

Cool Roof



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What is a Cool Roof?

Cool roofs are roofs that are designed to maintain a lower roof temperature than traditional roofs while the sun is shining. Sunlight is the primary factor that causes roofs to become very hot.



A dark roof (left) becomes much hotter than a cool white roof (right) on a sunny afternoon.

Source: Guidelines for Selecting Cool Roofs, DOE/EERE

A cool roof can be desirable to a building owner for several reasons. Cool roofs can:

- reduce energy bills by decreasing air conditioning needs.
- improve indoor thermal comfort for spaces that are not air conditioned.
- decrease roof operating temperature, which may extend roof service life.

Offset CO₂ and Delay Global Warming

It's estimated that world-wide reflective (cool) roofing would produce a global cooling effect equivalent to offsetting 24 billion tons of CO₂ over the lifetime of the roofs (20-year)¹.

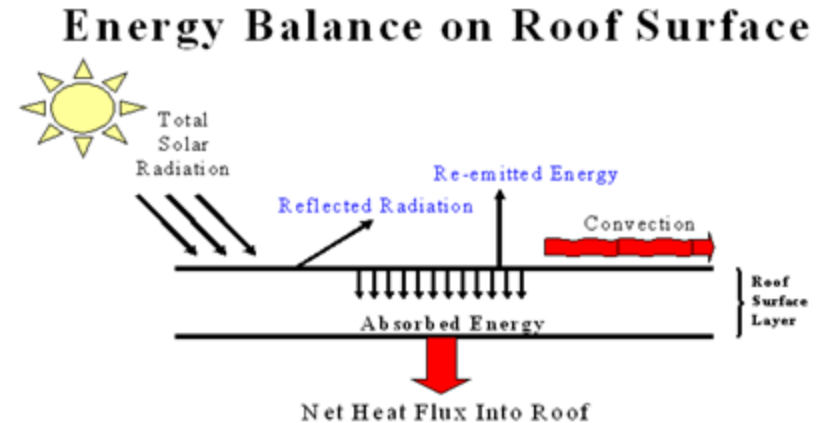
This is equivalent to taking the world's approximately 600 million cars off the road for 18 years.

(The average world car emits about 4 tons of CO₂ each year.)

¹ Akbari, H. (2008). Global Cooling: Increasing Solar Reflectance of Urban Areas to Offset CO₂. In press, *Climate Change*.

How does a Cool Roof Work?

Solar reflectance and **thermal emittance** are the two key material surface properties that determine a roof's temperature



Source: www.wbdg.org/resources/coolmetalroofing.php

Solar Reflectance:

- The fraction of sunlight that a surface reflects (note: sunlight that is not reflected is absorbed as heat.)
- Solar reflectance is measured on a scale of 0 to 1.
(1 = 100% reflectance)

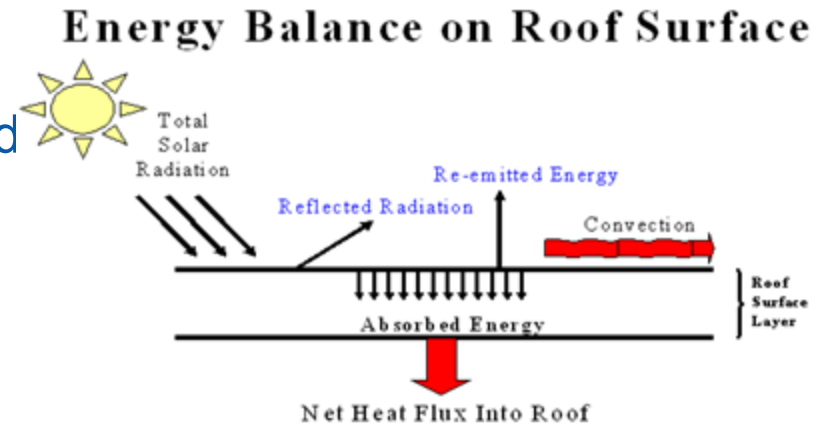
Thermal Emittance:

- Describes how efficiently a surface cools itself by emitting thermal radiation.
- Thermal emittance is measured on a scale of 0 to 1.
(1=100 % perfect emitter)

Solar Reflectance Index (SRI)?

SRI is another metric for comparing the “coolness” of roof surfaces. It is calculated from *solar reflectance* and *thermal emittance* values.

