Radiant Barrier Structural Roof Sheathing

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Radiant Barriers Structural Roof Sheathing

Presented By: LP Building Products
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Description: An overview of radiant barrier roof sheathing technology, how it works, its effectiveness, and installation guidelines.

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Purpose and Learning Objectives

Purpose: An overview of radiant barrier roof sheathing technology, how it works, its effectiveness, and installation guidelines.

Learning Objectives:

At the end of this program, participants will be able to:

- define the forms of heat transfer
- define radiant barriers and illustrate their function
- define reflectivity and emissivity and illustrate how they relate to each other and the function of a radiant barrier
- evaluate the use of a radiant barrier in both a heating and cooling environment, and
- specify key installation measures for both radiant barrier sheathing.

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Table of Contents

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Heat Transfer

Heat Transfer Mechanisms

Heat transfer occurs in three ways: by **conduction** (through solids or liquids), by **convection** (through liquids or gases in motion), and by **radiation** (through vacuums or open spaces via the electromagnetic spectrum).

Conduction is the direct flow of heat through a material resulting from physical contact. The transfer of heat by conduction is caused by molecular motion in which molecules transfer their energy to adjoining molecules and increase their temperature. A typical example of conduction would be heat transferred from hot coffee, through the cup, to the hand holding the cup.

Convection in buildings is the transfer of heat caused by the movement of heated air. In a building space, warm air rises and cold air settles to create a convective loop and is termed free convection. Convection can also be caused mechanically (termed forced convection) by a fan or by wind.

Heat Transfer Mechanisms cont'd

Radiation is the transfer of heat (infra red radiant energy) from a hot surface to a cold surface through air or a vacuum. All surfaces radiate to different degrees. Some examples would be a radiator in a car, a stove, the ceiling in a house or the roof over the house and the insulation in the attic. The radiant heat is invisible and has no temperature, just energy. When this energy strikes another surface, it is absorbed and increases the temperature of that surface. This concept can be understood with the following example.

On a bright sunny day radiant heat from the sun travels through a car's window strikes the steering wheel and is absorbed causing it to rise in temperature. Radiation from the sun strikes the outer surface of a building and is absorbed causing the surface to heat up. This heat flows from the outer wall to the inner wall through conduction which is then radiated again through the air spaces in a building to other surfaces within the building.

Heat Transfer Mechanisms cont'd

Two commonly encountered terms when discussing radiant heat transfer are emittance and reflectance.

Emittance or emissivity refers to the ability of a materials surface to emit radiant energy. All materials have emissivities ranging from zero to one. The lower the emittance of a material the lower the heat (infra red energy) radiated from its surface. Aluminum foil has a very low emittance which explains its use in radiant barriers.

Reflectance or reflectivity refers to the fraction of incoming radiant energy that is reflected from the surface. Reflectivity or emissivity are related and a low emittance is indicative of a highly reflective surface. For example aluminum with an emissivity of 0.03 has a reflectance of 0.97.

Characteristics of a Radiant Barrier - Emissivity and Reflectivity

Radiant barriers have two properties, **high reflectance** and **low emittance** (low-e), that enable them to reduce radiant heat transfer.

A radiant barrier system is always installed with its low-e surface facing an open air space, such as in an attic, to reduce radiant heat gain in the summer and radiant heat losses in the winter.

Radiant barriers must have an emittance of 0.1 or less (ASTM 1313), however, most products on the market have an emittance of 0.05 or less, as required by several code jurisdictions.

Characteristics of a Radiant Barrier – Reflectivity

Radiant barriers will have either one or more reflective surfaces. Aluminum foil makes an excellent radiant barrier, having an emittance of ~0.03-~0.05, and thus a reflectance of ~0.95-~0.97. In contrast, common building materials found in attics, such as wood, fiberglass, and cellulose, have emittances in the range of 0.8 to 0.9 (Source: RIMA).

Because these materials have relatively high emittances, installing a radiant barrier in an attic, with its low-e surface facing the air space, is an effective strategy for reducing summer heat gain through the attic.

In the winter season the insulation is designed to slow down the heat loss from the conditioned space. As the insulation heats up it radiates upward and the radiant barrier reflects the radiant heat back into the insulation.

What is Radiant Barrier Structural Sheathing?

Structural Radiant Barrier Sheathing

Prior to the early 1990’s, the most common way to install a radiant barrier in new construction was to take a roll of radiant barrier and drape it over the tops of the rafters and staple it into place.

