

Sonoma County Green Building Ordinance Energy Cost-Effectiveness Study

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Report prepared for:

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1.0 Executive Summary

Gabel Associates has researched and reviewed 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 the proposed Sonoma County Ordinance for local energy efficiency standards. The ordinance states that new construction must meet the overall requirements summarized below:

Applicable Project	Effective Date: January 1, 2010
New Residential Buildings: Low-rise and High-rise Construction	2008 – 2011 GreenPoint Rated
Residential Alterations & Additions	No Requirements Beyond 2008 Title 24

The study contained in this report shall be included in Sonoma County's application to the California Energy Commission. The application to the Energy Commission must meet the requirements specified in Section 10-106 of the California Code of Regulations, Title 24, Part 1, **LOCALLY ADOPTED ENERGY STANDARDS**. The proposed Ordinance shall be enforceable after the Commission has reviewed and approved the local energy standards as meeting all requirements of Section 10-106; and the Ordinance has been adopted by the County and filed with the Building Standards Commission.

This cost-effectiveness study has been completed with using the 2008 Building Energy Efficiency Standards which are scheduled to take effect on January 1, 2010.

2.0 Impacts of the New Ordinance

The energy performance impacts of the Ordinance have been evaluated using several case studies which collectively reflect a broad range of building types.

- Single family house: 2-story 2,025 sf
- Single family house: 2-story 2,682 sf
- Low-rise Multi-family building, 8 dwelling units: 2-story 8,442 sf
- High-rise Multi-family building, 40 dwelling units: 4-story 36,800 sf

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 Standards. The energy measures chosen are a combination of measures which reflects how designers, builders and developers are likely to achieve a specified level of performance.
- (b) Starting with a 2008 Standards minimally compliant set of measures, various items are changed to just reach the minimum energy performance required by the Ordinance (e.g, 15% better than 2008 Title 24). In this study, the design choices are based on many years of 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.
- (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.

2.1 Single Family Homes

Energy design descriptions of the single family building prototypes which just meet the 2008 Title 24 Building Energy Efficiency Standards:

Single Family House: 2,025 square feet, 2-story, 20.2% glazing/floor area ratio

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

Single Family House: 2,682 square feet, 2-story, 21.1% glazing/floor area ratio

Energy Efficiency Measures
R-30 Roof w/ Radiant Barrier
R-13 Walls
R-19 Raised Floor
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-6 Attic Ducts
Reduced Duct Leakage/Testing (HERS)
50 Gallon Gas Water Heaters: EF=0.60

Energy Measures Needed to Meet the County's Ordinance

The following energy features have been modified from the Title 24 set of measures so that the house design uses 15% less TDV energy than the corresponding Title 24 base case design per the 2008-2011 GreenPoint Rated minimum energy requirement. The incremental first cost to provide that measure in comparison with the equivalent base case measure is listed to the right.

The incremental energy improvements specified above to meet the proposed Ordinance requirements are variables selected by designer, builder or owner. There are a number of considerations in choosing the final mix of energy measures including first cost, aesthetics, maintenance and replacement.

15% Better Than Title 24 Base Case, Option 1

2025 sf

Climate Zone 2

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

15% Better Than Title 24 Base Case, Option 2

2025 sf

Climate Zone 2

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

15% Better Than Title 24 Base Case, Option 1

2682 sf

Climate Zone 2

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

15% Better Than Title 24 Base Case, Option 2

2682 sf

Climate Zone 2

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

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

2.2 Low-rise Multi-family Building

Energy design description of the low-rise residential building which just meets the 2008 Title 24 Building Energy Efficiency Standards:

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

Energy Efficiency Measures
R-38 Roof w/ Radiant Barrier
R-15 Walls
R-0 Slab on Grade
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
(8) Furnaces: 80% AFUE
(8) Air Conditioners: 13 SEER
R-8 Attic Ducts
(8) 40 Gallon Gas Water Heaters: EF=0.63

Energy Measures Needed to Meet the County’s Ordinance

The following energy features have been modified from the Title 24 set of measures so that the house design uses 15% less TDV energy than the corresponding Title 24 base case design per the 2008-2011 GreenPoint Rated minimum energy requirement. The incremental first cost to provide that measure in comparison with the equivalent base case measure is listed to the right.

The incremental energy improvements specified above to meet the proposed Ordinance requirements are variables selected by designer, builder or owner. There are a number of considerations in choosing the final mix of energy measures including first cost, aesthetics, maintenance and replacement.