Calculator at:
http://coolcolors.lbl.gov/assets/docs/SRI%20Calculator/SRI_calc10.xls



Source: www.wbdg.org/resources/coolmetalroofing.php

Why an SRI value?

- Some materials have a very high reflectance value combined with a low emittance value or visa versa.
- Some standards require minimum values for both reflectance and emittance.
- SRI composite value enables some materials to meet cool roof minimums that wouldn't based on individual reflectance and emittance values.

Types of Cool Roofs

Not all Cool Roofs are white...



R=0.41	R=0.44	R=0.44	R=0.48	R=0.46	R=0.41
black	blue	gray	terracotta	green	chocolate
R=0.04	R=0.18	R=0.21	R=0.33	R=0.17	R=0.12

Cool-colored tiles (top row) look just like conventionally colored tiles but have higher solar reflectance (R). *Image Source: American Rooftile Coatings and Lawrence Berkeley National Laboratory*

Cool Roof Selection and Applications

Existing Roof

Cool Roof Coatings:

- Contain white or special reflective pigments that reflect sunlight.
- Coatings are like very thick paints that can protect the roof surface from ultra-violet (UV) light and chemical damage, and some offer water protection and restorative features as well.
- Typical 5 year life (consider this when near end of roof's useful life, but not yet ready for roof replacement).

Coating Type	Properties
Acrylic	Water based, easy to handle, good adhesion to most roof types, most commonly used reflective coating, cures by evaporation, reasonably strong, very sensitive to weather.
Silicone	Solvent based, typically used for spray polyurethane roofs, weather very well, weaker tensile strength, good water resistance.
Urethane	Solvent based, 3-10 times stronger than acrylic, greater adhesion to most roof types than acrylic, most cure with exposure to air, less sensitive to weather, more difficult to work with.

Cool Roof Selection and Applications

New Construction and Roof Replacement

Single-ply Membranes (low sloped roofs):

- TPO¹ and PVC² membranes are usually white and reflective -- do not require additional formulations or cool coatings.
- EPDM³ membranes are black, but can be produced in white or cool colors.

¹TPO - Thermoplastic polyolefin

²PVC - Polyvinyl chloride

³EPDM - Ethylene propylene diene M-class, a kind of synthetic rubber

Built-Up Roofs (low sloped roofs):

- Light-colored aggregate, such as marble chips.
- Reflective aluminum pigments.
- Cap sheets with white mineral granules.

Modified Bitumen Sheet Membranes (low sloped roofs):

- Protective coatings to provide heat resistance, ultraviolet resistance, and fire resistance.
- Protective surfacing layer can be made of aggregate, mineral, metal foil laminate, or smooth surfaced with a liquid coating.

Cool Roof Selection and Applications

New Construction and Roof Replacement – continued

Spray Polyurethane Foam (low sloped roofs):

- Coated and periodically re-coated with reflective coatings to protect the foam from UV and water damage.
- Acrylic being the most common coating.

Shingled Roofs (steep sloped roofs):

Asphalt Shingles

- Not typically coated in the field and doing so may void the manufacturer's warranty.
- Need to replace the shingles with reflective shingles.
- More cost effective to wait until the shingles reach the end of their service life before replacing them with cool shingles.

Other shingles - wood, polymer, or metal

- Can be coated to achieve cool roof.

Cool Roof Selection and Applications

New Construction and Roof Replacement – continued

Tile Roofs (steep sloped roofs):

- Clay, Concrete, Slate.
- Color may be retained or not with aging depending on the type of tile, and surface.
- Selecting cool roof tiles that retain their surface properties can yield better lifetime energy savings.

Metal Roofs (low and steep sloped roofs):

- Often coated with Fluoropolymer- or Silicone-Polyester based paints.
- Many colors can achieve cool roof performance.
- Usually, unpainted metals are good solar reflectors but poor thermal emitters, though some may still have a high enough SRI to count as a cool roof.

