 Reseda
72 Rosemead
73 Rowland Heights
74 San Dimas
75 San Fernando
76 San Fernando Valley
77 San Gabriel
78 San Gabriel Mountains
79 San Marino
80 Santa Clarita
81 Santa Fe Springs
82 Santa Paula
83 Santa Susana
84 Saugus
85 Sepulveda
86 Sepulveda Dam
87 Sespe
88 Sherman Oaks
89 Sierra Madre
90 Simi Valley
91 Solemint
92 South El Monte
93 South Pasadena
94 South San Gabriel
95 South Whittier
96 Studio City
97 Sulphur Springs
98 Sun Valley
99 Sunland
100 Sylmar
101 Tarzana
102 Temple City
103 Thousand Oaks
104 Tujunga
105 UCLA
106 Val Verde Park
107 Valencia
108 Valinda
109 Van Nuys
110 Verdugo Mountains
111 Walnut
112 West Covina
113 West Hollywood
114 West Puente Valley
115 West Whittier-Los Nietos
116 Westlake Village
117 Whittier
118 Whittier Narrows Dam
119 Woodland Hills


Santa Clarita
Ventura
Simi Valley
Oxnard
Thousand Oaks
Burbank
Glendale
Pasadena
Alhambra
Los Angeles
Santa Monica
East Los Angeles
Inglewood
Downey
Hawthorne
South Gate
Compton
Torrance
Lakewood
Anaheim
Carson
Long Beach
Garden Grove
Orange
Image U.S. Geological Survey
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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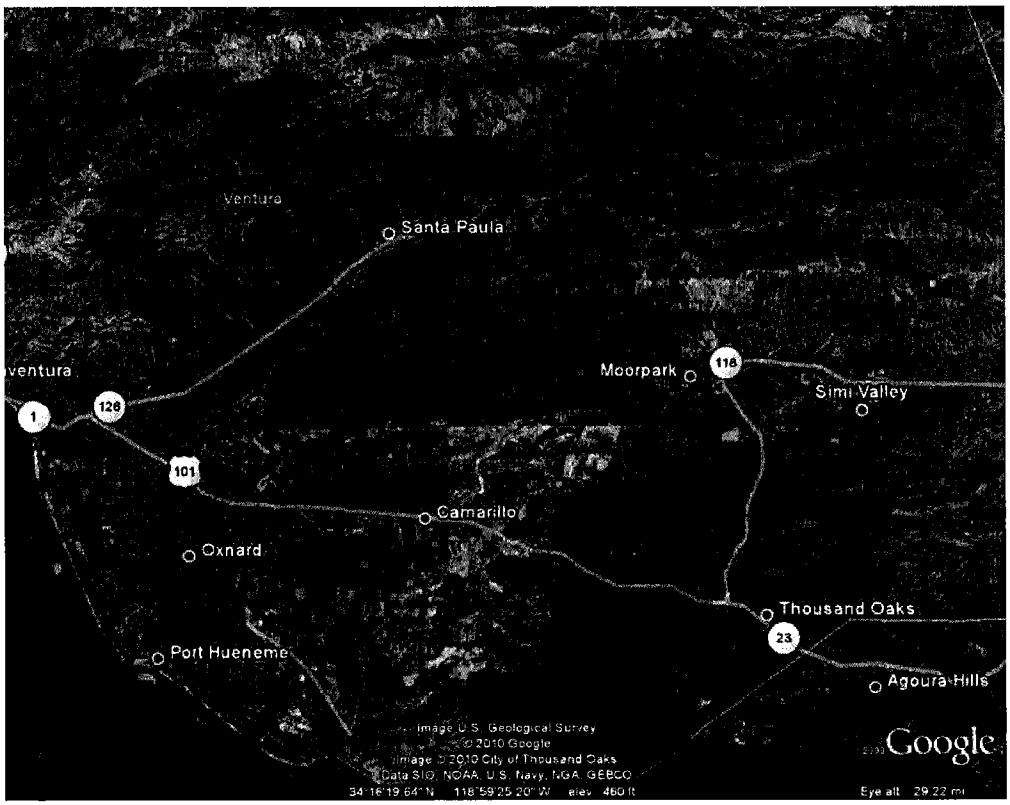
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Camarillo
Oxnard
Thousand Oaks
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Port Hueneme
Agoura Hills
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Image © 2010 City of Thousand Oaks
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34°16'19.64" N 118°59'25.20" W elev 460 ft
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Santa Clarita
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San Fernando
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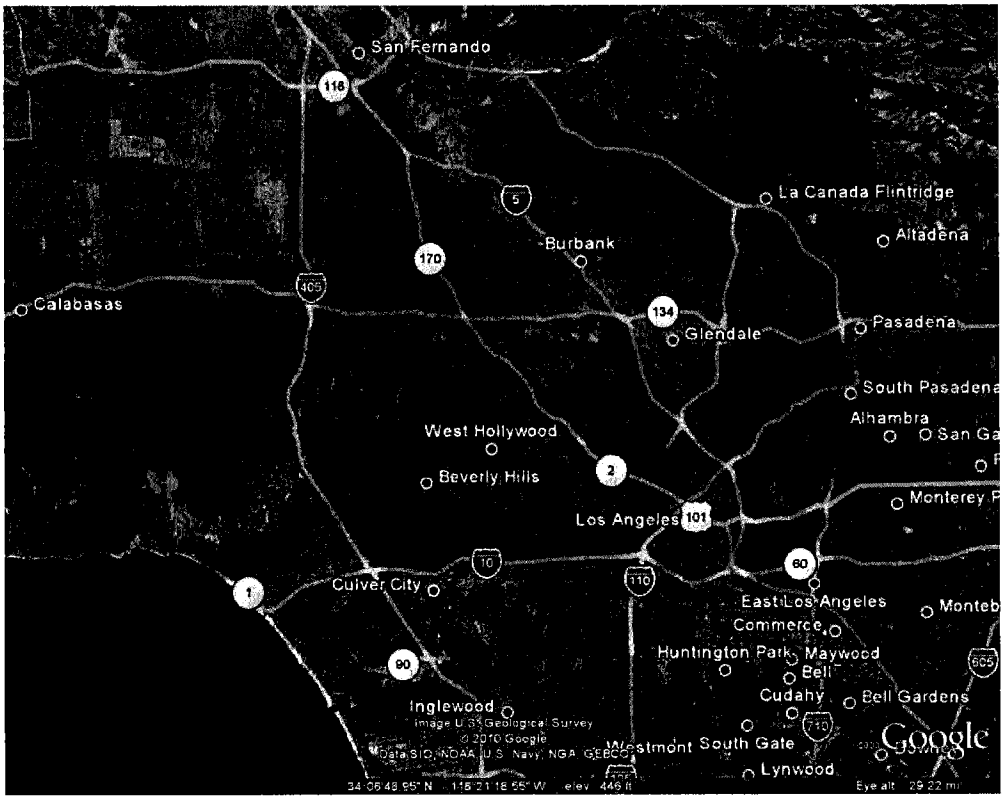
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Altadena
Burbank
Calabasas
Glendale
Pasadena
South Pasadena
Alhambra
West Hollywood
Beverly Hills
Los Angeles
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Maywood
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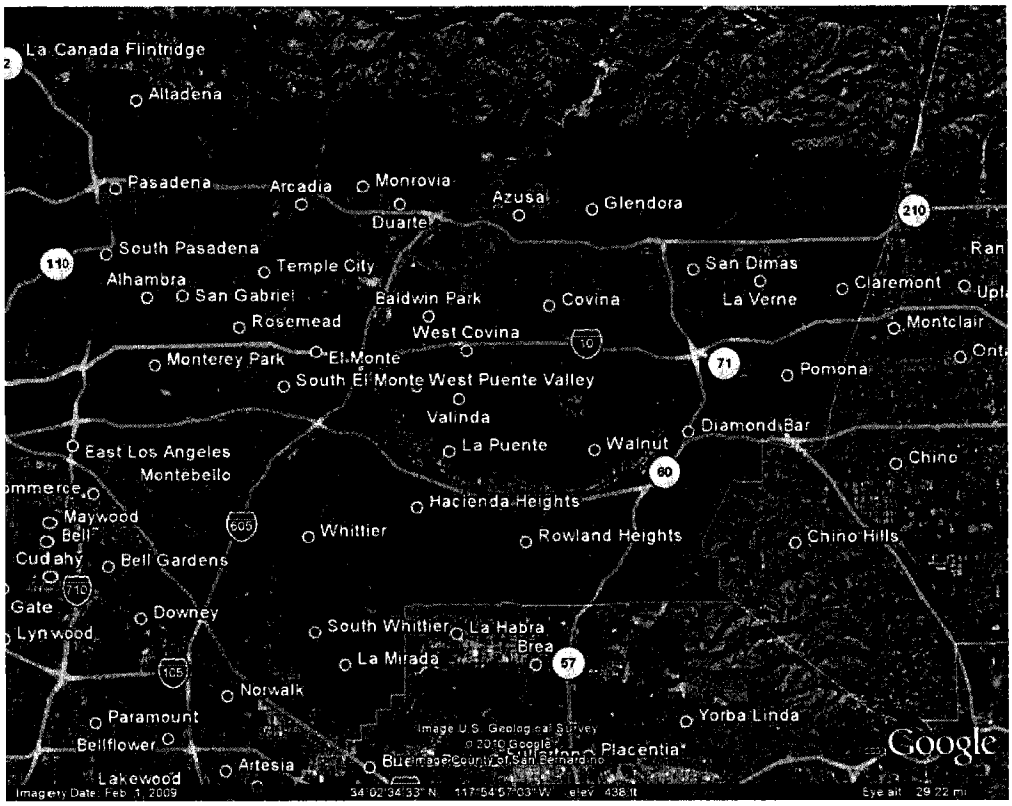
La Canada Flintridge
Altadena
Pasadena
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Azusa
Glendora
Duarte
South Pasadena
Temple City
Alhambra
San Gabriel
Baldwin Park
Covina
San Dimas
La Verne
Claremont
Rosemead
West Covina
Montclair
Monterey Park
El Monte
South El Monte
West Puente Valley
Pomona
Valinda
Diamond Bar
East Los Angeles
Montebello
La Puente
Walnut
Chino
Hacienda Heights
Maywood
Bell
Whittier
Rowland Heights
Chino Hills
Cudahy
Bell Gardens
Gate
Lynwood
Downey
South Whittier
La Habra
Brea
La Mirada
Norwalk
Paramount
Yorba Linda
Bellflower
Placentia
Lakewood
Artesia
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CA Statewide Codes and Standards Program
Title 24 Local Energy Efficiency Ordinances

Title:
Climate Zone 14
Energy Cost-Effectiveness Study

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Table of Contents

1.0 Executive Summary

Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards (Standards) establish a process which allows local adoption of energy standards that are more stringent than the statewide Standards. This process allows local governments to adopt and enforce energy standards before the statewide Standards effective date, require additional energy conservation measures, and/or set more stringent energy budgets. Because these energy standards "reach" beyond the minimum requirements of Title 24, Part 6 of the California Building Code, they are commonly referred to as Reach Codes when adopted as a collective set by a local jurisdiction.

The process for adopting a Reach Code requires that local governments apply to the California Energy Commission (CEC) for approval. The applicant jurisdiction must document the supporting analysis for determining that the proposed Reach Code Standards will save more energy than the current statewide Standards. The applicant jurisdiction must also prepare a **Cost Effectiveness Study** that provides the basis of the local government's determination that the proposed Reach Code Standards are cost-effective. Once the CEC staff has verified that the local Reach Code Standards will require buildings to use no more energy than the current statewide Standards and that the documentation requirements in Section 10-106 are met, the application is brought before the full California Energy Commission for approval.

