Energy Cost-Effectiveness Case Studies Using the 2008 Title 24 Building Energy Efficiency Standards

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1.0 Purpose of Study

Gabel Associates, LLC conducted an energy cost-effectiveness analysis using case studies of several building designs that meet and exceed the 2008 Title 24 Building Energy Efficiency Standards in the two California climate zones within Alameda County: Zones 3 and 12. The goal was to answer the following questions for each building type in in each climate zone:

- What set of energy measures are needed to just meet the 2008 Standards? And what sets of additional measures are needed to reduce the standard Time Dependent Valuation (TDV) energy in KBtu/sf-yr by 10%, 15%, 20% and 35%?
- What is the incremental (added) construction cost of the various sets of energy measures? And what are those costs per square foot?
- What is the annual energy saving for each scenario? And using current utility rates, what is the annual energy cost saving for each scenario?
- What is the Simple Payback for the added energy measures?
- What is the CO2-equivalent reduction in emissions from each scenario (lb./sf-yr)? And what is the added cost of CO2-equivalent reduction ($/sf-lb.-yr)?
- What level or levels of energy efficiency that exceed the 2008 Standard appear cost-effective in these climate zones?

The following data has been developed and compiled to consider these and related questions for single family residential, multifamily low-rise and multifamily high-rise residential and non-reisdential office buildings. This report can be used by Alameda County jurisdictions wishing to adopt mandatory energy policy(ies) that exceed T-24 part 6. The goal of these case studies is to provide relatively real-world order-of-magnitude results for local jurisdictions attempting to understand and calibrate energy and cost impacts of local energy ordinances or local green building ordinances. In this limited study, no attempt has been made to gather statistically significant data that can be applied to all new construction projects and thereby determine the macro-effects of specific policy decisions.

2.0 Methodology

2.1 Performance Approach

One important basis of this study is that the performance approach is used almost exclusively as the method which permit applicants use to demonstrate compliance with the Title 24 Building Energy Efficiency Standards. California Energy Commission studies have shown that well over 95% of new low-rise residential buildings are submitted with a performance Title 24 report. In addition, utility incentive programs use the performance

approach metric to establish eligibility for energy incentives; and the state uses the performance approach (e.g., exceeding the 2005 standards by 15%) to establish eligibility for the New Solar Homes Partnership (NSHP) program.

Some important reasons for the pre-dominant use of the performance approach are:

1. It allows the building designers the greatest flexibility in deciding which energy measures, in combination, meet the overall energy budget for the building;

2. It provide the best way to find the lowest first cost or the most cost-effective ways to meet or exceed the standards; and,

3. It allows building designers and developers an excellent means to assess the energy performance of specific energy measures or combinations of measures.

2.2 Title 24 Time Dependent Valuation (TDV) Energy and Other Possible Energy Metrics

Building energy efficiency programs and the GreenPoint Rated system use the Title 24 metric of TDV energy (KBtuh/sq.ft.-year) in measuring building energy performance. This metric weights the value of mostly electricity according to the day of the year and time of year (similar to Time-of-Use utility rates). Because the Title 24 rules, calculations, compliance rules and forms are familiar to the building industry, energy consultants and building departments, it makes sense to use the same procedures and the same metric to require higher energy efficiency. However, this may change in the future as the California Energy Commission may, by 2011, require that several other metrics of building energy performance be listed on the Certificate of Compliance which must be on the drawings. Other metrics in the future may include:

- The Home Energy Rating System (HERS) Phase 2 score for existing and new buildings which is a much better indication of how well specific building is performing with respect to a Zero Net Energy version of that building.

- The site energy use of the building in total KWh and Therms, or KBtuh/sf.

- The overall or per square foot CO2-equivalent reduction in greenhouse gases.

Until one or more of the above metrics is an automatic part of the Title 24 analysis and documentation, building energy performance will generally focus on TDV energy as the basis of improved energy performance.

2.3 Case Study Method

The methodology used in the case studies is based on the way that real buildings are designed and evaluated to meet or exceed the energy standards.

(a) Each prototype building design is tested for compliance with the 2008 Standards, and all energy measures are adjusted with common construction options to just barely meet the 2005 and 2008 Standards. The energy measures chosen are not all the prescriptive measures, but are a combination of measures which reflects how designers, builders and developers are likely to achieve a specified level of performance. It is worth noting that almost no new construction ever uses the prescriptive approach to demonstrate compliance, but instead uses a mix of features which are evaluated by an energy analyst using the performance approach.

(b) Starting with a 2008 Standards minimally compliant set of measures, various items are changed to just reach the next increment of energy performance (e.g, 10% better than Title 24). In this study, the design choices are based on years of work experience with architects, mechanical engineers and builders and general knowledge of the relative incremental costs of most measures. The intent of this approach is for the study to reflect how building energy performance is actually studied and used to select final energy measures in real life situations.

(c) A minimum and maximum range of incremental costs of added energy measures is established by a variety of research means. A construction cost estimator, Building Advisory LLC, was contracted to conduct research and surveys to obtain accurate and current measure cost information. Site energy in KWh and Therms, is calculated for each run to establish the annual energy savings, energy cost savings and CO2-equivalent reductions in greenhouse gases.

(d) A variety of charts are generated to illustrate and consider different aspects of cost-effectiveness by building type and climate zone.

2.4 Cost Effectiveness

The tables in section 4.0 are based upon the following:

- Incremental site electricity (kWh) and natural gas (therms) saved per year as calculated using the state-approved energy compliance;
- Average utility rates of $0.16/kWh for electricity and $1.30/therm for natural gas in constant dollars
- The assumption of no change (i.e., no inflation or deflation) of utility rates in constant dollars over time

- The assumption of no increase in summer temperatures, even though recent scientific studies suggest that global climate change will increase temperatures in the Western U.S. which in turn will increase air conditioning energy use

The tables illustrating Simply Payback include a cost-effectiveness analysis assuming:

- No external cost of global climate change -- and the corresponding value of additional investment in energy efficiency and CO2 reduction – is included

- The cost of money invested in the incremental cost of energy measures is not included.

3.0 Impacts of the 2008 Standards

This study focuses on incremental impacts of exceeding the 2008 energy standards by specific percentages in different climate zones for each building design. We have also included the incremental measures and costs associated with upgrading a building that just meets the 2005 standards to the same building which meets the 2008 standards. This data is included in Section 4 with the various charts which illustrate additional first cost per dwelling unit, and additional first cost per square foot.

3.1 Single Family House Case Studies

House Designs. A typical single family home design is modeled to just meet the overall TDV energy performance requirements of 2008 Title 24 standards using a 2008 Standards research version of Micropas. Incremental improvements to building energy efficiency measures then are made to reduce TDV energy to:

(a) from 2005 standards, meet the 2008 standards;
(b) 10% less than the 2008 standards;
(c) 15% less than the 2008 standards;
(d) 20% less than the 2008 standards; and,
(e) 35% less than the 2008 standards.

The following measures were first evaluated so that the house design just meets the 2008 standards in each climate zone as follows:

Climate Zone #3: 2,025 SF 2-story home 2008 Title 24 Base Case, **20.2% total glazing** area:

- R-38 roof w/ radiant barrier
- R-13 exterior walls
- R-19 raised floor
- Dual vinyl windows, U=0.40, SHGC=0.40 w/ no overhangs
- Furnace: 80% AFUE; No Cooling
- R-6 ducts in the attic
- DHW: 50 gallon gas water heater, EF=0.62; no extra pipe insulation

Climate Zone #12: 2,025 SF 2-story home 2008 Title 24 Base Case, **20.2% total glazing** area:

- R-38 roof w/ radiant barrier
- R-19 exterior walls
- Covered slab-on-grade floor
- Dual vinyl windows, U=0.37, SHGC=0.25 w/ no overhangs
- Furnace, 80% AFUE; Air Conditioner, 15.0 SEER/12.0 EER
- Reduced duct leakage/testing (HERS)
- R-6 ducts in the attic
- DHW: 50 gallon gas water heater, EF=0.62; no extra pipe insulation

Climate Zone #3: 1,582 SF 1-story home 2008 Title 24 Base Case, **14.3% total glazing** area:

- R-38 roof w/ radiant barrier
- R-13 exterior walls
- R-19 raised floor
- Dual vinyl windows, U=0.36, SHGC=0.30 w/ no overhangs
- Furnace: 80% AFUE; No Cooling
- R-6 ducts in the attic
- DHW: 50 gallon gas water heater, EF=0.58; no extra pipe insulation

Climate Zone #12: 1,582 SF 1-story home 2008 Title 24 Base Case, **14.3% total glazing** area:

- R-38 roof w/ radiant barrier
- R-13 exterior walls
- Covered slab-on-grade floor
- Dual vinyl windows, U=0.36, SHGC=0.30 w/ no overhangs
- Furnace, 80% AFUE; Air Conditioner, 15.0 SEER/12.0 EER (HERS)
- Reduced duct leakage/testing (HERS)
- R-6 ducts in the attic
- DHW: 50 gallon gas water heater, EF=0.62; no extra pipe insulation

Energy Measures Needed to Meet the 2008 Standards

The following energy features were modified from the 2005 Title 24 set of measures so that the building just meets the 2008 standards. The added first cost of that measure compared with the equivalent 2005 Title 24 design measure is listed to the right, and the sum of all incremental costs is listed.

CLIMATE ZONE #3

2,025 sq.ft. (from 2005 Stds to 2008 Stds)

• Low-E glazing: 409 sf @ $1.35 - $1.50/sf	$ 550 - 615
• Water heater EF=0.62 (from EF=0.58)	$ 100 - 200
Total incremental cost of Ordinance energy measure:	**$ 650 - 815**
Incremental cost in $/sq.ft.:	**$ 0.32 to 0.40 /sq.ft.**
	Avg = $0.69 /sf

1,582 sq.ft. (from 2005 Stds to 2008 Stds)

• Radiant Barrier: 1,582 sf @ $0.12 - $0.18/sf	$ 190 - 285
Total incremental cost of Ordinance energy measure:	**$ 190 - 285**
Incremental cost in $/sq.ft.:	**$ 0.12 to 0.18 /sq.ft.**
	Avg = $0.15 /sf

CLIMATE ZONE #12

2,025 sq.ft. (from 2005 Stds to 2008 Stds)

• 15 SEER/12 EER air conditioner	$ 300 - 1350
• Water heater EF=0.62 (from EF=0.58)	$ 100 - 200
Total incremental cost of Ordinance energy measure:	**$ 400 - 1550**
Incremental cost in $/sq.ft.:	**$ 0.20 to 0.77 /sq.ft.**
	Avg = $0.48 /sf

1,582 sq.ft. (from 2005 Stds to 2008 Stds)

• Walls: from R-13 + R4 to R-19, 1116 sf -$0.45 to -$0.60	$ -500 - -400
• 15 SEER/12 EER air conditioner	$ 300 - 1350
• Reduced duct leakage (installation testing & HERS inspection)	$ 300 - 600
Total incremental cost of Ordinance energy measure:	**$ 100 - 1550**
Incremental cost in $/sq.ft.:	**$ 0.06 to 0.98 /sq.ft.**
	Avg = $0.52 /sf

Energy Measures Needed to Exceed the 2008 Standards

The following energy features have been modified from the above Title 24 set of measures so that the proposed design uses less TDV energy than the 2008 standards. The added first cost of that measure compared with the equivalent 2008 Title 24 design measure is listed to the right, and the sum of all incremental costs is listed.

CLIMATE ZONE #3

(A-10%) 2,025 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• 92% AFUE furnace	$ 500 - 1,200
• R-49 roof insulation: 1,443 sf @$0.19 to $0.22/sf	$ 275 - 320
• House wrap: 2,550 sf @ $0.08 to $0.12/sf	$ 205 - 305
Total incremental cost of Ordinance energy measure:	**$ 980 - 1,825**
Incremental cost in $/sq.ft.:	**$ 0.48 to 0.90 /sq.ft.**
	Avg = $0.69 /sf

(A-15%) 2,025 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• 92% AFUE furnace	$ 500 - 1,200
• Reduced duct leakage (installation testing & HERS inspection)	$ 300 - 600
• House wrap: 2,550 sf @ $0.08 to $0.12/sf	$ 205 - 305
Total incremental cost of Ordinance energy measure:	**$ 1,005 - 2,105**
Incremental cost in $/sq.ft.:	**$ 0.50 to 1.04 /sq.ft.**
	Avg = $0.77 /sf

(A-20%) 2,025 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• 92% AFUE furnace	$ 500 - 1,200
• Reduced duct leakage (installation testing & HERS inspection)	$ 300 - 600
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• House wrap: 2,550 sf @ $0.08 to $0.12/sf	$ 205 - 305
Total incremental cost of Ordinance energy measure:	**$ 1,180 - 2,355**
Incremental cost in $/sq.ft.:	**$ 0.58 to 1.16 /sq.ft.**
	Avg = $0.87 /sf

(A-35%) 2,025 sq.ft. (Reduction in 2008 T24 TDV Energy by 35%)

• 92% AFUE furnace	$ 500 - 1,200
• Reduced duct leakage (installation testing & HERS inspection)	$ 300 - 600
• R-19 walls: 2,550 sf @$0.27 to $0.39/sf	$ 690 - 995
• R-49 roof insulation: 1,443 sf @$0.19 to $0.22/sf	$ 275 - 320
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• Tankless gas DHW, 0.80 EF (5 to 10 gpm)	$ 900 - 1,500
• House wrap: 2,550 sf @ $0.08 to $0.12/sf	$ 205 - 305
Total incremental cost of Ordinance energy measure:	**$ 3,045 - 5,170**
Incremental cost in $/sq.ft.:	**$ 1.50 to 2.55 /sq.ft.**
	Avg = $2.03 /sf

(A-10%) 1,582 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• Reduced duct leakage (installation testing & HERS inspection)	$ 300 - 600
• Water heater EF=0.62 (from EF=0.58)	$ 100 - 200
• R-49 roof insulation: 1,582 sf @$0.19 to $0.22/sf	$ 300 - 350
• House wrap: 1,116 sf @ $0.08 to $0.12/sf	$ 90 - 135
Total incremental cost of Ordinance energy measure:	**$ 790 - 1,225**
Incremental cost in $/sq.ft.:	**$ 0.50 to 0.77 /sq.ft.**
	Avg = $0.64 /sf

(A-15%) 1,582 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• 92% AFUE furnace	$ 500 - 1,200
• Reduced duct leakage (installation testing & HERS inspection)	$ 300 - 600
• Water heater EF=0.62 (from EF=0.58)	$ 100 - 200
• R-49 roof insulation: 1,582 sf @$0.19 to $0.22/sf	$ 300 - 350
• House wrap: 1,116 sf @ $0.08 to $0.12/sf	$ 90 - 135
Total incremental cost of Ordinance energy measure:	**$ 1,290 - 2,485**
Incremental cost in $/sq.ft.:	**$ 0.82 to 1.57 /sq.ft.**
	Avg = $1.19 /sf

(A-20%) 1,582 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• 92% AFUE furnace	$ 500 - 1,200
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• Reduced duct leakage (installation testing & HERS inspection)	$ 300 - 600
• Water heater EF=0.62 (from EF=0.58)	$ 100 - 200
• R-49 roof insulation: 1,582 sf @$0.19 to $0.22/sf	$ 300 - 350
• House wrap: 1,116 sf @ $0.08 to $0.12/sf	$ 90 - 135
Total incremental cost of Ordinance energy measure:	**$ 1,465 - 2,735**
Incremental cost in $/sq.ft.:	**$ 0.93 to 1.73 /sq.ft.**
	Avg = $1.33 /sf

(A-35%) 1,582 sq.ft. (Reduction in 2008 T24 TDV Energy by 35%)

• 92% AFUE furnace	$ 500 - 1,200
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• Tankless gas DHW, 0.80 EF (5 to 10 gpm)	$ 900 - 1,500
• R-15 wall insulation: 1,116 sf @ $0.06 to $0.08/sf	$ 70 - 90
• Reduced duct leakage (installation testing & HERS inspection)	$ 300 - 600
• Water heater EF=0.62 (from EF=0.58)	$ 100 - 200
• R-49 roof insulation: 1,582 sf @$0.19 to $0.22/sf	$ 300 - 350
• House wrap: 1,116 sf @ $0.08 to $0.12/sf	$ 90 - 135
Total incremental cost of Ordinance energy measure:	**$ 2,435 - 4,325**
Incremental cost in $/sq.ft.:	**$ 1.54 to 2.73 /sq.ft.**
	Avg = $2.14 /sf

CLIMATE ZONE #12

(A-10%) 2,025 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• R-19 walls: 2,550 sf @$0.27 to $0.39/sf	$ 690 - 995
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• TXV/EER (HERS inspection)	$ 25 - 50
• Verified air flow (HERS inspection)	$ 100 - 150
Total incremental cost of Ordinance energy measure:	**$ 990 - 1,445**
Incremental cost in $/sq.ft.:	**$ 0.49 to 0.71 /sq.ft.**
	Avg = $0.60 /sf

(A-15%) 2,025 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• 92% AFUE furnace	$ 500 - 1,200
• Reduced building leakage SLA=3.0 (testing & HERS inspection)	$ 250 - 400
• R-19 walls: 2,550 sf @$0.27 to $0.39/sf	$ 690 - 995
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• TXV/EER (HERS inspection)	$ 25 - 50
• Verified air flow (HERS inspection)	$ 100 - 150
Total incremental cost of Ordinance energy measure:	**$ 1,740 - 3,045**
Incremental cost in $/sq.ft.:	**$ 0.86 to 1.50 /sq.ft.**
	Avg = $1.18 /sf

(A-20%) 2,025 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• 92% AFUE furnace	$ 500 - 1,200
• Reduced building leakage SLA=3.0 (testing & HERS inspection)	$ 250 - 400
• R-19 walls: 2,550 sf @$0.27 to $0.39/sf	$ 690 - 995
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• TXV/EER (HERS inspection)	$ 25 - 50
• Super Low-E glazing: 409 sf @ $1.35 - $1.50/sf	$ 550 - 615
• R-49 roof insulation: 1,443 sf @$0.19 to $0.22/sf	$ 275 - 320
• Verified air flow (HERS inspection)	$ 100 - 150
Total incremental cost of Ordinance energy measure:	**$ 2,565 - 4,280**
Incremental cost in $/sq.ft.:	**$ 1.27 to 2.11 /sq.ft.**
	Avg = $1.69 /sf

(A-35%) 2,025 sq.ft. (Reduction in 2008 T24 TDV Energy by 35%)

• 92% AFUE furnace	$ 500 - 1,200
• Reduced building leakage SLA=3.0 (testing & HERS inspection)	$ 250 - 400
• R-19 walls: 2,550 sf @$0.27 to $0.39/sf	$ 690 - 995
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• TXV/EER (HERS inspection)	$ 25 - 50
• Super Low-E glazing: 409 sf @ $1.35 - $1.50/sf	$ 550 - 615
• R-49 roof insulation: 1,443 sf @$0.19 to $0.22/sf	$ 275 - 320
• 70% NSF solar hot water system	$ 5,000 - 6,000
• Tankless gas DHW, 0.80 EF (5 to 10 gpm)	$ 900 - 1,500
• Verified air flow (HERS inspection)	$ 100 - 150
Total incremental cost of Ordinance energy measure:	**$ 8,465- 11,480**
Incremental cost in $/sq.ft.:	**$ 4.18 to 5.67 /sq.ft.**
	Avg = $4.92 /sf

(A-10%) 1,582 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• R-21 walls: 1,116 sf @$0.37 to $0.52/sf	$ 415 - 580
• Refrig. Charge & Adequate Airflow (HERS inspection)	$ 100 - 150
• House wrap: 1,116 sf @ $0.08 to $0.12/sf	$ 90 - 135
Total incremental cost of Ordinance energy measure:	**$ 780 - 1,115**
Incremental cost in $/sq.ft.:	**$ 0.49 to 0.70 /sq.ft.**
	Avg = $0.60 /sf

(A-15%) 1,582 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• 92% AFUE furnace	$ 500 - 1,200
• R-49 roof insulation: 1,582 sf @$0.19 to $0.22/sf	$ 300 - 350
• R-19 walls: 1,116 sf @$0.27 to $0.39/sf	$ 300 - 435
• Refrig. Charge (HERS inspection)	$ 75 - 125
• House wrap: 1,116 sf @ $0.08 to $0.12/sf	$ 90 - 135
Total incremental cost of Ordinance energy measure:	**$ 1,265 - 2,245**
Incremental cost in $/sq.ft.:	**$ 0.80 to 1.42 /sq.ft.**
	Avg = $1.11 /sf

(A-20%) 1,582 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• Low-E3 windows: U-factor=0.36, SHGC=0.23 226 sf @ $1.35 - $1.50/sf	$ 305 - 340
• Refrig. Charge & Adequate Airflow (HERS inspection)	$ 100 - 150
• Hot water pipe insulation (from minimum to all)	$ 250 - 300
• R-21 walls: 1,116 sf @$0.37 to $0.52/sf	$ 415 - 580
• 94% AFUE furnace	$ 800 - 1,300
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• Water heater EF=0.62 (from EF=0.58)	$ 100 - 200
• R-49 roof insulation: 1,582 sf @$0.19 to $0.22/sf	$ 300 - 350
• House wrap: 1,116 sf @ $0.08 to $0.12/sf	$ 90 - 135
Total incremental cost of Ordinance energy measure:	**$ 2,535 - 3,605**
Incremental cost in $/sq.ft.:	**$ 1.60 to 2.28 /sq.ft.**
	Avg = $1.94 /sf

(A-35%) 1,582 sq.ft. (Reduction in 2008 T24 TDV Energy by 35%)

• 92% AFUE furnace	$ 500 - 1,200
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• Tankless gas DHW, 0.80 EF (5 to 10 gpm)	$ 900 - 1,500
• Low-E3 windows: U-factor=0.36, SHGC=0.30 226 sf @ $1.35 - $1.50/sf	$ 305 - 340
• Hot water pipe insulation (from minimum to all)	$ 250 - 300
• R-21 walls: 1,116 sf @$0.37 to $0.52/sf	$ 415 - 580
• Quality insulation installation (includes HERS inspection)	$ 175 - 250
• R-49 roof insulation: 1,582 sf @$0.19 to $0.22/sf	$ 300 - 350
• House wrap: 1,116 sf @ $0.08 to $0.12/sf	$ 90 - 135
• 60% Net Solar Fraction solar hot water collector system	$ 4,000 - 5,000
Total incremental cost of Ordinance energy measure:	**$ 7,110 - 9,905**
Incremental cost in $/sq.ft.:	**$ 4.49 to 6.26 /sq.ft.**
	Avg = $5.38 /sf

3.2 Low-rise Multi-family Building Case Study

Building Design. A typical 8-unit, 2-story low-rise multi-family building is modeled to just meet the overall TDV energy performance requirements of 2008 Title 24 standards using a 2008 Standards research version of Micropas. Incremental improvements to building energy efficiency measures then are made to reduce TDV energy to:

(f) 10% less than the 2008 standards;
(g) 15% less than the 2008 standards;
(h) 20% less than the 2008 standards; and,
(i) 35% less than the 2008 standards.

The following measures were first evaluated so that the house design just meets the 2008 standards in each climate zone as follows:

Climate Zone #3: 8,442 SF 2-story building 2008 Title 24 Base Case, **12.5% total glazing** area:

- R-38 roof w/ radiant barrier, R-13 exterior walls, slab-on-grade 1st floor
- Dual vinyl windows, U=0.39, SHGC=0.33 w/ no overhangs
- Furnace: 80% AFUE; No Cooling
- R-6 ducts in the attic
- DHW: 50 gallon gas water heater, EF=0.575; no extra pipe insulation

Climate Zone #12: 8,442 SF 2-story building 2008 Title 24 Base Case, **12.5% total glazing** area:

- R-38 roof w/ radiant barrier, R-19 exterior walls, slab-on-grade 1st floor
- House wrap
- Dual vinyl windows, U=0.35, SHGC=0.31 w/ no overhangs
- Furnace: 80% AFUE
- Air conditioner: 13.0 SEER, 11.0 EER
- R-6 ducts in the attic
- DHW: 50 gallon gas water heater, EF=0.62; no extra pipe insulation

Energy Measures Needed to Meet the 2008 Standards

The following energy features were modified from the 2005 Title 24 set of measures so that the building just meets the 2008 standards. The added first cost of that measure compared with the equivalent 2005 Title 24 design measure is listed to the right.

CLIMATE ZONE #3

• (8) Water heaters EF=0.62 (from EF=0.58)	$ 800 - 1,600
Total incremental cost of Ordinance energy measure:	**$ 800 - 1,600**
Incremental cost in $/sq.ft.:	**$ 0.09 to 0.19 /sq.ft.**
	Avg = $0.14 /sf

CLIMATE ZONE #12

• R-19 from R-13 walls, 9,266 sf @$0.27 - $0.39/sf	$ 2,505 - 3,615
Total incremental cost of Ordinance energy measure:	**$ 2,505 - 3,615**
Incremental cost in $/sq.ft.:	**$ 0.30 to 0.43 /sq.ft.**
	Avg = $0.37 /sf

Energy Measures Needed to Exceed the 2008 Standards

The following energy features have been modified from the above Title 24 set of measures so that the proposed design uses less TDV energy than the 2008 standards. The added first cost of that measure compared with the equivalent 2008 Title 24 design measure is listed to the right, and the sum of all incremental costs is listed.

CLIMATE ZONE #3

(A-10%) 8,442 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• Reduced duct leakage (installation testing & HERS inspection)	$ 2000 - 4000
• R-15 wall insulation: 9,266 sf @ $0.06 to $0.08/ sf	$ 560 - 745
• House wrap: 9,266 sf @ $0.08 to $0.12/sf	$ 745 - 1,115
Total incremental cost of Ordinance energy measure:	**$ 3,305 - 5,860**
Incremental cost in $/sq.ft.:	**$ 0.39 to 0.69 /sq.ft.**
	Avg = $0.54 /sf

(A-15%) 8,442 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• Reduced duct leakage (installation testing & HERS inspection)	$ 2000 - 4000
• R-15 wall insulation: 9,266 sf @ $0.06 to $0.08/ sf	$ 560 - 745
• House wrap: 9,266 sf @ $0.08 to $0.12/sf	$ 745 - 1,115
• (8) 92% AFUE furnaces	$ 4,000 - 9,600
• R-49 roof/ceiling insulation, 2,880 sf @$0.19 - $0.22/sf	$ 550 - 635
Total incremental cost of Ordinance energy measure:	**$ 7,855- 16,095**
Incremental cost in $/sq.ft.:	**$ 0.93 to 1.91 /sq.ft.**
	Avg = $1.42 /sf

(A-20%) 8,442 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• Reduced duct leakage (installation testing & HERS inspection)	$ 2,000 - 4,000
• R-19 wall insulation: 9,266 sf @ $0.27 to $0.39/ sf	$ 2,505 - 3,615
• House wrap: 9,266 sf @ $0.08 to $0.12/sf	$ 745 - 1,115
• (8) 92% AFUE furnaces	$ 4,000 - 9,600
• No roof radiant barrier 2,880sf @-$0.12 to -$0.18/sf	$ -520 - -345
Total incremental cost of Ordinance energy measure:	**$ 8,730 - 17,985**
Incremental cost in $/sq.ft.:	**$ 1.03 to 2.13 /sq.ft.**
	Avg = $1.58 /sf

(A-35%) 8,442 sq.ft. (Reduction in 2008 T24 TDV Energy by 35%)

• Reduced duct leakage (installation testing & HERS inspection)	$ 2,000 - 4,000
• R-19 wall insulation: 9,266 sf @ $0.27 to $0.39/ sf	$ 2,505 - 3,615
• (8) Tankless water heaters EF=0.805 @$900 - $1,500 each	$ 7,200 - 12,000
Total incremental cost of Ordinance energy measure:	**$ 11,705 - 19,615**
Incremental cost in $/sq.ft.:	**$ 1.39 to 2.32 /sq.ft.**
	Avg = $1.86 /sf

CLIMATE ZONE #12

(A-10%) 8,442 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• Quality insulation installation (includes HERS inspection)	$ 1,100 - 1,600
• R-21 walls: 9,266 sf @$0.10 to $0.13/sf	$ 930 - 1,205
• (8) 15 SEER/12 EER air conditioner	$ 2,400 -10,800
Total incremental cost of Ordinance energy measure:	**$ 4,430 -13,605**
Incremental cost in $/sq.ft.:	**$ 0.52 to 1.61 /sq.ft.**
	Avg = $1.07 /sf

(A-15%) 8,442 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• Quality insulation installation (includes HERS inspection)	$ 1,100 - 1,600
• R-21 walls: 9,266 sf @$0.10 to $0.13/sf	$ 930 - 1,205
• (8) 15 SEER/12 EER air conditioners	$ 2,400 -10,800
• (8) 92% AFUE furnaces	$ 4,000 - 9,600
• Refrigerant charge tests	$ 300 - 1,600
Total incremental cost of Ordinance energy measure:	**$ 8,730 -21,605**
Incremental cost in $/sq.ft.:	**$ 1.03 to 2.56 /sq.ft.**
	Avg = $1.80 /sf

(A-20%) 8,442 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• Quality insulation installation (includes HERS inspection)	$ 1,100 - 1,600
• R-21 walls: 9,266 sf @$0.10 to $0.13/sf	$ 930 - 1,205
• (8) 15 SEER/12 EER air conditioners @$300 - $1,350 each	$ 2,400 -10,800
• (8) 92% AFUE furnaces @$500 - $800 each	$ 4,000 - 6,400
• Refrigerant charge tests	$ 300 - 1,600
• Low-E3 windows: U-factor=0.36, SHGC=0.23 1,055 sf @ $1.35 - $1.50/sf	$ 1,425 - 1,585
• Verified Air Flow	$ 300 - 1.600
• R-49 roof/ceiling insulation, 2,880 sf @$0.19 - $0.22/sf	$ 550 - 635
• Pipe insulation @$150 - $300/unit	$ 1,200 - 2,400
Total incremental cost of Ordinance energy measure:	**$12,205- 27,825**
Incremental cost in $/sq.ft.:	**$ 1.45 to 3.30 /sq.ft.**
	Avg = $2.37/sf

(A-35%) 8,442 sq.ft. (Reduction in 2008 T24 TDV Energy by 35%)

• Quality insulation installation (includes HERS inspection)	$ 1,100 - 1,600
• R-21 walls: 9,266_sf @$0.10 to $0.13/sf	$ 930 - 1,205
• (8) 15 SEER/12 EER air conditioners @$300 - $1,350 each	$ 2,400 -10,800
• (8) 92% AFUE furnaces @$800 - $1200 each	$ 6,400 - 9,600
• Refrigerant charge tests	$ 300 - 1,600
• Low-E3 windows: U-factor=0.36, SHGC=0.23 w/ argon gas 1,055 sf @ $2.35 - $2.50/sf	$ 2,480 - 2,640
• Verified Air Flow	$ 300 - 1.600
• R-49 roof/ceiling insulation, 2,880 sf @$0.19 - $0.22/sf	$ 550 - 635
• Pipe insulation @$150 - $300/unit	$ 1,200 - 2,400
• (8) Tankless water heaters EF=0.80 @$900 - $1,500 each	$ 7,200- 12,000
• R-8 ducts	$ 1,600 - 2,400
•	
Total incremental cost of Ordinance energy measure:	**$24,460- 46,480**
Incremental cost in $/sq.ft.:	**$ 2.90 to 5.51 /sq.ft.**
	Avg = $4.20 /sf

3.3 High-rise Residential Building Case Study

High-rise Residential Building Design. A typical high-rise residential buildings has been modeled according to the same criteria as in Section 2.1, except that a research version of EnergyPro has been used to evaluate compliance with the 2008 Nonresidential, Hotel/Motel and High-rise Residential standards.

The following measures were first evaluated so that the building just meets the 2008 standards in each climate zone as follows:

Climate Zone #3: 36,800 SF 5-story building 2008 Title 24 Base Case, **35.2% Window Wall Ratio glazing** area, 40 dwelling units:

(A) 36,800 SF 5-story apartment building which just meet Title 24:

- R-30 attic insulation w/ cool roof Reflectance=0.30, Emittance=0.75
- R-19 in metal frame exterior walls
- Un-insulated (R-0) raised slab floor over parking garage;
- Dual vinyl NFRC-rated Low-E windows: U-factor=0.33, SHGC=0.30, (SHGC includes minimal exterior shading)
- Split heat pump for each dwelling unit: HSPF=7.2, EER=10.2
- Central domestic hot water boiler, 82.7% AFUE; re-circulating system w/ timer and temperature controls; variable speed drive hot water pump

Energy Measures Needed to Meet the 2008 Standards

The same building designs that just meet the 2005 standards also must meet the 2008 standards, for both climate zones. Therefore, in this case study, there was no additional cost associated with meeting the 2008 standards.

Energy Measures Needed to Exceed the 2008 Standards

The following energy features have been modified from the above Title 24 set of measures so that the proposed design uses less TDV energy than the 2008 standards. The added first cost of that measure compared with the equivalent 2008 Title 24 design measure is listed to the right, and the sum of all incremental costs is listed.

CLIMATE ZONE #3

(A-10%) 36,800 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• R-3.5 (1") K-13 spray-on insulation under raised floor	
9,200 sf @ $1.20 - $1.50/sf	$ 11,040 - 13,800
• (2) Munchkin boilers @ $1200 - $2,000 additional each	$ 2,400 - 4,000
• Heat pumps: HSPF=7.84 / EER=11.2	
80 units @$150 - $250 each	$ 12,000 - 20,000
Total incremental cost of Ordinance energy measure:	**$ 25,440 - 37,800**
Incremental cost in $/sq.ft.:	**$ 0.69 to 1.03 /sq.ft.**
	Avg = $0.86 /sf

(A-15%) 36,800 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• Super Low-E glazing: U=0.33, SHGC=0.23,	
6,240 sf @ $1.35 - $1.50/sf	$ 8,425 - 9,360
• R-3.5 (1") K-13 spray-on insulation under raised floor	
9,200 sf @ $1.20 - $1.50/sf	$ 11,040 - 13,800
• (2) Munchkin boilers @ $1200 - $2,000 additional each	$ 2,400 - 4,000
• Heat pumps: HSPF=7.84 / EER=11.2	
80 units @$150 - $250 each	$ 12,000 - 20,000
Total incremental cost of Ordinance energy measure:	**$ 33,865 - 47,160**
Incremental cost in $/sq.ft.:	**$ 0.92 to 1.28 /sq.ft.**
	Avg = $1.18 /sf

(A-20%) 36,800 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• Super Low-E glazing: U=0.33, SHGC=0.23,	
6,240 sf @ $1.35 - $1.50/sf	$ 8,425 - 9,360
• R-3.5 (1") K-13 spray-on insulation under raised floor	
9,200 sf @ $1.20 - $1.50/sf	$ 11,040 - 13,800
• (2) Munchkin boilers @ $1200 - $2,000 additional each	$ 2,400 - 4,000
• 30% Net Solar Fraction solar DHW system	$ 48,000 - 60,000
• Heat pumps: HSPF=8.8 / EER=11.3	
80 units @$180 - $300 each	$ 14,400 - 24,000
Total incremental cost of Ordinance energy measure:	**$ 84,265 - 111,160**
Incremental cost in $/sq.ft.:	**$ 2.29 to 3.02 /sq.ft.**
	Avg = $2.66 /sf

(A-35%) 36,800 sq.ft. (Reduction in 2008 T24 TDV Energy by 36%)

• Super Low-E glazing: U=0.33, SHGC=0.23, 6,240 sf @ $1.35 - $1.50/sf	$ 8,425 - 9,360
• R-3.5 (1") K-13 spray-on insulation under raised floor 9,200 sf @ $1.20 - $1.50/sf	$ 11,040 - 13,800
• (2) Munchkin boilers @ $1200 - $2,000 additional each	$ 2,400 - 4,000
• 72% Net Solar Fraction solar DHW system	$140,000 - 168,000
• R-38 Roof: 9,200 sf @ $0.10 - $0.15/sf	$ 920 - 1,380
• Heat pumps: HSPF=8.8 / EER=11.3 80 units @$180 - $300 each	$ 14,400 - 24,000
Total incremental cost of Ordinance energy measure:	**$177,185 - 220,540**
Incremental cost in $/sq.ft.:	**$ 4.81 to 5.99 /sq.ft.**
	Avg = $5.40 /sf

CLIMATE ZONE #12

(A-10%) 36,800 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• Super Low-E glazing: U=0.33, SHGC=0.23, 6,240 sf @ $1.35 - $1.50/sf	$ 8,425 - 9,360
• R-3.5 (1") K-13 spray-on insulation under raised floor 9,200 sf @ $1.20 - $1.50/sf	$ 11,040 - 13,800
Total incremental cost of Ordinance energy measure:	**$ 19,465 - 23,160**
Incremental cost in $/sq.ft.:	**$ 0.53 to 0.63 /sq.ft.**
	Avg = $0.58 /sf

(A-15%) 36,800 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• Super Low-E glazing: U=0.33, SHGC=0.23, 6,240 sf @ $1.35 - $1.50/sf	$ 8,425 - 9,360
• (2) Munchkin boilers @ $1200 - $2,000 additional each	$ 2,400 - 4,000
• Heat pumps: HSPF=7.84 / EER=11.2 80 units @$150 - $250 each	$ 12,000 - 20,000
Total incremental cost of Ordinance energy measure:	**$ 22,825 - 33,360**
Incremental cost in $/sq.ft.:	**$ 0.62 to 0.91 /sq.ft.**
	Avg = $0.76 /sf

(A-20%) 36,800 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• Super Low-E glazing: U=0.33, SHGC=0.23, 6,240 sf @ $1.35 - $1.50/sf	$ 8,425 - 9,360
• R-7.0 (2") K-13 spray-on insulation under raised floor 9,200 sf @ $1.80 - $2.00/sf	$ 16,560 - 18,400
• (2) Munchkin boilers @ $1200 - $2,000 additional each	$ 2,400 - 4,000
• Heat pumps: HSPF=8.8 / EER=11.3 80 units @$180 - $300 each	$ 14,400 - 24,000
Total incremental cost of Ordinance energy measure:	**$ 41,785 - 55,760**
Incremental cost in $/sq.ft.:	**$ 1.14 to 1.52 /sq.ft.**
	Avg = $2.66 /sf

(A-35%) 36,800 sq.ft. (Reduction in 2008 T24 TDV Energy by 35%)

• Super Low-E glazing: U=0.33, SHGC=0.23, 6,240 sf @ $1.35 - $1.50/sf	$ 8,425 - 9,360
• R-8.75 (2.5") K-13 spray-on insulation under raised floor 9,200 sf @ $2.10 - $2.35/sf	$ 19,320 - 21,620
• (2) Munchkin boilers @ $1200 - $2,000 additional each	$ 2,400 - 4,000
• 55% Net Solar Fraction solar DHW system	$110,000 - 132,000
• Heat pumps: HSPF=8.8 / EER=11.3 80 units @$180 - $300 each	$ 14,400 - 24,000
Total incremental cost of Ordinance energy measure:	**$154,545 - 190,980**
Incremental cost in $/sq.ft.:	**$ 4.20 to 5.19 /sq.ft.**
	Avg = $4.69 /sf

3.4 Nonresidential Building Case Studies

Nonresidential 5-Story Office Building Design. A typical 5-story office building has been modeled according to the same criteria as in Section 2.1, except that a research version of EnergyPro has been used to evaluate compliance with the 2008 Nonresidential, Hotel/Motel and High-rise Residential standards.