Some Cool Roof Requirements

Minimum Cool Roof Requirements

Program	Roof Type	Solar Reflectance	AND	Thermal Emittance	OR	SRI
CEC	Low Slope	0.55 (3-yr)		0.75		64 (3-yr)
	Steep Slope	0.20 (3-yr)		0.75		16 (3-yr)
LEED	Low Slope	-		-		78
	Steep Slope	-		-		29
DOE	Low Slope	0.55 (3-yr)		0.75		64 (3-yr)
	Steep Slope	-		-		29 (3-yr)
Energy Star	Low Slope	0.65 (initial) 0.50 (3-yr)		-		-
	Steep Slope	0.25 (initial) 0.15 (3-yr)		-		-


Other Codes and Programs: http://www.coolroofs.org/codes_and_programs.html

- CEC-California Energy Commission
- LEED-Leadership in Energy and Environmental Design
- DOE- US Department of Energy (for use on DOE buildings)

Cool Roof Ratings

Cool Roof Rating Council (CRRC)

<http://www.coolroofs.org/products/results.php>

	Solar Reflectance	Initial 0.87	Weathered 0.77
	Thermal Emittance	0.87	0.86
	Rated Product ID Number		0614-0036
	Licensed Seller ID Number		0614
	Classification		Production Line
Cool Roof Rating Council ratings are determined for a fixed set of conditions, and may not be appropriate for determining seasonal energy performance. The actual effect of solar reflectance and thermal emittance on building performance may vary.			

Weathered solar reflectance values should be used when evaluating roof energy cost savings. *Image Source: CRRC*

ENERGY STAR Roof Product List

http://downloads.energystar.gov/bi/qplist/roofs_prod_list.pdf

Cool Roof Case Studies

Florida Solar Energy Center (FSEC) Flexible Roof Facility

The average cooling energy reduction based on tests in a dozen homes converted to white roofs has averaged 19%

Relative to a black asphalt shingle roof, our white tile roof saw a 76% reduction in overall summer ceiling heat flux

When summer air temperatures were at their peak, the coincident peak attic air temperature difference was 40 °F lower in the white tile test cell (91.4 °F) than the construction with black asphalt shingles (131.5°F)



Source: FSEC

http://www.fsec.ucf.edu/en/research/buildings/zero_energy/lakeland/roof.htm#

Cool Roof Economics

Materials & Labor

- Cool roof options are usually similar in cost or slightly more expensive than similar non-cool alternatives.
- Labor required to install or coat cool roofs is about the same as for non-cool roofs.
- Coating a good-condition dark roof just to make it a cool roof, the additional cost can be significant.

Maintenance

- Maintenance of cool roofs is similar to non-cool roofs
- In warm moist climates
 - more susceptible to algae or mold growth
 - look bad and reduce the roof's reflectance
- In cold climates
 - accumulate moisture through condensation
 - lead to material degradation

Cool Roof Economics – continued

Energy Savings

- Reducing building operating costs

Rebates and Incentives for cool roofs

- Offered by some utilities and agencies, visit CRRC
- 30% Federal Tax Credit, up to \$1,500

HVAC Equipment Savings

Extended Roof Lifetime

Typical Expected Savings and Premiums

Cool vs. Hot Roof		Notes
Upfront Savings (Costs) \$/ft2/yr roof area		
Installed Cost	(0.00-0.75)	Material cost premium. Most cool options have only a slight cost premium or none at all.
Rebates	0.00-0.20	Rebates are available in select locations, check here: www.coolroofs.org/codes_and_programs.html .
HVAC Downsizing	0.00-0.07	Reductions in peak cooling capacity tend to be modest, and are only possible when cool roofing coincides with HVAC replacement and reductions enable use of smaller AC systems.
Annual Savings (Costs) \$/ft2/yr roof area		
Cooling Energy	0.00-0.13	Varies by location, insulation levels, HVAC equipment and efficiency, and utility rates. Estimate energy cost savings with the Roof Savings Calculator: www.roofcalc.com . Snow on roofs can reduce the heating energy penalty.
Heating Energy	(0.00-0.03)	

Source: DOE Building Technologies Program, Guidelines for Selecting Cool Roofs, July 2010

Cool Roof Savings Calculation

- Oak Ridge National Laboratory developed a Cool Roof Calculator.