This Cost Effectiveness Study was prepared for Climate Zone 14 which encompasses many cities such as Palmdale, Lancaster, Victorville and Hesperia; and which straddles several counties including San Bernardino, San Diego, Riverside, Imperial, Inyo and Kern counties (see Appendix "A" for list of local jurisdictions). 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 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 14 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 several 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 CO2-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 for low-rise residential buildings are calculated using the state-approved energy compliance software for the 2008 Building Energy Efficiency Standards, Micropas 8; and for high-rise residential and nonresidential buildings using the state-approved 2008 energy compliance software EnergyPro v5.0.

2. 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.

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 14.

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-19 Walls
R-19 Raised Floor over Garage/Open at 2nd Floor
R-0 Slab on Grade
Super Low E Vinyl Windows, U=0.36, SHGC=0.23
Furnace: 80% AFUE
Air Conditioner: 13 SEER, 11 EER (HERS)
Air Conditioner: Refrigerant Charge (HERS)
R-6 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
50 Gallon Gas Water Heater: EF=0.60

Large Single Family House

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

Energy Efficiency Measures
R-38 Roof w/ Radiant Barrier
R-15 Walls
R-38 Raised Floor
Quality Insulation Installation (HERS)
Super Low E Vinyl Windows, U=0.36, SHGC=0.23
(2) Furnaces: 80% AFUE
(2) Air Conditioners: 13 SEER, 11 EER (HERS)
(2) Air Conditioners: Refrigerant Charge (HERS)
R-8 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
(2) 50 Gallon Gas Water Heaters: EF=0.63

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
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: Refrigerant Charge (HERS)
R-8 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-30 under Metal Roof; no cool roof
R-19 in Metal Frame Walls
R-5 (1.5" K-13 spray-on) Raised Slab over parking garage
Dual Metal Windows: default U-factor=0.70, SHGC=0.79
4-pipe fan coil, 80% AFUE boiler, 70-ton scroll air cooled chiller 0.72 KW/ton
Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls

Low-rise Office Building

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

Energy Efficiency Measures to Meet Title 24
R-19 integral with Metal roof and additional R-13 below (no framing interruption); cool roof Reflectance=0.55, Emittance = 0.75
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; 4' overhangs on 8' height windows
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, on/off lighting controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.
(2) 15-ton DX units EER=11.5; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage
(1) Tank Gas Water Heaters EF=0.58

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 39.4%

Energy Efficiency Measures to Meet Title 24
R-19 integral with Metal roof and additional R-19 below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Metal windows: default U-factor = .71, COG SHGC=0.38
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 58w fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.
(3) Packaged VAV system 81% TE and 10.1 EER, fixed temp. economizer, standard efficiency variable speed fan motors; 15% VAV boxes, reheat on perimeter zones with hot water using 82% AFUE boiler. Controls to included fault detection and diagnostic; and "cycle on at night" features.
R-8 duct insulation w/ ducts in conditioned
82% AFUE boiler for domestic hot water use

3.0 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 14**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/Radiant Barrier): 1,443 sf @ 0.15 to 0.20/sf	Upgrade	$ 216	$ 289	$ 253
R-21 Walls (from R-19): 2,550 sf @ $0.14 to $0.16/sf	Upgrade	$ 357	$ 408	$ 383
R-30 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.25 to $0.35	Upgrade	$ 112	$ 157	$ 134
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	Upgrade	$ 450	$ 600	$ 525
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
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 (from EF=0.60)	Upgrade	$ 100	$ 200	$ 150
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,960**	**$ 3,178**	**$ 2,569**
Total Incremental Cost per Square Foot:		**$ 0.97**	**$ 1.57**	**$ 1.27**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 2,025 SF, Option 2 **2025 sf** **Climate Zone 14**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/Radiant Barrier): 1,443 sf @ 0.15 to 0.20/sf	Upgrade	$ 216	$ 289	$ 253
R-21 Walls (from R-19): 2,550 sf @ $0.14 to $0.16/sf	Upgrade	$ 357	$ 408	$ 383
R-38 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.30 to $0.45	Upgrade	$ 134	$ 202	$ 168
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	Upgrade	$ 450	$ 600	$ 525
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
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)	-	$ -	$ -	$ -
Instantaneous Gas Water Heater: RE=0.80 (from 50 Gal Gas: EF=0.60)	Upgrade	$ 1,000	$ 1,700	$ 1,350
Pipe Insulation	Upgrade	$ 150	$ 200	$ 175
Total Incremental Cost of Energy Efficiency Measures:		**$ 2,533**	**$ 3,723**	**$ 3,128**
Total Incremental Cost per Square Foot:		**$ 1.25**	**$ 1.84**	**$ 1.54**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 2,025 SF, Option 3 **2025 sf** **Climate Zone 14**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/Radiant Barrier): 1,443 sf @ 0.15 to 0.20/sf	Upgrade	$ 216	$ 289	$ 253
R-19 Walls	-	$ -	$ -	$ -
R-38 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.30 to $0.45	Upgrade	$ 134	$ 202	$ 168
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	Upgrade	$ 450	$ 600	$ 525
Low E2 Vinyl Windows, U=0.36, SHGC=0.30 (from Super Low E, U=0.36, SHGC=0.230): 409 sf @ $1.40 - $1.75 / sf	Downgrade	$ (716)	$ (573)	$ (644)
Furnace: 90% AFUE (from 80% AFUE)	Upgrade	$ 500	$ 1,000	$ 750
Air Conditioning: 15 SEER, 12 EER (HERS) (from 13 SEER, 11 EER)	Upgrade	$ 500	$ 1,500	$ 1,000
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 (from EF=0.60)	Upgrade	$ 100	$ 200	$ 150
Pipe Insulation	Upgrade	$ 150	$ 200	$ 175
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,560**	**$ 3,743**	**$ 2,651**
Total Incremental Cost per Square Foot:		**$ 0.77**	**$ 1.85**	**$ 1.31**

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 14**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-21 Walls (from R-15): 2,518 sf @ $0.27 to $0.56/sf	Upgrade	$ 680	$ 1,410	$ 1,045
R-38 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(2) Furnaces: 94% AFUE (from 80% AFUE)	Upgrade	$ 1,800	$ 3,600	$ 2,700
(2) Air Conditioners: 15 SEER, 12 EER (HERS) (from 13 SEER, 11 EER)	Upgrade	$ 1,000	$ 3,000	$ 2,000
(2) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) 50 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Pipe Insulation	Upgrade	$ 300	$ 400	$ 350
Total Incremental Cost of Energy Efficiency Measures:		**$ 3,780**	**$ 8,410**	**$ 6,095**
Total Incremental Cost per Square Foot:		**$ 0.84**	**$ 1.87**	**$ 1.35**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 4,500 SF, Option 2 **4500 sf** **Climate Zone 14**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-21 Walls (from R-15): 2,518 sf @ $0.27 to $0.56/sf	Upgrade	$ 680	$ 1,410	$ 1,045
R-38 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioners: 15 SEER, 12 EER (HERS) (from 13 SEER, 11 EER)	Upgrade	$ 1,000	$ 3,000	$ 2,000
(2) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) Instantaneous Gas Water Heater: RE=0.80 (from 50 Gal Gas: EF=0.63)	Upgrade	$ 1,800	$ 2,900	$ 2,350
Total Incremental Cost of Energy Efficiency Measures:		**$ 3,480**	**$ 7,310**	**$ 5,395**
Total Incremental Cost per Square Foot:		**$ 0.77**	**$ 1.62**	**$ 1.20**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Option 3 **4500 sf** **Climate Zone 14**

Energy Efficiency Measures	Change	Incremental Cost Estimate		
R-49 Roof w/ Radiant Barrier (from R-38 w/ Radiant Barrier): 2,700 sf @ $0.30 to 0.45/sf	Upgrade	$ 810	$ 1,215	$ 1,013
R-19 Walls (from R-15): 2,518 sf @ $0.15 to $0.40/sf	Upgrade	$ 378	$ 1,007	$ 692
R-38 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioners: 15 SEER, 12 EER (HERS) (from 13 SEER, 11 EER)	Upgrade	$ 1,000	$ 3,000	$ 2,000
(2) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) Instantaneous Gas Water Heater: RE=0.80 (from 50 Gal Gas: EF=0.63)	Upgrade	$ 1,800	$ 2,900	$ 2,350
Total Incremental Cost of Energy Efficiency Measures:		**$ 3,988**	**$ 8,122**	**$ 6,055**
Total Incremental Cost per Square Foot:		**$ 0.89**	**$ 1.80**	**$ 1.35**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Option 4 **4500 sf** **Climate Zone 14**

Energy Efficiency Measures	Change	Incremental Cost Estimate		
R-38 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-15): 2,518 sf @ $0.15 to $0.40/sf	Upgrade	$ 378	$ 1,007	$ 692
R-38 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Steep Sloped Cool Roof, Refl=0.30, Em=0.85 (from Refl=0.08, Em=0.85): 2,700 sf @ 0.35 to 0.50/sf	Upgrade	$ 945	$ 1,350	$ 1,148
Super Low E Vinyl Windows, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(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 (from 50 Gal Gas: EF=0.63)	Upgrade	$ 1,800	$ 2,900	$ 2,350
Total Incremental Cost of Energy Efficiency Measures:		**$ 4,123**	**$ 7,657**	**$ 5,890**
Total Incremental Cost per Square Foot:		**$ 0.92**	**$ 1.70**	**$ 1.31**

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 14**

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)	-	$ -	$ -	$ -
Super Low E Vinyl, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(8) Furnaces: 90% AFUE (from 80% AFUE)	Upgrade	$ 4,000	$ 8,000	$ 6,000
(8) Air Conditioners: 15 SEER, 12 EER (HERS) (from 13 SEER, 11 EER)	Upgrade	$ 4,000	$ 12,000	$ 8,000
(8) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) 40 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 9,895**	**$ 25,049**	**$ 17,472**
Total Incremental Cost per Square Foot:		**$ 1.17**	**$ 2.97**	**$ 2.07**

Incremental Cost Estimate to Exceed Title 24 by 15%
Multi-Family Prototype: 8,442 SF, Option 2 **8442 sf** **Climate Zone 14**

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-19 Walls (from R-15): 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, U=0.36, SHGC=0.23	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(8) Air Conditioners: 13 SEER, 11 EER (HERS)	-	$ -	$ -	$ -
(8) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) Instantaneous Gas Water Heater: RE=0.80 (from 40 Gal Gas: EF=0.63)	Upgrade	$ 7,200	$ 11,600	$ 9,400
Total Incremental Cost of Energy Efficiency Measures:		**$ 7,878**	**$ 15,025**	**$ 11,451**
Total Incremental Cost per Square Foot:		**$ 0.93**	**$ 1.78**	**$ 1.36**

Incremental Cost Estimate to Exceed Title 24 by 15%

Multi-Family Prototype: 8,442 SF, Option 3 8442 sf Climate Zone 14

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 @ $0.27 to $0.56/sf	Upgrade	$ 2,739	$ 5,682	$ 4,211
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
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)	-	$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) Instantaneous Gas Water Heater: RE=0.80 (from 40 Gal Gas: EF=0.63)	Upgrade	$ 7,200	$ 11,600	$ 9,400
Total Incremental Cost of Energy Efficiency Measures:		**$ 8,093**	**$ 15,805**	**$ 11,949**
Total Incremental Cost per Square Foot:		**$ 0.96**	**$ 1.87**	**$ 1.42**