CLIMATE ZONE #3 CASE STUDY

The following measures were first evaluated so that the building just meets the 2008 standards in climate zone #3 as follows:

Climate Zone #3: 52,900 SF 5-story building 2008 Title 24 Base Case, **32.5% Window Wall Ratio glazing** area:

(A) 52,900 SF 5-story office building which just meet Title 24:

- R-30 attic insulation, R-19 in metal frame exterior walls, slab-on-grade 1st floor
- NFRC-rated Low-E windows: U-factor=0.50, SHGCc=0.38 (e.g., Viracon VE 1-2M) w/ no exterior shading
- Lighting = 0.887 w/sf: 720 2-lamp 4' T8 fixtures @ 62w each and 260 26w CFLs @ 26 w each; no lighting controls
- 4 identical Packaged VAV units: Aaron 25 ton, EER=10.4, 10,000 CFM, standard efficiency fan motors, 30% VAV boxes w/ reheat
- Ducts in conditioned space, R-4.2 duct insulation
- Hot water assumed to be standard gas water heater

Energy Measures Needed to Meet the 2008 Standards

The same building with the 2005 standards measures fails to meet the 2008 standards by a margin of 6%. To bring the building up to the 2008 standards, the following measures were added.

52,900 sq.ft. (from 2005 Stds to 2008 Stds)

- U=0.50, SHGCc=0.38 (e.g., Viracon VE 1-2M)

9,496 sf @$1.50 - 2.50/sq.ft.	$ 14,250 - 23,750
Total incremental cost of Ordinance energy measure:	**$ 14,250 - 23,750** **Avg = $19,000**
Incremental cost in $/sq.ft.:	**$ 0.27 to 0.45 /sq.ft.** **Avg = $0.36 /sf**

Energy Measures Needed to Exceed the 2008 Standards

The following energy features have been modified from the above Title 24 set of measures so that the proposed design uses less TDV energy than the 2008 standards. The added first cost of that measure compared with the equivalent 2008 Title 24 design measure is listed to the right, and the sum of all incremental costs is listed.

(A-10%) 52,900 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• R-38 w/ Cool Roof 10,580 sf @ $0.30 - $0.40/sf	$ 3,175 - 4,230
• 10 NEMA Premium fan motors on supply & return fans	$ 750 - 1,250
• 720 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.803	$ 18,000 - 21,600
• 120 occupant sensors controlling (2) 2-lamp T8 fixtures @$65.00 - $85.00 each	$ 7,800 - 10,200
• 40 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 7,000 - 10,000
Total incremental cost of Ordinance energy measure:	**$ 36,725 - 47,280**
	Avg = $42,003
Incremental cost in $/sq.ft.:	**$ 0.69 to $0.89/sq.ft.**
	Avg = $0.79 /sf

(A-15%) 52,900 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• 720 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.803	$ 18,000 - 21,600
• 120 occupant sensors controlling (2) 2-lamp T8 fixtures @$65.00 - $85.00 each	$ 7,800 - 10,200
• 40 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 7,000 - 10,000
• (5) Trane 25 ton units, EER=11.0 @ $9,000 to $13,000 each w/ premium fan motors	$ 45,000 - 65,000
Total incremental cost of Ordinance energy measure:	**$ 77,800 - 106,800**
	Avg = $92,300
Incremental cost in $/sq.ft.:	**$ 1.47 to $2.02/sq.ft.**
	Avg = $1.74 /sf

(A-20%) 52,900 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• 720 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.803	$ 18,000 - 21,600
• R-38 w/ Cool Roof 10,580 sf @ $0.25 - $0.35/sf	$ 2,645 - 3,700
• U=0.50, SHGCc=0.31 (e.g., Viracon VE 2-2M) 9,496 sf @$2.00 - 3.00/sq.ft.	$ 18,990 - 28,490
• 120 occupant sensors controlling (2) 2-lamp T8 fixtures; @$65.00 - $85.00 each	$ 7,800 - 10,200
• 40 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 7,000 - 10,000
• (5) Trane 25 ton units, EER=11.0 @ $9,000 to $13,000 each w/ premium fan motors	$ 45,000 - 65,000
Total incremental cost of Ordinance energy measure:	**$ 99,435 - 138,990**
	Avg = $119,213
Incremental cost in $/sq.ft.:	**$ 1.88 to $2.63/sq.ft.**
	Avg = $2.25 /sf

CLIMATE ZONE #12 CASE STUDY

The following measures were first evaluated so that the building just meets the 2008 standards in climate zone #12 as follows:

Climate Zone #12: 52,900 SF 5-story building 2008 Title 24 Base Case, **29.1% Window Wall Ratio glazing** area:

(A) 52,900 SF 5-story office building which just meet Title 24:

- R-30 attic insulation, w/ cool roof solar reflectance=0.55 and emttance=0.75, R-19 in metal frame exterior walls, slab-on-grade 1st floor;
- NFRC-rated Low-E windows: U-factor=0.50, SHGCc=0.31 (e.g., Viracon VE 2-2M) w/ exterior shading on front 1st floor glazing
- Lighting = 0.783 w/sf: 720 2-lamp 4' T8 fixtures (high efficiency lamps and ballasts) @ 50w each and 300 18w CFLs @ 18w each; no lighting controls
- 4 identical Packaged VAV units: Aaron 30 ton, EER=10.4, 12,000 CFM, standard efficiency fan motors, 30% VAV boxes w/ reheat
- Ducts in conditioned space, R-4.2 duct insulation
- Hot water assumed to be standard gas water heater

Energy Measures Needed to Meet the 2008 Standards

The same building with the 2005 standards measures fails to meet the 2008 standards by a margin of 23%. To bring the building up to the 2008 standards, the following measures were added.

52,900 sq.ft. (from 2005 Stds to 2008 Stds)

• U=0.50, SHGCc=0.31 (e.g., Viracon VE 1-2M) 8,500 sf @$2.50 - 3.50/sq.ft.	$ 21,250 - 29,750
• R-19 metal frame walls (from R-13 in 2x6 metal studs) 20,730 sf @ $0.08 – 0.10/sq.ft.	$ 1,660 - 2,075
• R-38 roof w/ cool roof, 10,580 sf @ $0.50 – 0.70/sq.ft.	$ 5,290 - 7,405
• 720 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.803	$ 18,000 - 21,600
Total incremental cost of Ordinance energy measure:	**$ 46,200 - 60,830**
	Avg = $53,515
Incremental cost in $/sq.ft.:	**$ 0.87 to 1.15 /sq.ft.**
	Avg = $1.01 /sf

Energy Measures Needed to Exceed the 2008 Standards

The following energy features have been modified from the above Title 24 set of measures so that the proposed design uses less TDV energy than the 2008 standards. The added first cost of that measure compared with the equivalent 2008 Title 24 design measure is listed to the right, and the sum of all incremental costs is listed.

(A-10%) 52,900 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• R-38 w/ no cool roof, 10,580 sf @$0.35 – 0.50	($ 3,705 - 5,290)
• (5) Trane 30 ton units, EER=11.0 @ $9,000 to $13,000 each w/ premium fan motors	$ 45,000 - 65,000
Total incremental cost of Ordinance energy measure:	**$ 41,295 - 59,710**
	Avg = $50,503
Incremental cost in $/sq.ft.:	**$ 0.78 to $1.13/sq.ft.**
	Avg = $0.95 /sf

(A-15%) 52,900 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• R-38 w/ Cool Roof 10,580 sf @ $0.25 - $0.35/sf	$ 2,645 - 3,700
• 120 occupant sensors controlling (2) 2-lamp T8 fixtures; @$65.00 - $85.00 each	$ 7,800 - 10,200
• ¾" R-4.88 rigid insulation + R-19 metal frame walls 20,730 sf @ $1.75 – 2.25/sq.ft.	$ 36,280 - 46,645
Total incremental cost of Ordinance energy measure:	**$ 46,725 - 60,545**
	Avg = $53,635
Incremental cost in $/sq.ft.:	**$ 0.88 to $1.14/sq.ft.**
	Avg = $1.01 /sf

(A-20%) 52,900 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• R-30 w/ no cool roof, 10,580 sf @$0.43 – 0.60	($ 4,550 - 6,350)
• 120 occupant sensors controlling (2) 2-lamp T8 fixtures; @$65.00 - $85.00 each	$ 7,800 - 10,200
• ¾" R-4.88 rigid insulation + R-19 metal frame walls 20,730 sf @ $1.75 – 2.25/sq.ft.	$ 36,280 - 46,645
• (5) Trane 25 ton units, EER=11.0 @ $9,000 to $13,000 each w/ premium fan motors	$ 45,000 - 65,000
Total incremental cost of Ordinance energy measure:	**$ 84,530 - 115,495**
	Avg = $100,013
Incremental cost in $/sq.ft.:	**$ 1.60 to $2.18/sq.ft.**
	Avg = $1.89 /sf

CLIMATE ZONE #3 CASE STUDY

The following measures were first evaluated so that the building just meets the 2008 standards in climate zone #12 as follows:

Climate Zone #3: 21,160 SF 2-story building 2008 Title 24 Base Case, **37.1% Window Wall Ratio glazing** area:

(A) 21,160 SF 2-story office building which just meets Title 24:

- R-38 attic insulation, R-19 in metal frame exterior walls, slab-on-grade 1st floor;
- NFRC-rated Low-E windows: U-factor=0.50, SHGCc=0.38 (e.g., Viracon VE 1-2M) w/ no exterior shading
- Lighting = 0.867 w/sf: 248 2-lamp 4' T8 fixtures @ 62w each and 104 26w CFLs @ 26 w each; no lighting controls
- (4) 10-ton Packaged DX units: Carrier EER=11.0, 4,000 CFM; (4) 7.5-ton Packaged DX units: Carrier EER=11.0, 3,000 CFM; all standard efficiency fan motors
- Ducts in conditioned space, R-4.2 duct insulation
- Domestic hot water assumed to be standard gas water heater

Energy Measures Needed to Meet the 2008 Standards

The same building with the 2005 standards measures fails to meet the 2008 standards by a margin of 9%. To bring the building up to the 2008 standards, the following measures were changed.

21,160 sq.ft. (from 2005 Stds to 2008 Stds)

• U=0.50, SHGCc=0.38 (e.g., Viracon VE 1-2M) from SHGCc=0.54; 5,160 sf @$2.50 - 3.50/sq.ft.	$ 12,900 - 18,060
Total incremental cost of Ordinance energy measure:	**$ 12,900 - 18,060**
	Avg = $15,480
Incremental cost in $/sq.ft.:	**$ 0.61 to 0.85 /sq.ft.**
	Avg = $0.73 /sf

Energy Measures Needed to Exceed the 2008 Standards

The following energy features have been modified from the above Title 24 set of measures so that the proposed design uses less TDV energy than the 2008 standards. The added first cost of that measure compared with the equivalent 2008 Title 24 design measure is listed to the right, and the sum of all incremental costs is listed.

(A-10%) 21,160 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• U=0.50, SHGCc=0.31 (e.g., Viracon VE 2-2M) 5,160 sf @$2.00 - 3.00/sq.ft.	$ 10,320 - 15,480
• 248 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.727	$ 5,800 - 6,960
Total incremental cost of Ordinance energy measure:	**$ 16,120 - 22,440**
	Avg = $19,280
Incremental cost in $/sq.ft.:	**$ 0.76 to $1.06/sq.ft.**
	Avg = $0.91 /sf

(A-15%) 21,160 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• U=0.50, SHGCc=0.31 (e.g., Viracon VE 2-2M) 5,160 sf @$2.00 - 3.00/sq.ft.	$ 10,320 - 15,480
• 248 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.676	$ 5,800 - 6,960
• 64 (26% of) T8 fixtures on 32 occupant sensors, small offices: @$65.00 - $85.00 each	$ 2,080 - 2,720
• 24 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 4,200 - 6,000
• (8) Premium Efficiency supply fans, @$100 - $200 each	$ 800 - 1,600
• R-38 w/ Cool Roof 10,580 sf @ $1.75 - $2.35/sf includes R-10 (2") rigid insulation	$ 18,515 - 24,865
Total incremental cost of Ordinance energy measure:	**$ 41,715 - 57,625**
	Avg = $49,670
Incremental cost in $/sq.ft.:	**$ 1.97 to $2.72/sq.ft.**
	Avg = $2.35 /sf

(A-20%) 21,160 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• U=0.50, SHGCc=0.31 (e.g., Viracon VE 2-2M) 5,160 sf @$2.00 - 3.00/sq.ft.	$ 10,320 - 15,480
• 248 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.676	$ 5,800 - 6,960
• 64 (26% of) T8 fixtures on 32 occupant sensors, small offices: @$65.00 - $85.00 each	$ 2,080 - 2,720
• 24 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 4,200 - 6,000
• (8) Premium Efficiency supply fans, @$100 - $200 each	$ 800 - 1,600
• (4) Global Energy Group 1400 Series 10-ton Packaged DX, EER = 13.4 @$2300 - $2900 each	$ 9,200 - 11,600
• (4) Global Energy Group 1400 Series 7.5-ton Packaged DX, EER = 13.0 @$1950 - $2450 each	$ 7,800 - 9,800
• R-6.5 rigid insulation + R-19 in metal stud walls, 8,752 sf @$1.50 - $2.00/sf	$ 13,130 - 17,505
• R-38 w/ Cool Roof 10,580 sf @ $1.75 - $2.35/sf includes R-10 (2") rigid insulation	$ 18,515 - 24,865
Total incremental cost of Ordinance energy measure:	**$ 71,845 - 96,530**
	Avg = $84,188
Incremental cost in $/sq.ft.:	**$ 3.40 to $4.56/sq.ft.**
	Avg = $3.98 /sf

(A-25%) 21,160 sq.ft. (Reduction in 2008 T24 TDV Energy by 25%)

• U=0.50, SHGCc=0.22 (e.g., Viracon VE 1-42M **) 5,160 sf @$3.50 - 4.50/sq.ft.	$ 18,060 - 23,220
• 248 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.676	$ 5,800 - 6,960
• 64 (26% of) T8 fixtures on 32 occupant sensors, small offices: @$65.00 - $85.00 each	$ 2,080 - 2,720
• 24 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 4,200 - 6,000
• (8) Premium Efficiency supply fans, @$100 - $200 each	$ 800 - 1,600
• (4) Global Energy Group 1400 Series 10-ton Packaged DX, EER = 13.4 @$2300 - $2900 each	$ 9,200 - 11,600
• (4) Global Energy Group 1400 Series 7.5-ton Packaged DX, EER = 13.0 @$1950 - $2450 each	$ 7,800 - 9,800
• R-6.5 rigid insulation + R-19 in metal stud walls, 8,752 sf @$1.50 - $2.00/sf	$ 13,130 - 17,505
• R-38 w/ Cool Roof 10,580 sf @ $1.75 - $2.35/sf includes R-10 (2") rigid insulation	$ 18,515 - 24,865

Total incremental cost of Ordinance energy measure:	**$ 79,585 - 104,270**
	Avg = $91,938
Incremental cost in $/sq.ft.:	**$ 3.76 to $4.93/sq.ft.**
	Avg = $4.34 /sf

** *Note: This glass type has a low visible light transmittance (31%) which reduces the opportunity for manual control of lighting in response to daylight not accounted for in the Title 24 calculation.*

CLIMATE ZONE #12 CASE STUDY

The following measures were first evaluated so that the building just meets the 2008 standards in climate zone #12 as follows:

Climate Zone #12: 21,160 SF 2-story building 2008 Title 24 Base Case, **37.1% Window Wall Ratio glazing** area:

(A) 21,160 SF 2-story office building which just meets Title 24:

- R-38 roof w/ cool roof, R-19 in metal frame exterior walls, slab-on-grade 1st floor;
- NFRC-rated Low-E windows: U-factor=0.50, SHGCc=0.38 (e.g., Viracon VE 1-2M) w/ exterior shading on front 1st floor glazing
- Lighting = 0.839 w/sf: 240 2-lamp 4' T8 fixtures @ 62w each and 100 26w CFLs @ 26 w each; no lighting controls
- (4) 10-ton Packaged DX units: Carrier EER=11.0, 4,000 CFM; (4) 7.5-ton Packaged DX units: Carrier EER=11.0, 3,000 CFM; all standard efficiency fan motors
- Ducts in conditioned space, R-4.2 duct insulation
- Domestic hot water assumed to be standard gas water heater

Energy Measures Needed to Meet the 2008 Standards

The same building with the 2005 standards measures fails to meet the 2008 standards by a margin of 22%. To bring the building up to the 2008 standards, the following measures were changed.

21,160 sq.ft. (from 2005 Stds to 2008 Stds)

• U=0.50, SHGCc=0.38 (e.g., Viracon VE 1-2M) from generic dual Low-E glazing; 5,160 sf @$5.00 - 7.00/sq.ft.	$ 25,800 - 36,120
Total incremental cost of Ordinance energy measure:	**$ 25,800 - 36,120**
	Avg = $30,960
Incremental cost in $/sq.ft.:	**$ 1.22 to 1.71 /sq.ft.**
	Avg = $1.46 /sf

Energy Measures Needed to Exceed the 2008 Standards

The following energy features have been modified from the above Title 24 set of measures so that the proposed design uses less TDV energy than the 2008 standards. The added first cost of that measure compared with the equivalent 2008 Title 24 design measure is listed to the right, and the sum of all incremental costs is listed.

(A-10%) 21,160 sq.ft. (Reduction in 2008 T24 TDV Energy by 10%)

• U=0.50, SHGCc=0.31 (e.g., Viracon VE 2-2M) 5,160 sf @$2.00 - 3.00/sq.ft.	$ 10,320 - 15,480
• 8 NEMA Premium fan motors on supply fans	$ 600 - 1,000
• 240 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.703	$ 6,000 - 7,200
Total incremental cost of Ordinance energy measure:	**$ 16,920 - 23,440**
	Avg = $20,180
Incremental cost in $/sq.ft.:	**$ 0.80 to $1.11/sq.ft.**
	Avg = $0.95 /sf

(A-15%) 21,160 sq.ft. (Reduction in 2008 T24 TDV Energy by 15%)

• U=0.50, SHGCc=0.31 (e.g., Viracon VE 2-2M) 5,160 sf @$2.00 - 3.00/sq.ft.	$ 10,320 - 15,480
• 240 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.676	$ 6,000 - 7,200
• 72 (30% of) T8 fixtures on 36 occupant sensors, small offices: @$65.00 - $85.00 each	$ 2,340 - 3,060
• 20 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 3,500 - 5,000
• 8 NEMA Premium fan motors on supply fans	$ 600 - 1,000
• ¾" R-4.88 rigid insulation + R-19 in metal stud walls, 8,752 sf @$1.75 - $2.25/sf	$ 15,315 - 19,690
Total incremental cost of Ordinance energy measure:	**$ 38,075 - 51,430**
	Avg = $44,753
Incremental cost in $/sq.ft.:	**$ 1.80 to $2.43/sq.ft.**
	Avg = $2.11/sf

(A-20%) 21,160 sq.ft. (Reduction in 2008 T24 TDV Energy by 20%)

• R-30 w/ no cool roof, 10,580 sf @$0.43 – 0.60	($ 4,550 - 6,350)
• U=0.50, SHGCc=0.31 (e.g., Viracon VE 2-2M) 5,160 sf @$2.00 - 3.00/sq.ft.	$ 10,320 - 15,480
• 240 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.676	$ 6,000 - 7,200
• 72 (30% of) T8 fixtures on 36 occupant sensors, small offices: @$65.00 - $85.00 each	$ 2,340 - 3,060

• 20 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 3,500 - 5,000
• (4) Global Energy Group 1400 Series 10-ton Packaged DX, EER = 13.4 @$2300 - $2900 each	$ 9,200 - 11,600
• (4) Global Energy Group 1400 Series 7.5-ton Packaged DX, EER = 13.0 @$1950 - $2450 each	$ 7,800 - 9,800
• ¾" R-4.88 rigid insulation + R-19 in metal stud walls, 8,752 sf @$1.75 - $2.25/sf	$ 15,315 - 19,690
Total incremental cost of Ordinance energy measure:	**$ 49,925 - 60,480**
	Avg = $55,203
Incremental cost in $/sq.ft.:	**$ 2.36 to $2.86/sq.ft.**
	Avg = $2.61 /sf

(A-25%) 21,160 sq.ft. (Reduction in 2008 T24 TDV Energy by 25%)

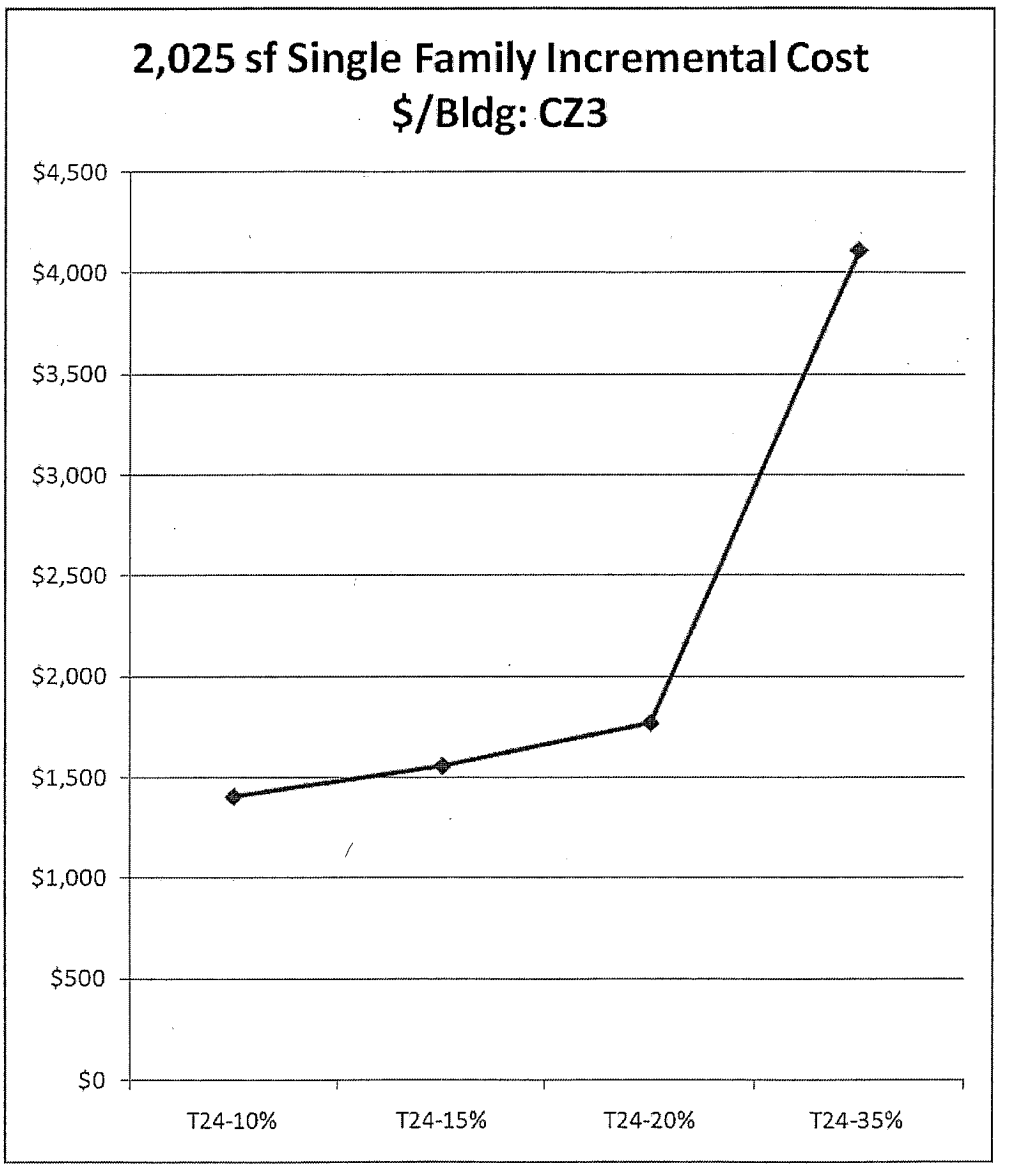
• U=0.50, SHGCc=0.22 (e.g., Viracon VE 1-42M **) 5,160 sf @$3.50 - 4.50/sq.ft.	$ 18,060 - 23,220
• 240 2-lamp 4' T8 fixtures with high efficiency instant start ballasts and premium T8 lamps, 50 input watts @$25.00 - $30.00/fixture; Installed LPD=0.676	$ 6,000 - 7,200
• 72 (30% of) T8 fixtures on 36 occupant sensors, small offices @$65.00 - $85.00 each	$ 2,340 - 3,060
• 20 more recessed CFL fixtures, all CFL fixtures w/ 18w lamps @$175 - $250 each	$ 3,500 - 5,000
• (4) Global Energy Group 1400 Series 10-ton Packaged DX, EER = 13.4 @$2300 - $2900 each	$ 9,200 - 11,600
• (4) Global Energy Group 1400 Series 7.5-ton Packaged DX, EER = 13.0 @$1950 - $2450 each	$ 7,800 - 9,800
• 1 ½" R-4.88 rigid insulation + R-19 in metal stud walls, 8,752 sf @$3.00 - $3.50/sf	$ 26,255 - 30,630
Total incremental cost of Ordinance energy measure:	**$ 73,155 - 90,510**
	Avg = $82,333
Incremental cost in $/sq.ft.:	**$ 3.46 to $4.28/sq.ft.**
	Avg = $3.89 /sf

** *Note: This glass type has a low visible light transmittance (31%) which reduces the opportunity for manual control of lighting in response to daylight not accounted for in the Title 24 calculation.*

4.0 Cost Effectiveness Graphs

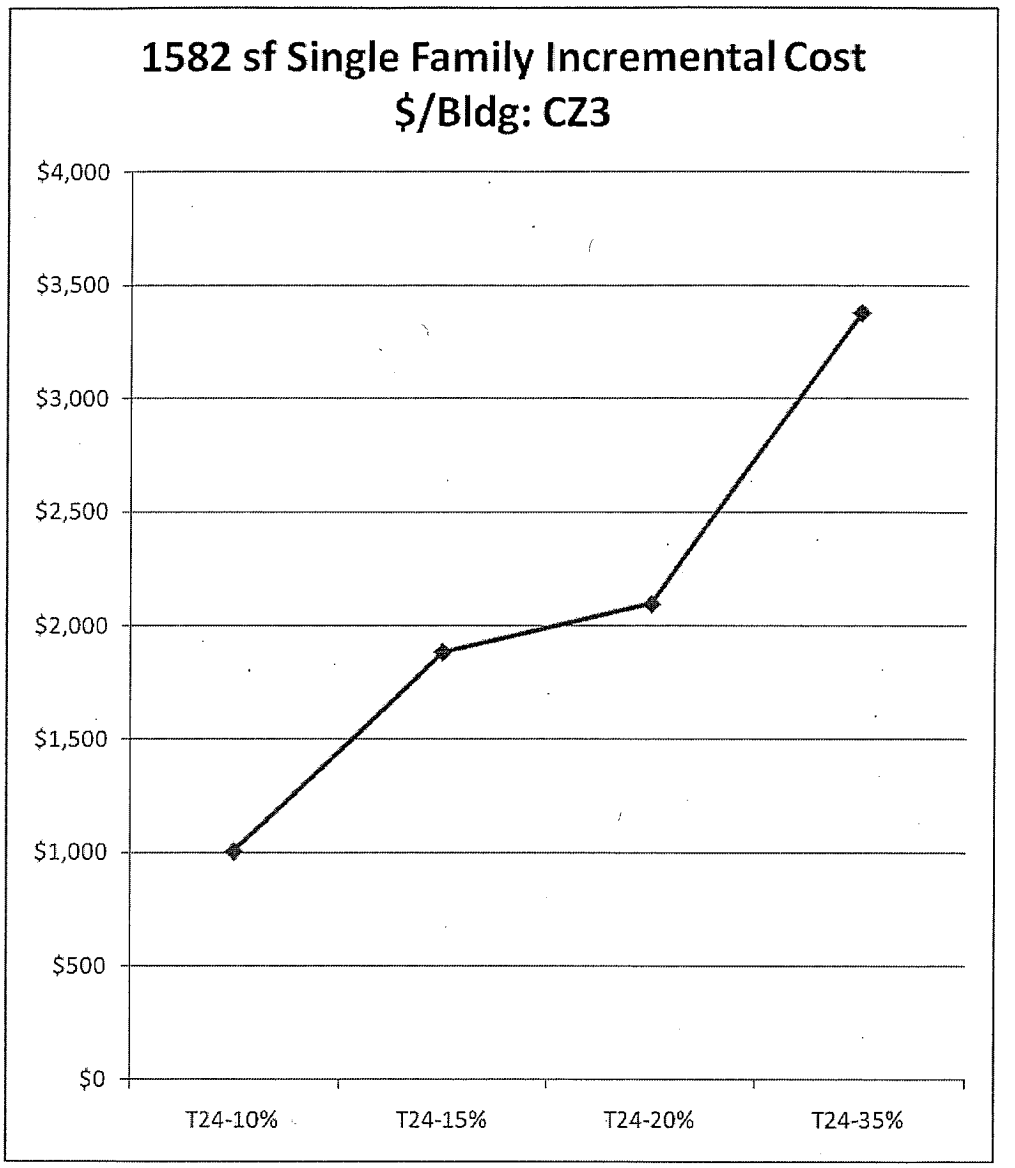
4.1 CLIMATE ZONE #3 CHARTS ILLUSTRATING RESULTS

Figure 4-CZ3a-1: Added First Cost – 2,025 sf 2-Story Single Family Home



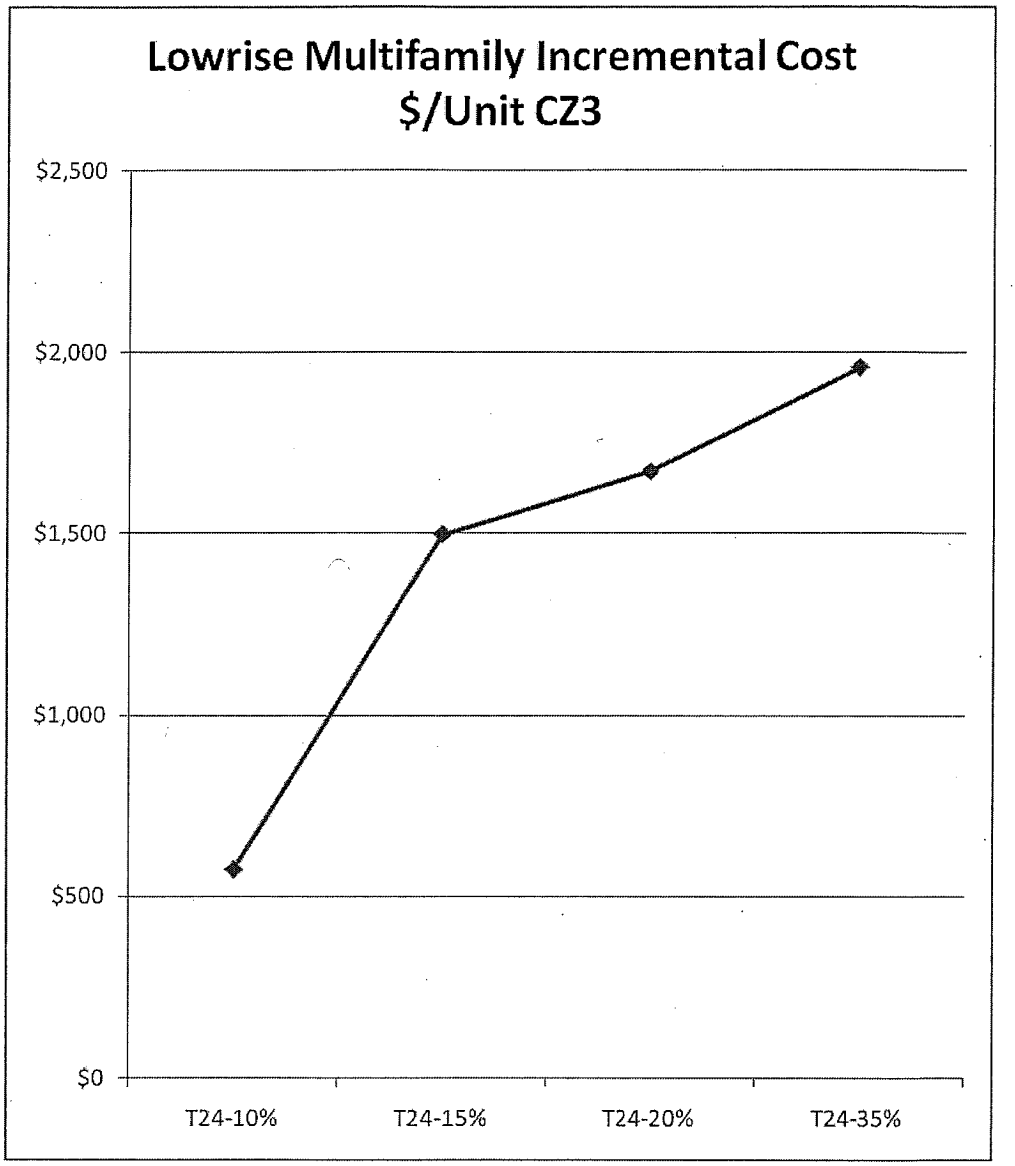
The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $733 in this single family house design.