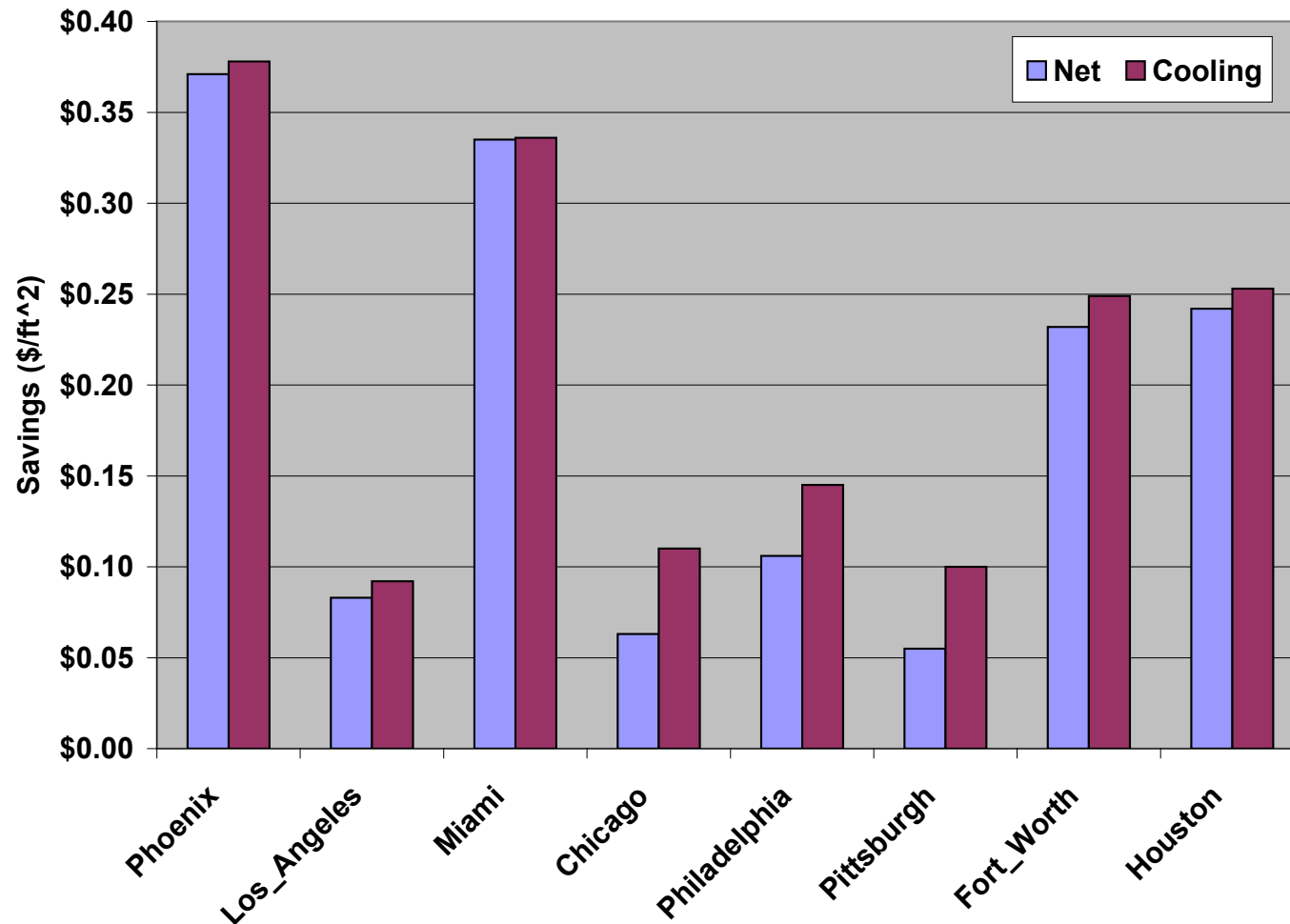
www.ornl.gov/sci/roofs+walls/facts/CoolCalcEnergy.htm

- A program was written to use the Calculator at various locations and conditions.
- Buildings are assumed to have no thermal mass.