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 14

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 under Metal Roof; no cool roof: 9,200 sf @ $0.15 - $0.20/sf	Upgrade	$ 1,380	$ 1,840	$ 1,610
R-19 in Metal Frame Walls	-			
R-5 (1.5" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows: **COG U-factor=0.3, COG SHGC=0.38** 6,240 sf @ $3.50 to $5.00/sf	Upgrade	$ 21,840	$ 30,700	$ 26,270
4-pipe fan coil, 80% AFUE boiler, 70-ton scroll air cooled chiller 0.72 KW/ton	-			
Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls	-			
Total Incremental Cost of Energy Efficiency Measures:		**$ 23,220**	**$ 32,540**	**$ 27,880**
Total Incremental Cost per Square Foot:		**$ 0.63**	**$ 0.88**	**$ 0.76**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 2 **Climate Zone 14**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-30 under Metal Roof; no cool roof	-			
R-19 in Metal Frame Walls	-			
R-5 (1.5" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows: **COG U-factor=0.3, COG SHGC=0.54** 6,240 sf @ $3.50 to $5.00/sf	Upgrade	$ 21,840	$ 30,700	$ 26,270
4-pipe fan coil, **98% AFUE** boiler, 70-ton scroll air cooled chiller 0.72 KW/ton	Upgrade	$ 3,000	$ 4,000	$ 3,500
Central DHW boiler: **98% AFUE** and recirculating system w/ timer-temperature controls	Upgrade	$ 3,000	$ 4,000	$ 3,500
Total Incremental Cost of Energy Efficiency Measures:		**$ 27,840**	**$ 38,700**	**$ 33,270**
Total Incremental Cost per Square Foot:		**$ 0.76**	**$ 1.05**	**$ 0.90**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 3 **Climate Zone 14**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-44 under Metal Roof; no cool roof: 9,200 sf @ $0.25 - $0.40/sf	Upgrade	$ 2,300	$ 3,680	$ 2,990
R-19 in Metal Frame Walls	-			
R-4 (1.25" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows: **COG U-factor=0.3, COG SHGC=0.54** 6,240 sf @ $3.50 to $5.00/sf	Upgrade	$ 21,840	$ 30,700	$ 26,270
4-pipe fan coil, **92% AFUE** boiler, 70-ton scroll air cooled chiller 0.72 KW/ton	Upgrade	$ 1,500	$ 3,000	$ 2,250
Central DHW boiler: **92% AFUE** and recirculating system w/ timer-temperature controls	Upgrade	$ 1,500	$ 3,000	$ 2,250
Total Incremental Cost of Energy Efficiency Measures:		**$ 27,140**	**$ 40,380**	**$ 33,760**
Total Incremental Cost per Square Foot:		**$ 0.74**	**$ 1.10**	**$ 0.92**

Low-rise Office Building

- 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 14**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 integral with Metal roof and additional **R-30** below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75; 10,580 sf $0.35 to $0.55/sf	Upgrade	$ 3,703	$ 5,819	$ 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**; 4' overhangs on 8' height windows: 3,200 sf @ $2.00 to $3.00/sf	Upgrade	$ 6,400	$ 9,600	$ 8,000
Lighting = 0.783 w/sf: pen 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 on T8s @ $75 to $100 each**; (40) 18w recessed CFLs **w/ multi-level occupancy sensors on CFLs @ $75 to $100 each.** 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 in these areas.	Upgrade	$ 2,100	$ 2,800	$ 2,450
(2) 15-ton DX units EER=11.5; 82% AFUE furnaces; standard efficiency fan motors; **differential temp.** integrated air economizers. **Controls to include "cycle on at night"**	Upgrade	$ 1,000	$ 2,000	$ 1,500
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters **EF=0.62**	Upgrade	$ 250	$ 500	$ 375
Total Incremental Cost of Energy Efficiency Measures:		**$ 13,453**	**$ 20,719**	**$ 17,086**
Total Incremental Cost per Square Foot:		**$ 1.27**	**$ 1.96**	**$ 1.61**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 2 **Climate Zone 14**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 integral with Metal roof and additional **R-25** below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75; 10,580 sf $0.30 to $0.50/sf	Upgrade	$ 3,174	$ 5,290	$ 4,232
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**; 4' overhangs on 8' height windows: 3,200 sf @ $1.50 to $2.50/sf	Upgrade	$ 4,800	$ 8,000	$ 6,400
Lighting = 0.678 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 **w/ multi-level occupancy sensors on CFLs @ $75 to $100 each.** 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 in these areas.	Upgrade	$ 948	$ 1,520	$ 1,234
(2) 15-ton DX units EER=11.5; 82% AFUE furnaces; standard efficiency fan motors; **differential temp.** integrated air economizers. **Controls to include "cycle on at night"**	Upgrade	$ 1,000	$ 2,000	$ 1,500
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters **EF=0.62**	Upgrade	$ 250	$ 500	$ 375
Total Incremental Cost of Energy Efficiency Measures:		**$ 10,172**	**$ 17,310**	**$ 13,741**
Total Incremental Cost per Square Foot:		**$ 0.96**	**$ 1.64**	**$ 1.30**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 3 **Climate Zone 14**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 integral with Metal roof and additional **R-30** below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75; 10,580 sf $0.35 to $0.55/sf	Upgrade	$ 3,703	$ 5,819	$ 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=0.38** 3,200 sf @ $1.50 to $2.50/sf	Upgrade	$ 4,800	$ 8,000	$ 6,400
Lighting = 0.678 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 **w/ multi-level occupancy sensors on CFLs @ $75 to $100 each.** 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 in these areas.	Upgrade	$ 948	$ 1,520	$ 1,234
(2) 15-ton DX units EER=11.5; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 9,451**	**$ 15,339**	**$ 12,395**
Total Incremental Cost per Square Foot:		**$ 0.89**	**$ 1.45**	**$ 1.17**

High-rise Office Building

- 5-story
- 52,900 sf,
- Window to Wall Ratio = 39.4%

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 52,900 SF, Option 1 **Climate Zone 14**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 integral with Metal roof and additional R-19 below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75				
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**; 16,000 sf @ $2.00 to $3.00/sf	Upgrade	$ 32,000	$ 48,000	$ 40,000
Lighting = 0.65 w/sf: Open Office Areas: **(140) HO 2-lamp T8 fixtures @74w each**; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (140) 2-lamp T8 fixtures **multi-level occupancy sensors on T8s @ $75 to $100 each**; (200) 18w recessed CFLs on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls. Net saving of $36 to $40 per new fixture in open offices because of a total reduction of 52% of T8 fixtures in these areas	Upgrade	$ 4,100	$ 8,240	$ 6,170
(3) Packaged VAV system 81% TE and 10.1 EER, fixed temp. economizer, standard efficiency variable speed fan motors; 15% VAV boxes, reheat on perimeter zones with hot water using **92% AFUE** boiler. Controls to included fault detection and diagnostic; and "cycle on at night" features.	Upgrade	$ 2,500	$ 5,000	$ 3,750
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
92% AFUE boiler for domestic hot water use	Upgrade	$ 2,500	$ 5,000	$ 3,750
Total Incremental Cost of Energy Efficiency Measures:		**$ 41,100**	**$ 66,240**	**$ 53,670**
Total Incremental Cost per Square Foot:		**$ 0.78**	**$ 1.25**	**$ 1.01**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 2 **Climate Zone 14**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 integral with Metal roof and additional **R-30** below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75; 10,580 sf $0.35 to $0.55/sf	Upgrade	$ 3,703	$ 5,819	$ 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=0.31**; 16,000 sf @ $1.75 to $2.75/sf	Upgrade	$ 28,000	$ 44,000	$ 36,000
Lighting = 0.65 w/sf: Open Office Areas: **(140) HO 2-lamp T8 fixtures @74w each**; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (140) 2-lamp T8 fixtures **multi-level occupancy sensors on T8s @ $75 to $100 each**; (200) 18w recessed CFLs on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls. Net saving of $36 to $40 per new fixture in open offices because of a total reduction of 52% of T8 fixtures in these areas	Upgrade	$ 4,100	$ 8,240	$ 6,170
(3) Packaged VAV system 81% TE and 10.1 EER, fixed temp. economizer, standard efficiency variable speed fan motors; 15% VAV boxes, reheat on perimeter zones with hot water using **94.5% AFUE boiler**. Controls to included fault detection and diagnostic; and **NO "cycle on at night"** features.	Upgrade & Downgrade	$ 2,600	$ 5,400	$ 4,000
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
94.5% AFUE boiler for domestic hot water use	-	$ 3,500	$ 6,000	$ 4,750
Total Incremental Cost of Energy Efficiency Measures:		**$ 41,903**	**$ 69,459**	**$ 55,681**
Total Incremental Cost per Square Foot:		**$ 0.79**	**$ 1.31**	**$ 1.05**

Incremental Cost Estimate to Exceed Title 24 by 15%
Nonresidential Prototype: 52,900 SF, Option 3 **Climate Zone 14**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 integrated with Metal roof and additional R-19 below (no framing interruption), **no cool roof**:10,580 sf @ -$0.30 to -$0.50/sf	Downgrade	$ (5,290)	$ (3,174)	$ (4,232)
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**; 16,000 sf @ $2.00 to $3.00/sf	Upgrade	$ 32,000	$ 48,000	$ 40,000
Lighting = 0.65 w/sf: Open Office Areas: **(140) HO 2-lamp T8 fixtures @74w each**; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (140) 2-lamp T8 fixtures **multi-level occupancy sensors on T8s @ $75 to $100 each**; (200) 18w recessed CFLs on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls. Net saving of $36 to $40 per new fixture in open offices because of a total reduction of 52% of T8 fixtures in these areas	Upgrade	$ 4,100	$ 8,240	$ 6,170
(3) Packaged VAV system 81% TE and 10.1 EER, **variable temp. economizer,** standard efficiency variable speed fan motors; 15% VAV boxes, reheat on perimeter zones with hot water using **94.5% AFUE boiler**. Controls to included fault detection and "cycle on at	Upgrade	$ 3,800	$ 6,500	$ 5,150
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
94.5% AFUE boiler for domestic hot water use	Upgrade	$ 3,500	$ 6,000	$ 4,750
Total Incremental Cost of Energy Efficiency Measures:		**$ 38,110**	**$ 65,566**	**$ 51,838**
Total Incremental Cost per Square Foot:		**$ 0.72**	**$ 1.24**	**$ 0.98**

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	120	$2,569	$174	14.7
2,025 sf (Option 2)	394	121	$3,128	$176	17.7
2,025 sf (Option 3)	349	126	$2,652	$174	15.2
Averages:	377	122	$2,783	$175	15.9

Annual Reduction in CO2-equivalent: ***1,594 lb./building-year***
0.79 lb./sq.ft.-year

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)	914	134	$6,095	$271	22.5
4,500 sf (Option 2)	914	149	$5,395	$285	18.9
4,500 sf (Option 3)	910	150	$6,055	$286	21.2
4,500 sf (Option 4)	580	205	$5,890	$285	20.7
Averages:	830	160	$5,859	$282	20.8

Annual Reduction in CO2-equivalent: ***2,230 lb./building-year***
0.50 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-Unit, 8,442 sf (Option 1)	2318	296	$17,472	$647	27.0
8-Unit, 8,442 sf (Option 2)	1146	523	$11,452	$674	17.0
8-Unit, 8,442 sf (Option 3)	709	630	$11,949	$705	17.0
Averages:	1391	483	$13,624	$675	20.3

Annual Reduction in CO2-equivalent: ***6,248 lb./building-year***
0.74 lb./sq.ft.-year

High-rise Multi-family Apartments

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost ($)	Annual Energy Cost Savings ($)
36,800 sf (Option 1)	21206	-595	$26,960	$2,812
36,800 sf (Option 2)	13098	1448	$33,270	$3,444
36,800 sf (Option 3)	14665	1109	$33,760	$3,374
Averages:	16323	654	$31,330	$3,210