Figure 4-CZ3a-2: Added First Cost – 1,582 sf 1-Story Single Family Home



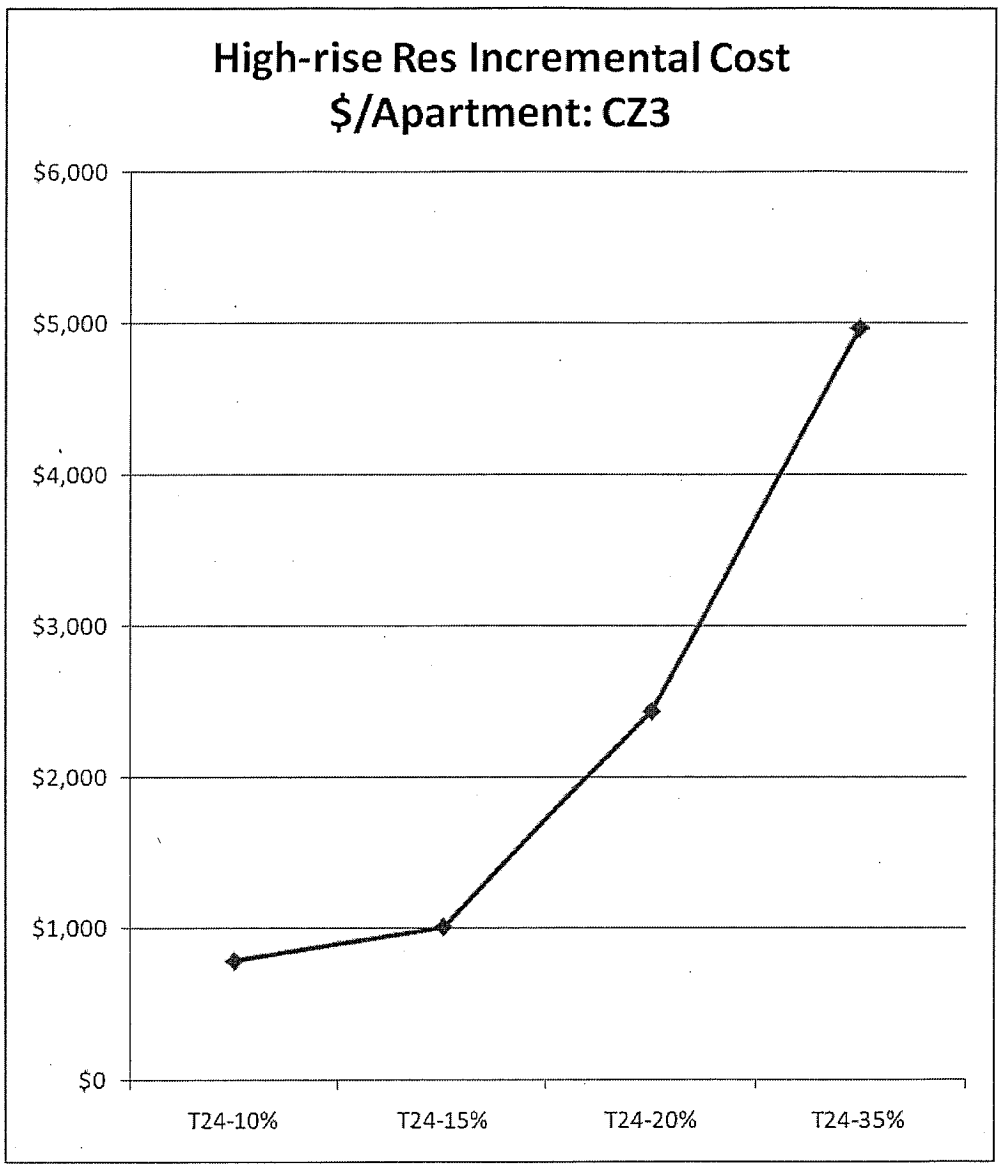
The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $238 in this single family house design.

Figure 4-CZ3a-3: Added First Cost/Dwelling Unit, 2-Story Multifamily Building



The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $150 per dwelling unit in this multifamily building design.

Figure 4-CZ3a-4: Added First Cost – 40 Unit, 5-Story High-rise Residential Building



The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $0 per dwelling unit in this high-rise residential building design.
(No changes in the building design were required to meet the 2008 standards.)

Figure 4-CZ3a-5: Added First Cost – 21,160 sf 2-Story Nonresidential Building

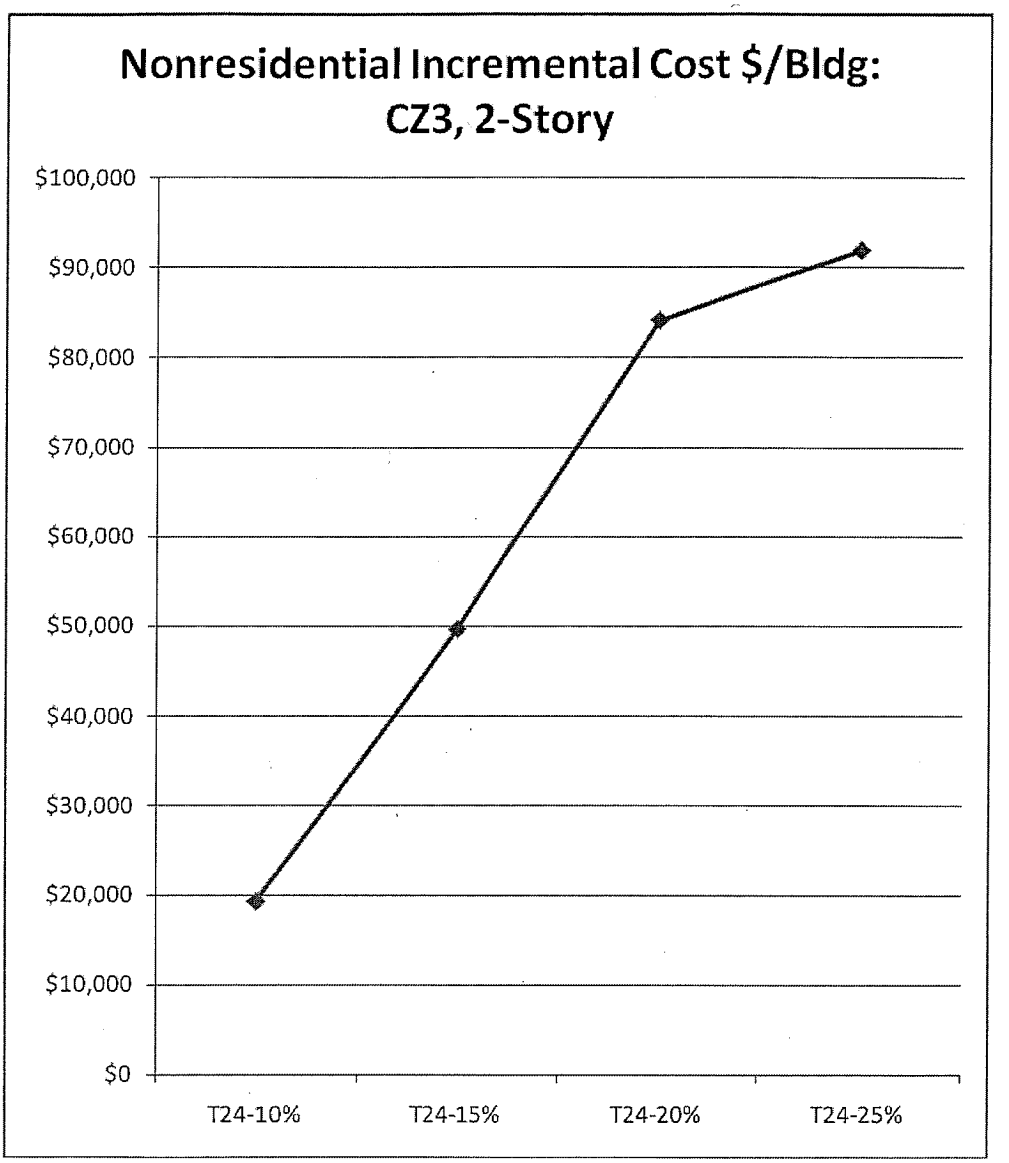


Figure 4-CZ3a-6: Added First Cost – 52,900 sf 5-Story Nonresidential Building

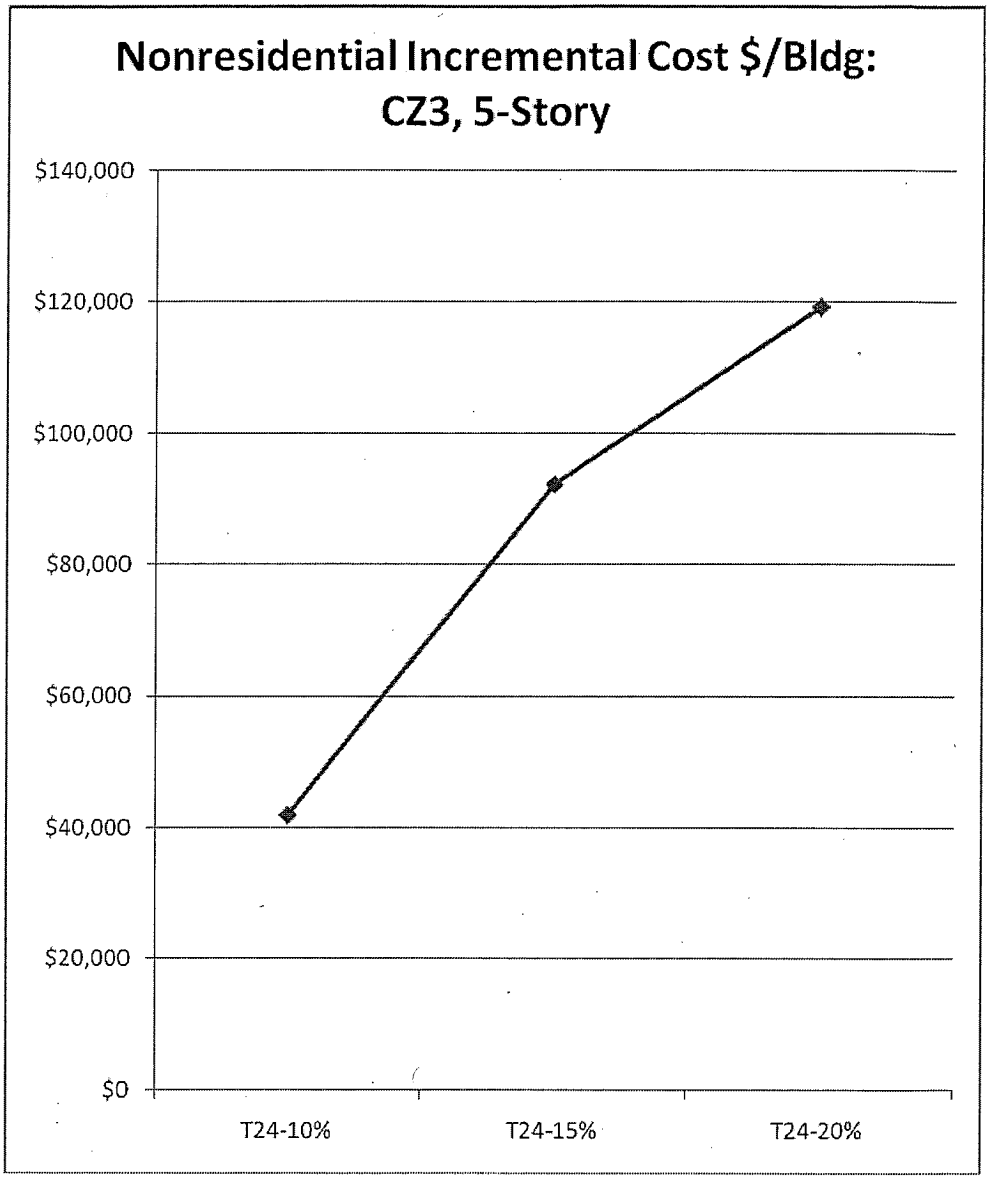


Figure 4-CZ3b-1: Added First Cost/Sq.Ft., – 2,025 sf 2-Story Single Family Home

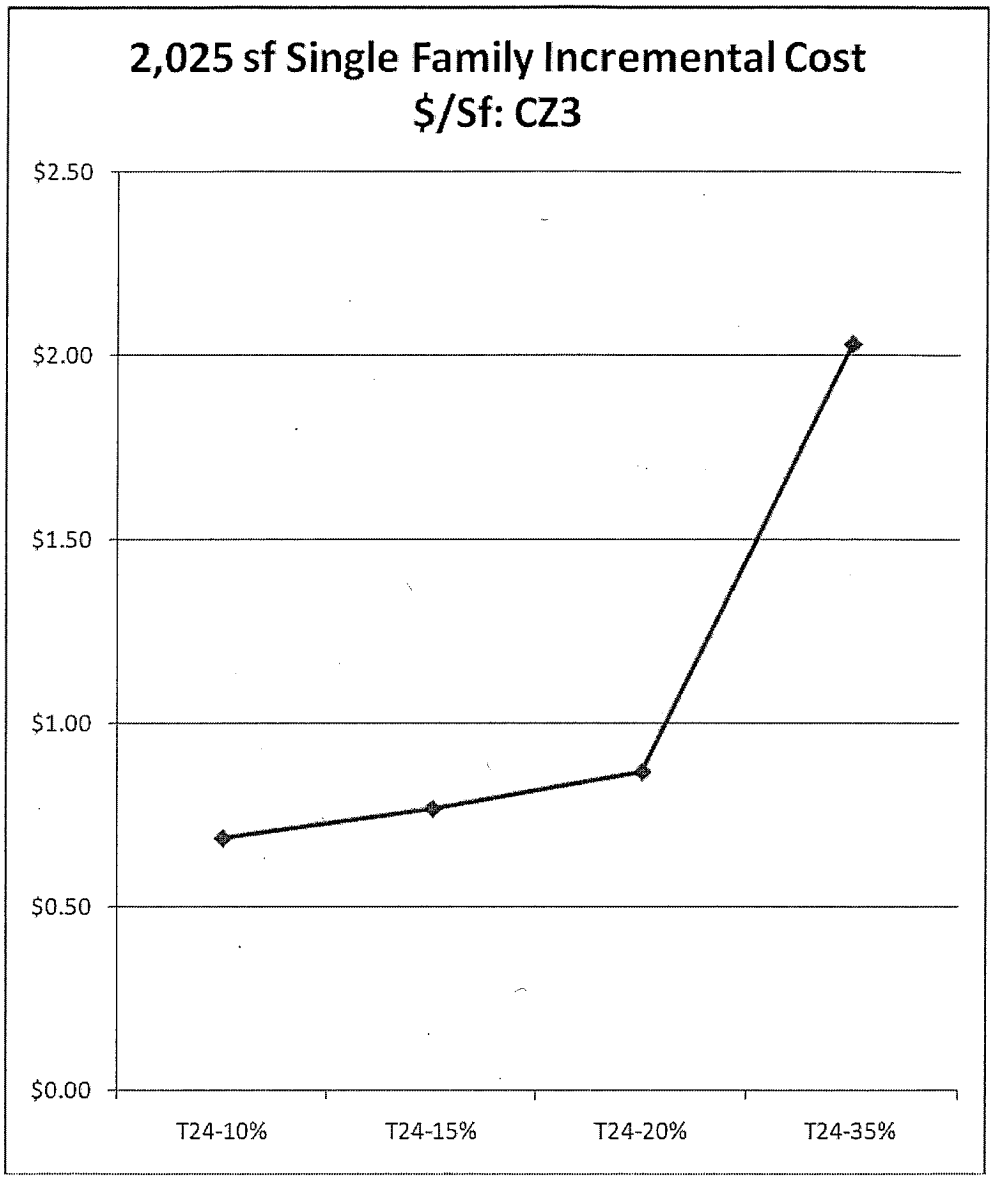


Figure 4-CZ3b-2: Added First Cost/Sq.Ft., – 1,582 sf 1-Story Single Family Home

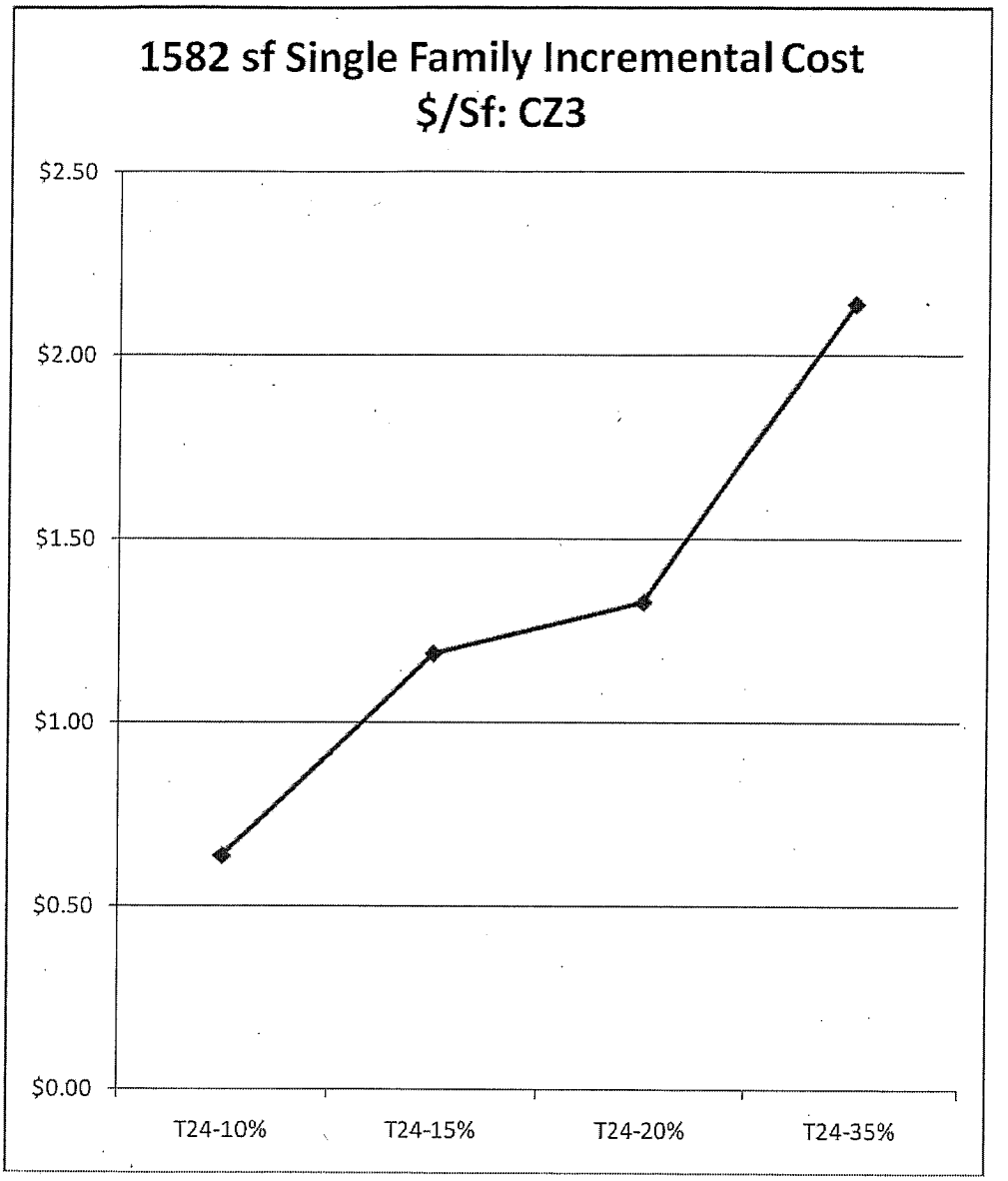


Figure 4-CZ3b-3: Added First Cost/Sq.Ft, 2-Story Multifamily Building

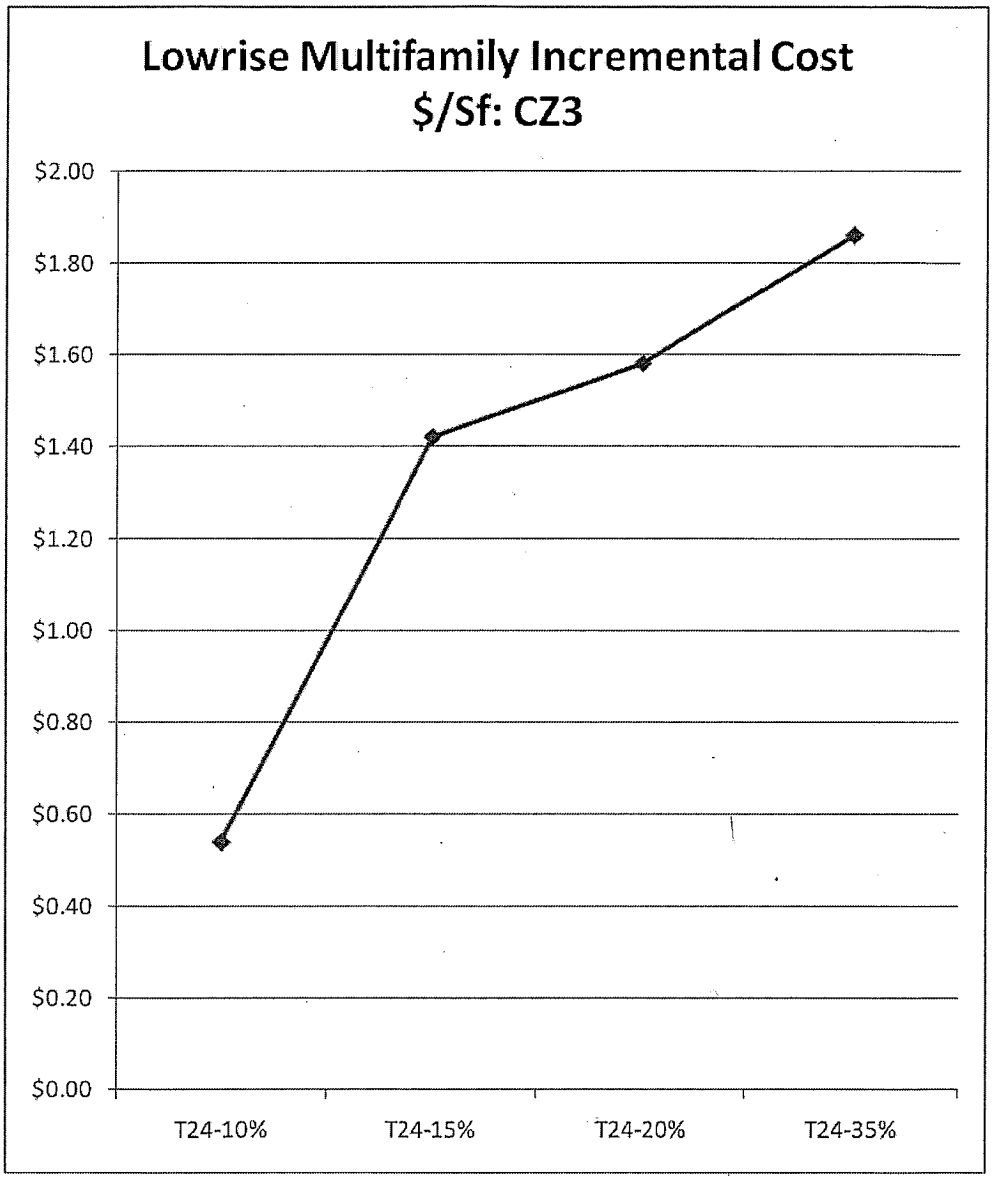
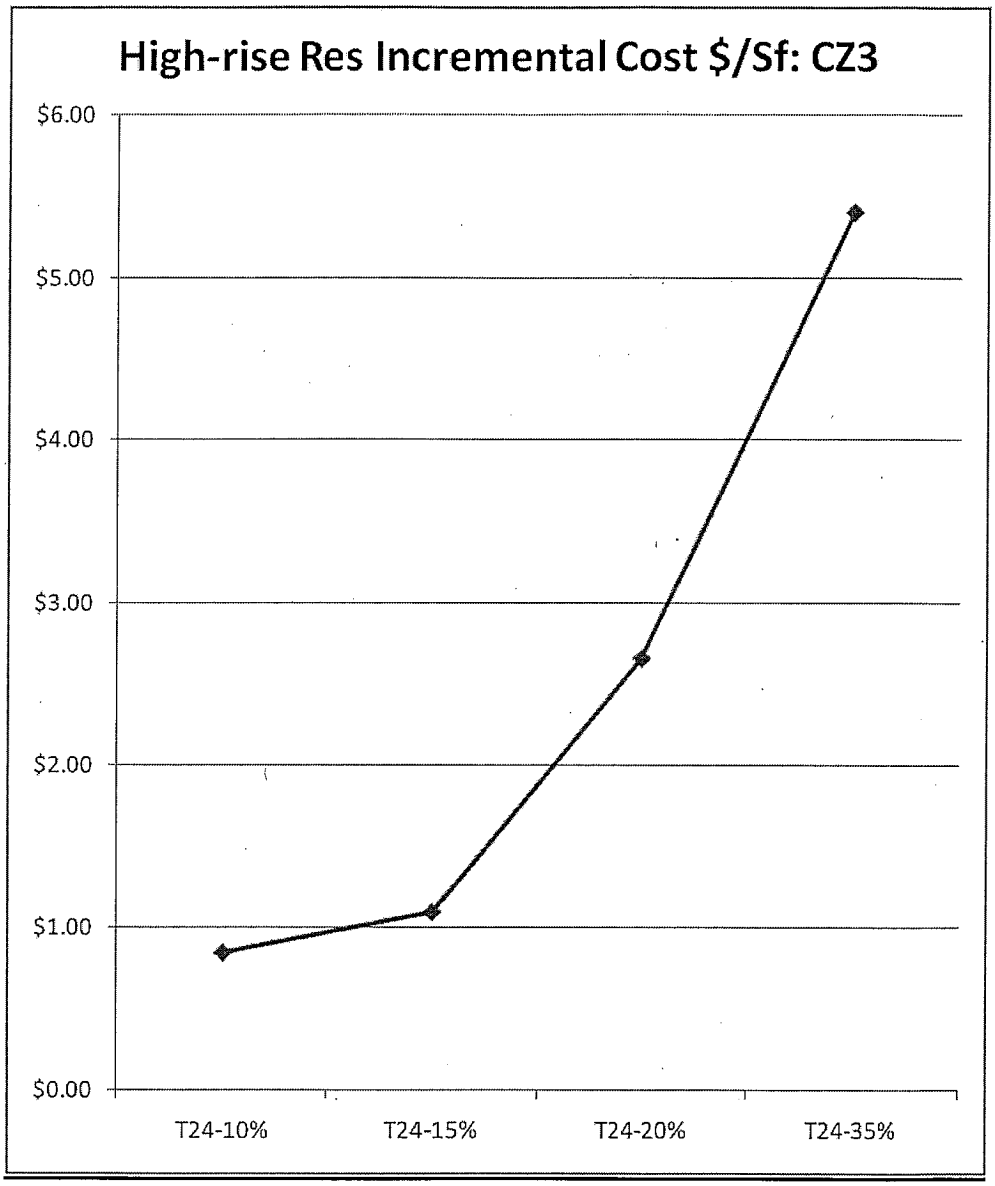


Figure 4-CZ3b-4: Added First Cost/Sq.Ft
– 40 Unit, 5-Story High-rise Residential Building



The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $0 per square foot in this high-rise residential building design.
(No changes in the building design were required to meet the 2008 standards.)

Figure 4-CZ3b-5: Added First Cost/Sq.Ft., 21,160 sf 2-Story Nonresidential Building

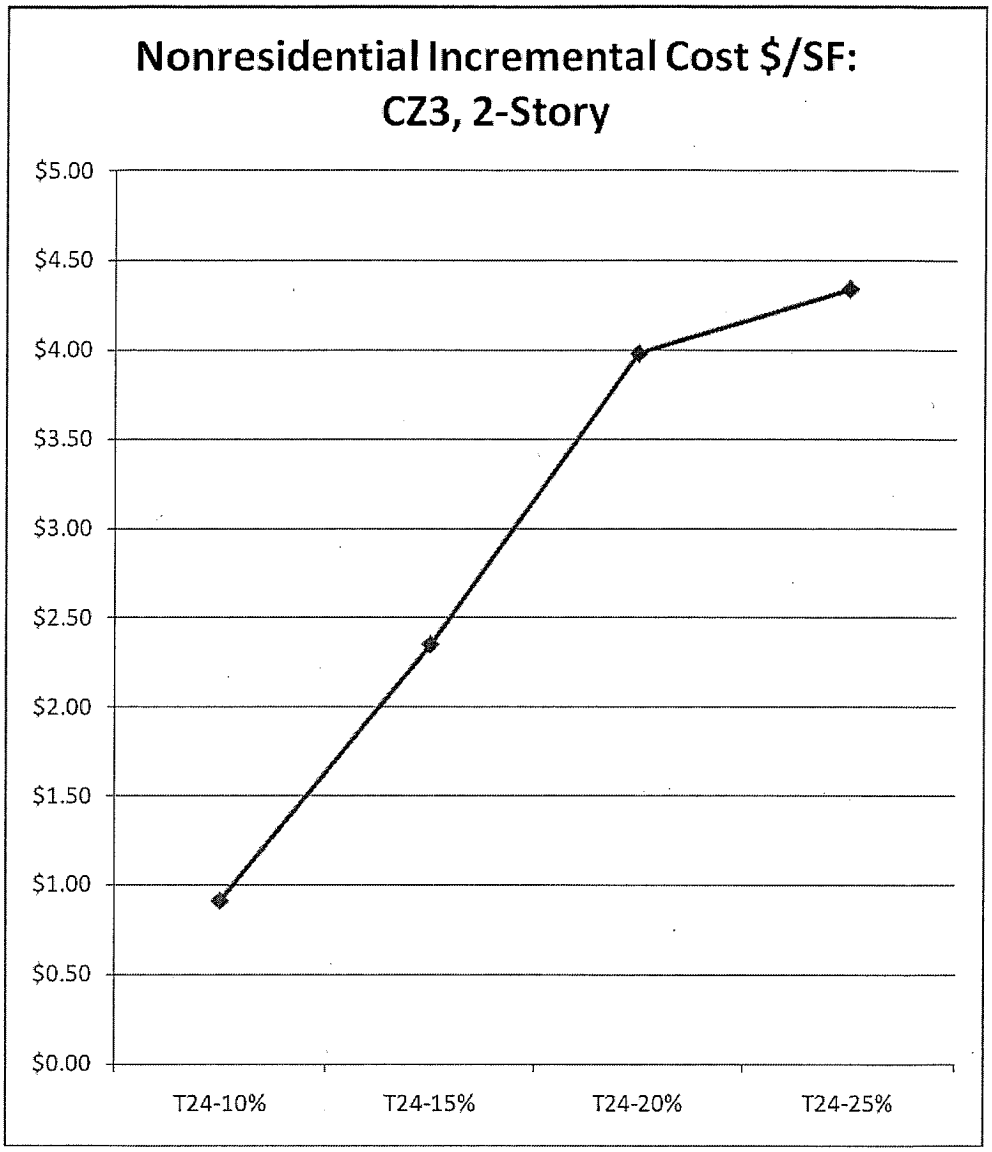


Figure 4-CZ3b-6: Added First Cost/Sq.Ft., 52,900 sf 5-Story Nonresidential Building

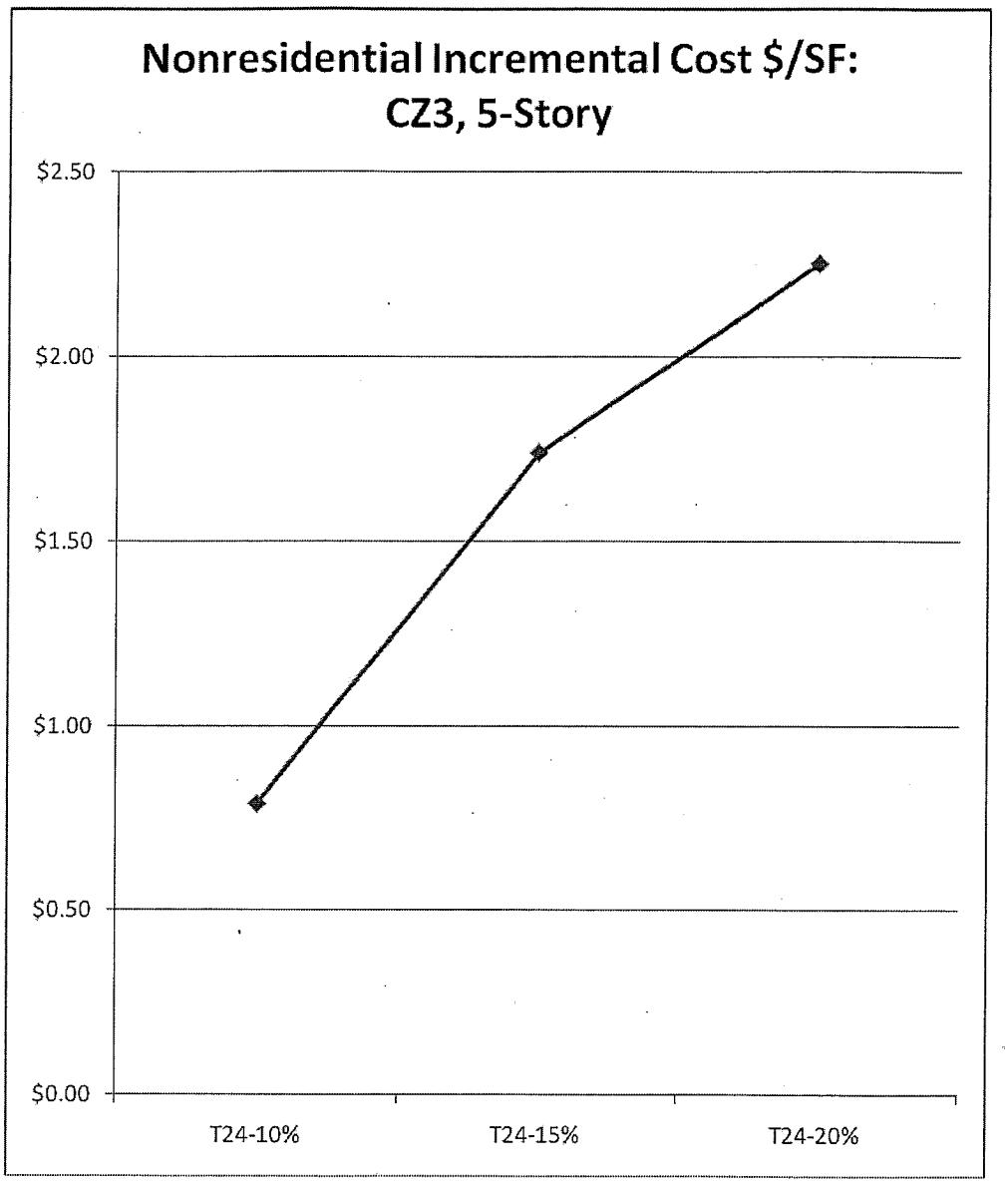


Figure 4-CZ3c-1: Simple Payback of Different Tiers of Energy Measures – 2,025 sf 2-Story Single Family Home

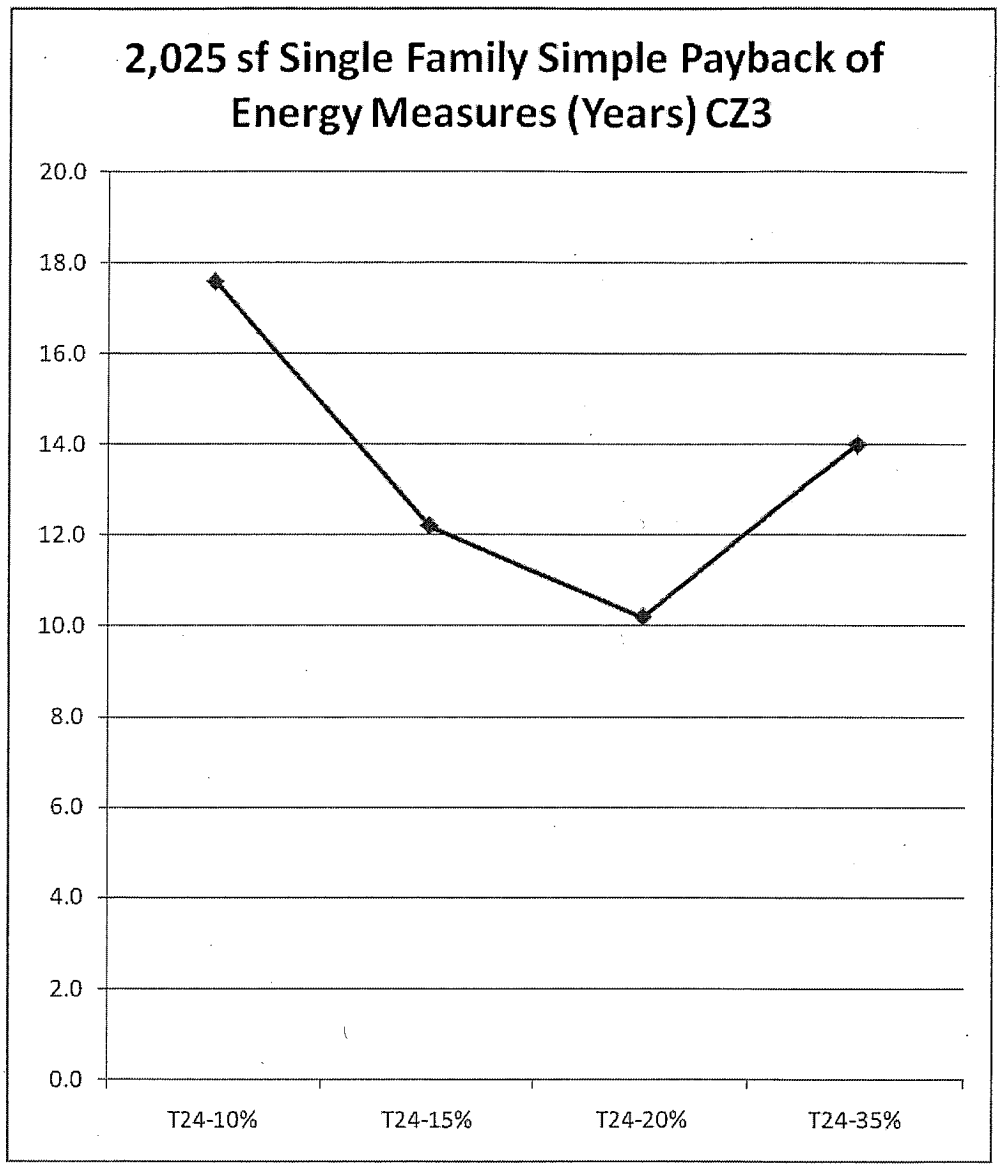


Figure 4-CZ3c-2: Simple Payback of Different Tiers of Energy Measures – 1,582 sf 1-Story Single Family Home