The first commercialized structural radiant barrier panel was introduced into the market in 1989 when a manufacturer developed a laminating process that glued a kraft backed aluminum material directly to the structural sheathing primarily used as roof sheathing. By the late 1900’s this technology caught on as builders saw the value in energy savings with no additional labor costs and architects began to take note of the importance of controlling heat migration in and out of the structure.

Radiant Heat Gain

The predominant mode of attic heat transfer for a home located in a warm summer climate is by radiation.

During summer days, the roof is heated by solar radiation. Since the hot roof components are separated from the attic floor by air, very little downward conductive heat transfer will occur. Likewise, very little or no downward convective heat transfer will occur because hot air rises. Therefore, most of the heat absorbed by roof components is transferred through the attic space by infrared radiation to the attic floor, and is then conducted to the ceiling of the living space below.

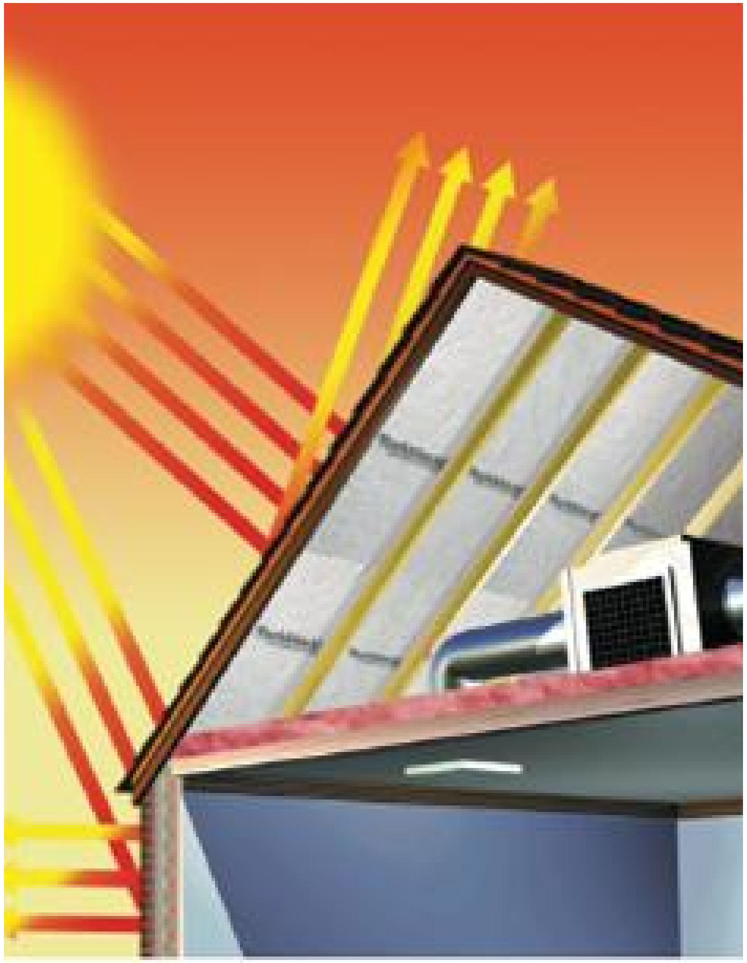
According to the Reflective Insulation Manufacturers Association International (RIMA-I), 93% of solar radiated heat enters a building through the attic. The result of this phenomenon is higher energy consumption by the home's air conditioner to compensate for the attic and ceiling heat gains.

Radiant gain during summer months

Summer Heat Gain

In the summer months it is common to see roof temperatures reach 160°F. Standard roof sheathing is a poor insulator letting 90% of the roofs heat to radiate into the attic. Radiant barrier roof sheathing blocks up to 97% of the heat behind the foil surface from entering the attic. It is common to see as much as a 30°F drop in attic temperatures.

In a study done by the Florida Solar Energy Center, the roof insulation's thermal resistance was found to be improved by 50% with a radiant barrier present in the roof system.



Summer radiant gain deflected with radiant barrier

Radiant Heat Loss

During the winter season, the predominant modes of heat transfer in an attic are convection and radiation. Heat from the living space is conducted through the ceiling to the attic floor and slowly through the attic insulation, if present. At the top of the insulation, heat is lost by upward radiation and convection to the air above.

Convection makes up the largest portion of total heat loss through the insulation on the attic floor during the winter months, but as the house ages and the insulation compresses the benefits of a radiant barrier roof sheathing increases by reflecting the radiant energy back into the attic space.