Annual Reduction in CO2-equivalent: *14,958 lb./building-year*
0.41 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)
10,580 sf (Option 1)	9057	-115	$17,086	$1,922	8.9
10,580 sf (Option 2)	8434	-25	$13,741	$1,791	7.7
10,580 sf (Option 3)	15803	54	$12,395	$3,628	3.4
Averages:	11098	-29	$14,407	$2,447	6.7

Annual Reduction in CO2-equivalent: *4,660 lb./building-year*
0.44 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	72341	1327	$53,670	$17,173	3.1
52,900 sf Option 2	114153	4386	$55,681	$28,511	2.0
52,900 sf Option 3	69863	1642	$51,838	$16,714	3.1
Averages:	85452	2452	$53,730	$20,799	2.7

Annual Reduction in CO2-equivalent: *56,512 lb./building-year*
1.07 lb./sq.ft.-year

Appendix A
Climate Zone 14 Cities

1 Actis
2 Acton
3 Adelanto
4 Afton
5 Airport Lake
6 Amargosa Range
7 Amargosa River
8 Antelope Center
9 Antelope Valley
10 Apple Valley
11 Argus
12 Arrowhead Junction
13 Atolia
14 Avawatz Mountains
15 Baker
16 Balch
17 Ballarat
18 Barstow
19 Bell Mountain
20 Bell Mountain Wash
21 Bennetts Well
22 Big Rock Wash
23 Bissell
24 Black Canyon Wash
25 Boron
26 Boulevard
27 Brant
28 Bristol Mountains
29 Brown
30 Bryman
31 Buckhorn Lake
32 Budweiser Wash
33 Bull Spring Wash
34 Bullion Mountains
35 Cady Mountains
36 Calada
37 California City
38 Camino
39 Campo
40 Cantil
41 Cedar Wash
42 China Lake, Kern
43 China Lake, San Bernardino
44 Chiriaco Summit
45 Chuckwalla Mountains
46 Cima
47 Clark Mountain
48 Cottonwood Canyon
49 Cottonwood Wash
50 Coyote Lake
51 Crucero
52 Cuddeback Lake
53 Cuyamaca Peak
54 Daggett
55 Dale Lake
56 Danby
57 Dawes
58 Death Valley
59 Death Valley Junction
60 Death Valley Wash
61 Descanso
62 Desert
63 Desert View Highland
64 Devils Playground
65 Devils Playground Wash
66 Eagle Crags
67 Eagle Mountain
68 Eagle Mountains
69 Echo Canyon
70 Edwards Air Force Base

Only a portion located within Climate Zone 14

Climate Zone 14 Cities – con't

71 El Capitan Reservoir
72 El Mirage
73 El Mirage Lake
74 El Paso Mountains
75 Emerson Lake
76 Essex
77 Fairmont
78 Fenner
79 Fenner Valley
80 Flynn
81 Fossil Canyon
82 Franklin Well
83 Freeman Junction
84 Fremont Peak
85 Fremont Valley
86 Fremont Wash
87 Fried Liver Wash
88 Funeral Park
89 Furnace Creek Wash
90 Garlock
91 George A.F.B.
92 Glasgow
93 Goffs
94 Goldstone
95 Goldstone Lake
96 Granite Mountains
97 Greenwater Range
98 Guatay
99 Halloran Springs
100 Harper Lake
101 Hart
102 Hawes
103 Hayfield
104 Hayfield Lake
105 Hector
106 Helendale
107 Hesperia
108 Hi Vista
109 Hinkley
110 Hodge
111 Homer
112 Homer Wash
113 Indian Wells Valley
114 Inyokern
115 Ivanpah
116 Ivanpah Lake
117 Ivanpah Valley
118 Jacumba
119 Johannesburg
120 Joshua Tree
121 Julian
122 Juniper Hills
123 Kaweah River (Middle Fork)
124 Kelso
125 Kelso Wash
126 Kingston Peak
127 Kingston Wash
128 Klondike
129 Koehn Lake
130 Kramer Junction
131 Lake Henshaw
132 Lake Los Angeles
133 Lancaster
134 Landers
135 Lane Mountain
136 Lanfair Valley
137 Last Chance Canyon
138 Lavic
139 Lavic Lake
140 Leach Lake

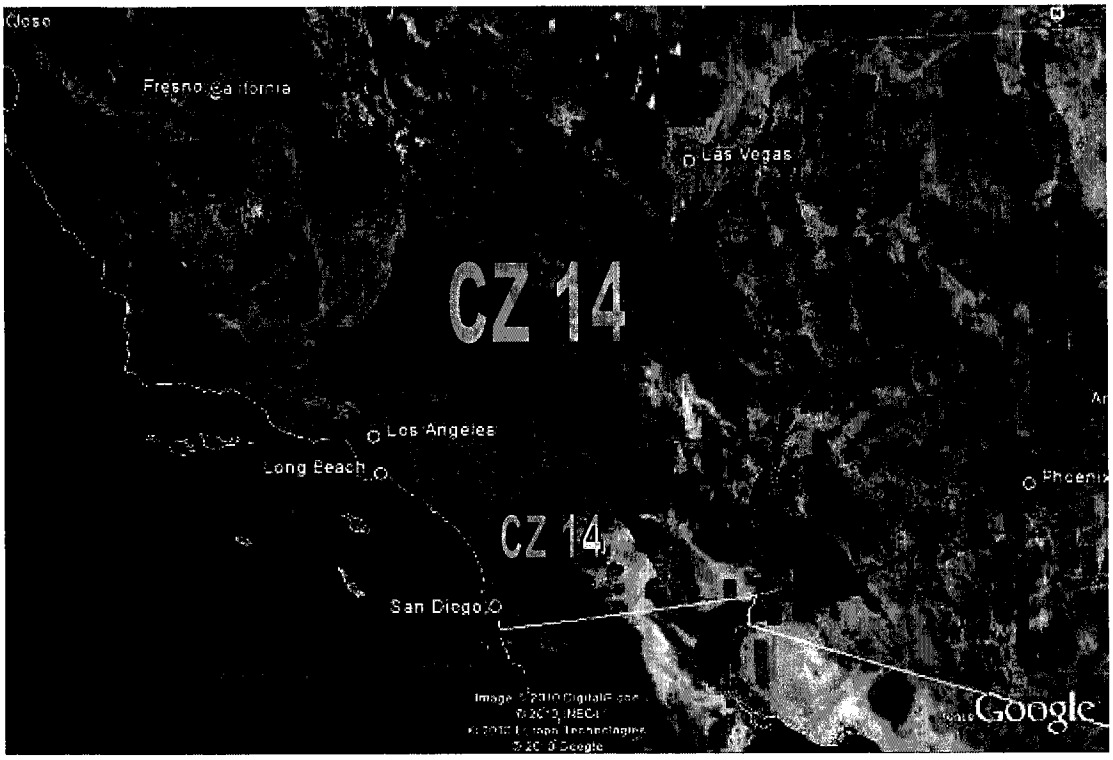
Only a portion located within Climate Zone 14

Climate Zone 14 Cities – con't

141 Valyermo
142 Victorville
143 Vincent
144 Warner Springs
145 Watson Wash
146 Westend
147 Willow Springs
148 Willow Wash
149 Wilsona Gardens
150 Wingate Wash
151 Winston Wash
152 Wynola
153 Yermo
154 Yucca Valley
155 Valyermo
156 Victorville
157 Miller Spring
158 Minneola
159 Mitchell Caverns
160 Mojave
161 Mojave River
162 Mojave River Forks Reservoir
163 Monument Peak
164 Morena VIllage
165 Morongo Valley
166 Mount Laguna
167 Mountain Pass
168 Neuralia
169 Newberry Springs
170 Nipton
171 Nopah Range
172 North Edwards
173 Oak Grove
174 Old Dale
175 Ord Mountain
176 Oro Grande
177 Oro Grande Wash
178 Owlshead Mountains
179 Pahrump Valley
180 Palm Wells
181 Palmdale AP
182 Palomar Mountain
183 Panamint Range
184 Pearblossom
185 Pearland
186 Phelan
187 Pine Valley
188 Pinnacles NM
189 Pinon Hills
190 Pinto Mountains
191 Pioneer Point
192 Pioneertown
193 Pipes Wash
194 Piute Valley
195 Piute Wash
196 Porcupine Wash
197 Potrero
198 Providence Mountains
199 Quartz Hill
200 Ranchita
201 Randsburg
202 Red Mountain
203 Redman
204 Rhodes Wash
205 Ridgecrest
206 Riggs Wash
207 Rosamond
208 Rosamond Lake
209 Ryan
210 Saltdale