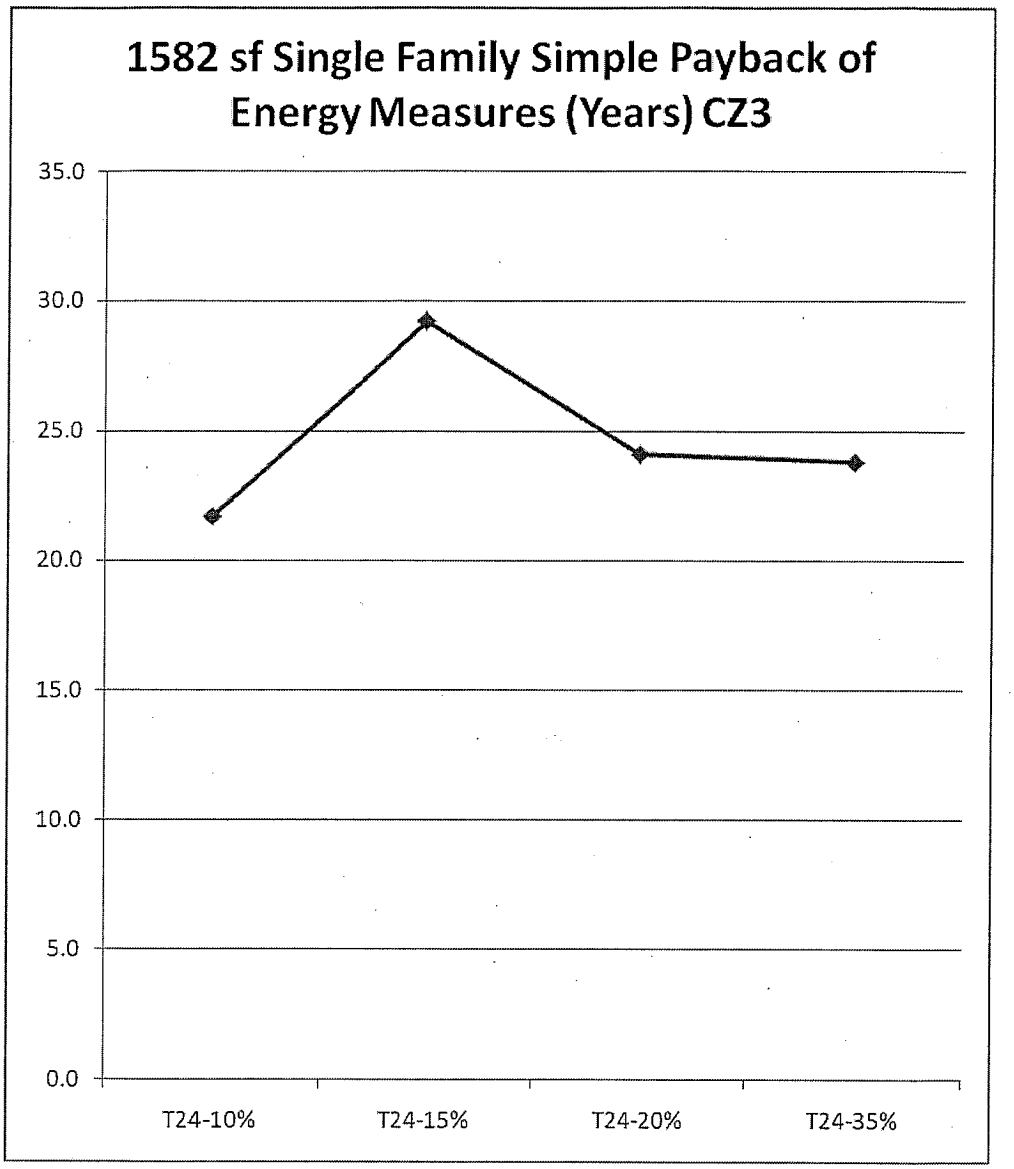


Figure 4-CZ3c-3: Simple Payback of Different Tiers of Energy Measures, 2-Story Multifamily Building

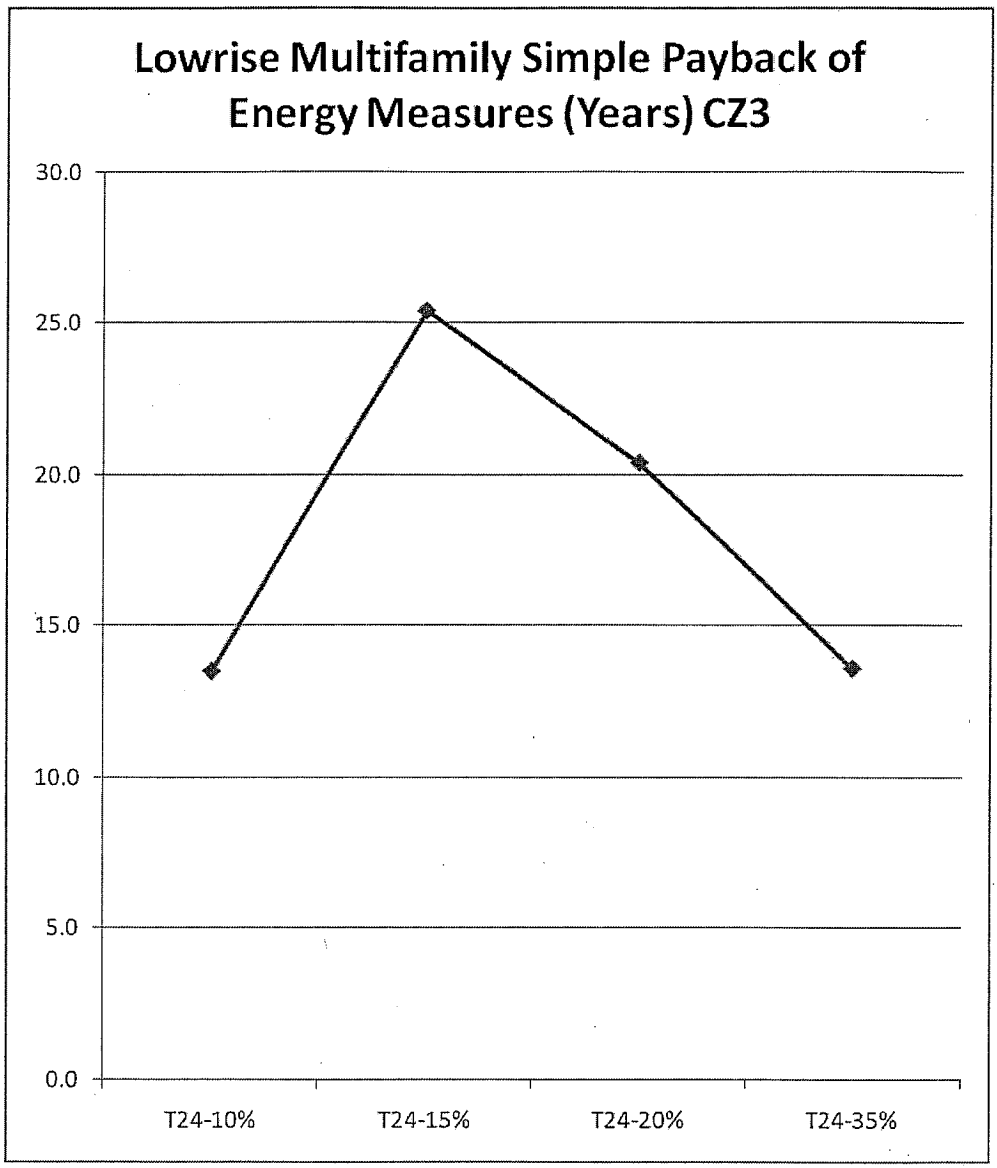


Figure 4-CZ3c-4: Simple Payback of Different Tiers of Energy Measures – 40 Unit, 5-Story High-rise Residential Building

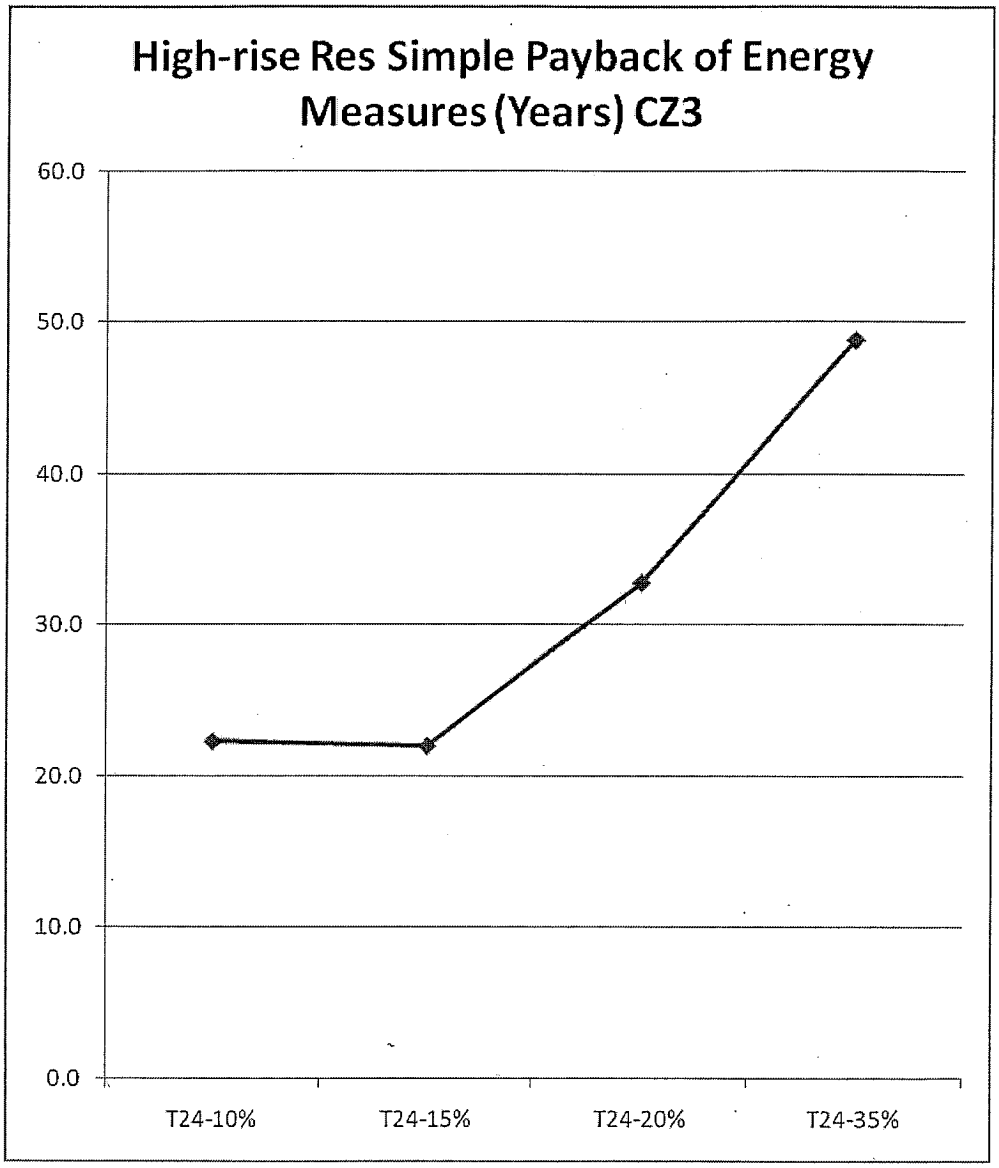


Figure 4-CZ3c-5: Simple Payback of Different Tiers of Energy Measures – 21,160 sf 2-Story Nonresidential Building

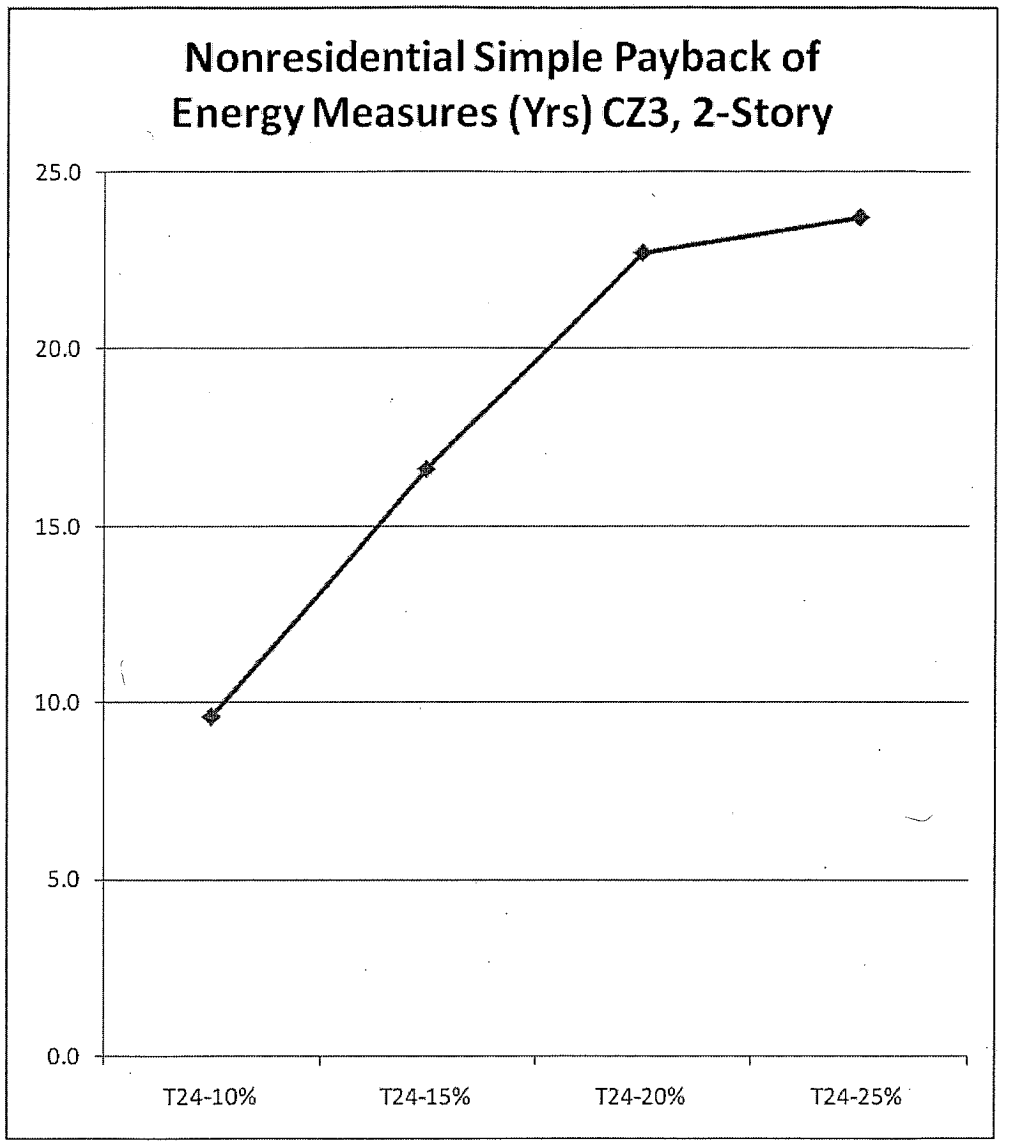


Figure 4-CZ3c-6: Simple Payback of Different Tiers of Energy Measures – 52,900 sf 5-Story Nonresidential Building

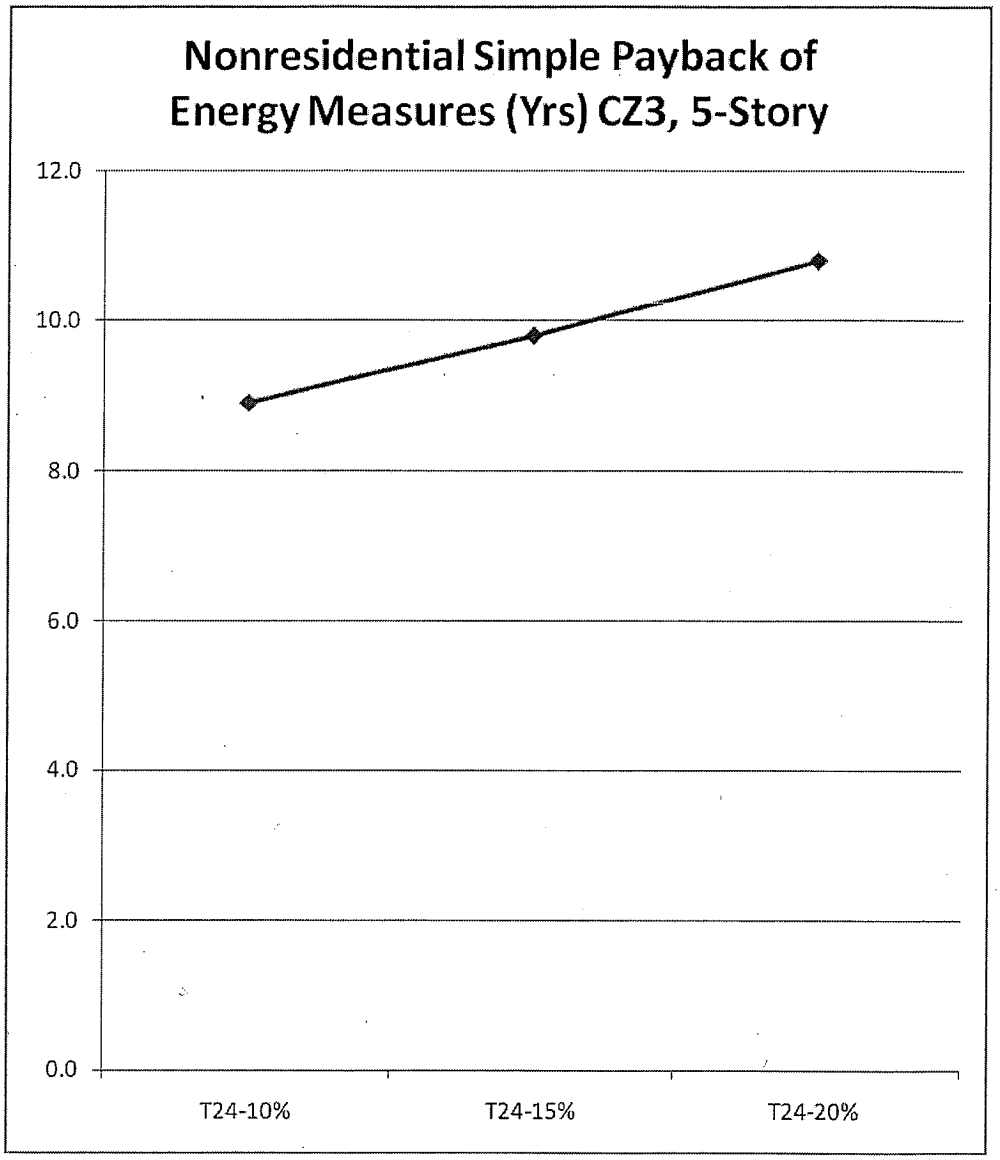


Figure 4-CZ3d-1: Added Cost/Sq.ft. per Lb. of CO2 Reduction – 2,025 sf 2-Story Single Family Home

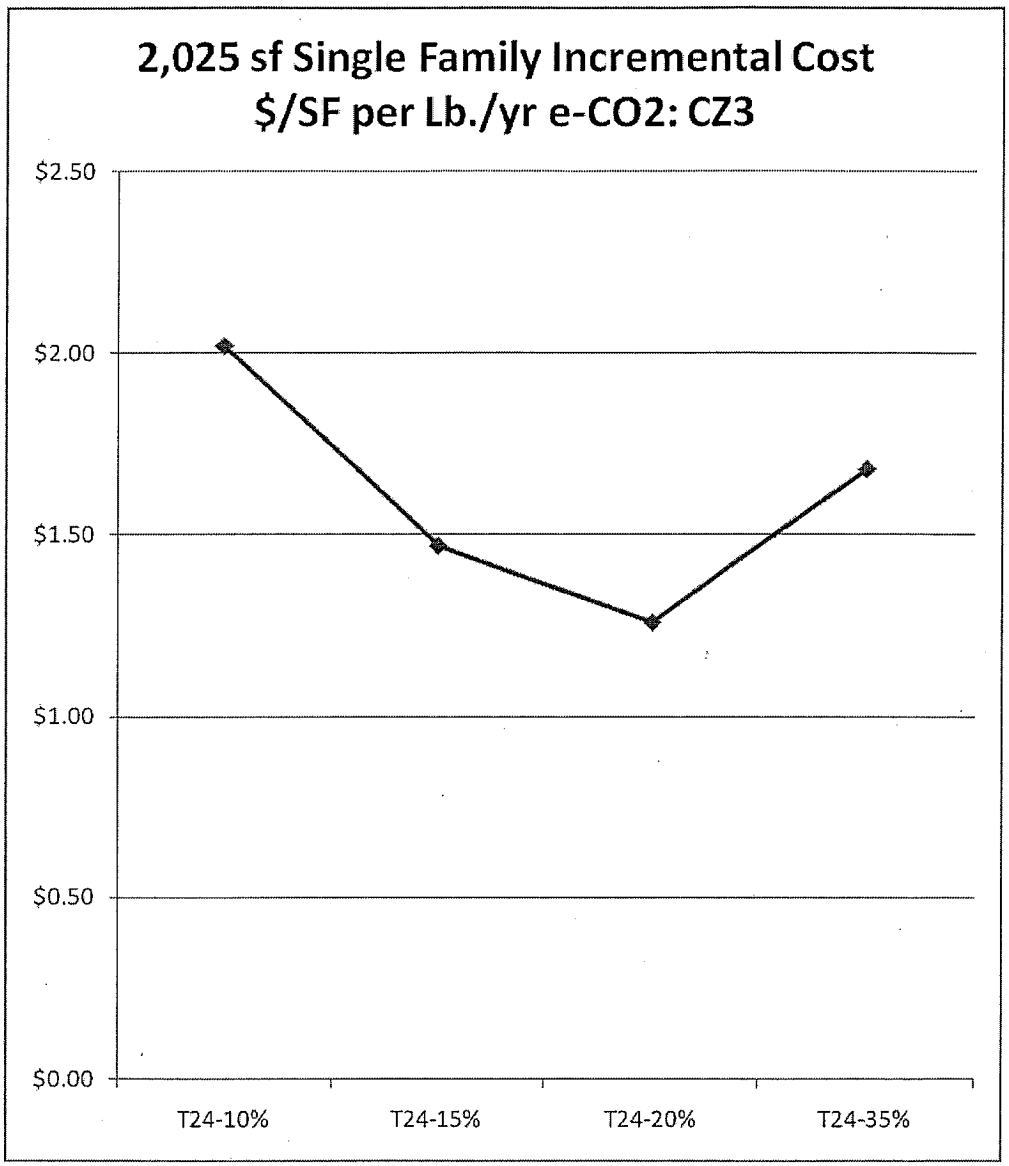


Figure 4-CZ3d-2: Added Cost/Sq.ft. per Lb. of CO2 Reduction – 1,582 sf 1-Story Single Family Home

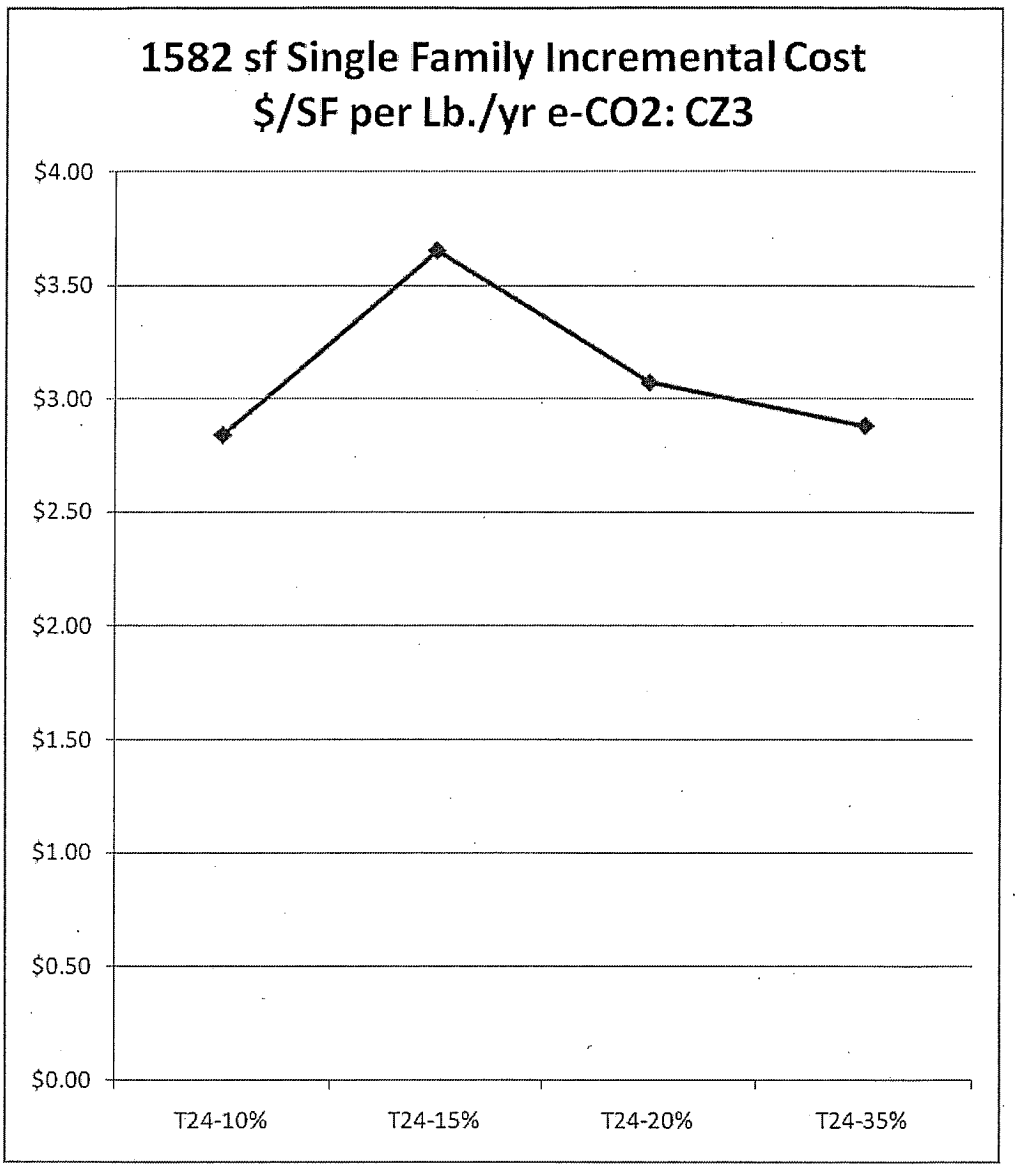


Figure 4-CZ3d-3: Added Cost/Sq.ft. per Lb. of CO2 Reduction, 2-Story Multifamily Building

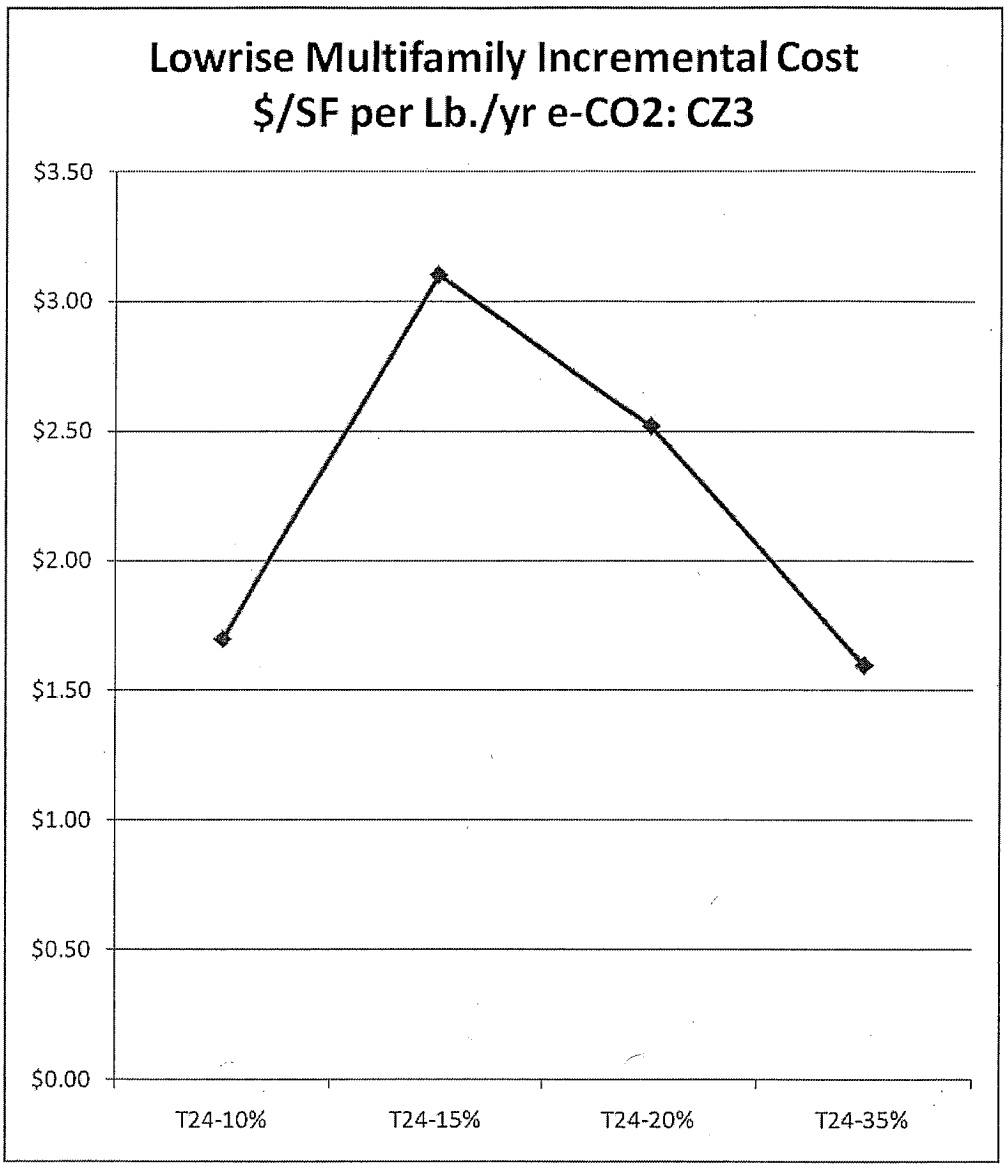


Figure 4-CZ3d-4: Added Cost/Sq.ft. per Lb. of CO2 Reduction – 40 Unit, 5-Story High-rise Residential Building

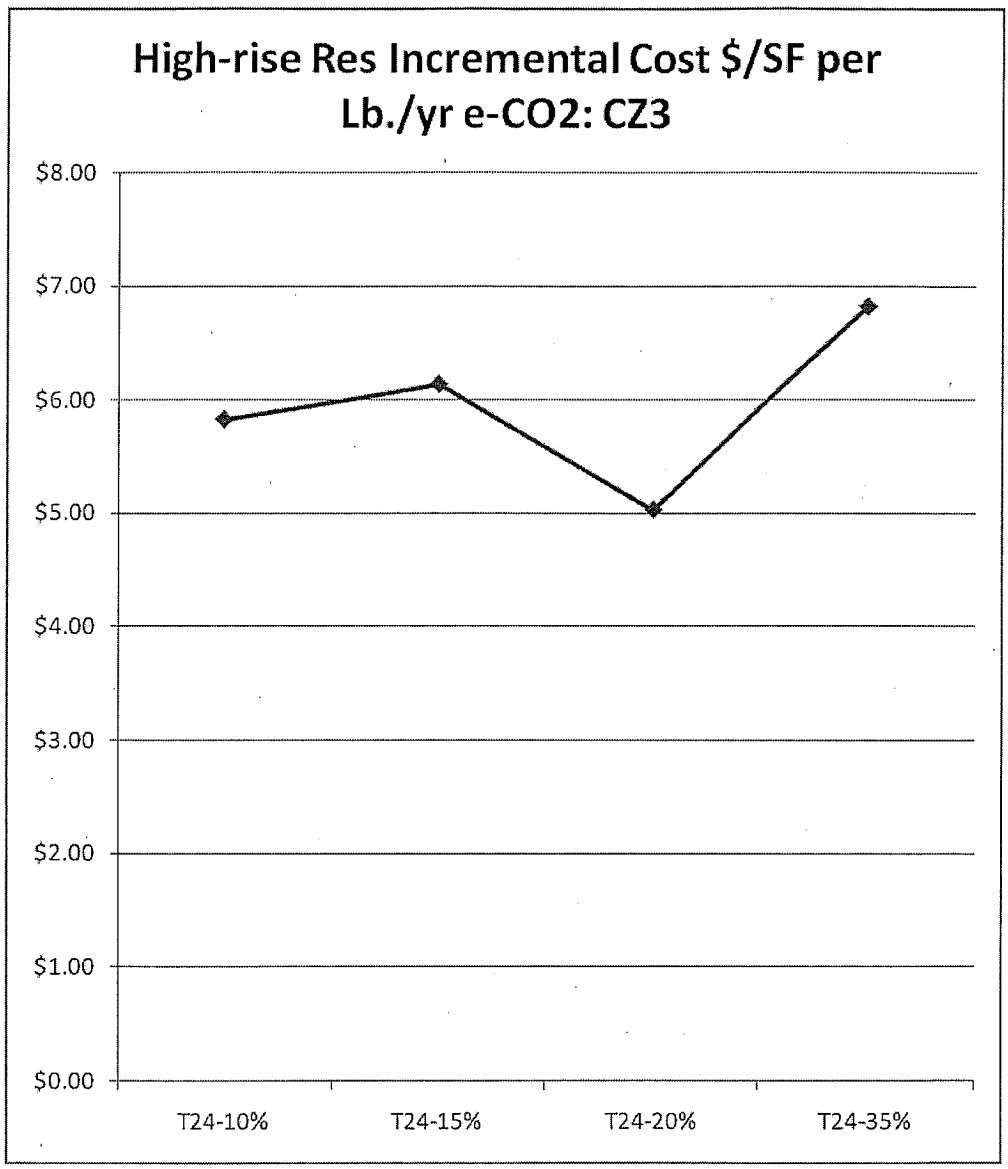


Figure 4-CZ3d-5: Added Cost/Sq.ft. per Lb. of CO2 Reduction – 21,160 sf 2-Story Nonresidential Building

