Energy Cost-Effectiveness of Radiant Barrier Roofs in the Glendale Green Building Ordinance

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1.0 Executive Summary

Gabel Associates has researched and reviewed the energy cost-effectiveness of the roof radiant barrier requirement within the City of Glendale Ordinance No. 5736, Section 4.205.1. This study considers the cost-effectiveness of a radiant barrier above an attic space in three prototypical single family homes. An analysis using state-approved compliance software, Micropas v8.1, has been conducted to evaluate annual site energy savings, site energy cost savings and cost-effectiveness of a radiant barrier. The conservative assumption made is that the radiant barrier has not already been specified in the base case design to meet the overall energy performance requirement of 15% better than state code. Omitted from the study are any external costs of climate change – either mitigation or adaptation -- associated with increase in CO2-e emissions; or widely predicted increases in summer temperatures in California which would tend to further increase cost effectiveness of cooling reduction measures.

2.0 Radiant Barrier Cost-Effectiveness in Climate Zone 9

A common approach to establishing cost-effectiveness of an energy measure is to consider the site impacts on prototypical buildings. Gabel Associates has performed such an approach which uses current state-approved compliance software to determine annual energy savings and energy cost savings associated with roof radiant barriers for three single family buildings:

(1) 1,850 square foot 2-story slab-on-grade home
(2) 2,450 square foot 2-story slab-on-grade home
(3) 2,850 square foot 2-story slab-on-grade home

For each building prototype, two base case energy designs are first established which just meet the current Title 24 Building Energy Efficiency Standards without a radiant barrier. The buildings are run in Climate Zone 9, the local California climate zone that covers all buildings within City limits. In the first scenario, *Base Case 1*, there is neither a radiant barrier nor a cool roof. In the second scenario, *Base Case 2*, there is only a cool roof but no radiant barrier. To each of these, a radiant barrier is added and the computer models re-run to see incremental energy impacts. From the hour-by-hour computer simulations used within the compliance software, it is possible to obtain a relatively accurate picture of the change in annual electricity and natural gas use and in annual energy costs by the inclusion of the attic radiant barrier.

From data researched by Gabel Associates, and also confirmed by independent research by the City of Glendale, a typical range of incremental cost for a continuous radiant barrier on the underside surface of roof sheathing (e.g., foil faced plywood) is in the range of $0.25 to $0.27 per square foot. The average unit cost of electricity is assumed to be $0.16/KWh and average unit cost of natural gas $0.95/therm. From first cost and energy cost assumptions, a Simple Payback is calculated.

Base Case: 1,850 SF

1,850 SF Title 24 Base Case: No Cool Roof

Energy Efficiency Measures
R-38 Roof (Reflectance=0.08, Emittance=0.85)
R-13 Walls
R-0 Slab on Grade
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-8 Attic Ducts
50 Gallon Gas Water Heater: EF=0.62
Pipe Insulation

1,850 SF Title 24 Base Case: Cool Roof

Energy Efficiency Measures
R-30 Cool Roof (Reflectance=0.55, Emittance=0.85)
R-13 Walls
R-0 Slab on Grade
Low E Vinyl Windows, U=0.40, SHGC=0.36
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-6 Attic Ducts
50 Gallon Gas Water Heater: EF=0.60

Incremental Cost: 1,850 SF

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-38 w/o Radiant Barrier): 1,110 sf @ 0.25 to 0.27/sf	Upgrade	$ 278	$ 300	$ 289
R-13 Walls	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER		$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62		$ -	$ -	$ -
Pipe Insulation	-	$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 278**	**$ 300**	**$ 289**
Total Incremental Cost per Square Foot of Home:		**$ 0.15**	**$ 0.16**	**$ 0.16**

Base Case: 2,450 SF

2,450 SF Title 24 Base Case: No Cool Roof

Energy Efficiency Measures
R-38 Roof (Reflectance=0.08, Emittance=0.85)
R-13 Walls
R-0 Slab on Grade
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-8 Attic Ducts
50 Gallon Gas Water Heater: EF=0.62

2,450 SF Title 24 Base Case: Cool Roof

Energy Efficiency Measures
R-30 Cool Roof (Reflectance=0.55, Emittance=0.85)
R-13 Walls
R-0 Slab on Grade
Low E Vinyl Windows, U=0.40, SHGC=0.36
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-6 Attic Ducts
50 Gallon Gas Water Heater: EF=0.61