Climate Zone 14 Cities – con't

211 San Felipe
212 Spangler
213 Squirrel Inn
214 Stovepipe Wells
215 Teagle Wash
216 Tecate
217 Tecopa
218 Three Points
219 Tiefort Mountains
220 Tierra del Sol
221 Trona
222 Twentynine Palms
223 Valley Wells
224 Valyermo
225 Victorville
226 Vincent
227 Warner Springs
228 Watson Wash
229 Westend
230 Willow Springs
231 Willow Wash
232 Wilsona Gardens
234 Wingate Wash
235 Winston Wash
236 Wynola
237 Yermo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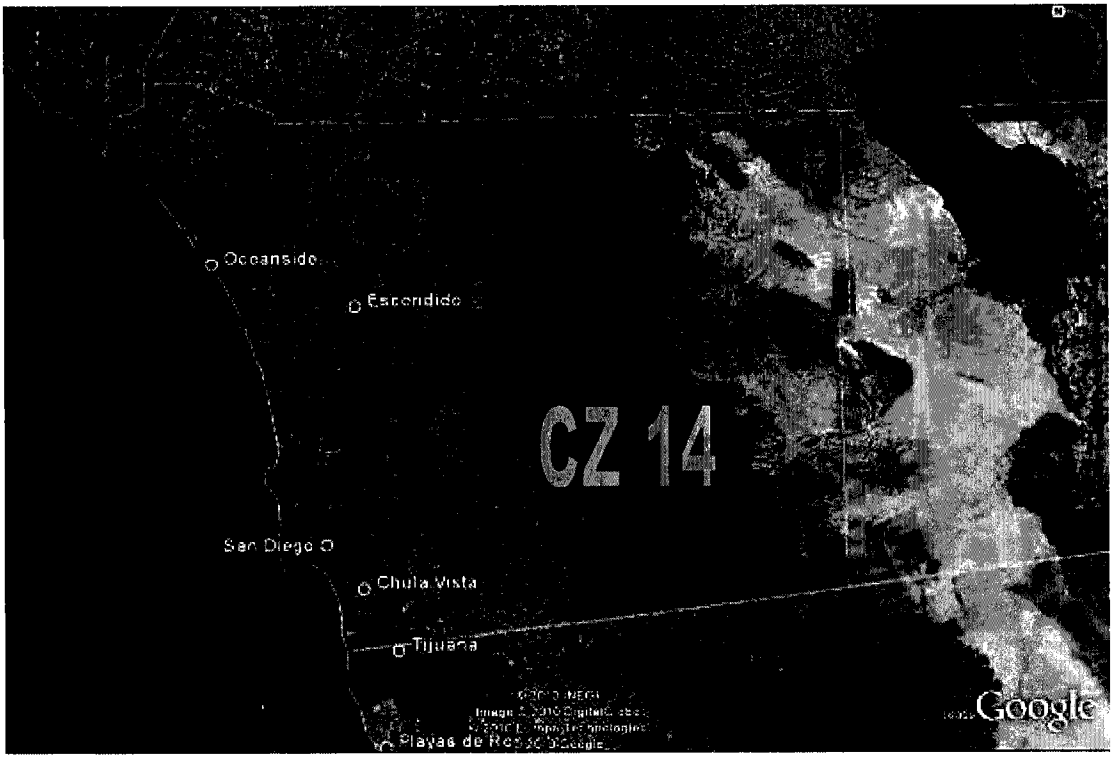
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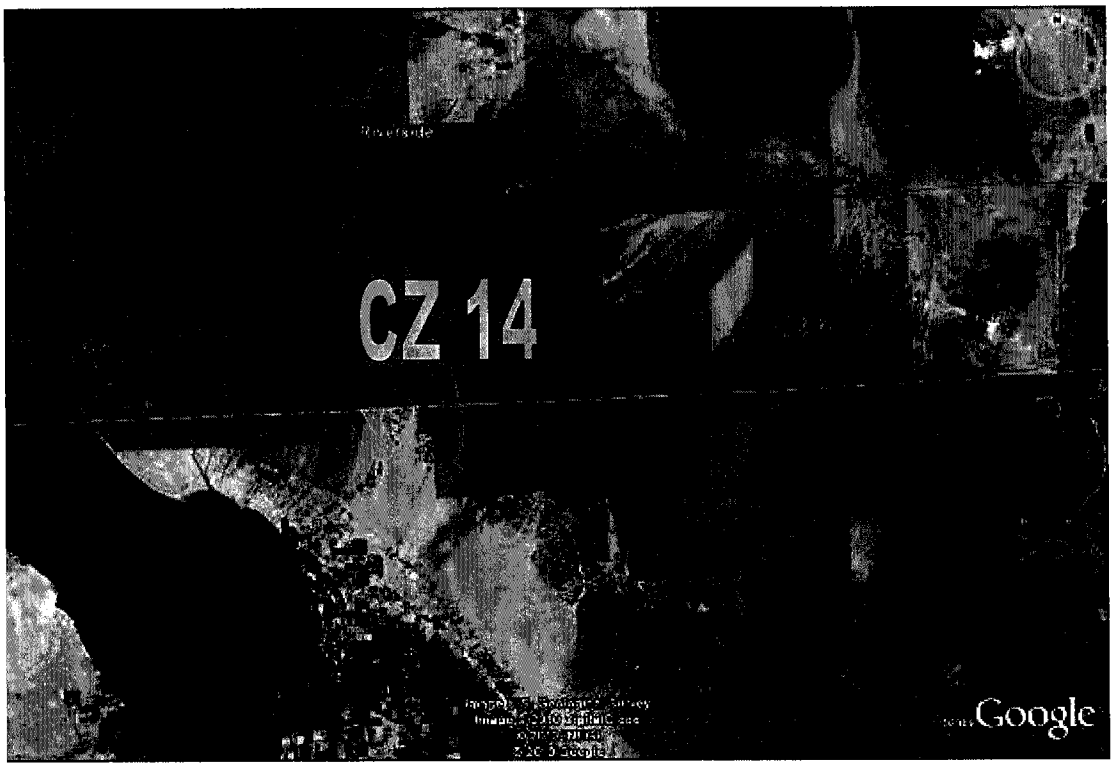
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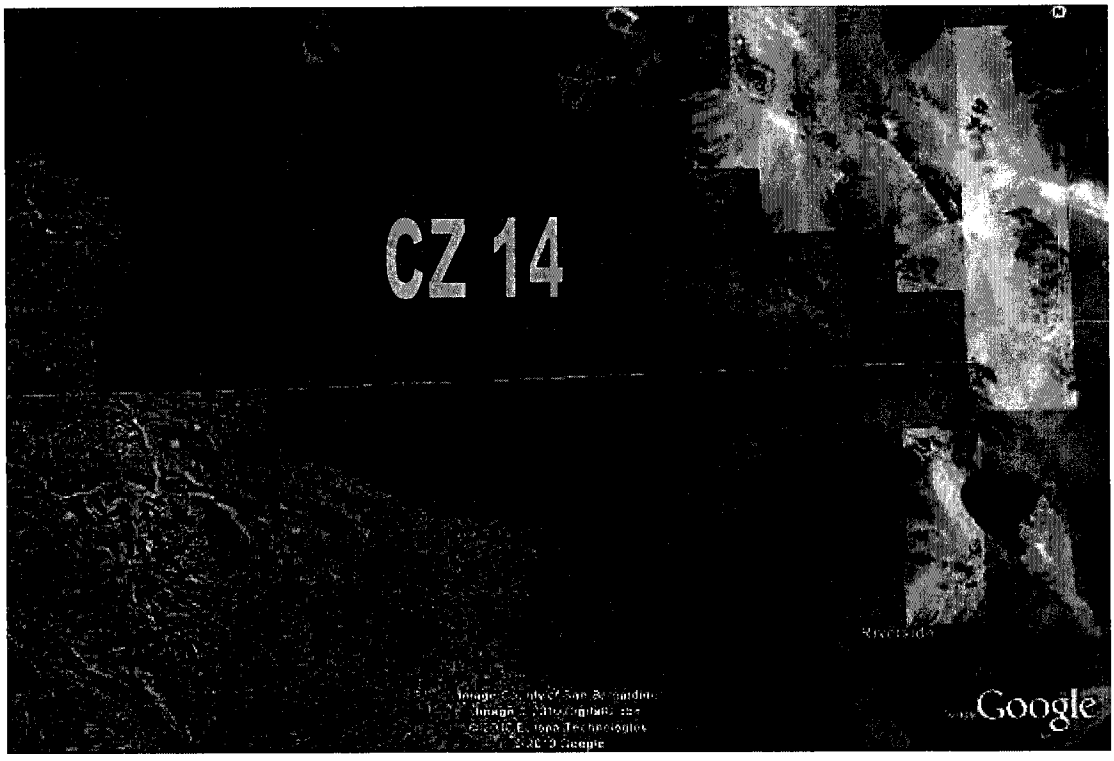
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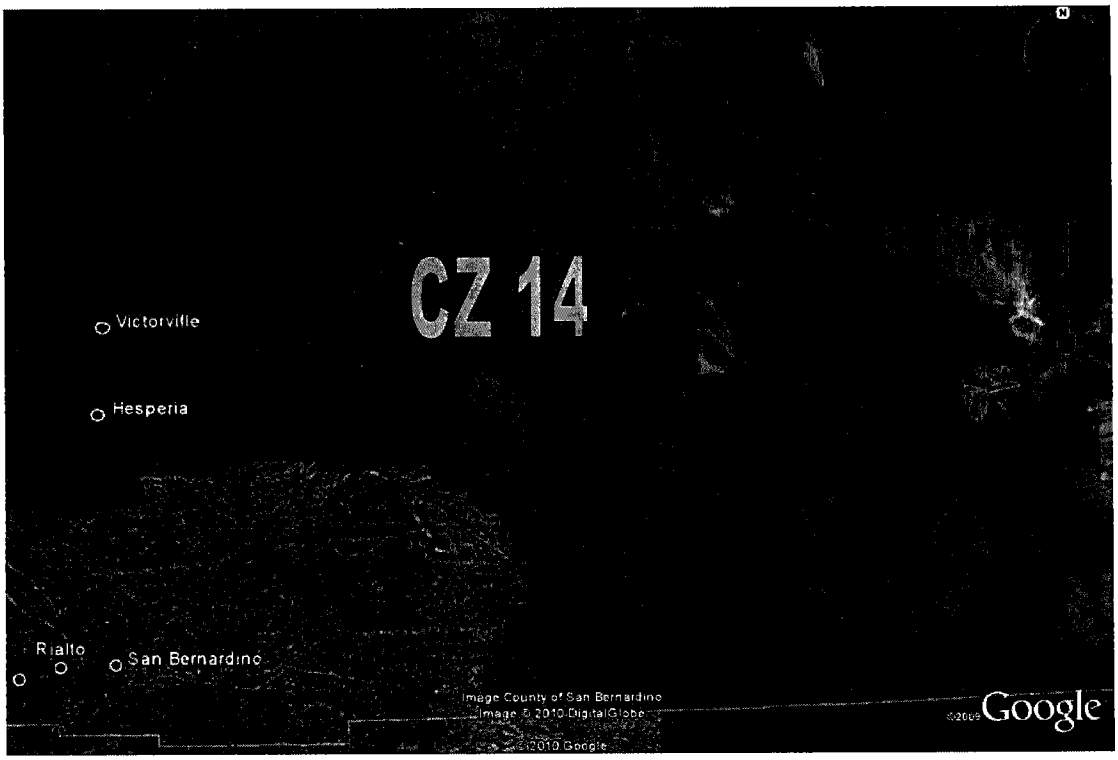
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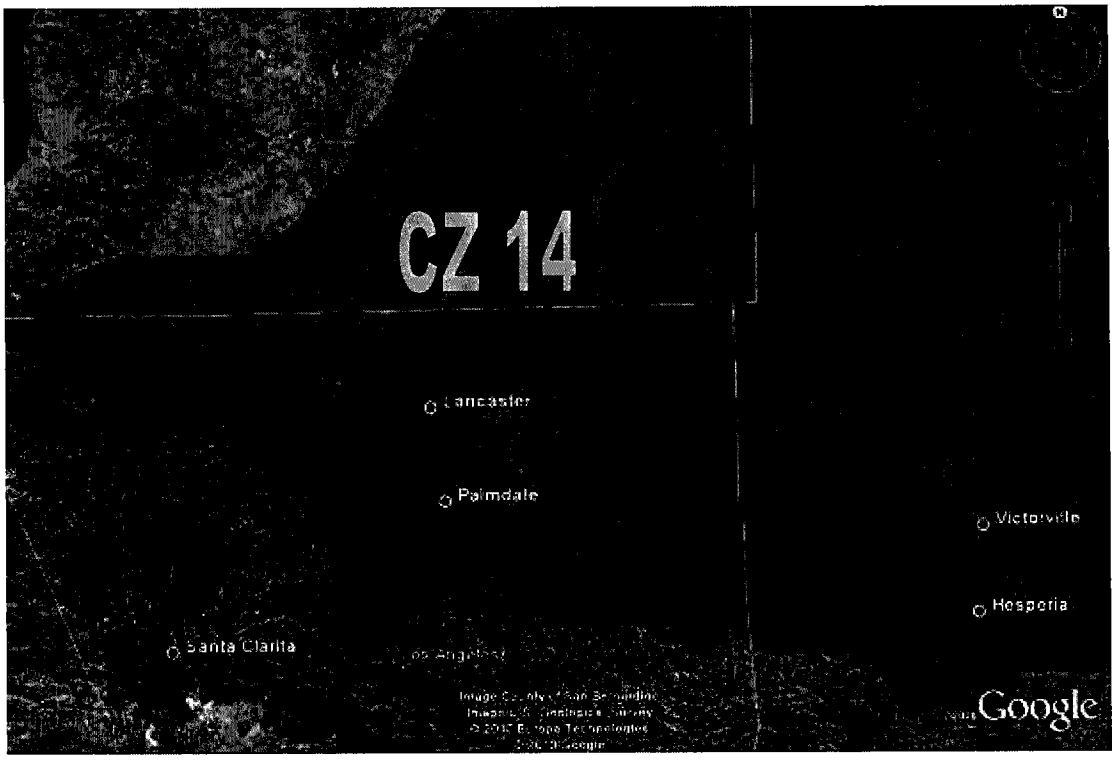
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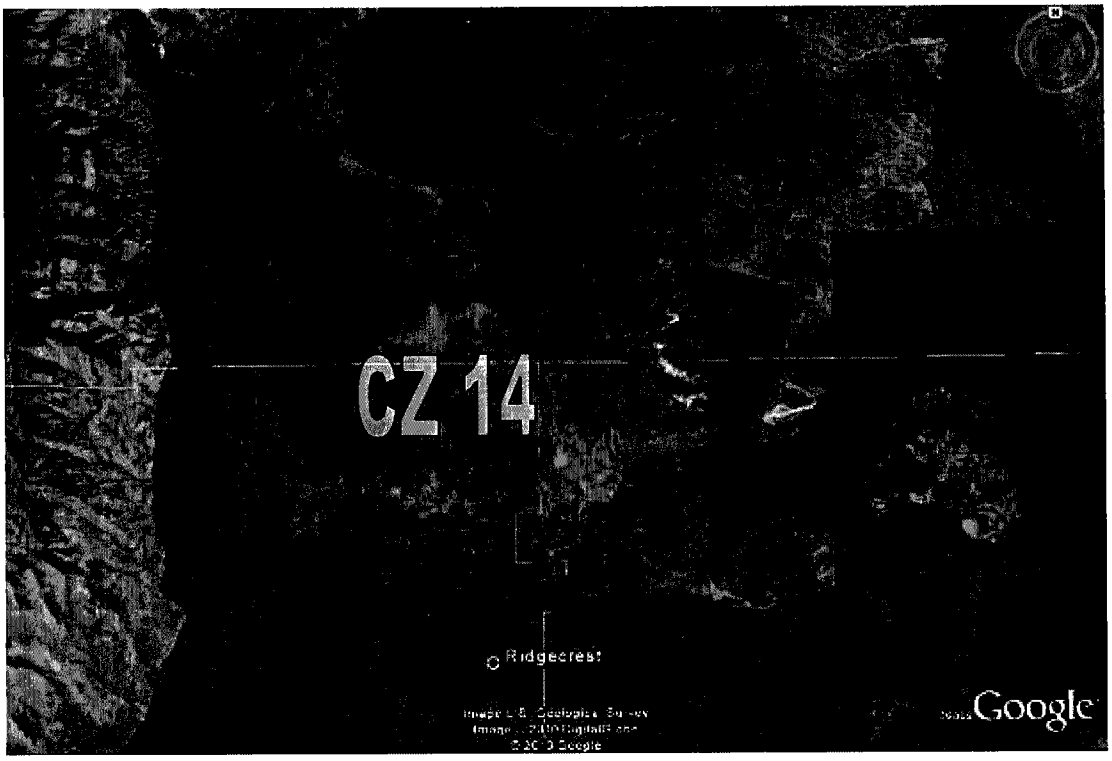
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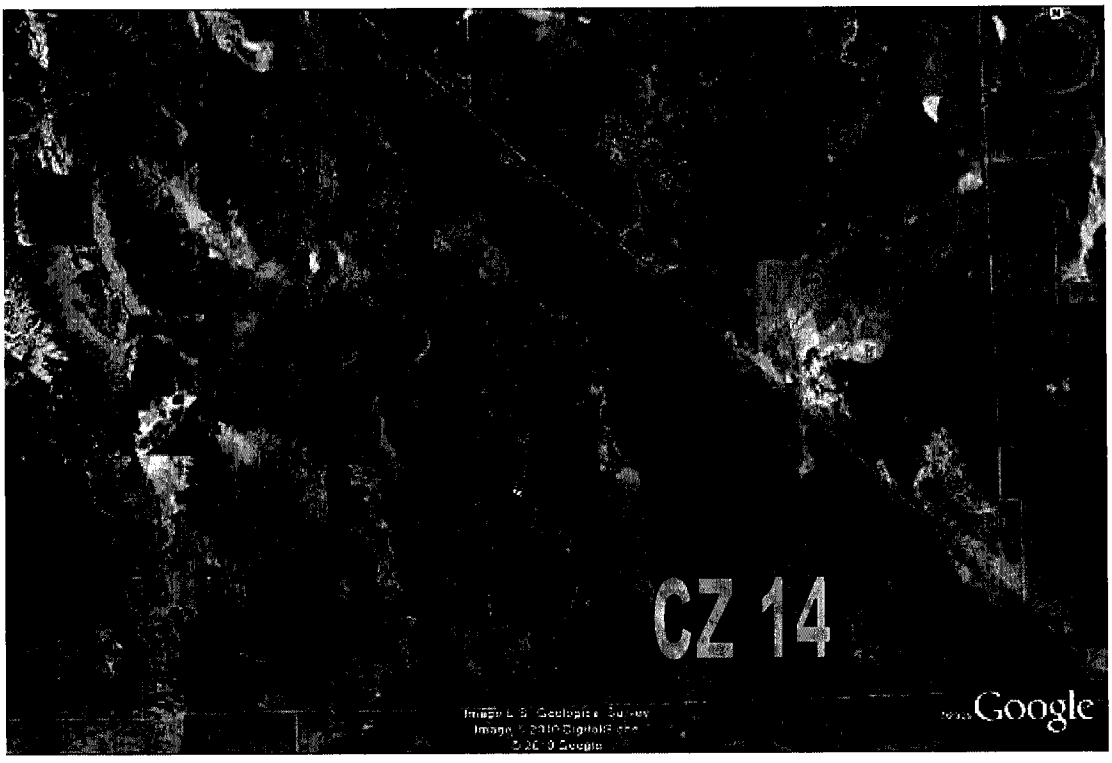
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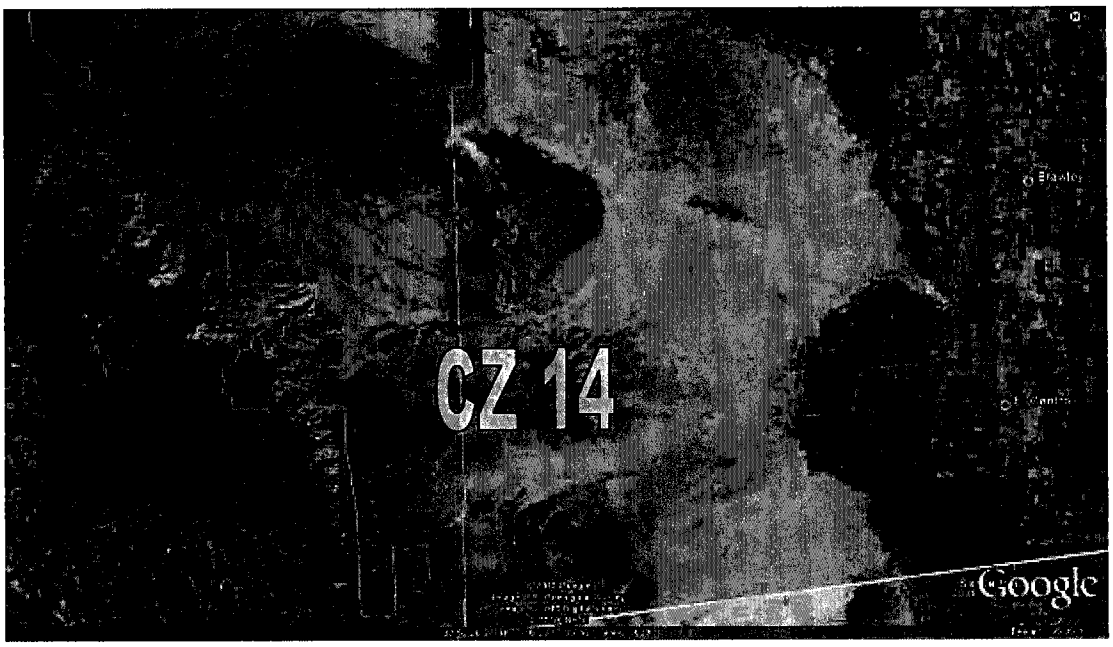
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Codes and Standards
Title 24 Energy-Efficient Local Ordinances