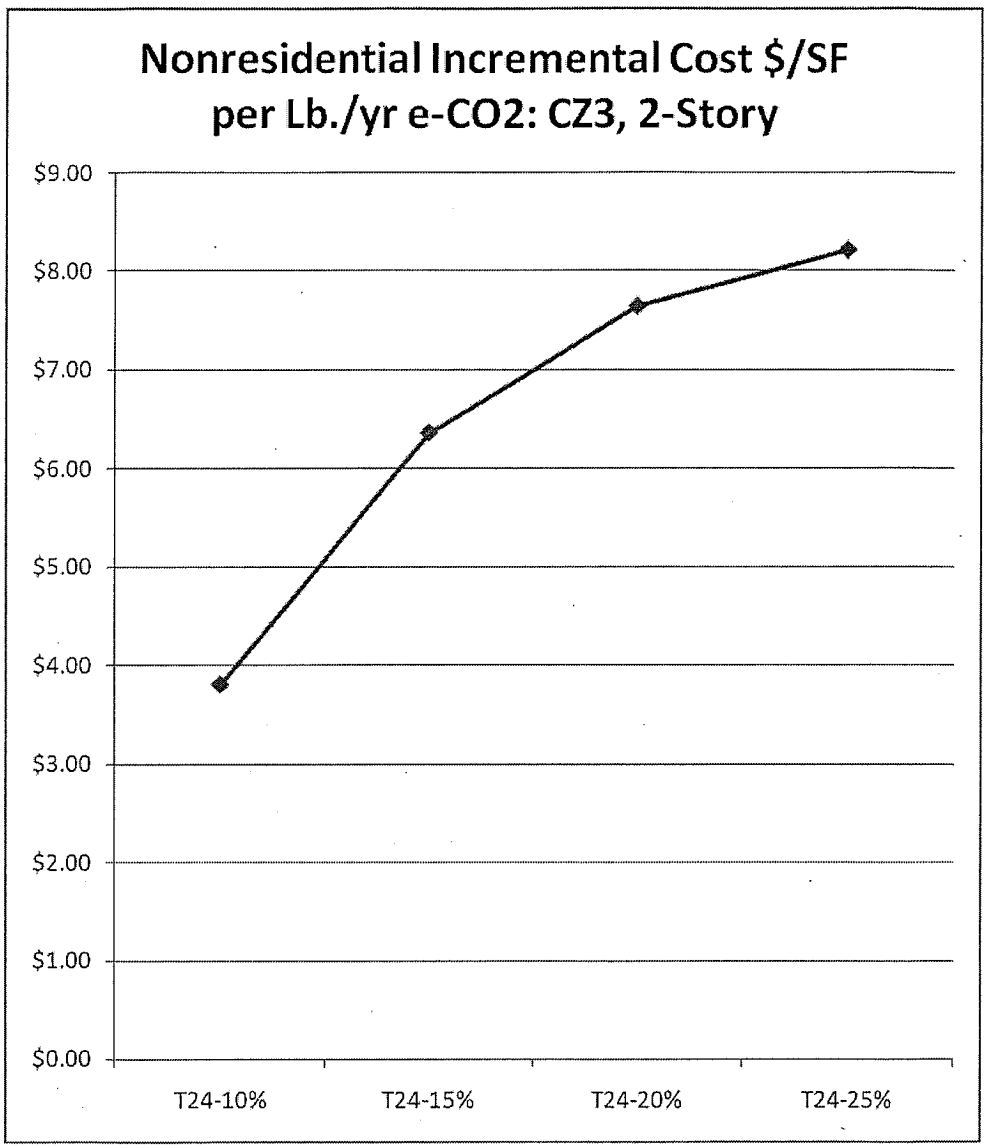


Figure 4-CZ3d-6: Added Cost/Sq.ft. per Lb. of CO2 Reduction – 52,900 sf 5-Story Nonresidential Building

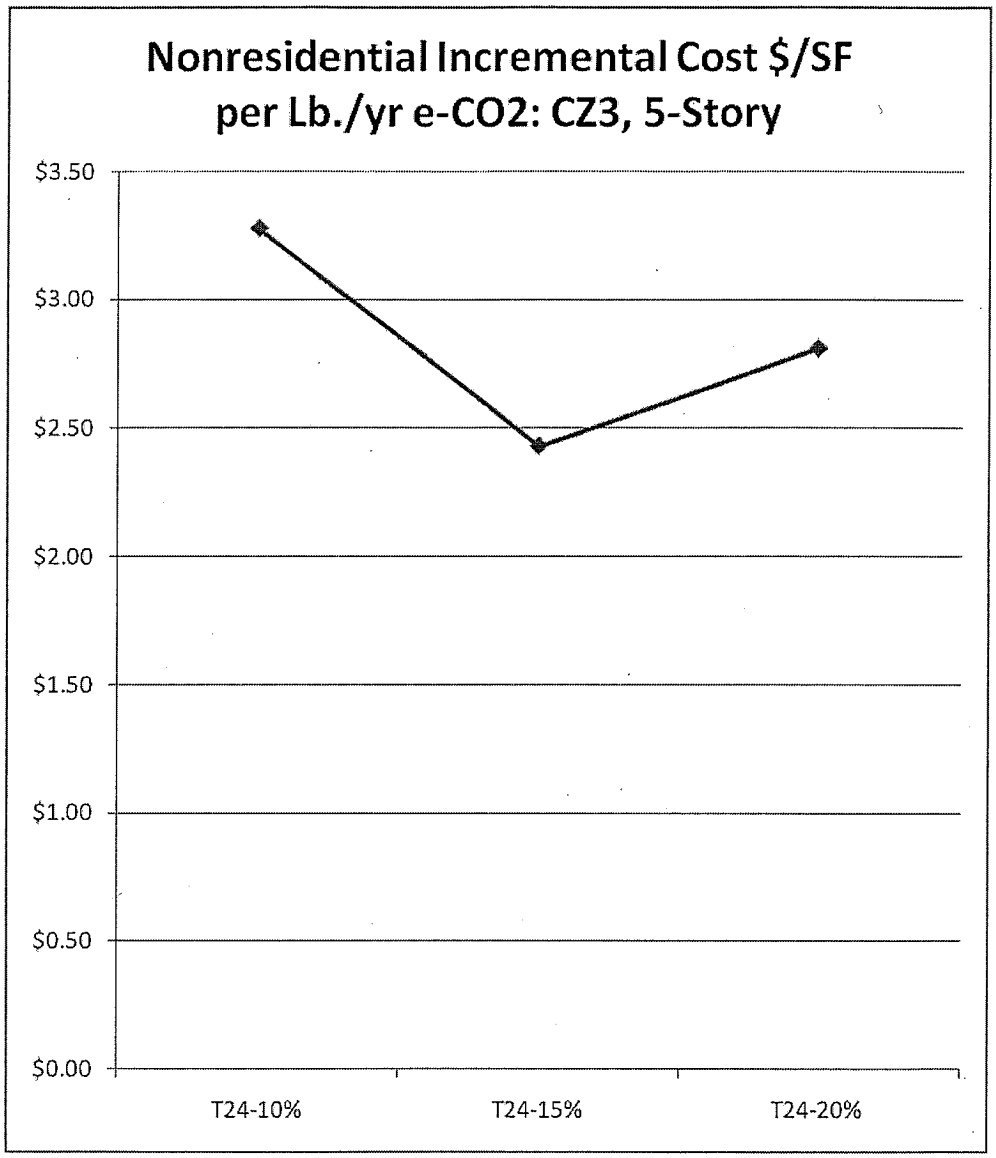


Figure 4-CZ3e-1: Annual Reduction in CO2 in Lbs./Sq.Ft. in Single Family – 2,025 sf 2-Story Single Family Home

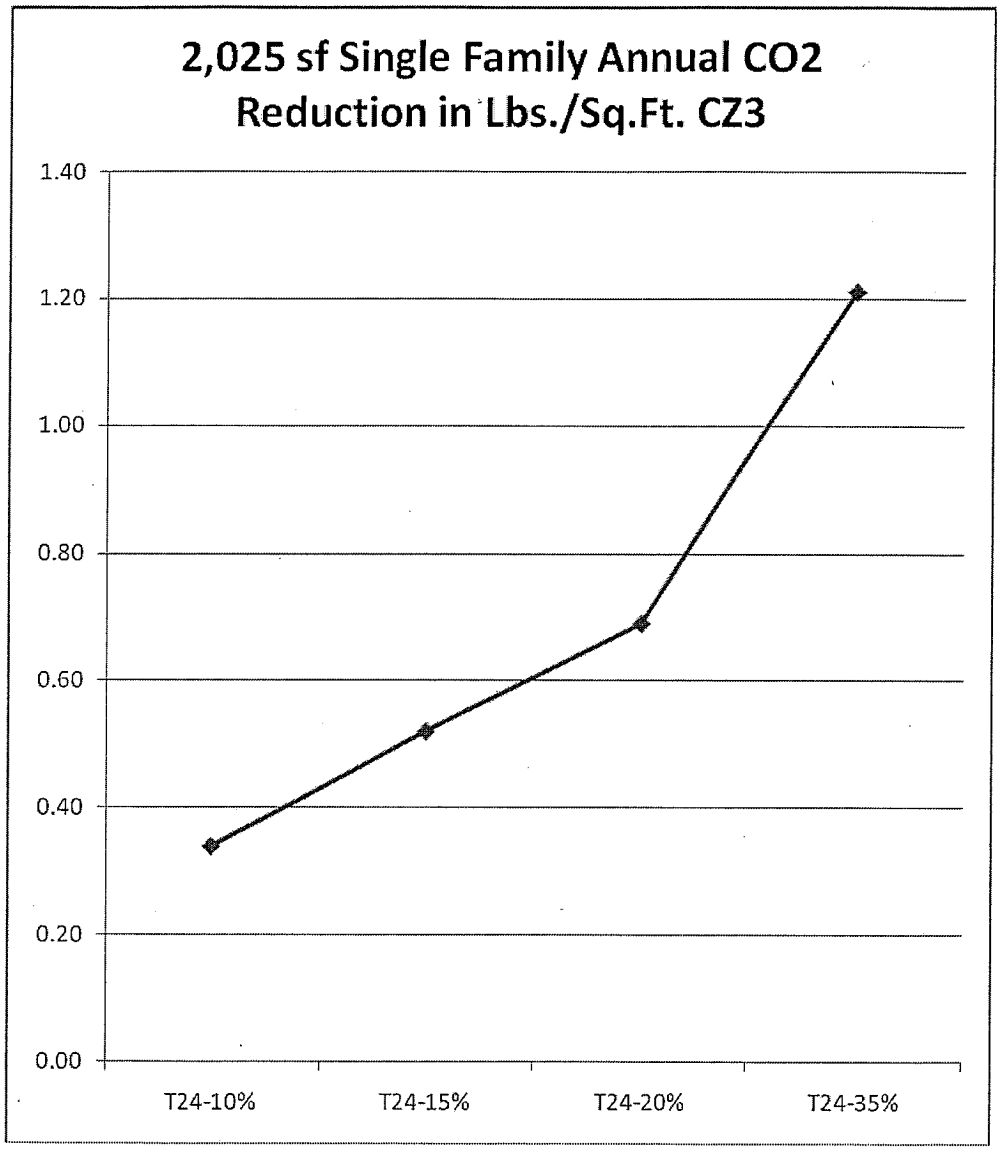


Figure 4-CZ3e-2: Annual Reduction in CO2 in Lbs./Sq.Ft. in Single Family – 1,582 sf 1-Story Single Family Home

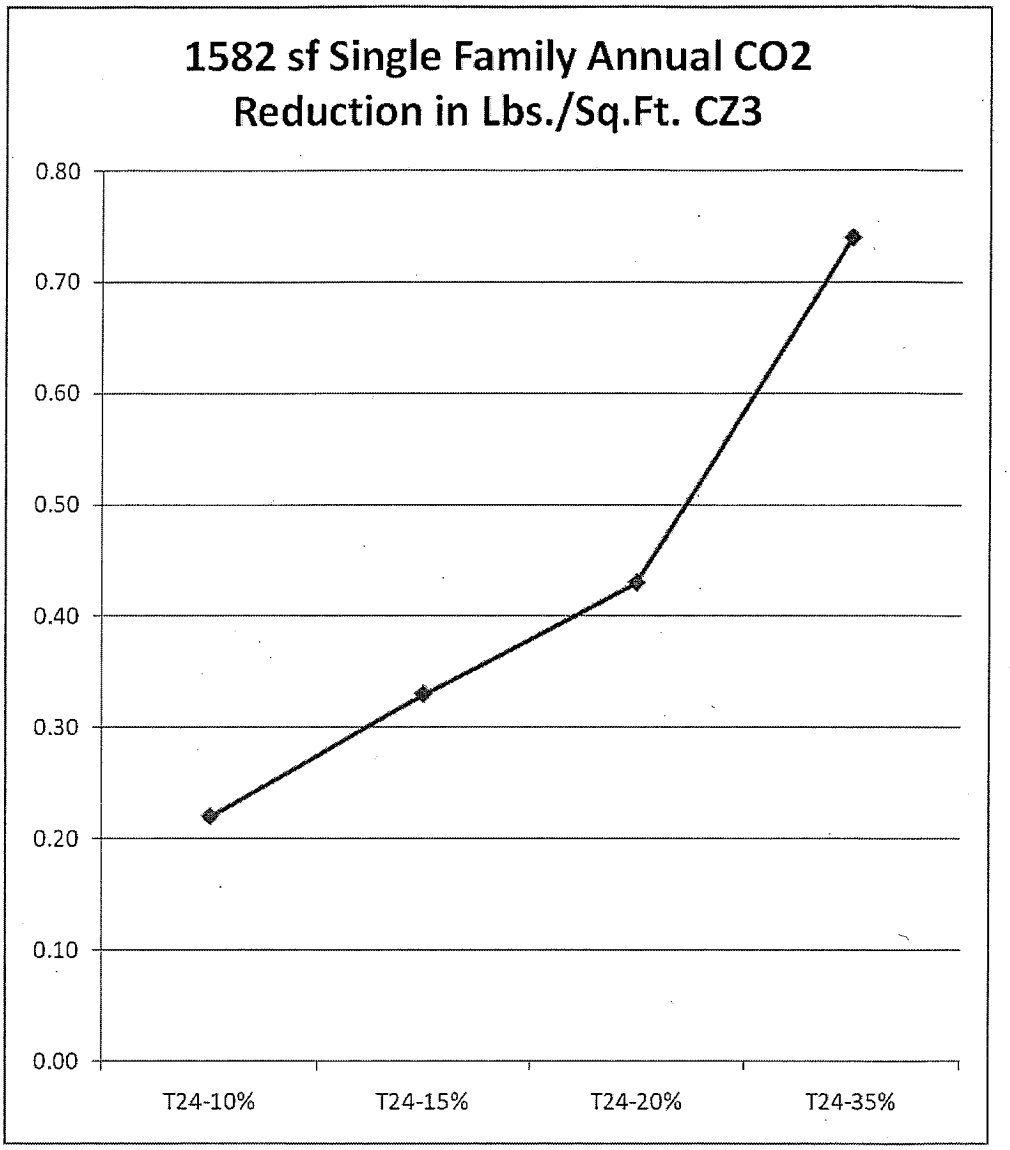


Figure 4-CZ3e-3: Annual Reduction in CO2 in Lbs./Sq.Ft., 2-Story Multifamily Building

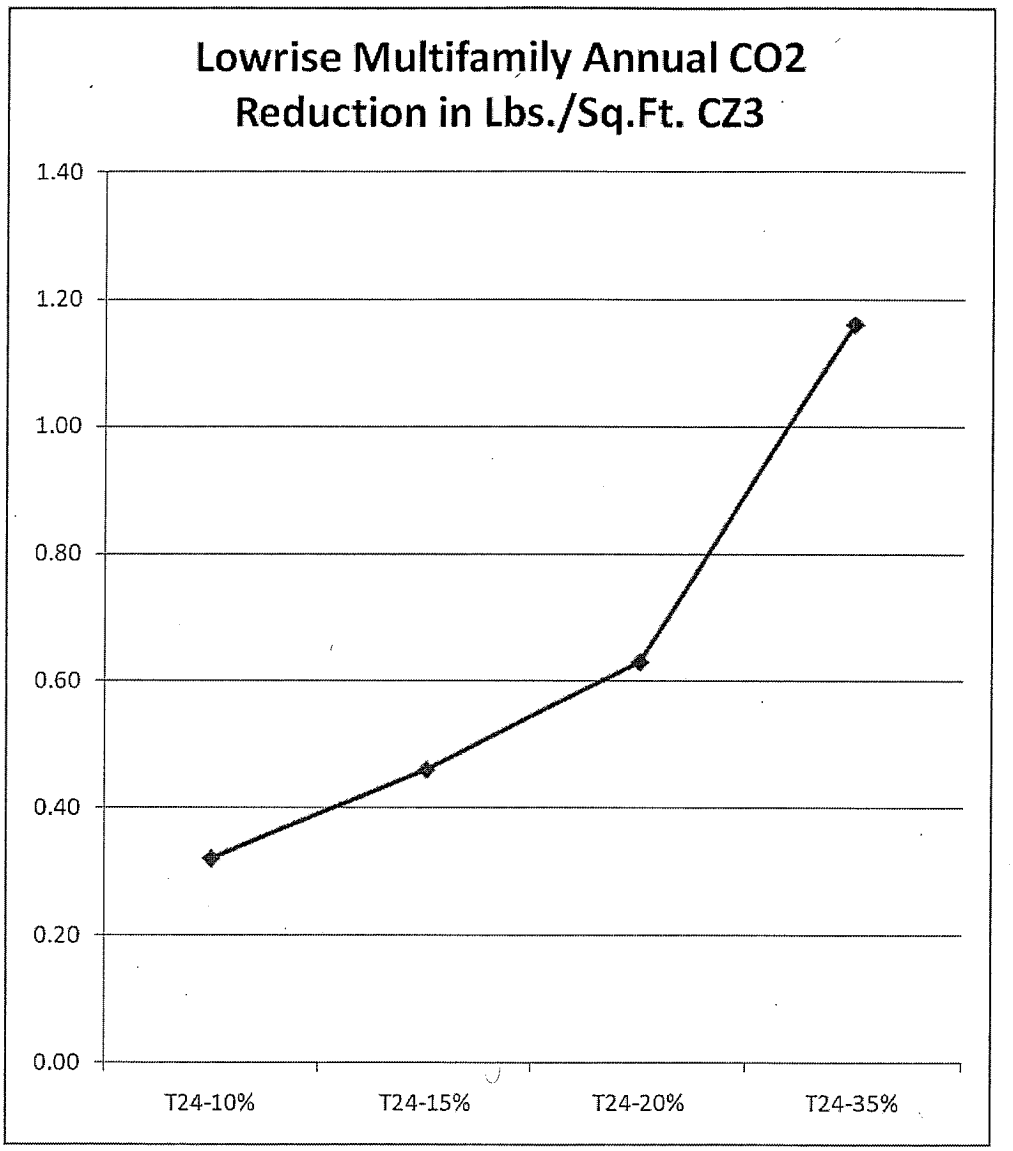


Figure 4-CZ3e-4: Annual Reduction in CO2 in Lbs./Sq.Ft., 40 Unit, 5-Story High-rise Residential Building

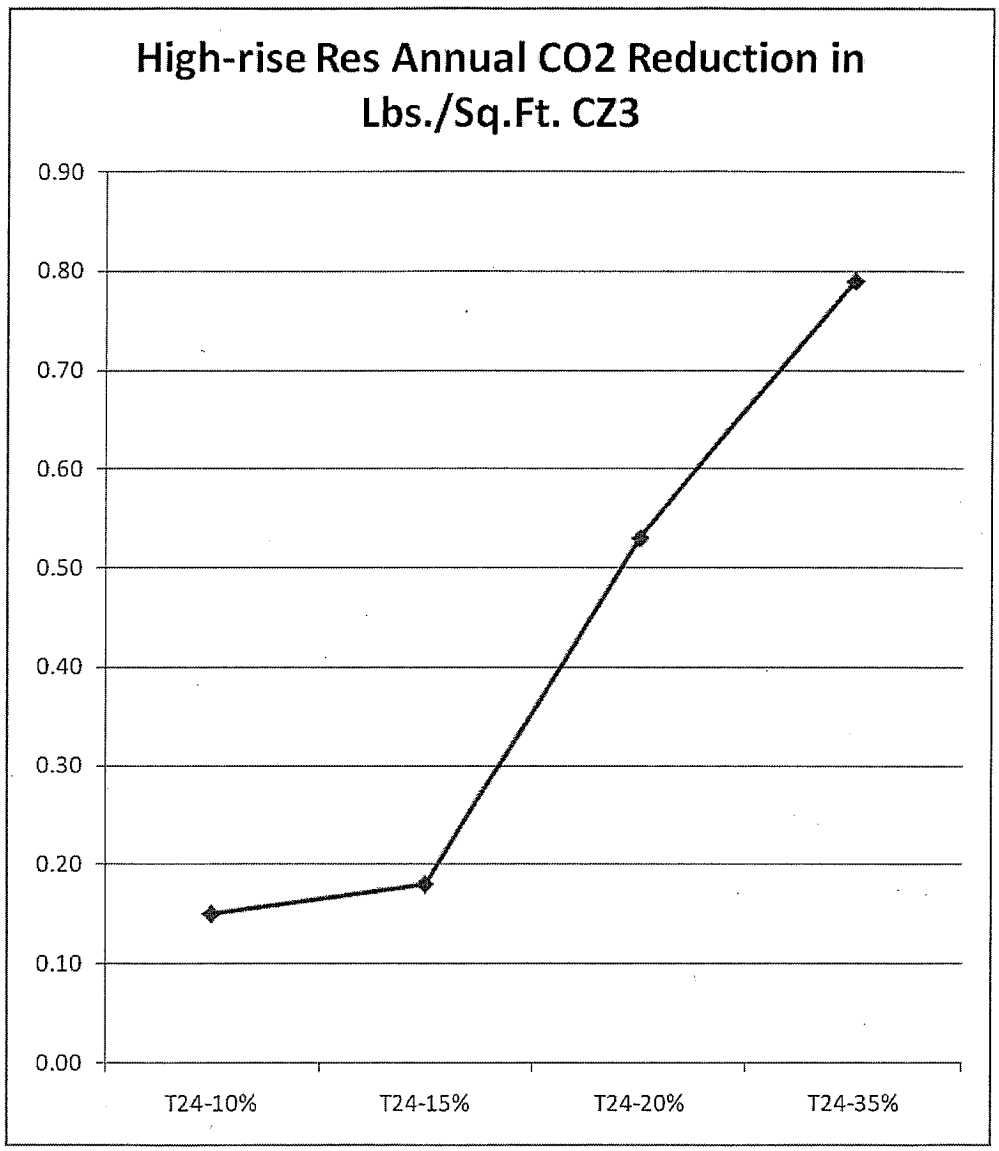


Figure 4-CZ3e-5: Annual Reduction in CO2 in Lbs./Sq.Ft., 21,160 sf 2-Story Nonresidential Building

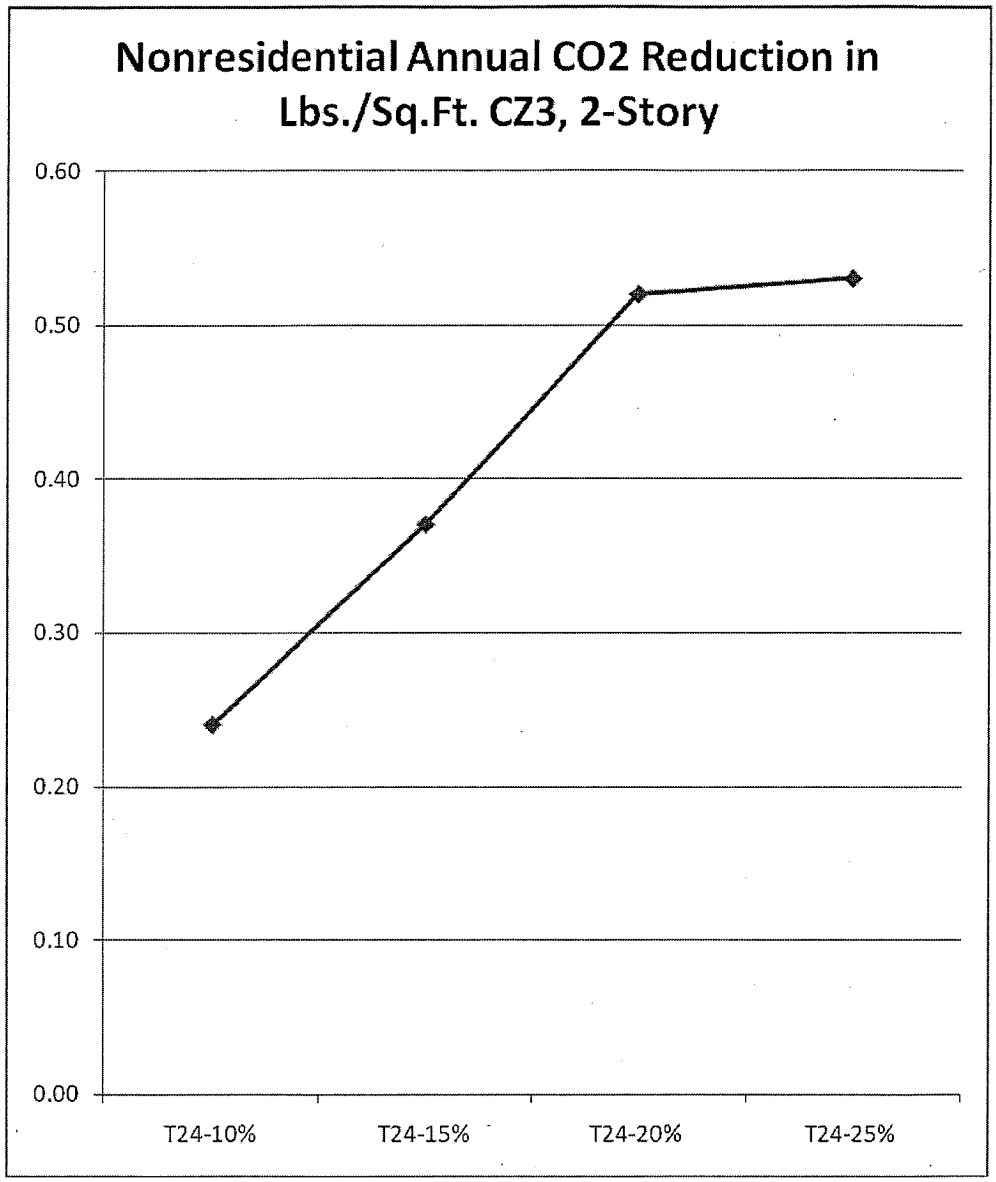
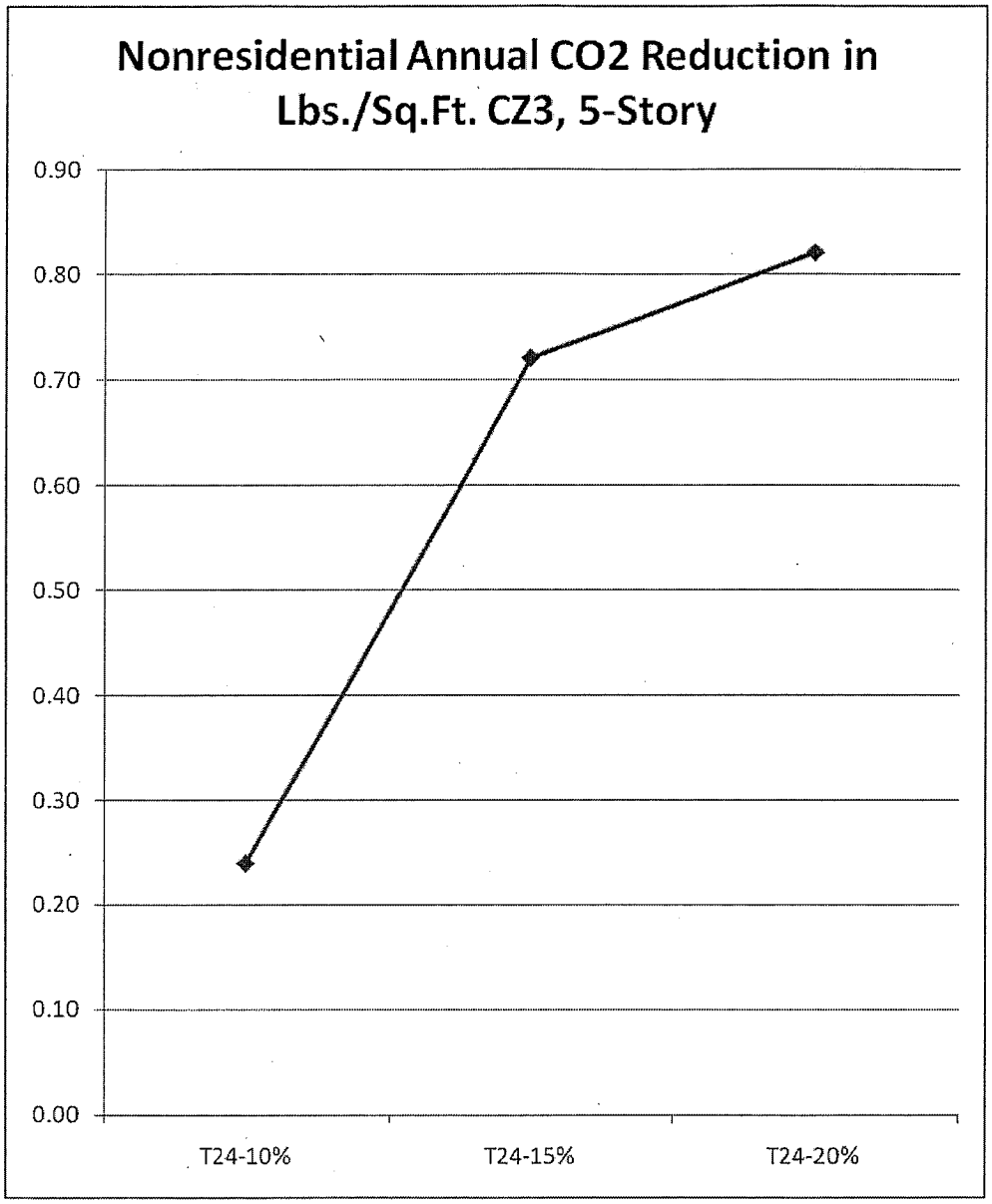
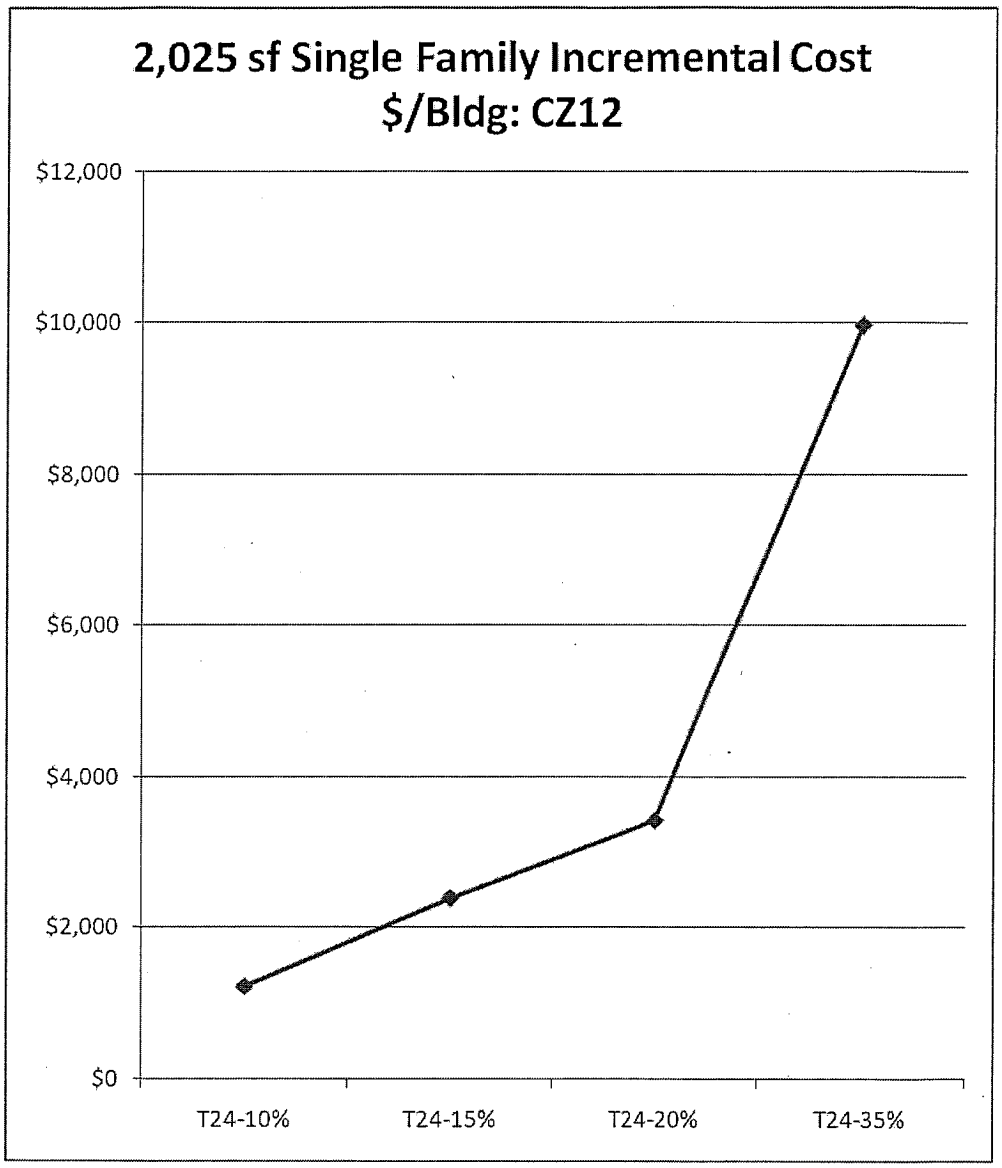


Figure 4-CZ3e-6: Annual Reduction in CO2 in Lbs./Sq.Ft., 52,900 sf 5-Story Nonresidential Building



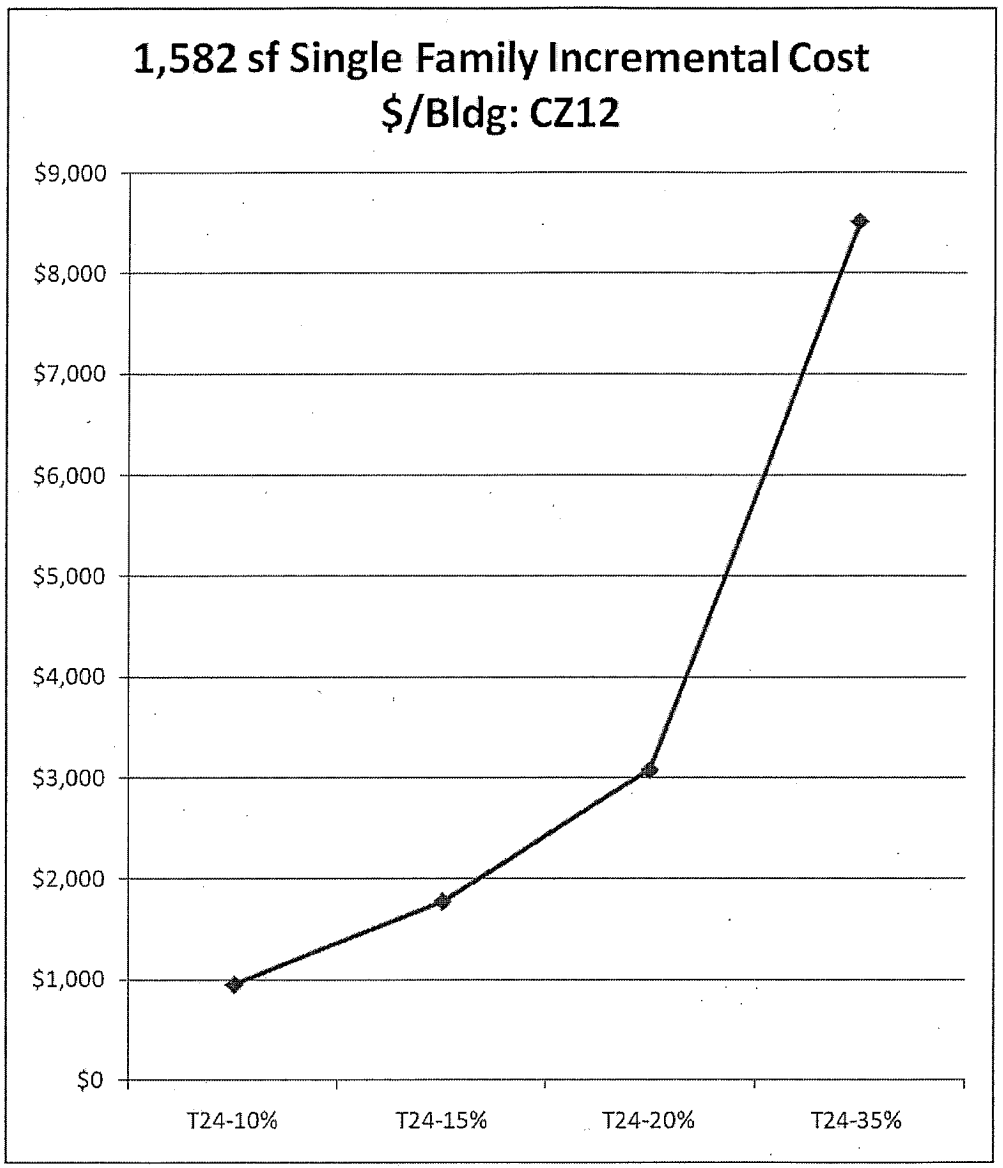
4.2 CLIMATE ZONE #12 CHARTS ILLUSTRATING RESULTS

Figure 4-CZ12a-1: Added First Cost – 2,025 sf 2-Story Single Family Home



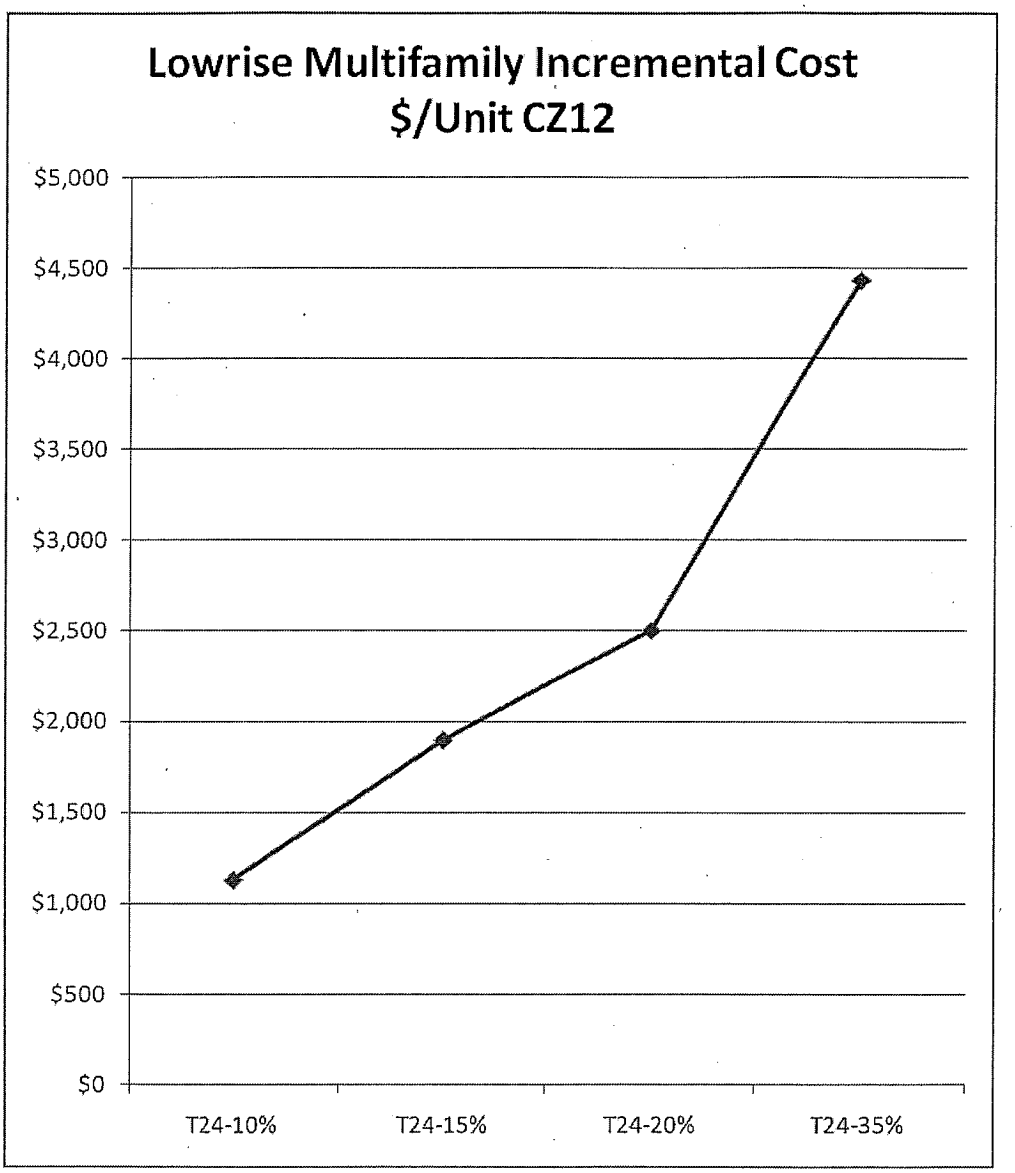
The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $975 per square foot in this single family house design.