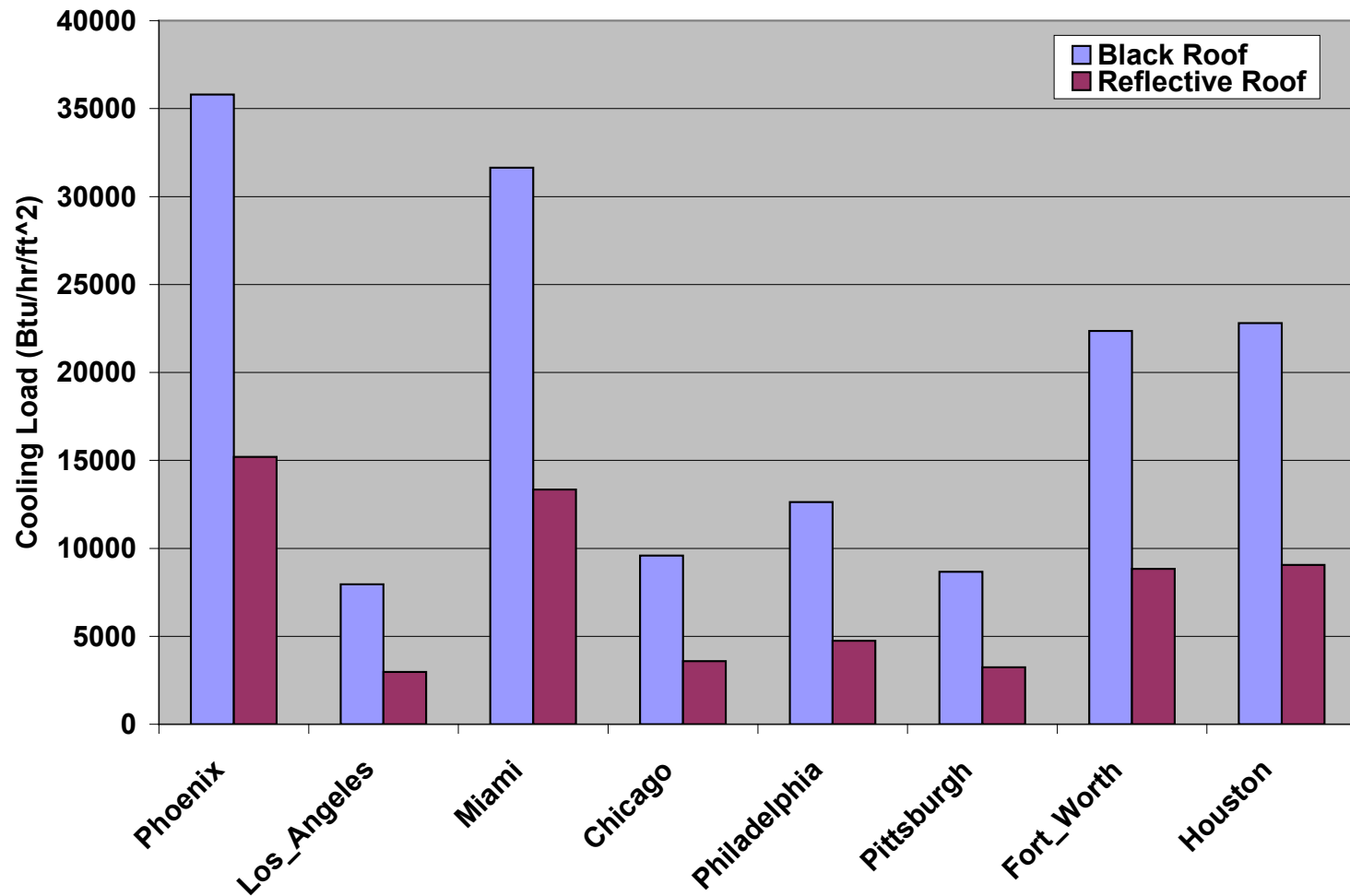
Assumptions

- Electricity rate: flat at \$0.125/kWh
- Air conditioning COP: 2
- Heating fuel: Natural gas
- Natural gas rate: \$1 per Therm
- Heating equipment efficiency: 0.7
- R-5 roof Insulation