Title:
Climate Zone 16
Energy Cost-Effectiveness Study

Prepared for:

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Codes and Standards Program
Pacific Gas and Electric Company

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Government Partnership Program
Pacific Gas and Electric Company

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Gabel Associates, LLC

Last Modified: June 17, 2010

Pacific Gas and Electric Company®

Climate Zone 16 Energy Cost-Effectiveness Study

June 17, 2010

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Table of Contents

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 16. 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 16 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 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 the following building prototypes just meet the 2008 Standards in Climate Zone 16.

Small Single Family House

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

Energy Efficiency Measures: Heating Only
R-30 Roof w/ Radiant Barrier
R-19 Walls
R-19 Raised Floor over Garage/Open at 2nd Floor
R-0 Slab on Grade
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: None
R-6 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
50 Gallon Gas Water Heater: EF=0.60

Energy Efficiency Measures: Heating & Air Conditioning
R-30 Roof w/ Radiant Barrier
R-19 Walls
R-19 Raised Floor over Garage/Open at 2nd Floor
R-0 Slab on Grade
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

Large Single Family House

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

Energy Efficiency Measures: Heating Only
R-30 Roof w/ Radiant Barrier
R-13 Walls
R-19 Raised Floor
Quality Insulation Installation (HERS)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(2) Furnaces: 80% AFUE
Air Conditioners: None
R-4.2 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
(2) 50 Gallon Gas Water Heaters: EF=0.62

Energy Efficiency Measures: Heating & Air Conditioning
R-30 Roof w/ Radiant Barrier
R-13 Walls
R-19 Raised Floor
Quality Insulation Installation (HERS)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(2) Furnaces: 80% AFUE
(2) Air Conditioners: 13 SEER
R-4.2 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
(2) 50 Gallon Gas Water Heaters: EF=0.62

Low-rise Multi-family Apartments

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

Energy Efficiency Measures: Heating Only
R-30 Roof w/ Radiant Barrier
R-15 Walls
R-0 Slab on Grade
Quality Insulation Installation (HERS)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(8) Furnaces: 80% AFUE
Air Conditioners: None
R-6 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
(8) 40 Gallon Gas Water Heaters: EF=0.63

Energy Efficiency Measures: Heating & Air Conditioning
R-30 Roof w/ Radiant Barrier
R-15 Walls
R-0 Slab on Grade
Quality Insulation Installation (HERS)
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(8) Furnaces: 80% AFUE
(8) Air Conditioners: 13 SEER
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 integral with Metal roof and additional R-11 below (no framing interruption).
R-19 in Metal Frame Walls
R-5 (1.5" K-13 spray-on) Raised Slab over parking garage
Dual Metal Windows: COG U-factor=0.30, SHGC=0.54
1.5 ton 4-pipe fan coil, 80% AFUE boiler, 70-ton scroll air cooled chiller 0.72 KW/ton
Central DHW boiler: 80% AFUE and recirculating system w/ timer-temperature controls

Low-rise Office Building

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

Energy Efficiency Measures to Meet Title 24
R-19 integral with Metal roof and additional R-13 below (no framing interruption); Cool Roof Reflect.=0.55, Emittance = 0.75
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Metal windows: Default glazing U=0.71, default COG SHGC=0.73: 4' overhangs on 8' height windows
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, on/off lighting controls. Support Areas: (32) 18w recessed CFLs; (48) 13w CFL wall sconces; no controls.
(2) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage
(1) Tank Gas Water Heaters EF=0.58

High-rise Office Building

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

Energy Efficiency Measures to Meet Title 24
R-19 integral with Metal roof and additional R-19 below (no framing interruption).
R-19 in Metal Frame Walls
R-0 (un-insulated) slab-on-grade 1st floor
Metal windows: default U-factor = .71, COG SHGC=0.38
Lighting = 0.858 w/sf: Open Office Areas: (300) 2-lamp T8 fixtures @58w each; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (280) 2-lamp T8 58w fixtures on/off lighting controls; (200) 18w recessed CFLs no lighting on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls.
(3) 55 ton Packaged VAV system 81% TE and 10.2 EER, fixed temp. economizer, standard efficiency variable speed fan motors; 15% VAV boxes, reheat on perimeter zones with hot water using 80% AFUE boiler. Controls to included fault detection and diagnostic; and "cycle on at night" features.
R-8 duct insulation w/ ducts in conditioned
80% AFUE boiler for domestic hot water use