Figure 4-CZ12a-2: Added First Cost – 1,582 sf 1-Story Single Family Home



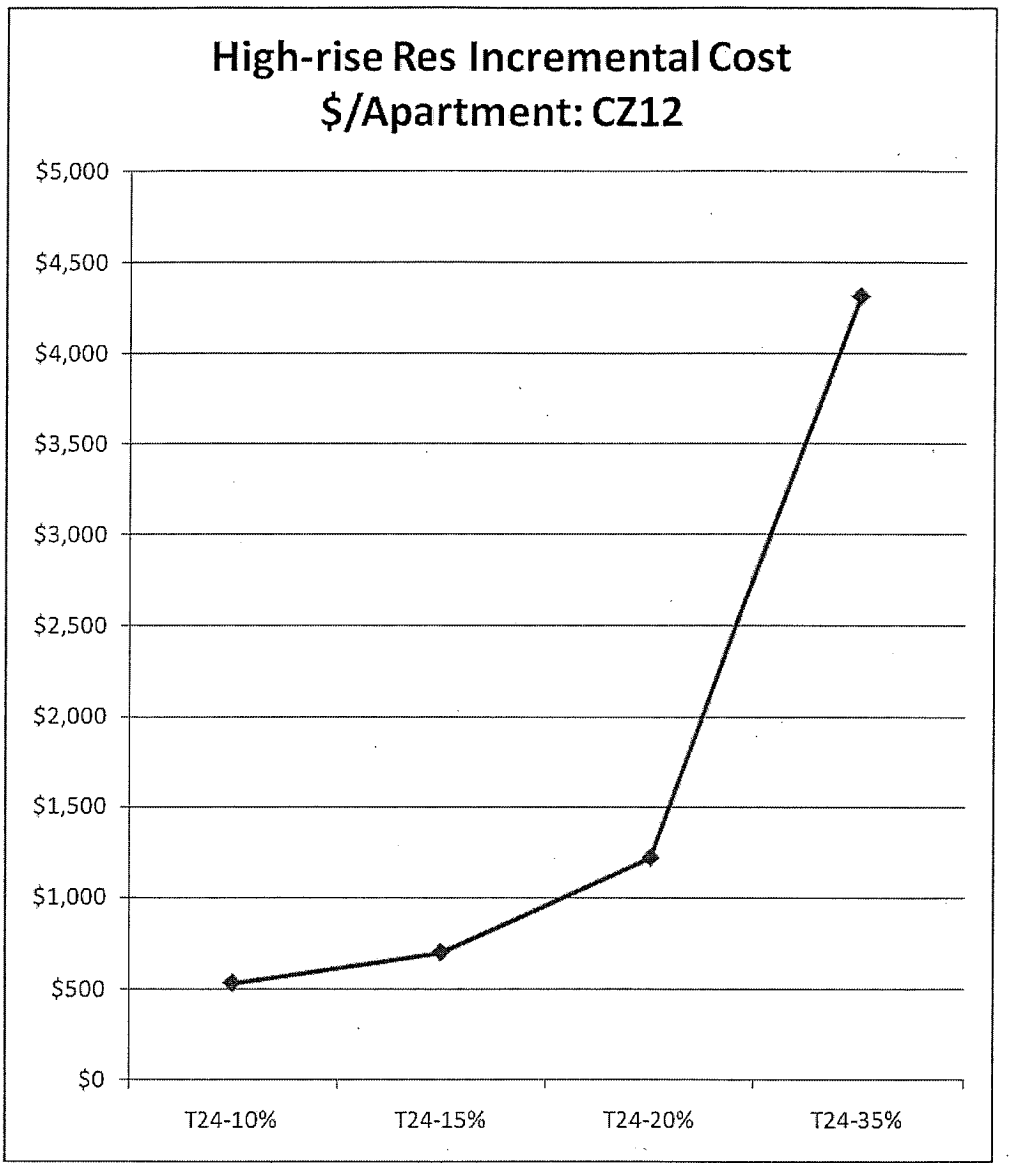
The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $825 per square foot in this single family house design.

Figure 4-CZ12a-3: Added First Cost/Dwelling Unit, 2-Story Multifamily Building



The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $383 per dwelling unit in this multifamily building design.

Figure 4-CZ12a-4: Added First Cost, 40 Unit, 5-Story High-rise Residential Building



The average incremental energy measures to go from the 2005 standards to the 2008 standards cost $0 per dwelling unit in this high-rise residential building design. (No changes in the building design were required to meet the 2008 standards.)

Figure 4-CZ12a-5: Added First Cost -- 21,160 sf 2-Story Nonresidential Building

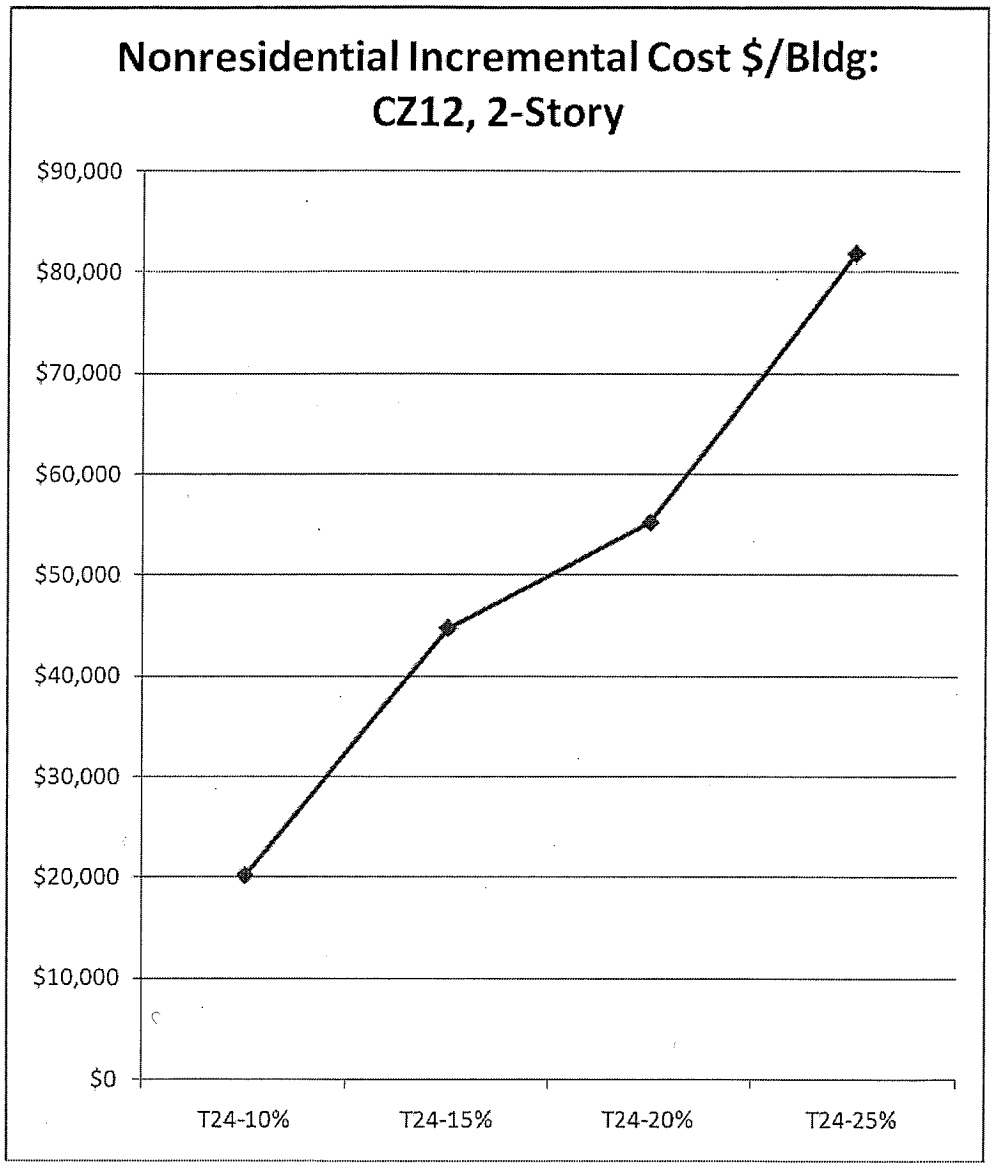


Figure 4-CZ12a-6: Added First Cost -- 52,900 sf 5-Story Nonresidential Building

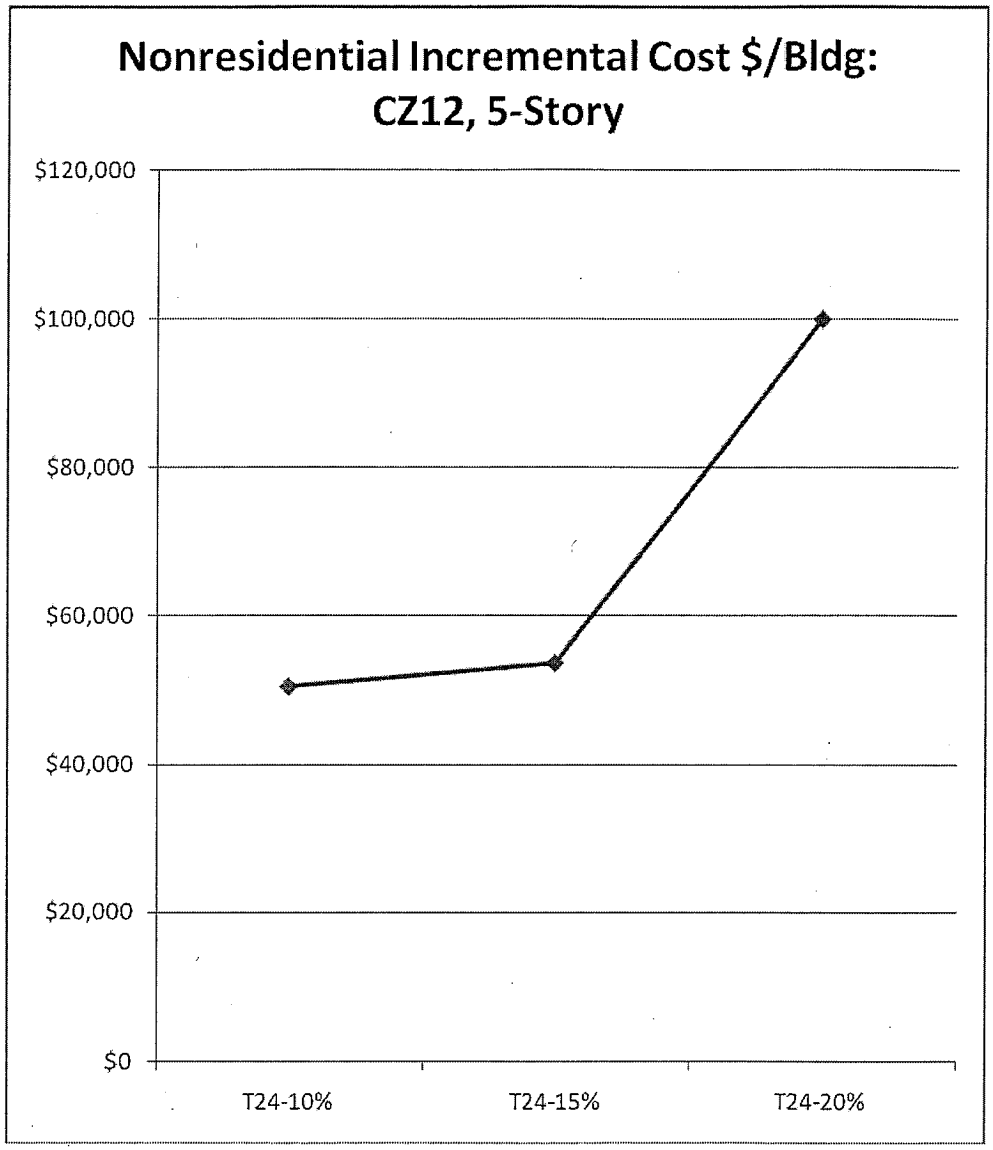


Figure 4-CZ12b-1: Added First Cost/Sq.Ft. – 2,025 sf 2-Story Single Family Home

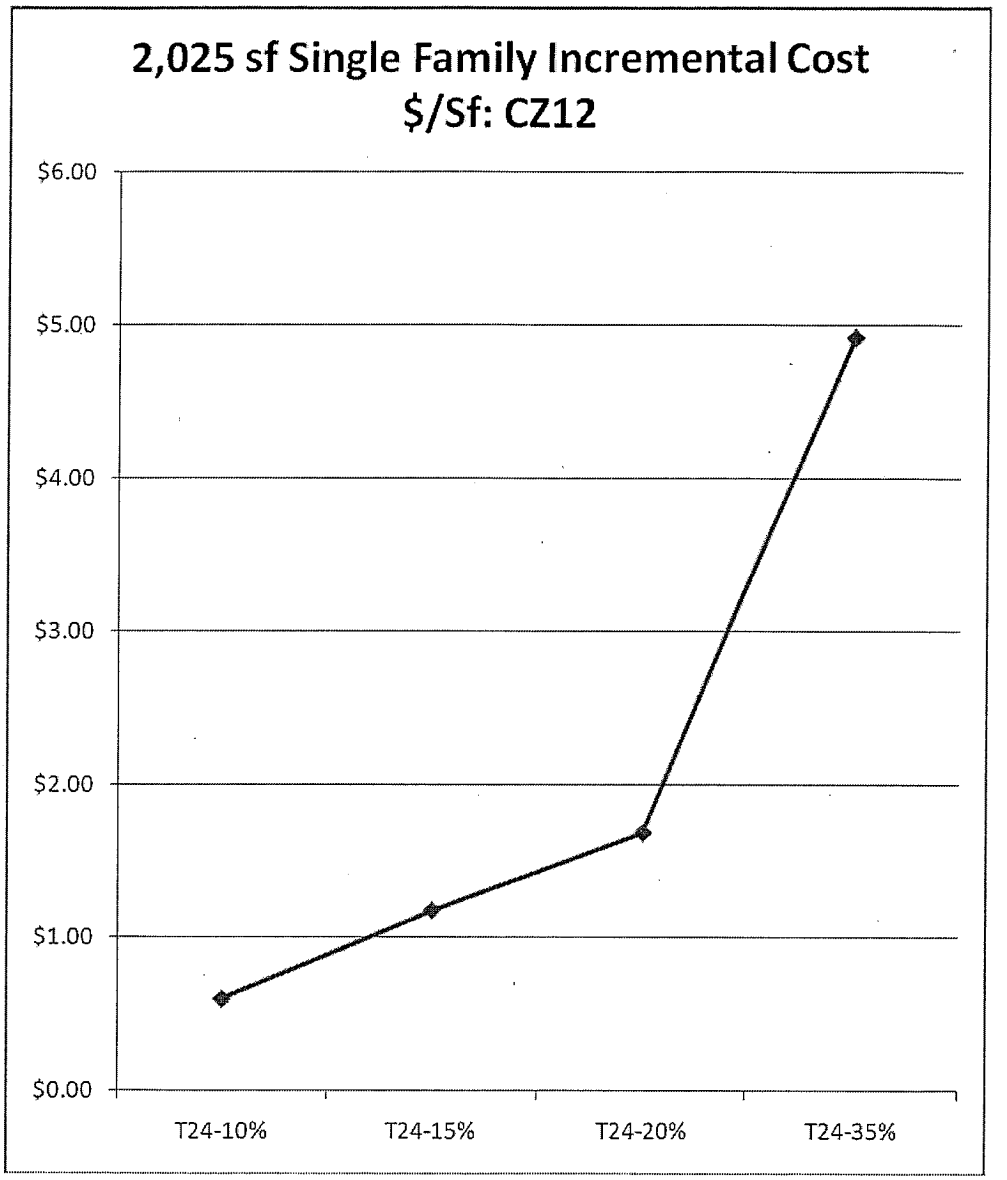


Figure 4-CZ12b-2: Added First Cost/Sq.Ft., – 1,582 sf 1-Story Single Family Home

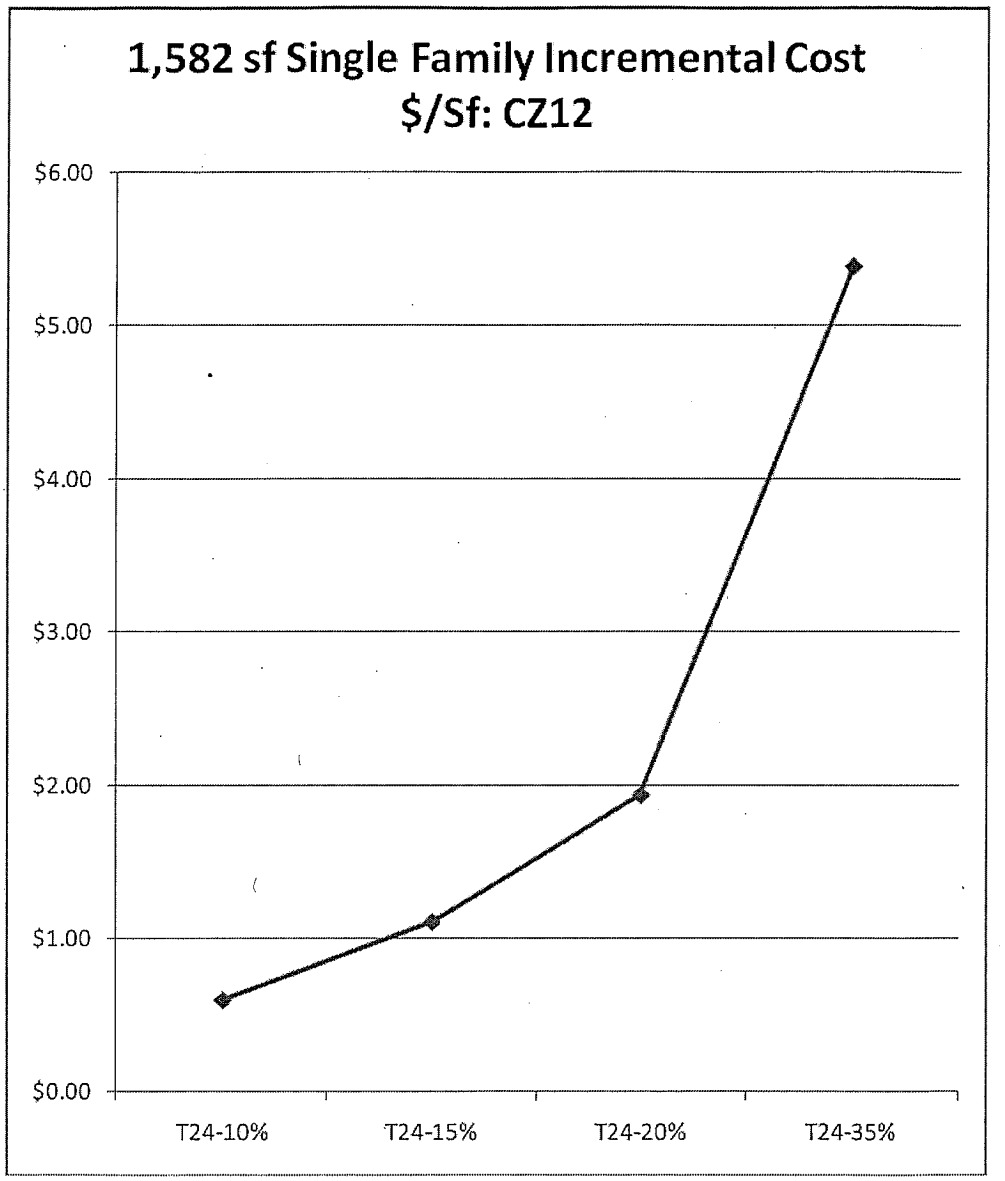


Figure 4-CZ12b-3: Added First Cost/Sq.Ft., 2-Story Multifamily Building

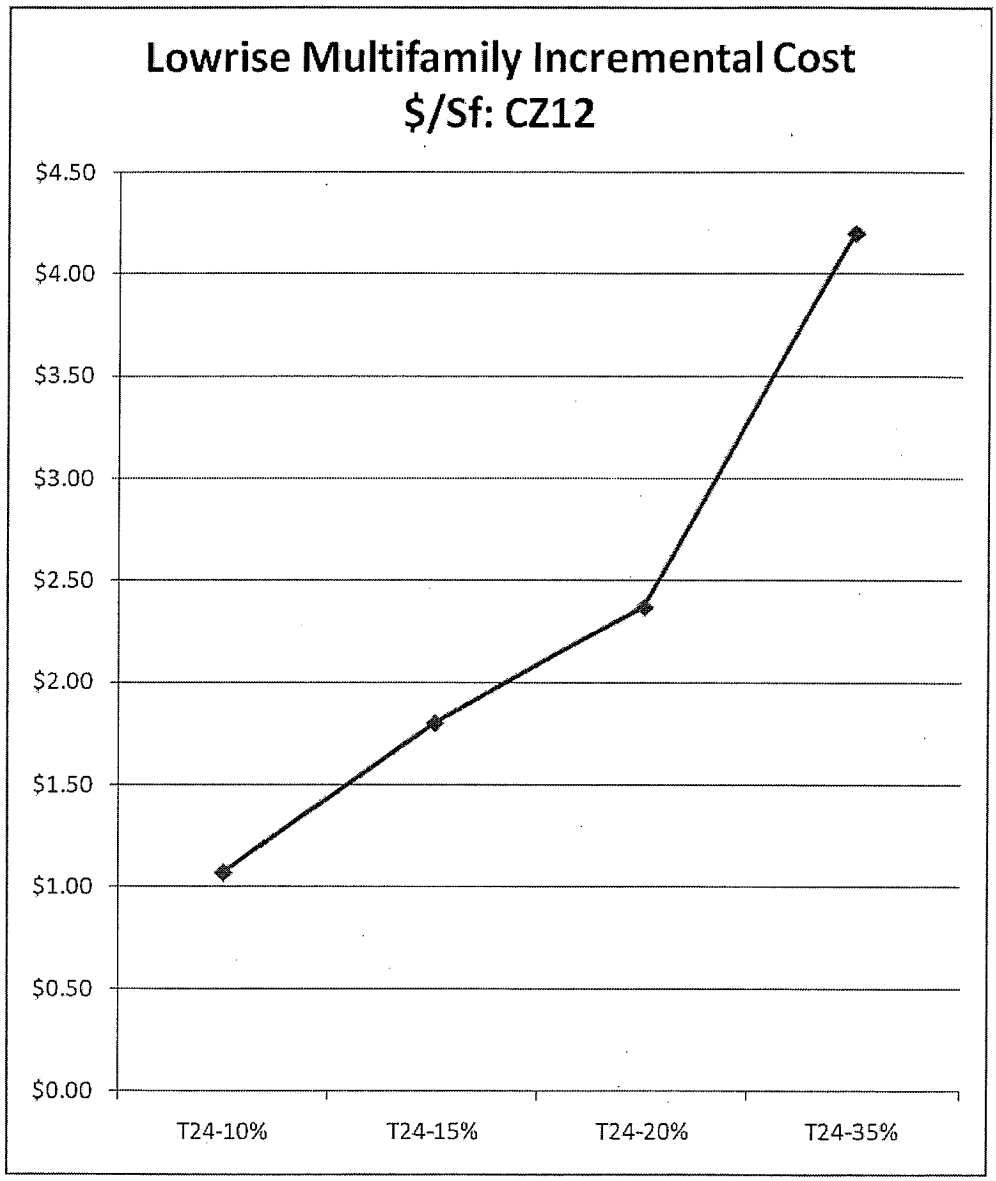


Figure 4-CZ12b-4: Added First Cost/Sq.Ft.
40 Unit, 5-Story High-rise Residential Building

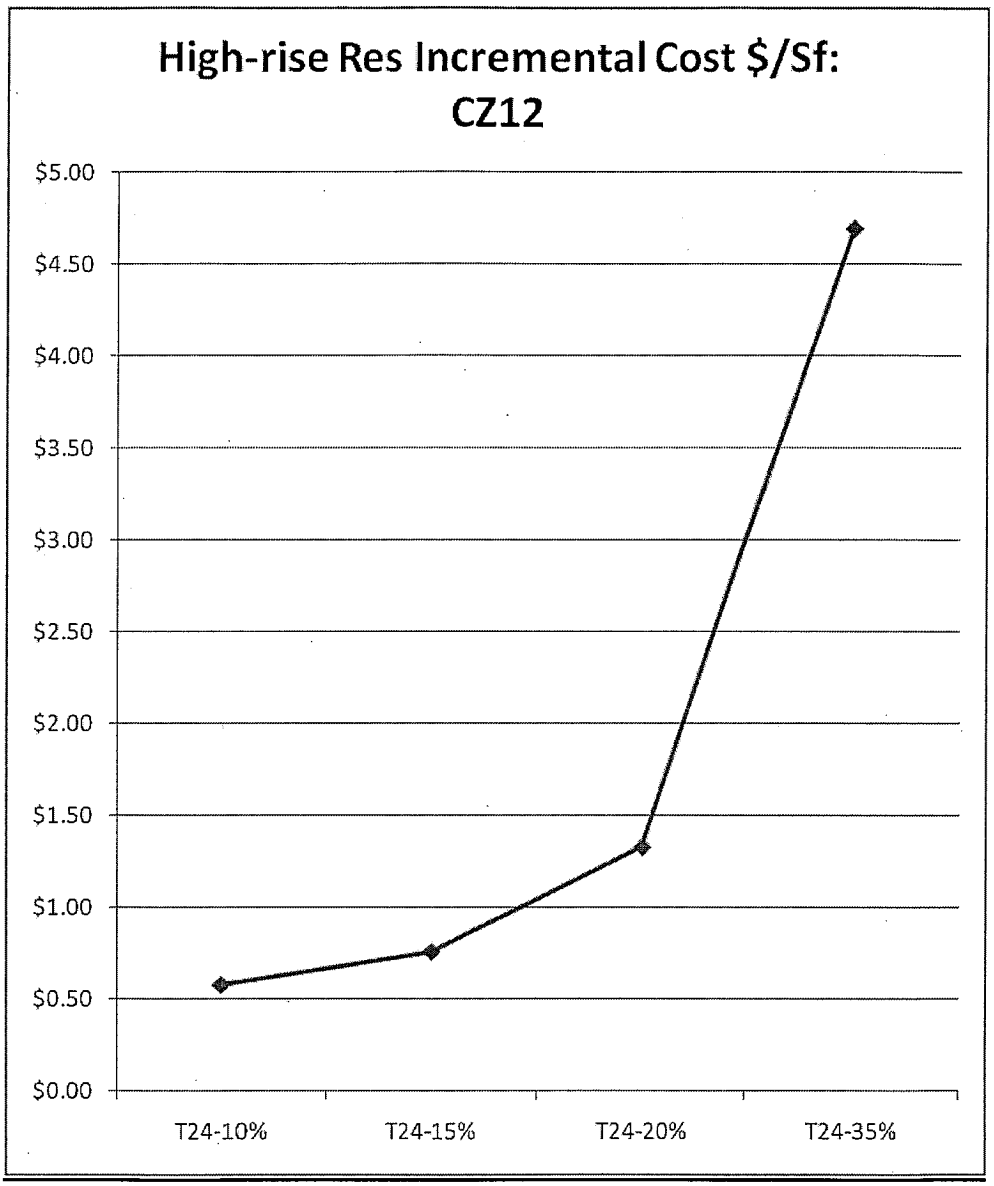


Figure 4-CZ12-b5: Added First Cost/Sq.Ft. -- 21,160 sf 2-Story Nonresidential Bldg

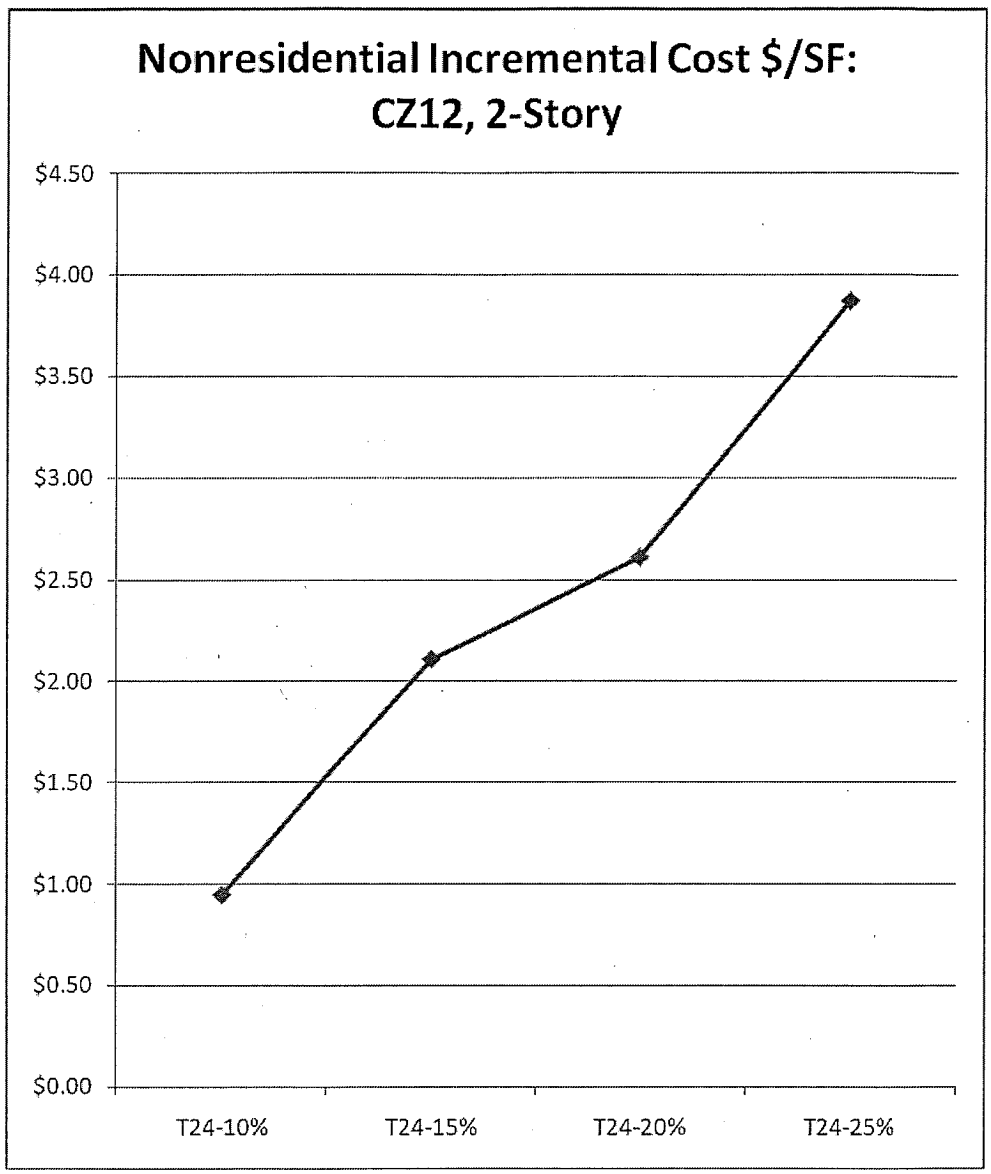


Figure 4-CZ12-b6: Added First Cost/Sq.Ft. -- 52,900 sf 5-Story Nonresidential Bldg

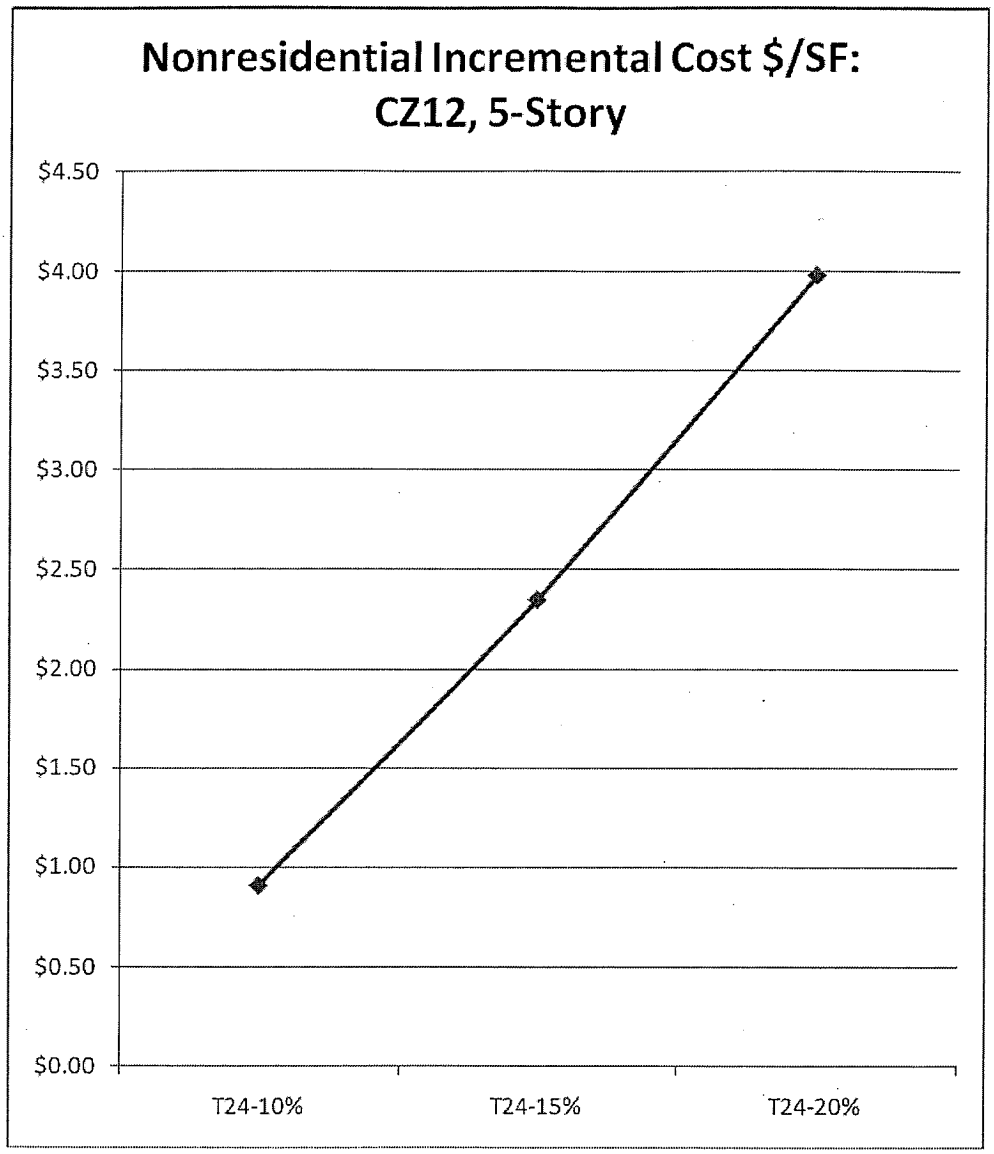


Figure 4-CZ12c-1: Simple Payback of Different Tiers of Energy Measures – 2,025 sf 2-Story Single Family Home