Incremental Cost: 2,450 SF

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-38 w/o Radiant Barrier): 1,470 sf @ 0.25 to 0.27/sf	Upgrade	$ 368	$ 397	$ 382
R-13 Walls	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER		$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62		$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 368**	**$ 397**	**$ 382**
Total Incremental Cost per Square Foot per Home:		**$ 0.15**	**$ 0.16**	**$ 0.16**

Base Case: 2,850 SF

2,850 SF Title 24 Base Case: No Cool Roof

Energy Efficiency Measures
R-38 Roof (Reflectance=0.08, Emittance=0.85)
R-13 Walls
R-0 Slab on Grade
Low E2 Vinyl Windows, U=0.36, SHGC=0.30
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-8 Attic Ducts
50 Gallon Gas Water Heater: EF=0.62

2,850 SF Title 24 Base Case: Cool Roof

Energy Efficiency Measures
R-30 Cool Roof (Reflectance=0.55, Emittance=0.85)
R-13 Walls
R-0 Slab on Grade
Low E Vinyl Windows, U=0.40, SHGC=0.36
Furnace: 80% AFUE
Air Conditioner: 13 SEER
R-6 Attic Ducts
50 Gallon Gas Water Heater: EF=0.61

Incremental Cost: 2,850 SF

Energy Efficiency Measures	Change Type	Incremental Cost Estimate		
		Min	Max	Avg
R-38 Roof w/ Radiant Barrier (from R-38 w/o Radiant Barrier): 1,710 sf @ 0.25 to 0.27/sf	Upgrade	$ 428	$ 462	$ 445
R-13 Walls	-	$ -	$ -	$ -
R-0 Slab on Grade	-	$ -	$ -	$ -
Low E2 Vinyl Windows, U=0.36, SHGC=0.30	-	$ -	$ -	$ -
Furnace: 80% AFUE	-	$ -	$ -	$ -
Air Conditioner: 13 SEER		$ -	$ -	$ -
R-8 Attic Ducts	-	$ -	$ -	$ -
50 Gallon Gas Water Heater: EF=0.62		$ -	$ -	$ -
Total Incremental Cost of Energy Efficiency Measures:		**$ 428**	**$ 462**	**$ 445**
Total Incremental Cost per Square Foot:		**$ 0.15**	**$ 0.16**	**$ 0.16**

Results

As noted above, the following results assume that a radiant barrier has not initially been specified in the building energy design, but may contribute to the overall energy performance to achieve 15% better than state code as another section of the Glendale ordinance requires for new homes. In that sense, the radiant barrier is only one of the set of energy measures which achieves 15% better than Title 24 Part 6.

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (Years)
1,850 sf Base 1 + Radiant	**235**	**2**	**$289**	**$40**	**7.3**
1,850 sf Base 2 + Radiant	**101**	**4**	**$289**	**$20**	**14.5**
Averages:	**168**	**3**	**$289**	**$30**	**10.9**

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (Years)
2,450 sf Base 1 + Radiant	285	1	$383	$47	8.2
2,450 sf Base 2 + Radiant	124	5	$383	$25	15.6
Averages:	205	3	$383	$36	11.9

Building Description	Total Annual KWh Saving	Total Annual Therms Saving	Incremental First Cost ($)	Annual Energy Cost Savings ($)	Simple Payback (Years)
2,850 sf Base 1 + Radiant	317	1	$445	$52	8.6
2,850 sf Base 2 + Radiant	142	6	$445	$28	15.7
Averages:	230	4	$445	$40	12.1

3.0 Conclusions

Simple paybacks for radiant barrier in the three prototype single family homes range from 7 to 16 years in the Glendale climate, with an average payback in the 11 to 12 year range. Assuming that the useful life of roof sheathing is 30 years, and based on this analysis, radiant barriers are cost-effective as a mandatory requirement for roofing above attic spaces in Climate Zone 9.

It is also worth noting that even without radiant barrier as a local mandatory measure, it is highly likely that the vast majority of new single family homes would include a radiant barrier in order to meet the 15%-better-than-Title 24 performance requirement.