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, Opt 1 Heat Only **2025 sf** **Climate Zone 16**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls	-	$ -	$ -	$ -
R-19 Raised Floor over Garage/Open at 2nd Floor	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	Upgrade	$ 450	$ 600	$ 525
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 92% AFUE (from 80% AFUE)	Upgrade	$ 500	$ 1,200	$ 850
Air Conditioner: None	-	$ -	$ -	$ -
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.63 (from EF=0.60)	Upgrade	$ 100	$ 250	$ 175
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,050**	**$ 2,050**	**$ 1,550**
Total Incremental Cost per Square Foot:		**$ 0.52**	**$ 1.01**	**$ 0.77**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Opt 2 Heat Only **2025 sf** **Climate Zone 16**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/Radiant Barrier): 1,443 sf @ 0.15 to 0.20/sf	Upgrade	$ 216	$ 289	$ 253
R-21 Walls (from R-19): 2,550 sf @ $0.14 to $0.16/sf	Upgrade	$ 357	$ 408	$ 383
R-30 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.25 to $0.35	Upgrade	$ 112	$ 157	$ 134
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 92% AFUE (from 80% AFUE)	Upgrade	$ 500	$ 1,200	$ 850
Air Conditioner: None	-	$ -	$ -	$ -
R-8 Attic Ducts (from R-6)	Upgrade	$ 225	$ 325	$ 275
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:		**$ 1,510**	**$ 2,578**	**$ 2,044**
Total Incremental Cost per Square Foot:		**$ 0.75**	**$ 1.27**	**$ 1.01**

Incremental Cost Estimate to Exceed Title 24 by 15%
Single Family Prototype: 2,025 SF, Opt 3 Heat + AC **2025 sf** **Climate Zone 16**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/Radiant Barrier): 1,443 sf @ 0.15 to 0.20/sf	Upgrade	$ 216	$ 289	$ 253
R-21 Walls (from R-19): 2,550 sf @ $0.14 to $0.16/sf	Upgrade	$ 357	$ 408	$ 383
R-30 Raised Floor over Garage/Open at 2nd Floor (from R-19): 448 sf @ $0.25 to $0.35	Upgrade	$ 112	$ 157	$ 134
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 92% AFUE (from 80% AFUE)	Upgrade	$ 500	$ 1,200	$ 850
Air Conditioning: 13 SEER, 11 EER (HERS) (from 13 SEER No HERS)	Upgrade	$ 25	$ 75	$ 50
Air Conditioner: Refrig. Charge (HERS)	Upgrade	$ 150	$ 200	$ 175
R-8 Attic Ducts (from R-6)	Upgrade	$ 225	$ 325	$ 275
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.61 (from EF=0.60)	Upgrade	$ 50	$ 150	$ 100
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,635**	**$ 2,803**	**$ 2,219**
Total Incremental Cost per Square Foot:		**$ 0.81**	**$ 1.38**	**$ 1.10**

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, Opt 1 Heat Only **4500 sf** **Climate Zone 16**

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-19 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
Air Conditioners: None	-	$ -	$ -	$ -
R-4.2 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) 50 Gallon Gas Water Heaters: EF=0.60	Downgrade	$ (400)	$ (200)	$ (300)
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,381**	**$ 3,560**	**$ 2,470**
Total Incremental Cost per Square Foot:		**$ 0.31**	**$ 0.79**	**$ 0.55**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Opt 2 Heat Only **4500 sf** **Climate Zone 16**

Energy Efficiency Measures: Heating & Air Conditioning	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-30 Raised Floor (from R-19): 2,700 sf @ $0.25 to $0.35	Upgrade	$ 675	$ 945	$ 810
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
Air Conditioners: None	-	$ -	$ -	$ -
R-8 Attic Ducts (from R-4.2)	Upgrade	$ 500	$ 750	$ 625
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) 50 Gallon Gas Water Heaters: EF=0.60	Downgrade	$ (400)	$ (200)	$ (300)
Total Incremental Cost of Energy Efficiency Measures:		**$ 1,961**	**$ 3,395**	**$ 2,678**
Total Incremental Cost per Square Foot:		**$ 0.44**	**$ 0.75**	**$ 0.60**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Opt 3 Heat + AC **4500 sf** **Climate Zone 16**

Energy Efficiency Measures	Change	Incremental Cost Estimate		
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-19 Raised Floor	-	$ -	$ -	$ -
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 90% AFUE (from 80% AFUE)	Upgrade	$ 1,000	$ 2,000	$ 1,500
(2) Air Conditioners: 13 SEER, 11 EER (HERS) (from 13 SEER No HERS)	Upgrade	$ 50	$ 150	$ 100
(2) Air Conditioners: Refrig. Charge (HERS)	Upgrade	$ 300	$ 400	$ 350
R-4.2 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) 50 Gallon Gas Water Heaters: EF=0.62	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 2,131**	**$ 3,910**	**$ 3,020**
Total Incremental Cost per Square Foot:		**$ 0.47**	**$ 0.87**	**$ 0.67**

Incremental Cost Estimate to Exceed Title 24 by 15%

Single Family Prototype: 4,500 SF, Opt 4 Heat + AC **4500 sf** **Climate Zone 16**

Energy Efficiency Measures	Change	Incremental Cost Estimate		
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 (from R-19): 2,700 sf @ $0.25 to $0.35	Upgrade	$ 675	$ 945	$ 810
Quality Insulation Installation (HERS)	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(2) Furnaces: 80% AFUE	-	$ -	$ -	$ -
(2) Air Conditioners: 13 SEER, 11 EER (HERS) (from 13 SEER No HERS)	Upgrade	$ 50	$ 150	$ 100
(2) Air Conditioners: Refrig. Charge (HERS)	Upgrade	$ 300	$ 400	$ 350
R-6 Attic Ducts (from R-4.2)	Upgrade	$ 250	$ 400	$ 325
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(2) 50 Gallon Gas Water Heaters: EF=0.60	Downgrade	$ (400)	$ (200)	$ (300)
Total Incremental Cost of Energy Efficiency Measures:		**$ 2,413**	**$ 3,998**	**$ 3,205**
Total Incremental Cost per Square Foot:		**$ 0.54**	**$ 0.89**	**$ 0.71**

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, Opt 1 Heat Only **8442 sf** **Climate Zone 16**

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/Radiant Barrier): 4,221 sf @ 0.15 to 0.20/sf	Upgrade	$ 633	$ 844	$ 739
R-19 Walls (from R-15): 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)	-	$ -	$ -	$ -
Low E2 Vinyl, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(8) Furnaces: 80% AFUE	-	$ -	$ -	$ -
Air Conditioners: None	-	$ -	$ -	$ -
(8) Air Conditioners: Refrig. Charge (HERS)	-	$ -	$ -	$ -
R-4.2 Attic Ducts (from R-6)	Downgrade	$ (1,600)	$ (1,000)	$ (1,300)
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) Instantaneous Gas Water Heater: RE=0.80 (from 40 Gal Gas: EF=0.63)	Upgrade	$ 7,200	$ 11,600	$ 9,400
Total Incremental Cost of Energy Efficiency Measures:		**$ 7,755**	**$ 15,503**	**$ 11,629**
Total Incremental Cost per Square Foot:		**$ 0.92**	**$ 1.84**	**$ 1.38**

Incremental Cost Estimate to Exceed Title 24 by 15%

Multi-Family Prototype: 8,442 SF, Opt 2 Heat Only 8442 sf Climate Zone 16

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-30 w/Radiant Barrier): 4,221 sf @ 0.15 to 0.20/sf	Upgrade	$ 633	$ 844	$ 739
R-19 Walls (from R-15): 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)	-	$ -	$ -	$ -
Low E2 Vinyl, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(8) Furnaces: 92% AFUE (from 80% AFUE)	Upgrade	$ 4,000	$ 9,600	$ 6,800
Air Conditioners: None	-	$ -	$ -	$ -
R-4.2 Attic Ducts (from R-6)	Downgrade	$ (1,600)	$ (1,000)	$ (1,300)
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) 50 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 4,555**	**$ 13,503**	**$ 9,029**
Total Incremental Cost per Square Foot:		**$ 0.54**	**$ 1.60**	**$ 1.07**

Incremental Cost Estimate to Exceed Title 24 by 15%

Multi-Family Prototype: 8,442 SF, Opt 3 Heat + AC 8442 sf Climate Zone 16

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-30 Roof w/ Radiant Barrier	-	$ -	$ -	$ -
R-19 Walls (from R-15): 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)	-	$ -	$ -	$ -
Low E2 Vinyl, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
(8) Furnaces: 90% AFUE (from 80% AFUE)	Upgrade	$ 4,000	$ 8,000	$ 6,000
(8) Air Conditioners: 13 SEER, 11 EER (HERS) (from 13 SEER No HERS)	Upgrade	$ 200	$ 600	$ 400
R-6 Attic Ducts	-	$ -	$ -	$ -
Reduced Duct Leakage/Testing (HERS)	-	$ -	$ -	$ -
(8) 50 Gallon Gas Water Heaters: EF=0.63	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 5,722**	**$ 12,658**	**$ 9,190**
Total Incremental Cost per Square Foot:		**$ 0.68**	**$ 1.50**	**$ 1.09**

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 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 integral with Metal roof and **additional R-30** below (no framing interruption); **cool roof Reflect.=0.55, Emittance = 0.75;** 9,200 sf @ $0.70 - $1.10/sf	Upgrade	$ 6,440	$ 10,210	$ 8,325
R-19 in Metal Frame Walls	-			
R-5 (1.5" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows: **COG U-factor=0.3, COG SHGC=0.38** 6,240 sf @ $1.50 to $2.50/sf	Upgrade	$ 9,360	$ 15,600	$ 12,480
4-pipe fan coil, **96% AFUE boiler,** 70-ton scroll air cooled chiller 0.72 KW/ton	Upgrade	$ 3,000	$ 4,000	$ 3,500
Central DHW boiler: **96% AFUE** and recirculating system w/ timer-temperature controls	Upgrade	$ 3,000	$ 4,000	$ 3,500
Total Incremental Cost of Energy Efficiency Measures:		**$ 21,800**	**$ 33,810**	**$ 27,805**
Total Incremental Cost per Square Foot:		**$ 0.59**	**$ 0.92**	**$ 0.76**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 2 **Climate Zone 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 integral with Metal roof and **additional R-30** below (no framing interruption). 9,200 sf @ $0.35 - $0.60/sf	Upgrade	$ 3,220	$ 5,520	$ 4,370
R-19 in Metal Frame Walls	-			
R-5 (1.5" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows: **COG U-factor=0.3, COG SHGC=0.31** 6,240 sf @ $2.50 to $3.50/sf	Upgrade	$ 15,600	$ 21,840	$ 18,720
4-pipe fan coil, **94% AFUE** boiler, 70-ton scroll air cooled chiller 0.72 KW/ton	Upgrade	$ 2,000	$ 3,500	$ 2,750
Central DHW boiler: **94% AFUE** and recirculating system w/ timer-temperature controls	Upgrade	$ 2,000	$ 3,500	$ 2,750
Total Incremental Cost of Energy Efficiency Measures:		**$ 22,820**	**$ 34,360**	**$ 28,590**
Total Incremental Cost per Square Foot:		**$ 0.62**	**$ 0.93**	**$ 0.78**