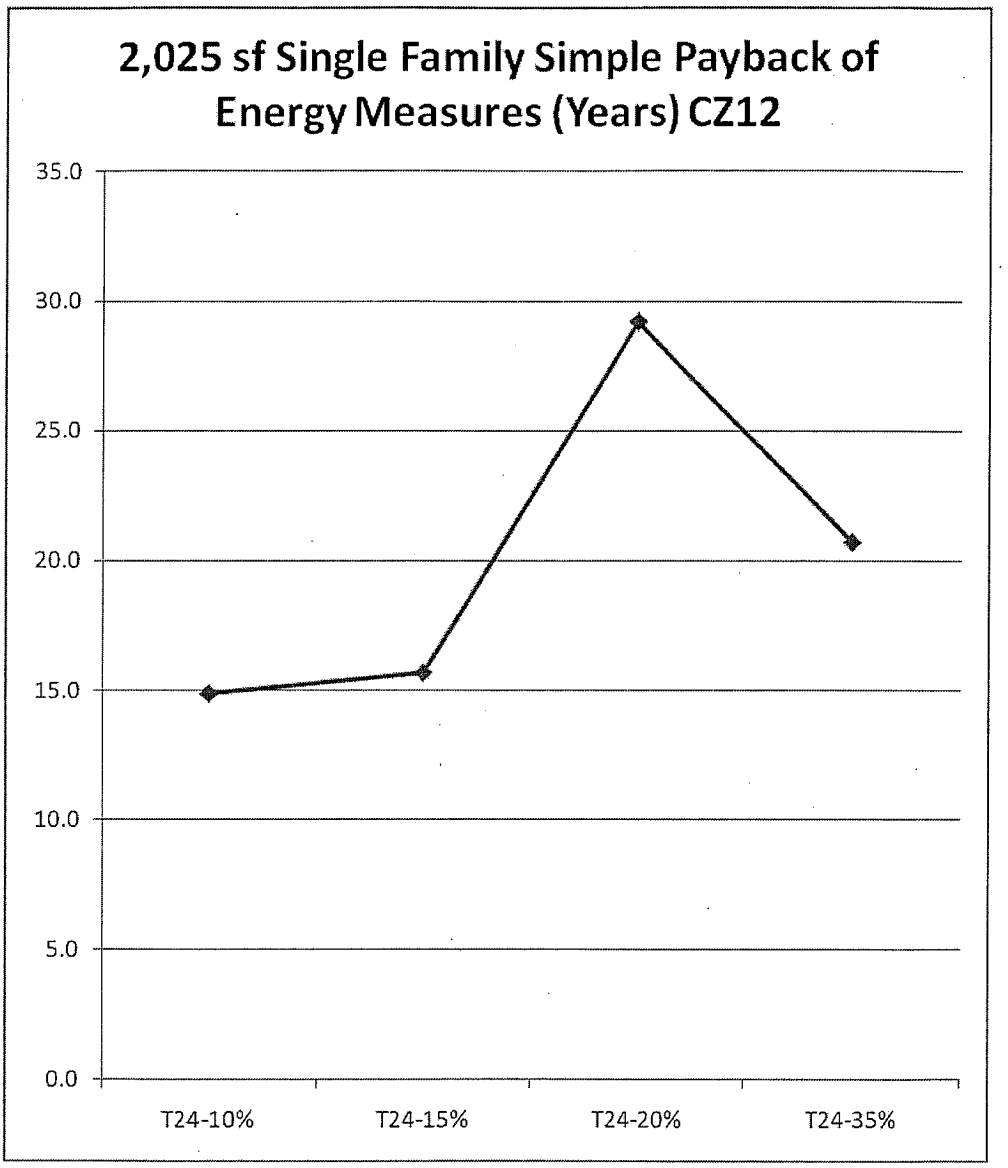


Figure 4-CZ12c-2: Simple Payback of Different Tiers of Energy Measures – 1,582 sf 1-Story Single Family Home

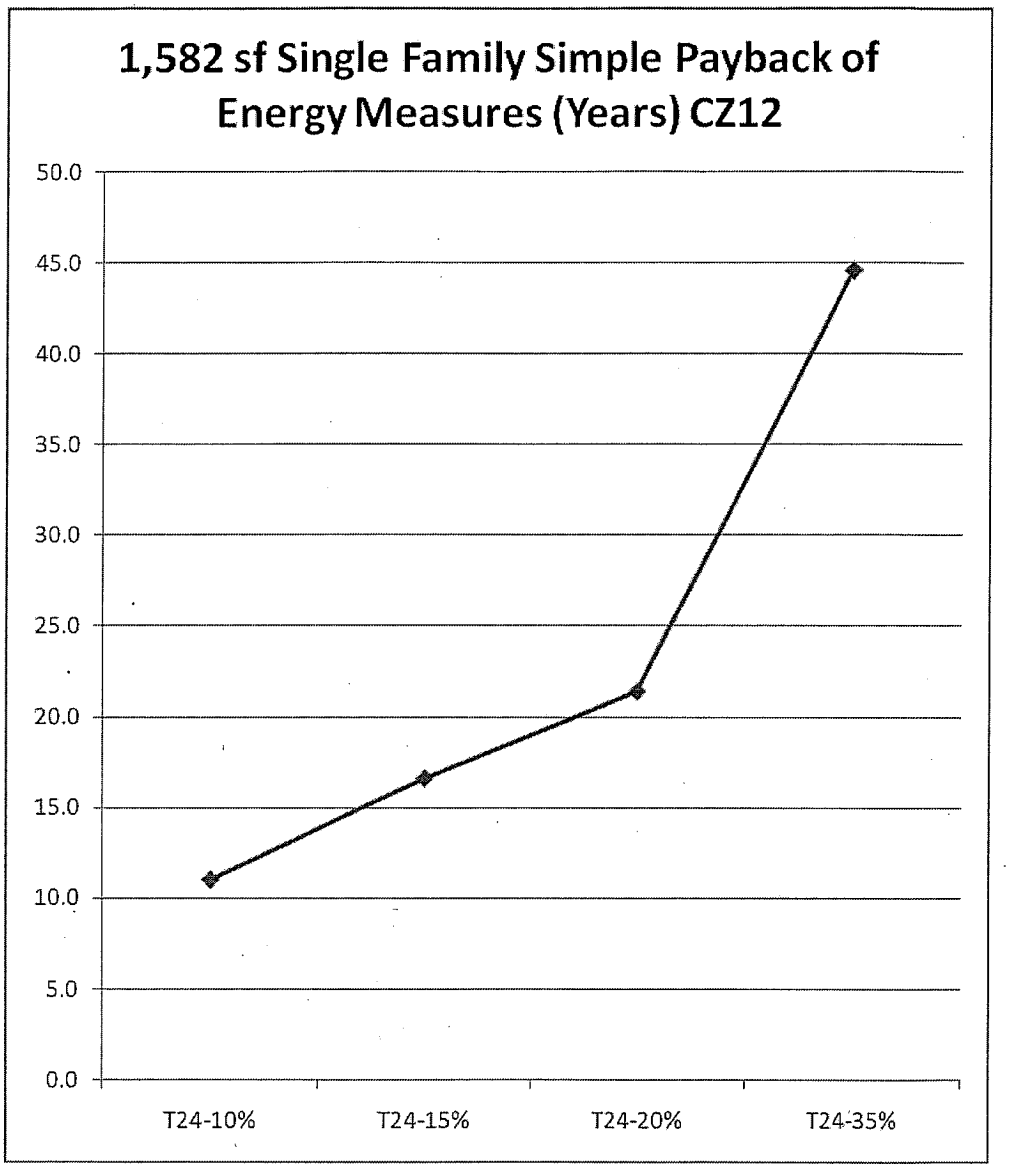


Figure 4-CZ12c-3: Simple Payback of Different Tiers of Energy Measures, 2-Story Multifamily Building

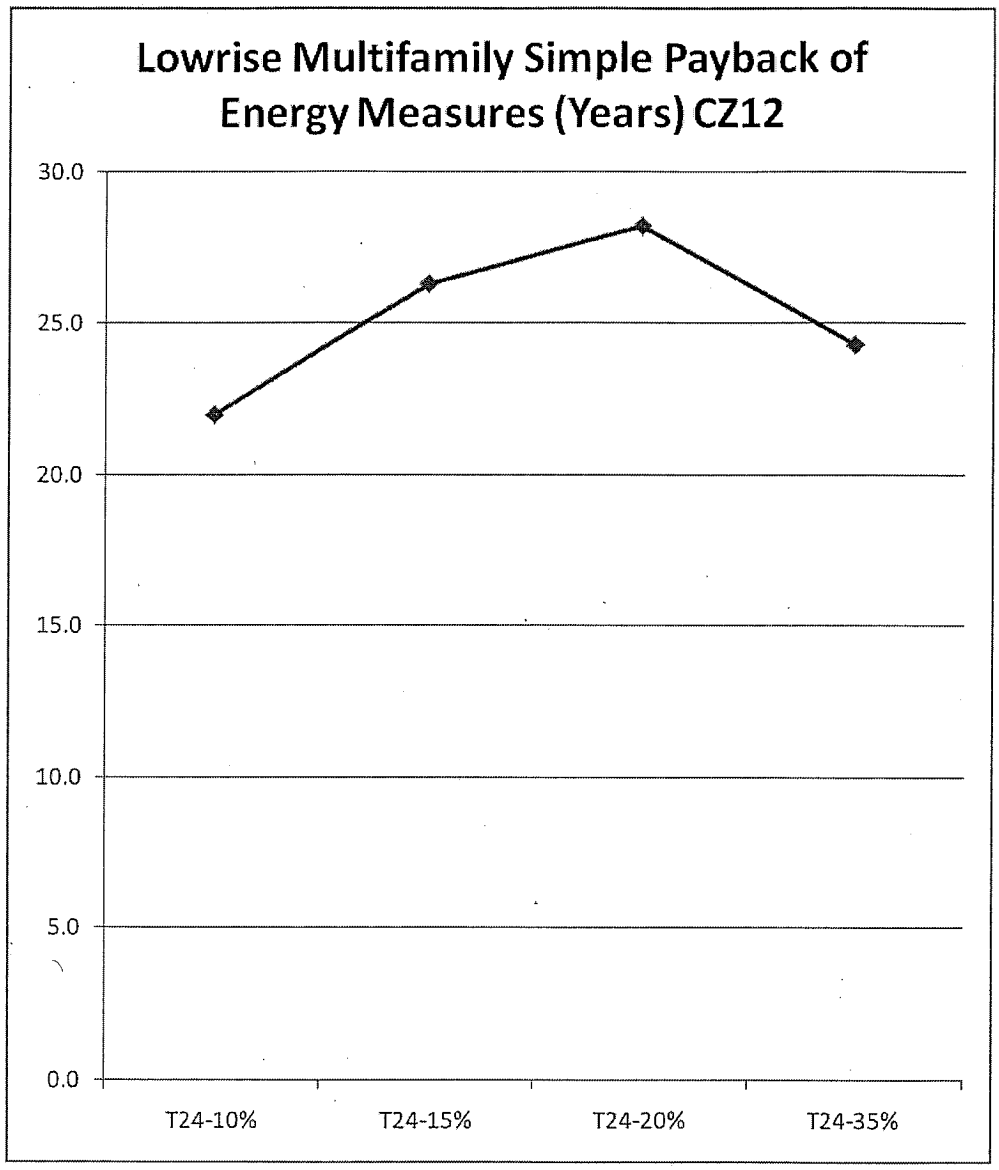


Figure 4-CZ12c-4: Simple Payback of Different Tiers of Energy Measures, 40 Unit, 5-Story High-rise Residential Building

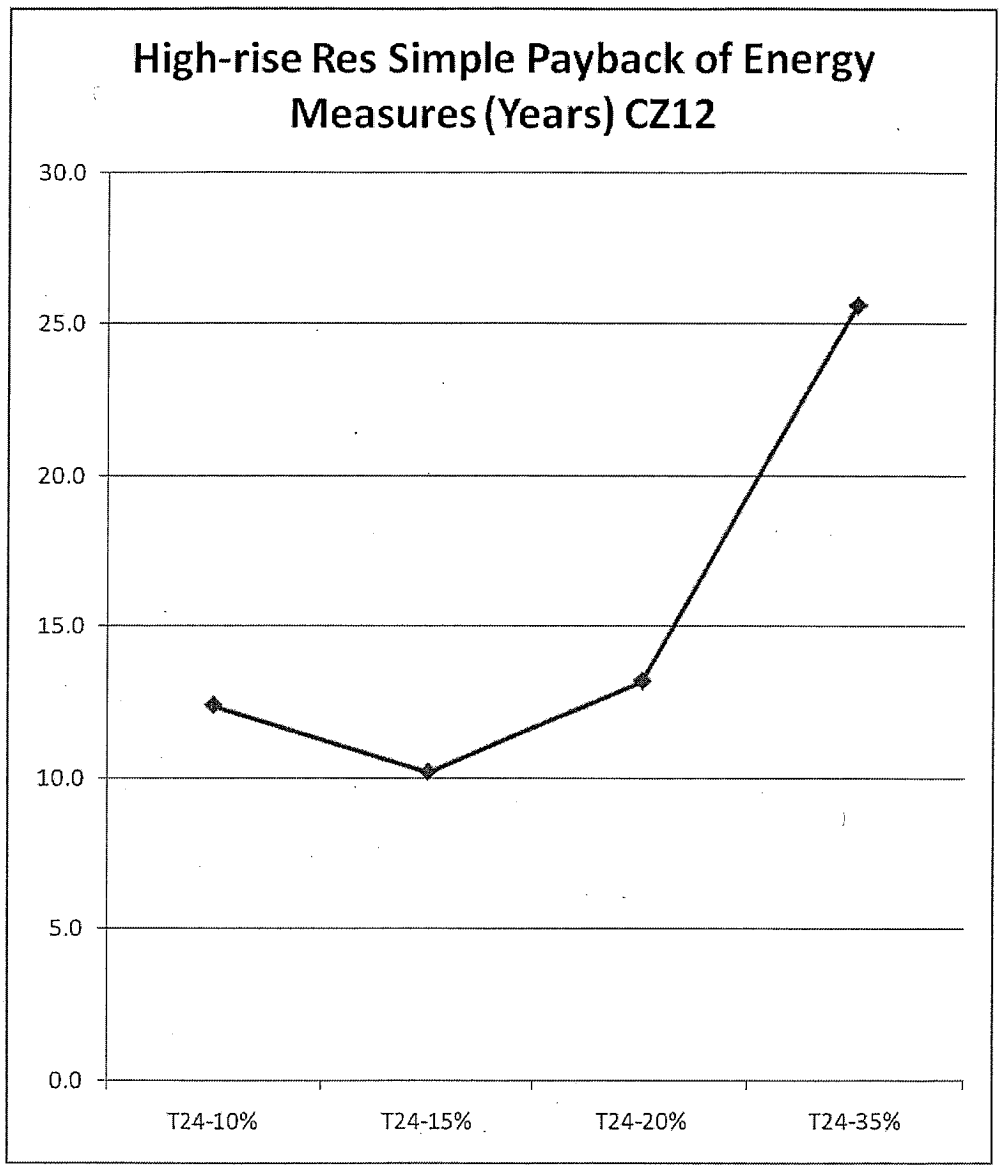


Figure 4-CZ12c-5: Simple Payback of Different Tiers of Energy Measures, 21,160 sf 2-Story Nonresidential Building

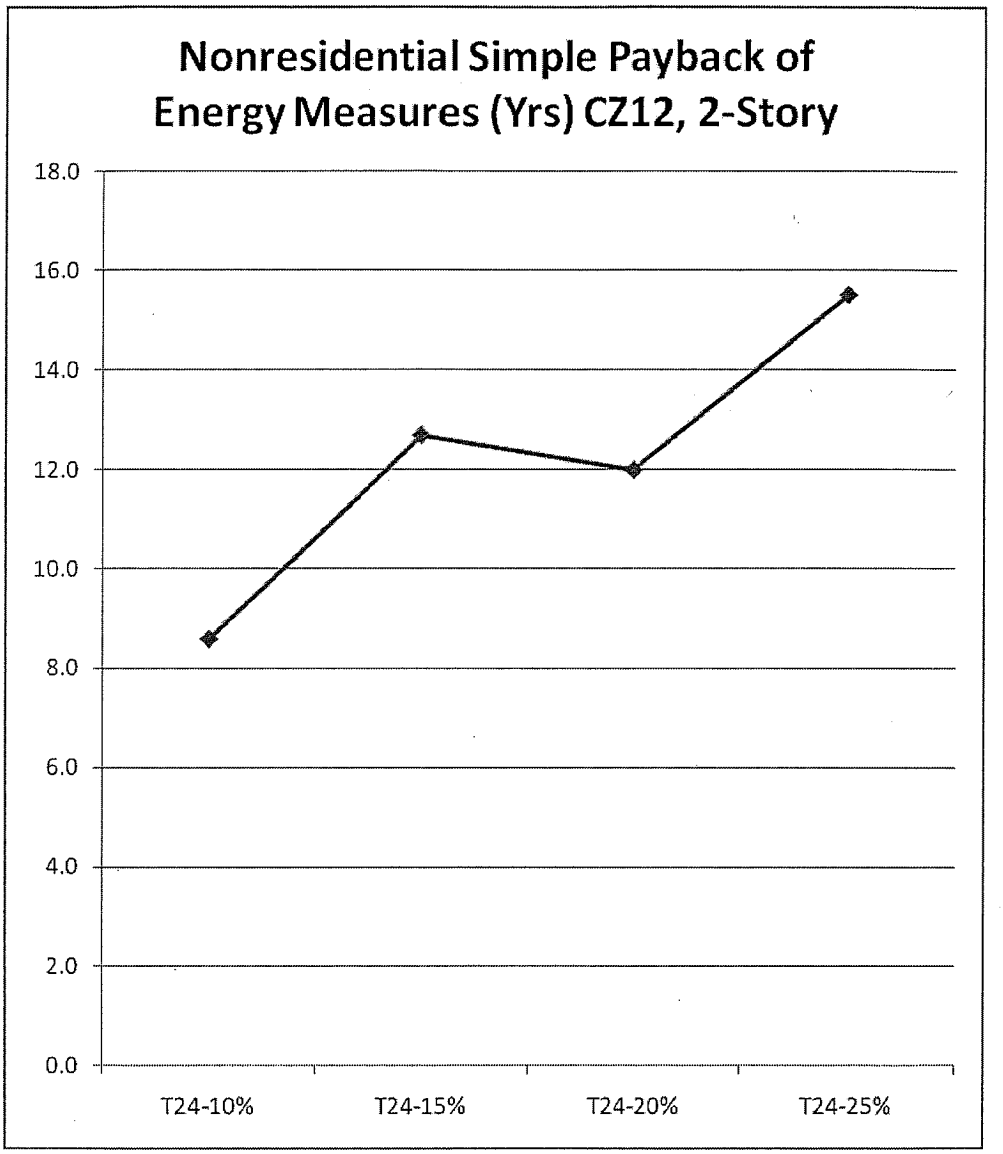


Figure 4-CZ12c-6: Simple Payback of Different Tiers of Energy Measures, 52,900 sf 5-Story Nonresidential Building

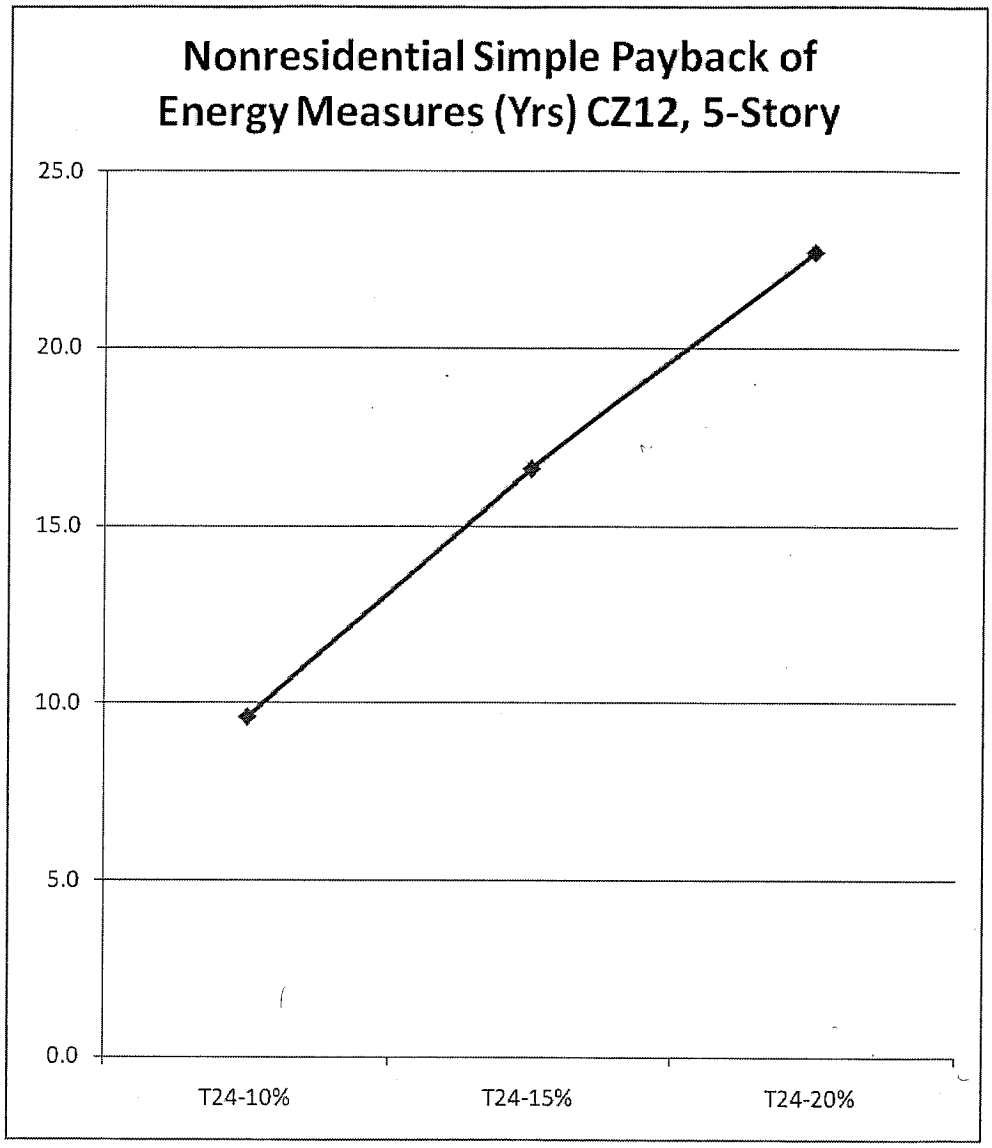


Figure 4-CZ12d-1: Added Cost/Sq.ft. per Lb. of CO2 Reduction, 2,025 sf 2-Story Single Family Home

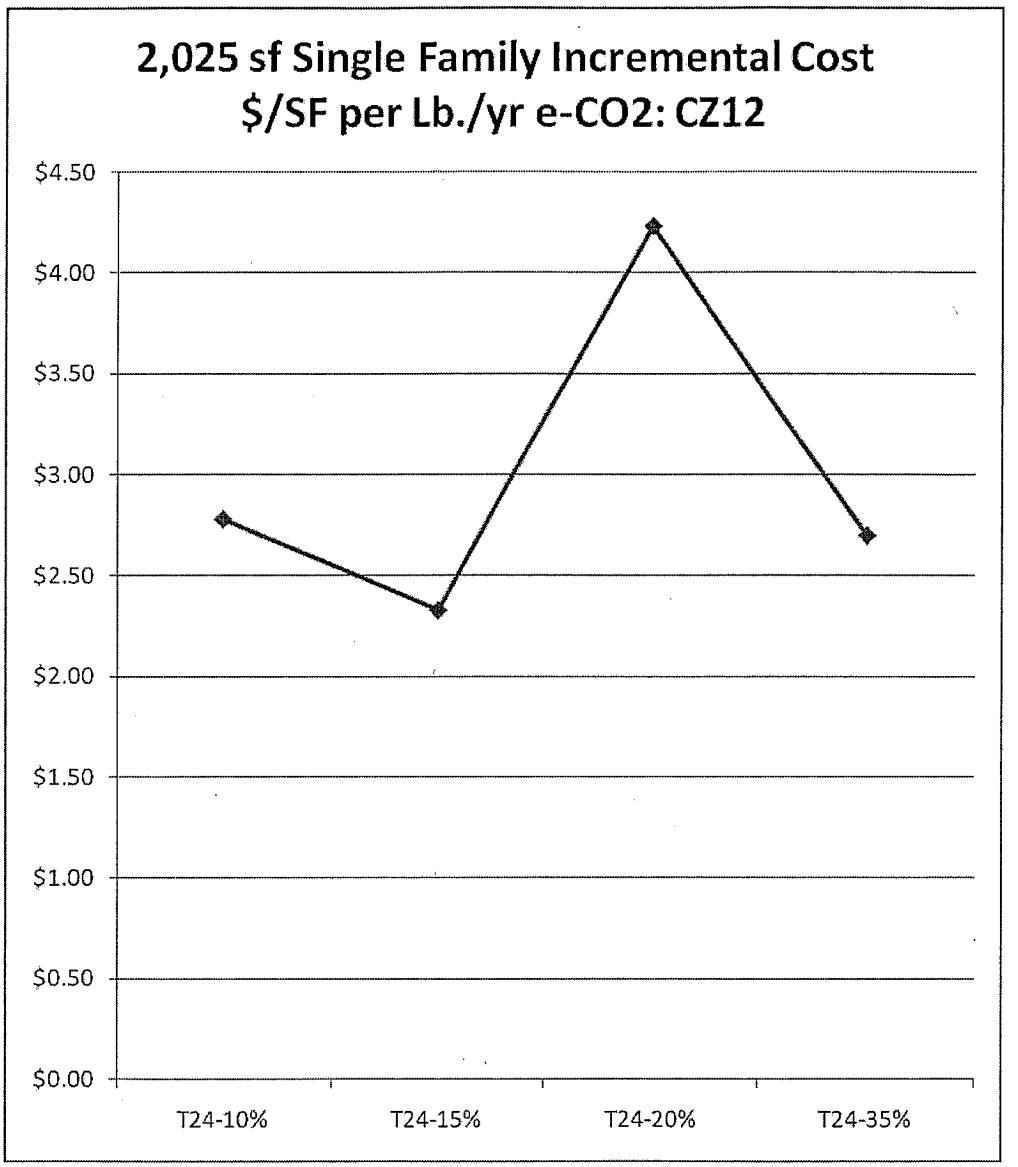


Figure 4-CZ12d-2: Added Cost/Sq.ft. per Lb. of CO2 Reduction, 1,582 sf 1-Story Single Family Home

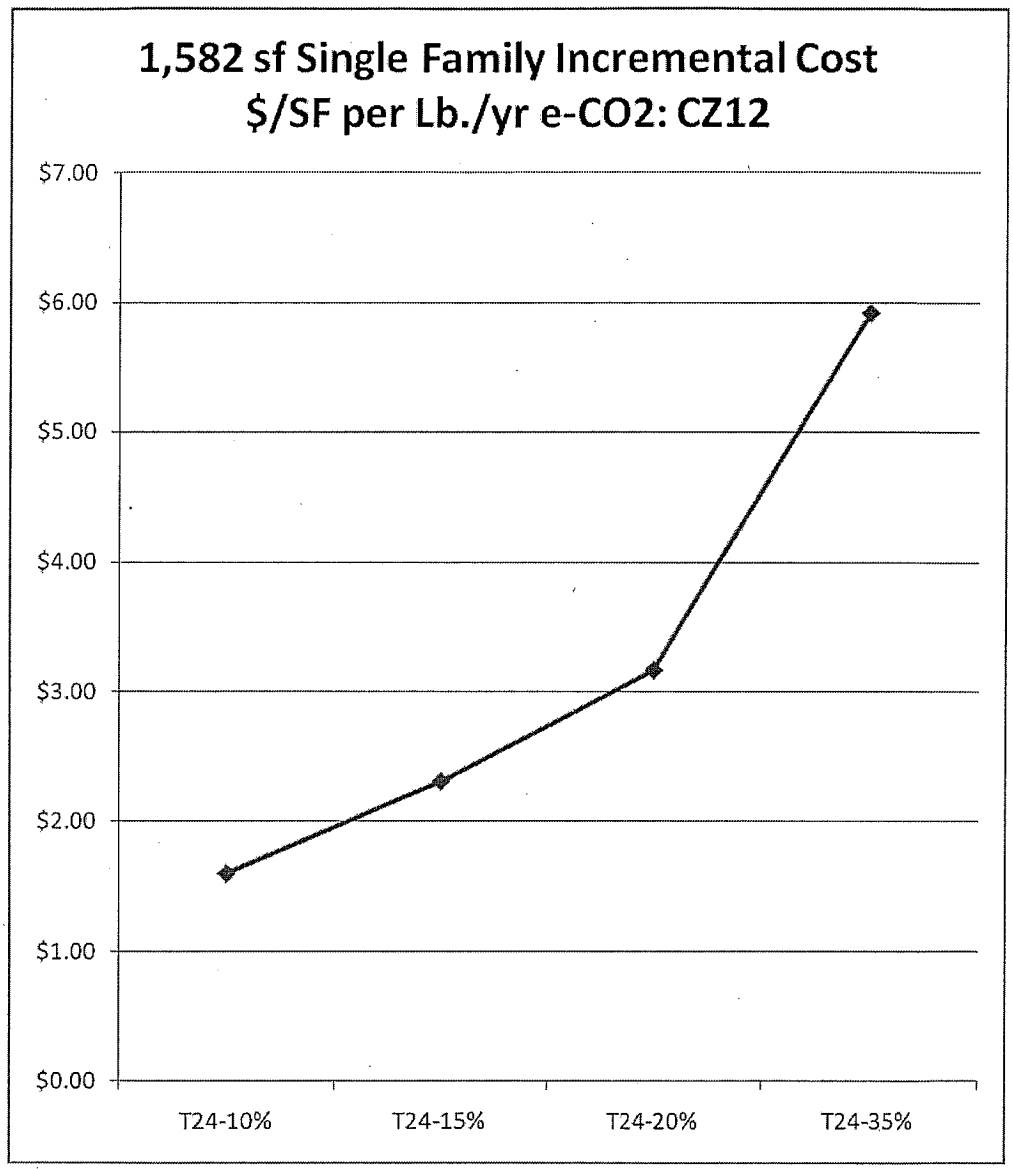


Figure 4-CZ12d-4: Added Cost/Sq.ft. per Lb. of CO2 Reduction, 2-Story Multifamily Building

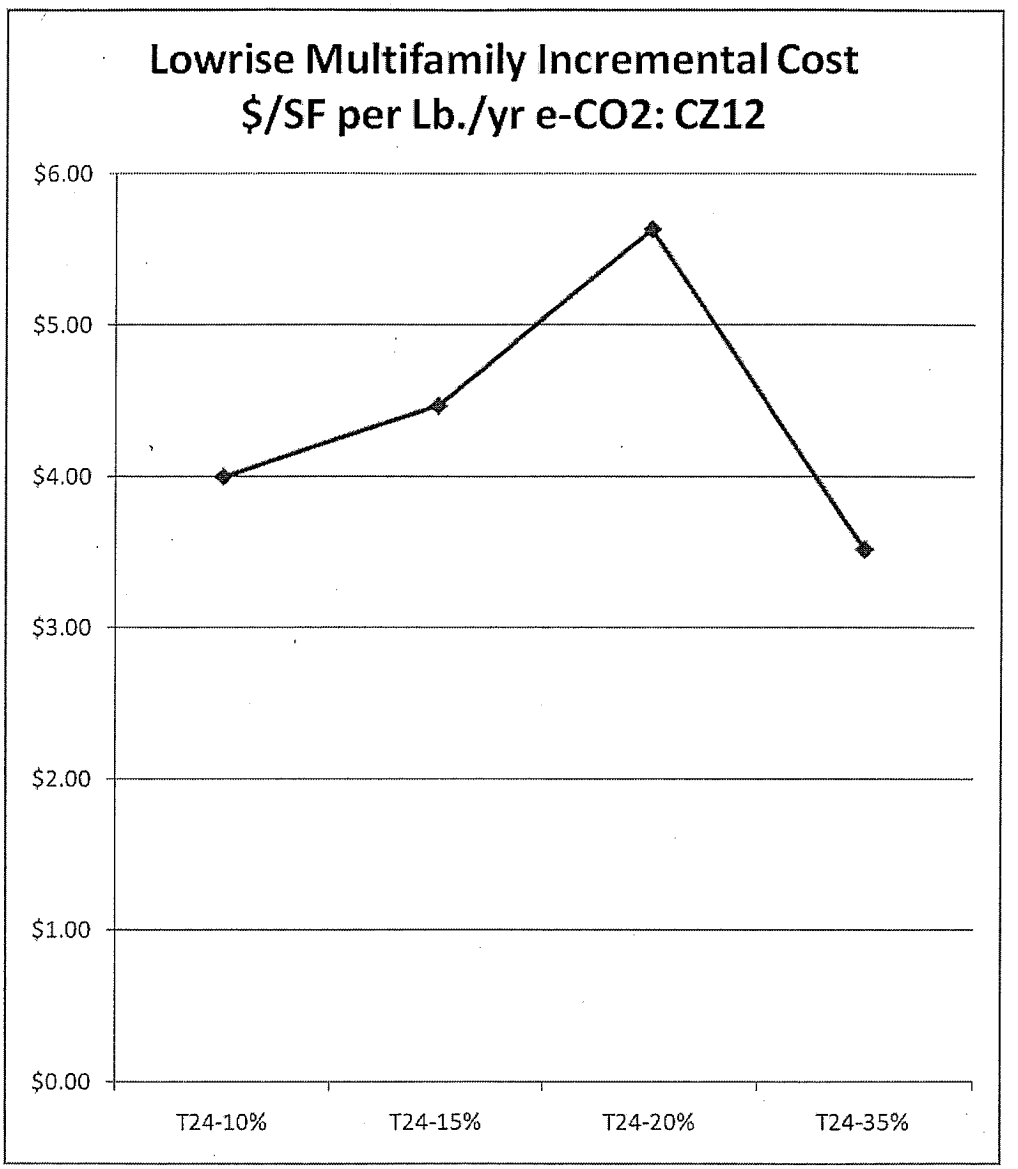


Figure 4-CZ12d-4: Added Cost/Sq.ft. per Lb. of CO2 Reduction, 40 Unit, 5-Story High-rise Residential Building