15% Better Than Title 24 Base Case, Option 1

8442 sf

Climate Zone 2

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

15% Better Than Title 24 Base Case, Option 2

8442 sf

Climate Zone 2

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

2.3 High-rise Multi-family Building

Energy design description of the high-rise residential building which just meets the 2008 Title 24 Building Energy Efficiency Standards:

High-rise Residential: 4-story 36,800 sq. ft., 40 units, Window Wall Ratio = 35.2%

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

- R-38 attic insulation w/ cool roof Reflectance=0.70, Emittance=0.75
- R-19 in metal frame exterior walls
- R-6 raised slab floor over parking garage;
- Dual vinyl NFRC-rated Low-E windows: U-factor=0.36, SHGC=0.35
- 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

High-rise Residential Energy Measures Needed to Meet the County's Ordinance

Option A: Reduction in 2008 T24 TDV Energy by 15%:

• Super Low-E Vinyl Windows U=0.36, SHGC=0.25; 6,240 sf @ \$1.40 - \$1.60/sf	\$ 8,736 - 9,984
• R-8 (1" added) K-13 spray-on insulation under raised floor 9,200 sf @ \$0.40 - \$0.60/sf	\$ 3,680 - 5,520
• Premium efficiency DHW pump	\$ 150 - 250
• (80) Room PTACs: HSPF=7.84, EER=11.2 (No Ducts) @ \$150 - \$250/unit	\$ 12,000 - 20,000
Total incremental cost of Ordinance energy measure:	\$ 24,566 - 35,754
	Avg = \$30,160
Incremental cost in \$/sq.ft.:	\$ 0.67 to \$0.97/sq.ft.
	Avg = \$0.82 /sf

Option B: Reduction in 2008 T24 TDV Energy by 15%:

• Super Low-E Vinyl Windows U=0.36, SHGC=0.25; 6,240 sf @ \$1.40 - \$1.60/sf	\$ 8,736 - 9,984
• (2) Munchkin boilers @ 1,500 – 2,500 each	\$ 3,000 - 4,000
• R-19+R-5 exterior wall insulation; 11,472 sf @ \$5.00 - \$8.00/sf	\$ 57,360 - 91,776
Total incremental cost of Ordinance energy measure:	\$ 69,096 - 105,760
	Avg = \$87,428
Incremental cost in \$/sq.ft.:	\$ 1.88 to \$2.87/sq.ft.
	Avg = \$2.38 /sf

3.0 Cost Effectiveness

The summary of results in this section are based upon the following assumptions:

- Incremental site electricity (kWh) and natural gas (therms) saved per year as calculated using the state-approved energy compliance software for the 2008 Building Energy Efficiency Standards, a research version of Micropas 8.
- Average utility rates of \$0.163/kWh for electricity and \$1.30/therm for natural gas in current 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 Simple Payback data includes a cost-effectiveness analysis of the Ordinance with respect to each case study building design and assumes:

- No external cost of global climate change -- and corresponding value of additional investment in energy efficiency and CO2 reduction – is included
- The cost of money invested in the incremental cost of energy measures is not included.

3.1 New Single Family Houses

Building Description	Total Incremental First Cost (\$)	Net Incremental Annual Energy Cost Savings (\$)	Simple Payback (years)
2,025 sf (Opt1-15%)	\$2,011	\$154	13.1
2,025 sf (Opt2-15%)	\$2,104	\$161	13.1
Averages:	\$2,057	\$157	13.1

Annual Reduction in CO2-equivalent: 0.51 lbs./sq.ft.- year

Building Description	Average Incremental First Cost (\$)	Net Incremental Annual Energy Cost Savings (\$)	Simple Payback (years)
2,682 sf (Opt1-15%)	\$2,072	\$176	11.8
2,682 sf (Opt2-15%)	\$2,549	\$198	12.8
2,682 sf (Opt3-15%)	\$2,327	\$188	12.4
Averages:	\$2,316	\$187	12.3

Annual Reduction in CO2-equivalent: 0.47 lbs./sq.ft.- year

3.2 Low-rise Multi-family Building

Building Description	Average Incremental First Cost (\$)	Net Incremental Annual Energy Cost Savings (\$)	Simple Payback (years)
8,442 sf (Opt1-15%)	\$8,089	\$591	13.7
8,442 sf (Opt2-15%)	\$6,388	\$604	10.6
Averages:	\$7,238	\$598	12.1

Annual Reduction in CO2-equivalent: 0.46 lbs./sq.ft.- year

3.3 High-rise Multi-family Building

Building Description	Average Incremental First Cost (\$)	Net Incremental Annual Energy Cost Savings (\$)	Simple Payback (years)
36,800 sf (Opt1-15%)	\$30,160	\$2,287	13.2
36,800 sf (Opt2-15%)	\$87,428	\$1,883	46.4
Averages:	\$58,794	\$2,085	29.8

Annual Reduction in CO2-equivalent: 0.19 lbs./sq.ft.- year

Conclusions

Regardless of the building design, occupancy profile and number of stories, the incremental improvement in overall annual energy performance of buildings under the Sonoma County Green Building Ordinance and the 2008 Title 24 Building Energy Efficiency Standards is cost-effective. However, each building's specific design, occupancy type and the design choices may allow for a large range of incremental first cost and payback. As is the case in just meeting the requirements of the Title 24 energy standards, a permit applicant complying with the energy requirements of the Sonoma County Green Building Ordinance should carefully analyze building energy performance to reduce incremental first cost and reduce the payback for the required additional energy measures.