Incremental Cost Estimate to Exceed Title 24 by 15%
High-rise Residential Prototype: 36,800 SF, Option 3 **Climate Zone 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 integral with Metal roof and **additional R-30** below (no framing interruption). 9,200 sf @ $0.35 - $0.60/sf	Upgrade	$ 3,220	$ 5,520	$ 4,370
R-19 in Metal Frame Walls	-			
R-5 (1.5" K-13 spray-on) Raised Slab over parking garage	-			
Dual Metal Windows: **COG U-factor=0.3, COG SHGC=0.27** 6,240 sf @ $3.50 to $5.00/sf	Upgrade	$ 21,840	$ 31,200	$ 26,520
4-pipe fan coil, **92% AFUE** boiler, 70-ton scroll air cooled chiller 0.72 KW/ton	Upgrade	$ 1,500	$ 3,000	$ 2,250
Central DHW boiler: **92% AFUE** and recirculating system w/ timer-temperature controls	Upgrade	$ 1,500	$ 3,000	$ 2,250
Total Incremental Cost of Energy Efficiency Measures:		**$ 28,060**	**$ 42,720**	**$ 35,390**
Total Incremental Cost per Square Foot:		**$ 0.76**	**$ 1.16**	**$ 0.96**

Low-rise Office Building

- 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 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 integral with Metal roof and additional **R-38** below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75; 10,580 sf $0.55 to $0.75/sf	Upgrade	$ 5,819	$ 7,935	$ 6,877
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: **COG U=0.30, COG SHGC=0.31**; 4' overhangs on 8' height windows: 3,200 sf @ $4.00 to $6.00/sf	Upgrade	$ 12,800	$ 19,200	$ 16,000
Lighting = 0.783 w/sf: pen 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 on T8s @ $75 to $100 each**; (40) 18w recessed CFLs **w/ multi-level occupancy sensors on CFLs @ $75 to $100 each.** 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 in these areas.	Upgrade	$ 2,100	$ 2,800	$ 2,450
(2) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 20,719**	**$ 29,935**	**$ 25,327**
Total Incremental Cost per Square Foot:		**$ 1.96**	**$ 2.83**	**$ 2.39**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 2 **Climate Zone 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 integral with Metal roof and additional **R-25** below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75; 10,580 sf $0.20 to $0.30/sf	Upgrade	$ 2,116	$ 3,174	$ 2,645
R-19 in Metal Frame Walls	-			
R-0 (un-insulated) slab-on-grade 1st floor	-			
Metal windows: **COG U=0.30, COG SHGC=0.54**; 4' overhangs on 8' height windows: 3,200 sf @ $3.00 to $5.00/sf	Upgrade	$ 9,600	$ 14,400	$ 12,000
Lighting = 0.678 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 **w/ multi-level occupancy sensors on CFLs @ $75 to $100 each.** 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 in these areas.	Upgrade	$ 948	$ 1,520	$ 1,234
(2) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters **EF=0.62**	Upgrade	$ 250	$ 500	$ 375
Total Incremental Cost of Energy Efficiency Measures:		**$ 12,914**	**$ 19,594**	**$ 16,254**
Total Incremental Cost per Square Foot:		**$ 1.22**	**$ 1.85**	**$ 1.54**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 10,580 SF, Option 3 **Climate Zone 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 integral with Metal roof and additional **R-19** below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75; 10,580 sf $0.15 to $0.25/sf	Upgrade	$ 1,587	$ 2,645	$ 2,116
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**; 4' overhangs on 8' height windows: 3,200 sf @ $3.50 to $5.50/sf	Upgrade	$ 11,200	$ 17,600	$ 14,400
Lighting = 0.678 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 **w/ multi-level occupancy sensors on CFLs @ $75 to $100 each.** 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 in these areas.	Upgrade	$ 948	$ 1,520	$ 1,234
(2) 13-ton DX units EER=11.6; 82% AFUE furnaces; standard efficiency fan motors; fixed temp. integrated air economizers	-	$ -	$ -	$ -
R-8 duct insulation w/ ducts on roof, HERS verified duct leakage	-	$ -	$ -	$ -
(1) Tank Gas Water Heaters EF=0.58	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 13,735**	**$ 21,765**	**$ 17,750**
Total Incremental Cost per Square Foot:		**$ 1.30**	**$ 2.06**	**$ 1.68**

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 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 integral with Metal roof and additional R-19 below (no framing interruption).	-	$ -	$ -	$ -
R-19 in Metal Frame Walls	-	$ -	$ -	$ -
R-0 (un-insulated) slab-on-grade 1st floor	-	$ -	$ -	$ -
Metal windows: **COG U=0.30, COG SHGC=0.31**; 16,000 sf @ $1.60 to $2.70/sf (includes NFRC label certificate)	Upgrade	$ 25,600	$ 43,200	$ 34,400
Lighting = 0.65 w/sf: Open Office Areas: **(140) HO 2-lamp T8 fixtures @74w each**; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (140) 2-lamp T8 fixtures **multi-level occupancy sensors on T8s @ $75 to $100 each**; (200) 18w recessed CFLs on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls. Net saving of $36 to $40 per new fixture in open offices because of a total reduction of 52% of T8 fixtures in these areas	Upgrade	$ 4,100	$ 8,240	$ 6,170
(3) 55 ton Packaged VAV system 81% TE and 10.2 EER, fixed temp. economizer, standard efficiency variable speed fan motors; 15% VAV boxes, reheat on perimeter zones with hot water using **90% AFUE boiler**. Controls to included fault detection and diagnostic; and "cycle on at night" features.	Upgrade	$ 2,500	$ 5,000	$ 3,750
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
90% AFUE boiler for domestic hot water use	Upgrade	$ 2,500	$ 5,000	$ 3,750
Total Incremental Cost of Energy Efficiency Measures:		**$ 34,700**	**$ 61,440**	**$ 48,070**
Total Incremental Cost per Square Foot:		**$ 0.66**	**$ 1.16**	**$ 0.91**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 2 **Climate Zone 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate Min	Max	Avg
R-19 integral with Metal roof and additional R-19 below (no framing interruption).	-	$ -	$ -	$ -
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**; 16,000 sf @ $0.60 to $0.70/sf (includes NFRC label certificate)	Upgrade	$ 9,600	$ 11,200	$ 10,400
Lighting = 0.65 w/sf: Open Office Areas: **(140) HO 2-lamp T8 fixtures @74w each**; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (140) 2-lamp T8 fixtures **multi-level occupancy sensors on T8s @ $75 to $100 each**; (200) 18w recessed CFLs on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls. Net saving of $36 to $40 per new fixture in open offices because of a total reduction of 52% of T8 fixtures in these areas	Upgrade	$ 4,100	$ 8,240	$ 6,170
(3) 55 ton Packaged VAV system 81% TE and 10.2 EER, fixed temp. economizer, standard efficiency variable speed fan motors; 15% VAV boxes, reheat on perimeter zones with hot water using **92% AFUE boiler**. Controls to included fault detection and diagnostic; and "cycle on at night" features.	Upgrade	$ 4,000	$ 6,000	$ 5,000
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
92% AFUE boiler for domestic hot water use	Upgrade	$ 4,000	$ 6,000	$ 5,000
Total Incremental Cost of Energy Efficiency Measures:		**$ 21,700**	**$ 31,440**	**$ 26,570**
Total Incremental Cost per Square Foot:		**$ 0.41**	**$ 0.59**	**$ 0.50**

Incremental Cost Estimate to Exceed Title 24 by 15%

Nonresidential Prototype: 52,900 SF, Option 3 **Climate Zone 16**

Energy Efficiency Measures to Exceed Title 24 by 15%	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-19 integral with Metal roof and additional **R-25** below (no framing interruption); cool roof Reflect.=0.55, Emittance = 0.75; 10,580 sf $0.20 to $0.30/sf	Upgrade	$ 2,116	$ 3,174	$ 2,645
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**; 16,000 sf @ $0.60 to $0.70/sf (includes NFRC label certificate)	Upgrade	$ 9,600	$ 11,200	$ 10,400
Lighting = 0.65 w/sf: Open Office Areas: **(140) HO 2-lamp T8 fixtures @74w each**; no lighting controls; (120) 18w recessed CFLs no lighting controls. Small Offices: (140) 2-lamp T8 fixtures **multi-level occupancy sensors on T8s @ $75 to $100 each**; (200) 18w recessed CFLs on/off lighting controls. Support Areas: (160) 18w recessed CFLs no lighting controls; (240) 13w CFL wall sconces; no lighting controls. Net saving of $36 to $40 per new fixture in open offices because of a total reduction of 52% of T8 fixtures in these areas	Upgrade	$ 4,100	$ 8,240	$ 6,170
(3) 55 ton Packaged VAV system 81% TE and 10.2 EER, fixed temp. economizer, standard efficiency variable speed fan motors; **20% VAV boxes**, reheat on perimeter zones with hot water using **90% AFUE boiler**. Controls to included fault detection and diagnostic; and "cycle on at night" features.	Upgrade	$ 2,500	$ 5,000	$ 3,750
R-8 duct insulation w/ ducts in conditioned	-	$ -	$ -	$ -
90% AFUE boiler for domestic hot water use	Upgrade	$ 2,500	$ 5,000	$ 3,750
Total Incremental Cost of Energy Efficiency Measures:		**$ 20,816**	**$ 32,614**	**$ 26,715**
Total Incremental Cost per Square Foot:		**$ 0.39**	**$ 0.62**	**$ 0.51**

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 (Opt. 1 Htg Only)	113	186	$1,550	$244	6.4
2,025 sf (Opt. 2 Htg Only)	119	184	$2,044	$242	8.4
2,025 sf (Opt. 3 Htg + AC)	137	180	$2,219	$241	9.2
Averages:	123	183	$1,938	$242	8.0

Annual Reduction in CO2-equivalent: 1.08 lb./sq.ft.-year, 2,189 lb./building-year
Increased Cost / lb. CO2-e reduction: $0.89

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 (Opt. 1 Htg Only)	295	273	$2,471	$381	6.5
4,500 sf (Opt. 2 Htg Only)	571	243	$2,678	$394	6.8
4,500 sf (Opt. 3 Htg + AC)	382	261	$3,021	$382	7.9
4,500 sf (Opt. 4 Htg + AC)	637	232	$3,206	$393	8.2
Averages:	471	252	$2,844	$388	7.3

Annual Reduction in CO2-equivalent: 0.70 lb./sq.ft.-year, 3,148 lb./building-year
Increased Cost / lb. CO2-e reduction: $0.90

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 (Opt. 1 Htg Only)	668	645	$11,629	$894	13.0
8,442 sf (Opt. 2 Htg Only)	668	615	$9,029	$858	10.5
8,442 sf (Opt. 3 Htg + AC)	734	606	$9,190	$859	10.7
Averages:	690	622	$9,949	$871	11.4

Annual Reduction in CO2-equivalent: 0.89 lb./sq.ft.-year, 7,551 lb./building-year
Increased Cost / lb. CO2-e reduction: $1.32

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)	16027	1454	$27,805	$3,915	7.1
36,800 sf (Option 2)	19903	834	$28,590	$3,949	7.2
36,800 sf (Option 3)	21742	303	$35,390	$3,742	9.5
Averages:	19224	864	$30,595	$3,868	7.9

Annual Reduction in CO2-equivalent: 0.51 lb./sq.ft.-year, 18,704 lb./building-year
Increased Cost / lb. CO2-e reduction: $1.51

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)	17074	-409	$25,327	$4,140	6.1
10,580 sf (Option 2)	14604	39	$16,254	$3,888	4.2
10,580 sf (Option 3)	18681	-472	$17,750	$4,421	4.0
Averages:	16786	-281	$19,777	$4,150	4.8

Annual Reduction in CO2-equivalent: 0.41 lb./sq.ft.-year, 4,287 lb./building-year
Increased Cost / lb. CO2-e reduction: $4.85

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	50406	3291	$48,070	$16,923	2.8
52,900 sf Option 2	40778	4790	$26,570	$15,228	1.7
52,900 sf Option 3	46162	4099	$26,715	$15,714	1.7
Averages:	45782	4060	$33,785	$15,955	2.1

Annual Reduction in CO2-equivalent: 1.28 lb./sq.ft.-year, 67,860 lb./building-year
Increased Cost / lb. CO2-e reduction: $0.55

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.