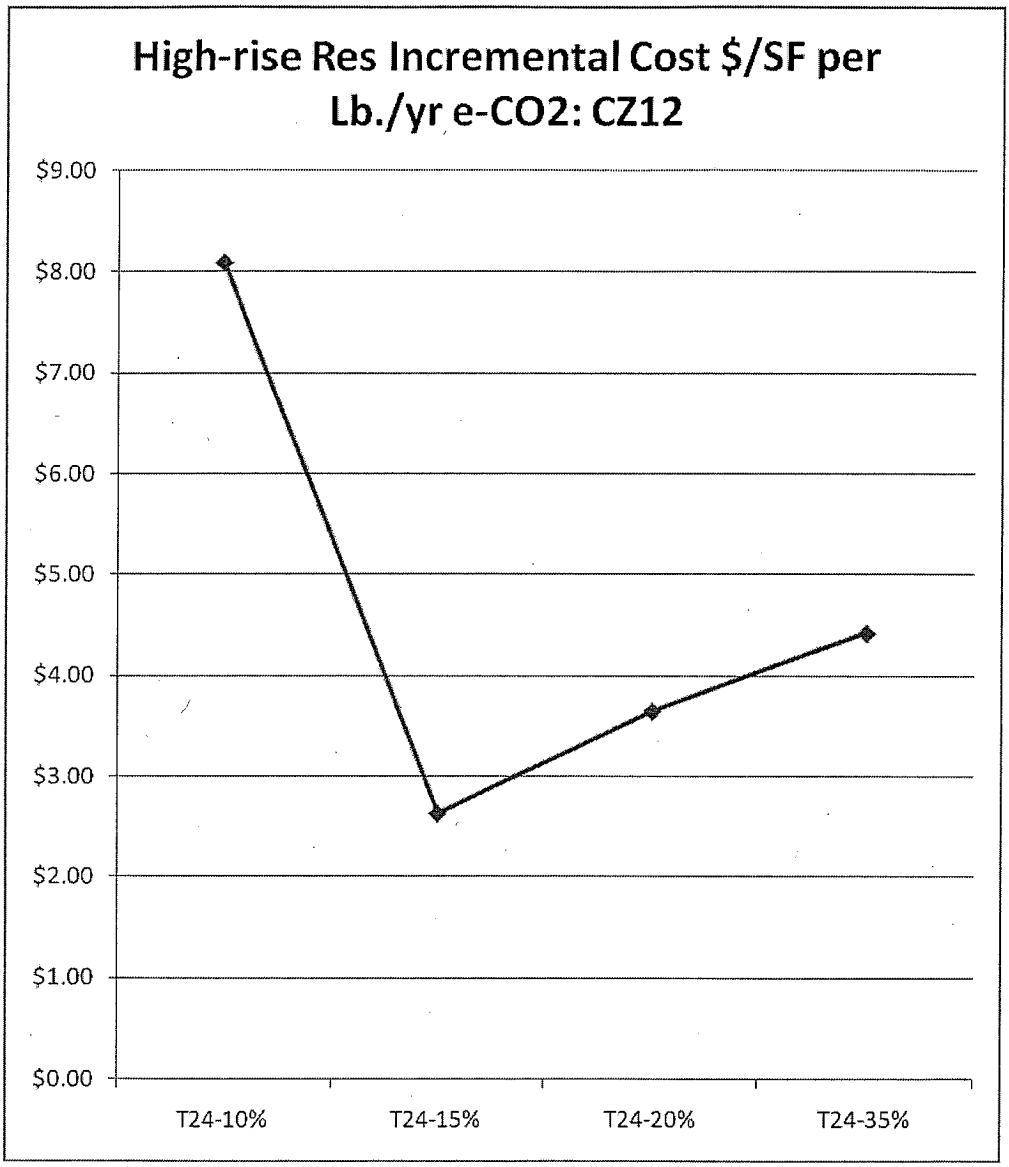


Figure 4-CZ12d-5: Added Cost/Sq.ft. per Lb. of CO2 Reduction, 21,160 sf 2-Story Nonresidential Building

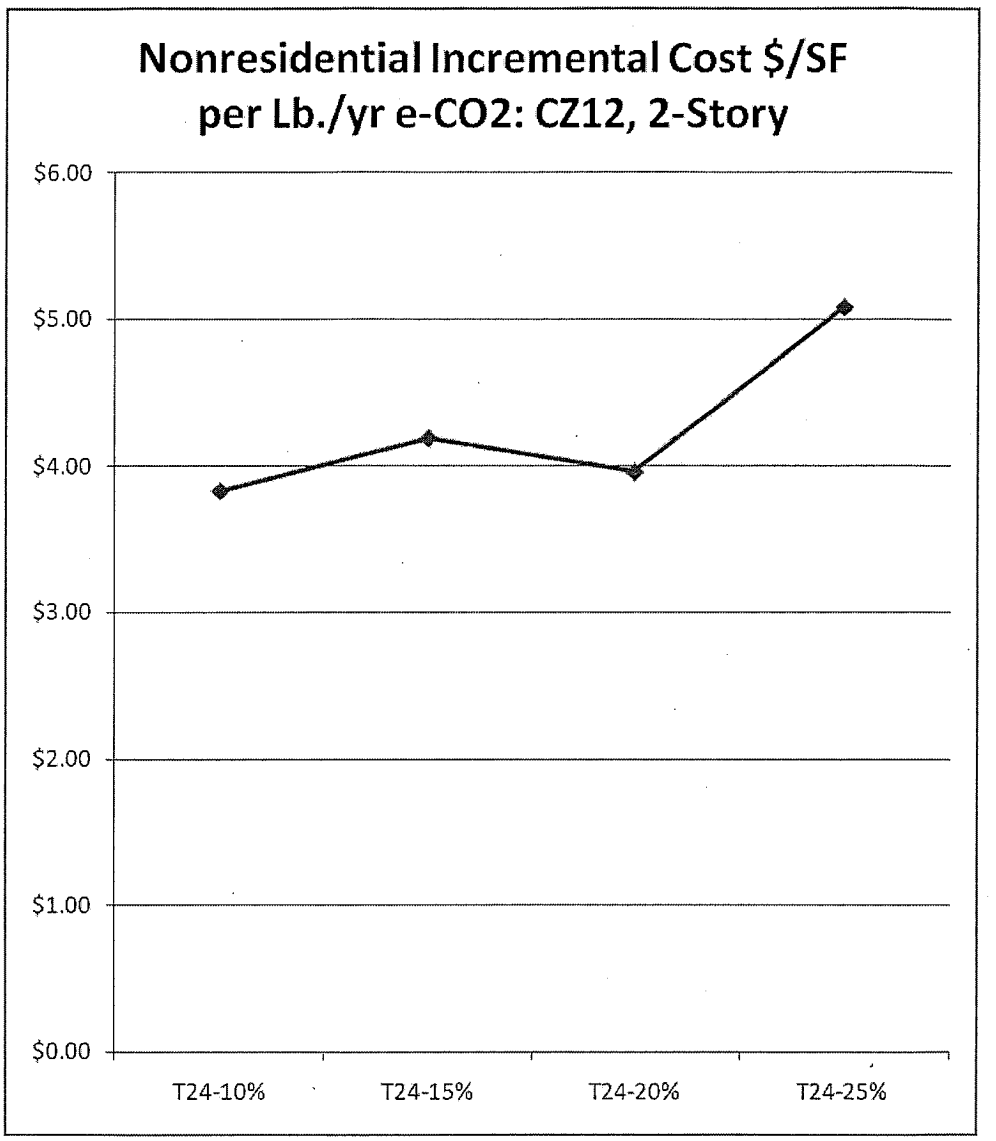


Figure 4-CZ12d-6: Added Cost/Sq.ft. per Lb. of CO2 Reduction, 52,900 sf 5-Story Nonresidential Building

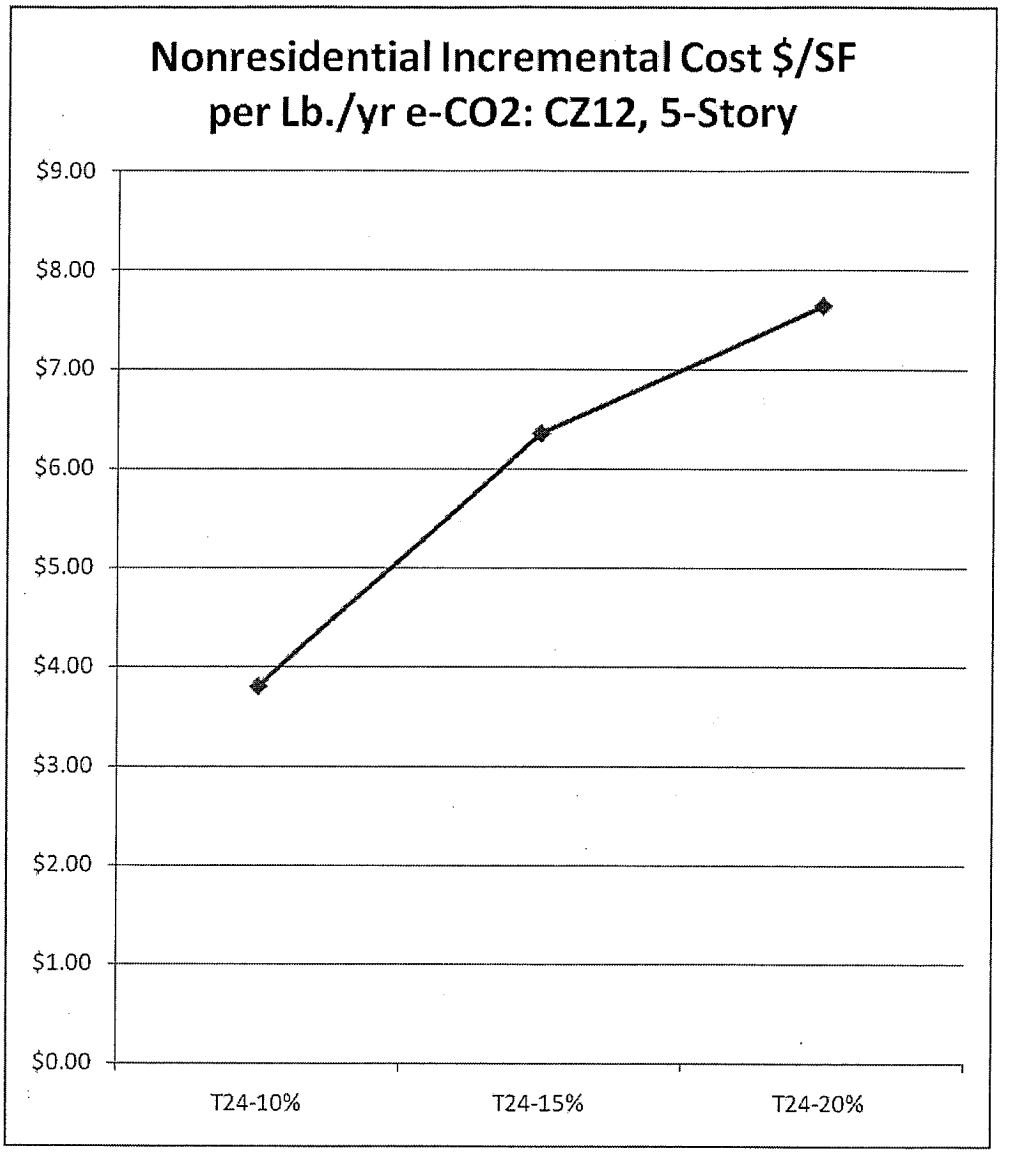


Figure 4-CZ12e-1: Annual Reduction in CO2 in Lbs./Sq.Ft. in Single Family, 2,025 sf 2-Story Single Family Home

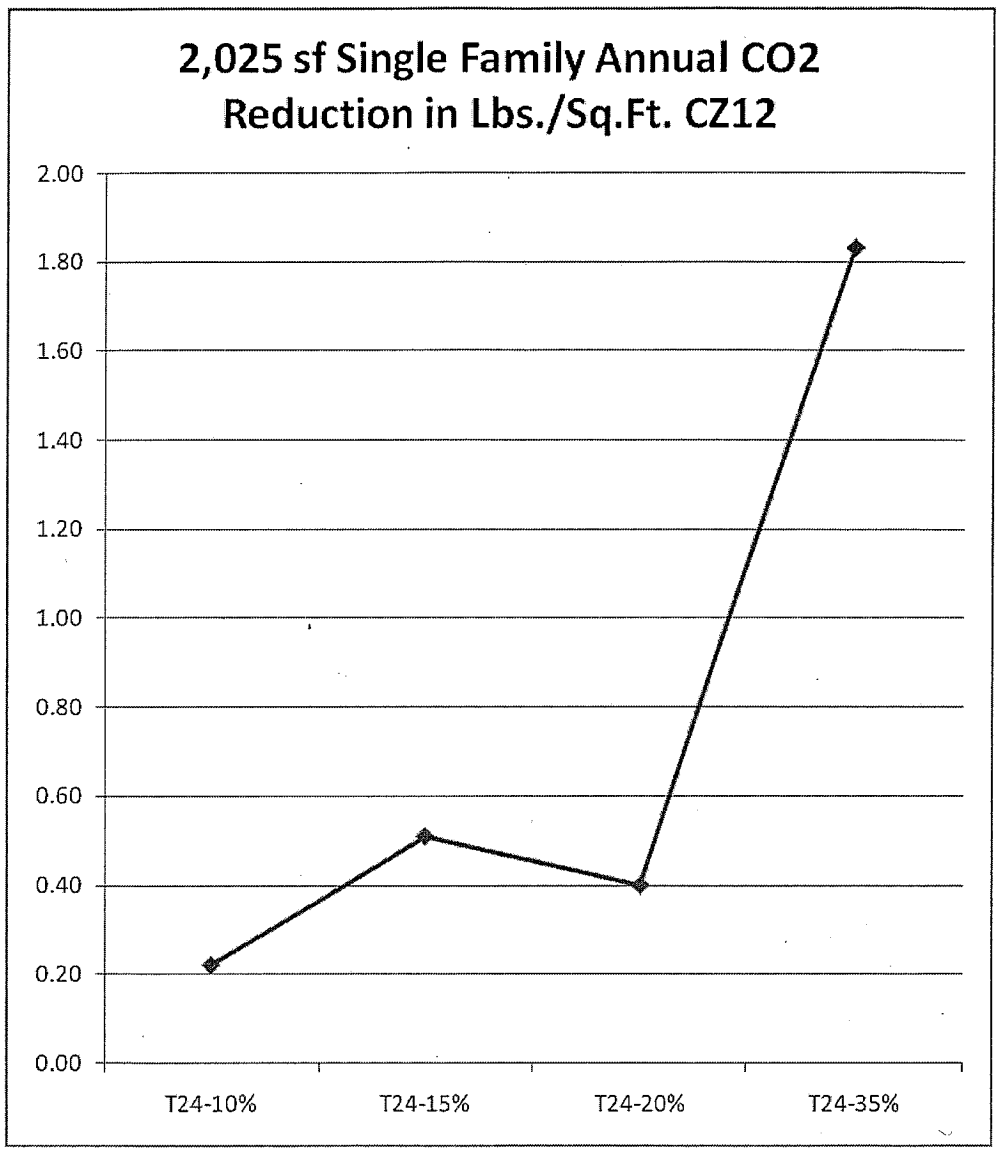


Figure 4-CZ12e-2: Annual Reduction in CO2 in Lbs./Sq.Ft. in Single Family, 1,582 sf 1-Story Single Family Home

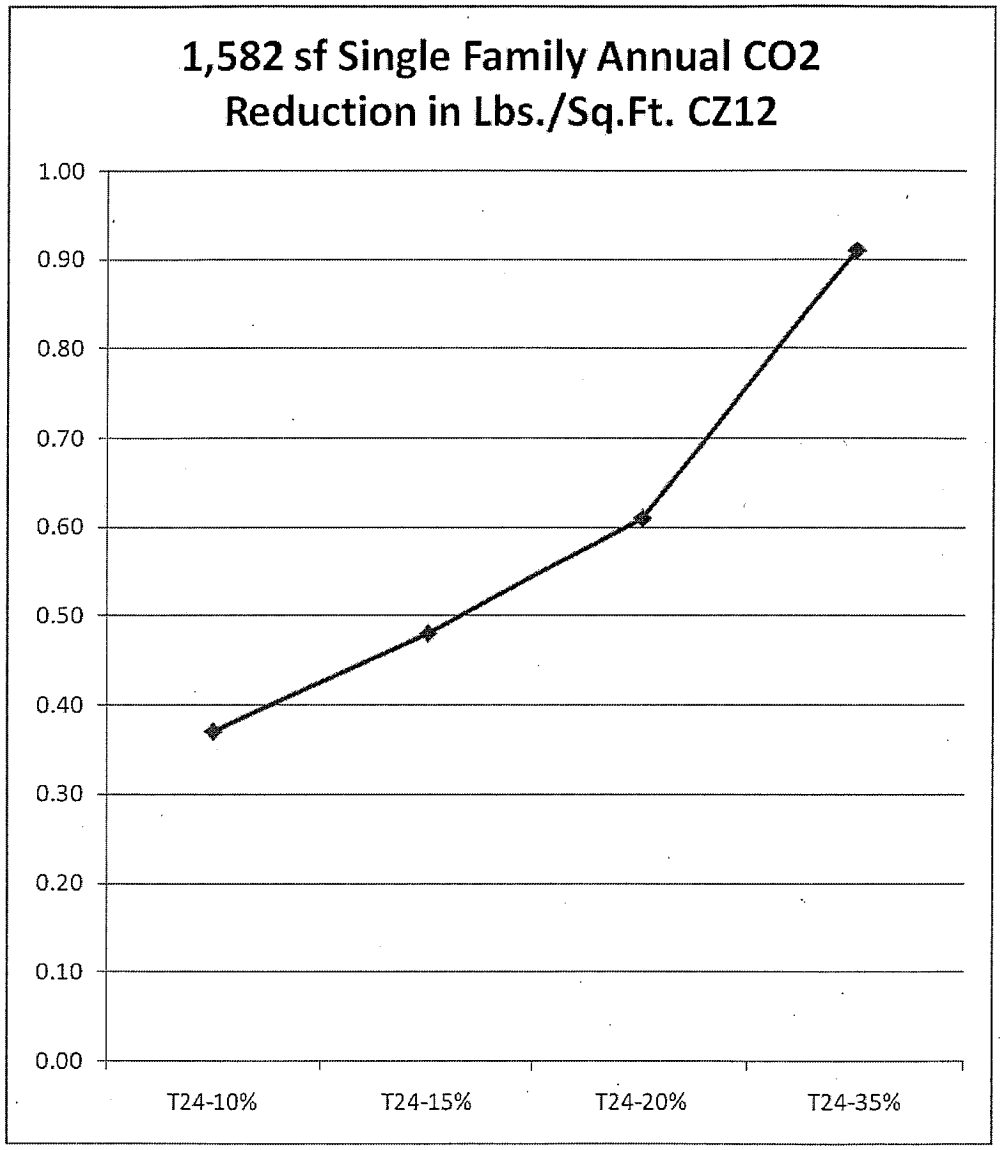


Figure 4-CZ12e-3: Annual Reduction in CO2 in Lbs./Sq.Ft., 2-Story Multifamily Building

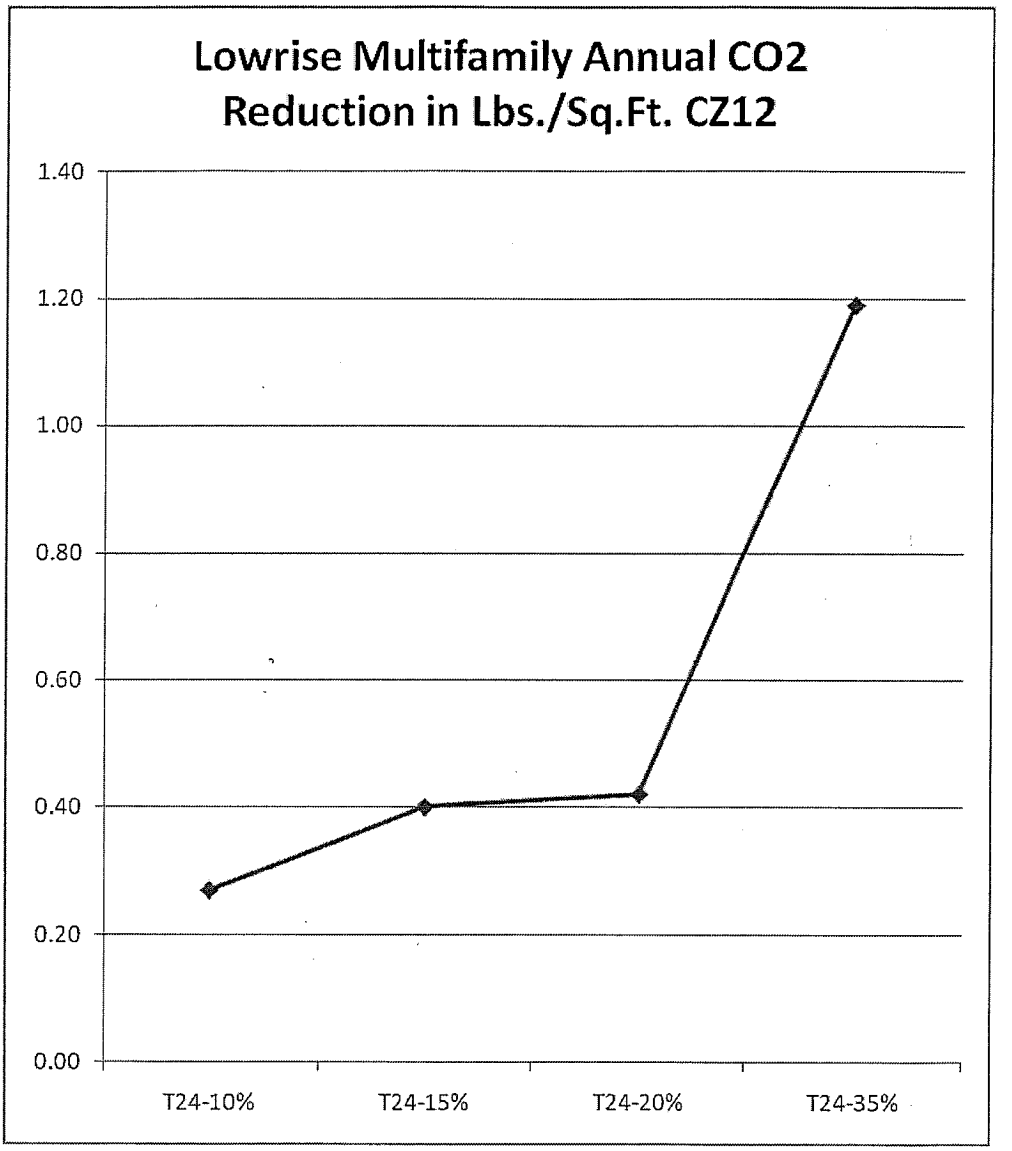


Figure 4-CZ12e-4: Annual Reduction in CO2 in Lbs./Sq.Ft., 40 Unit, 5-Story High-rise Residential Building

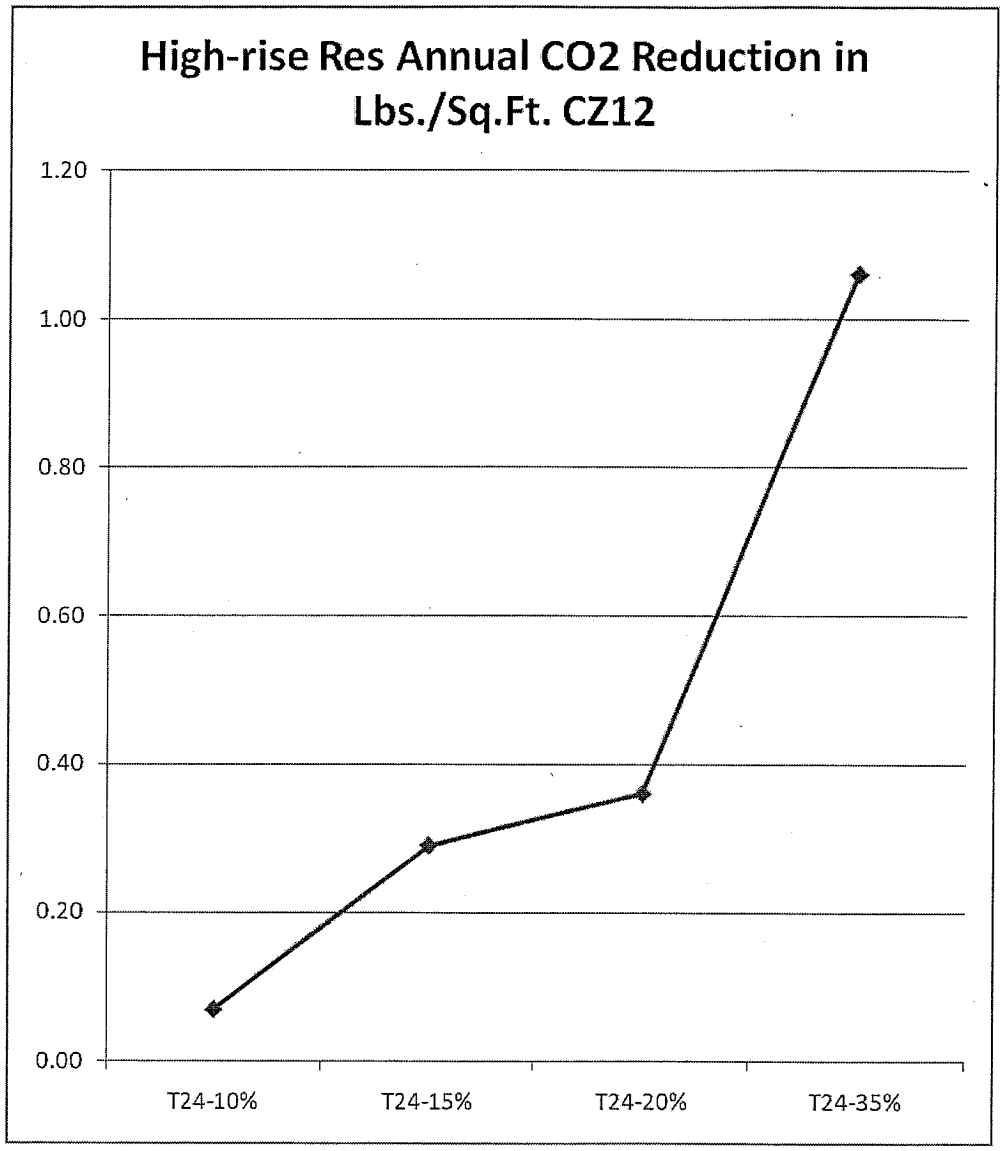


Figure 4-CZ12e-5: Annual Reduction in CO2 in Lbs./Sq.Ft., 21,160 sf 2-Story Nonresidential Building

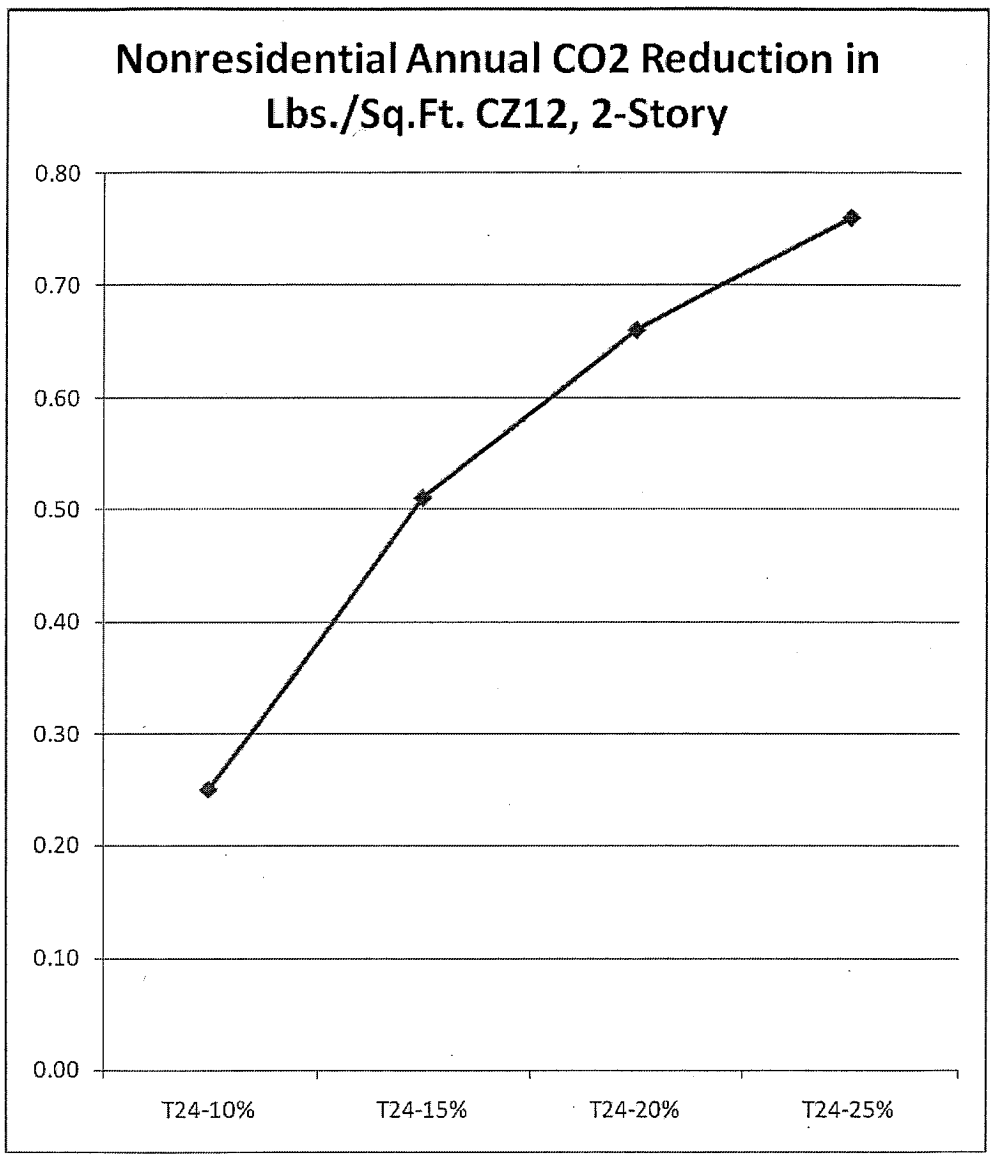
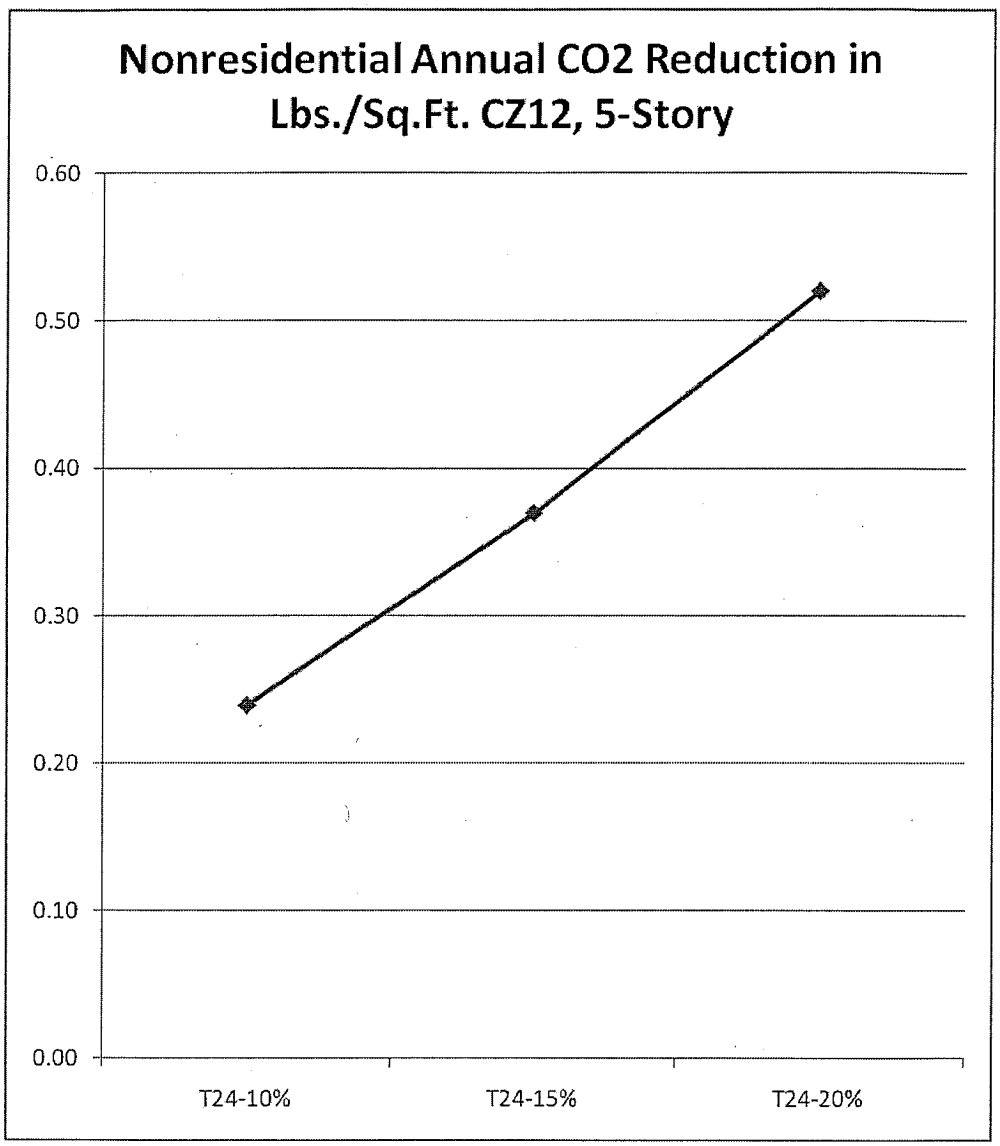


Figure 4-CZ12e-6: Annual Reduction in CO2 in Lbs./Sq.Ft., 52,900 sf 5-Story Nonresidential Building



5.0 Conclusions and Recommendations

5.1 Performance vs. Prescriptive Approach

While some local energy ordinances have in rare instances provided prescriptive options for local nonresidential envelope and lighting energy requirements, the performance approach has been implemented in all local ordinances for residential and nonresidential buildings as the most effective and cost-effective way to achieve higher levels of building energy efficiency. Rather than selecting specific energy measures as required, it is better to have the building industry determine how to reach energy-equivalence with the required efficiency level using the performance method. This is the approach used in a large variety of applications such as:

- Utility incentive programs
- State tax credits for solar PV systems (NSHP program)
- GreenPoint Rated green building system
- LEED green building system
- Local energy ordinances
- Low Income Housing Tax Credits
- ENERGY STAR New Homes
- Federal energy efficiency tax credits
- HERS Phase 2 for Existing and New Homes (2010)

Conversely, we strongly recommend against a local ordinance requiring prescriptive measures that can be modeled in the performance method. The reason is that, on a case-by-case basis, and because of many different variables, a specific energy measure (e.g., high performance Low-E windows with a U=0.33 and SHGC=0.23) may or may not be the most cost-effective solution in reducing energy use for a particular project.

5.2 Title 24 Analysis, Metric and Forms

Because of the familiarity of the building industry and building departments with Title 24 standards, it is best, as a minimum, to use the approved Title 24 software and modeling guidelines, the TDV energy in KBtu/sf-yr for Standard and Proposed designs, and the Title 24 compliance and installation/acceptance forms to document building energy performance measures. Special credits for solar PV systems and other options can be documented separately by the permit applicant, especially if a simple local compliance form is provided by the building department which augments the Title 24 report.

We recommend that all local ordinances use Title 24 methods, rules, software and reports wherever possible; and that those be augmented only when necessary to comply with or document a special energy credit.

5.3 LEED Energy Performance

Because there is a minimum energy requirement for LEED, and nonresidential buildings must meet LEED requirements in many local green building ordinances, it is worthwhile noting that:

(1) LEED 2009 (the next LEED program after v2 which is scheduled to be released sometime in 2009) is based on the ASHRAE 90.1-2007 energy performance standards, which uses the Energy Cost Budget (ECB) method to determine compliance. The minimum energy requirement for LEED 2009 is reducing annual energy cost by at least 10% below the 90.1-2007 baseline annual energy cost.

(2) The 90.1-2007 calculation and ECB metric is very different from the 2008 Title 24 calculation and TDV energy. The building industry in California does not generally understand how to meet and document the LEED requirement.

(3) Some local jurisdictions (e.g., San Francisco and Palo Alto) have adopted ordinances which give the chief building official or other designated City official the option to allow a Title 24 calculation and report to document LEED energy equivalence whether or not the project will be registered and reviewed by USGBC.

We recommend that any local ordinance which references LEED provide an administrative mechanism whereby a permit applicant can meet the minimum energy LEED requirement with a designated Title 24 energy equivalent performance.

5.4 Energy Efficiency before On-site Generation

To ensure consistency with State programs and maximum benefit to applicants seeking to apply for available incentives, a local energy ordinance that includes provisions for PV must meet all installation criteria in the "Guidelines for California's Solar Electric Incentive Programs Pursuant to Senate Bill 1." The methodology used to calculate the energy equivalent to the solar PV credit shall be the CECPV Calculator using the most recent version prior to the permit application date, which may be found at: http://www.gosolarcalifornia.ca.gov/nshpcalculator/. Because energy-efficiency is a more cost-effective investment than generation, programs such as State and Utility incentives, LEED and GreenPoint Rated award solar PV credit only after a building has already achieved the minimum energy efficiency performance.

5.5 Certified Energy Plans Examiners (CEPEs)

The California Association of Building Energy Consultants (CABEC) sponsors and administers the Certified Energy Plans Examiner (CEPE) program for the Residential and Nonresidential Standards. CEPE candidates must pass an examination to demonstrate knowledge of the applicable standards. We recommend that local ordinances include a requirement, or create a permit incentive, for the energy analysis and documentation to be prepared by an individual with the current applicable CEPE credential.