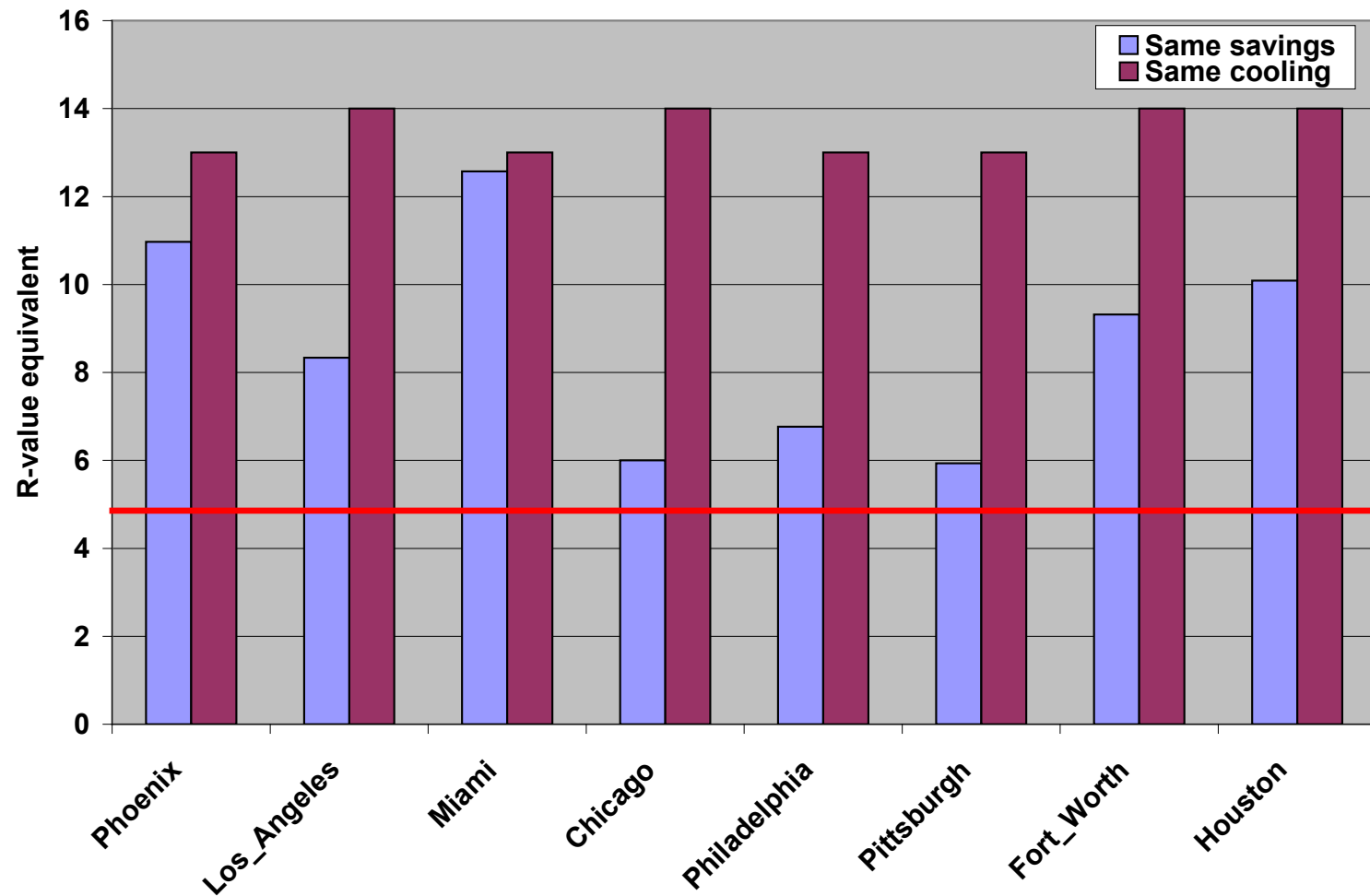
Energy Cost Savings



Cooling Loads



Equivalent Insulation in Black Roof



Conclusions

- Cool roofs reduce the cooling load.
- Potential AC equipment downsizing -- cost savings.
- Cool roofs produce energy savings.
- Improve space comfort.
- Cool roofs achieve the greatest cooling savings in hot climates (Climates 1-3).
- Cool roofs can increase energy costs in colder climates due to reduced beneficial winter time heat gains.
- Extended roof life and reduced roof maintenance.
- Equivalent energy savings from the roofing surface may be achieved with a higher R-value insulation.
- Cool roofs offset CO₂ and delay global warming.
- Urban heat island reduction.

References

Guidelines for Selecting Cool Roofs,

<http://www1.eere.energy.gov/femp/pdfs/coolroofguide.pdf>

DOE Cool Roof Calculator,

<http://www.ornl.gov/sci/roofs+walls/facts/CoolCalcEnergy.htm>

Cool Roof Rating Council, www.coolroofs.org

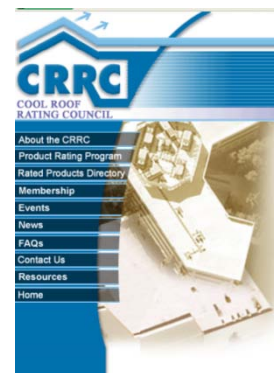
Roof Savings Calculator, <http://www.roofcalc.com/>

Cool Roof Fact Sheet,

http://www1.eere.energy.gov/buildings/pdfs/cool_roof_fact_sheet.pdf

Cool Roof Design Brief,

<http://www.pge.com/includes/docs/pdfs/shared/saveenergymoney/rebates/remodeling/coolroof/coolroofdesignbrief.pdf>



Thank you