This is where it is important to understand the dynamics that occur in a conventional attic space.

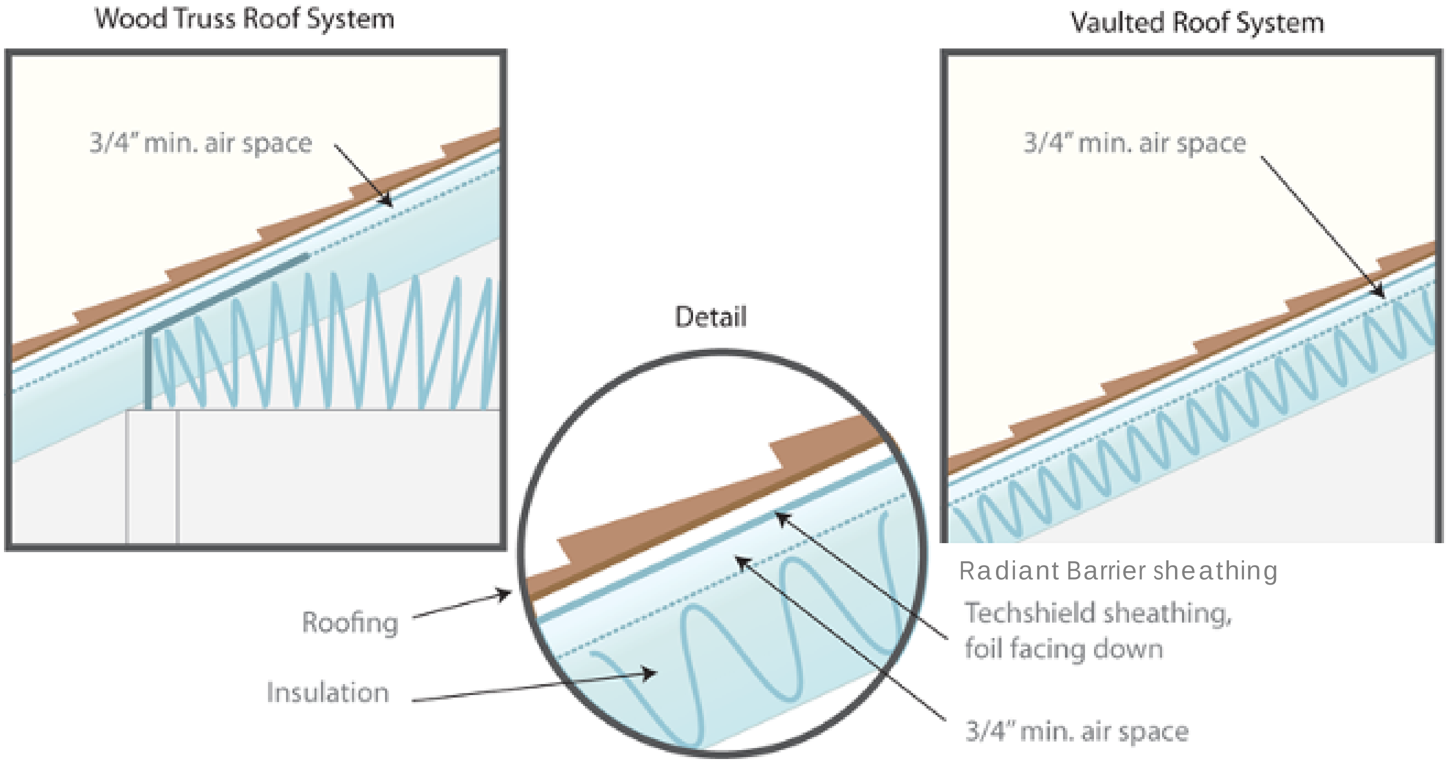
- R-Values reduce over time due to compression, and
- Airflow does not move radiant energy.

Conclusion is that radiant barrier roof sheathing increases in efficiency over time and increasing the ventilation rate will not replace the efficiency levels of a radiant barrier.

Radiant Barrier Structural Sheathing

Foil Faced Sheathing

Radiant barrier sheathing is an aluminum based material laminated directly to OSB or plywood roof sheathing. The sheathing is usually available in standard sheathing sizes and thicknesses making it ideal for new home construction. It is installed just like conventional roof sheathing but with the foil facing into the attic space and it requires no additional labor cost to the installation.



Choosing a Foil Faced Structural Sheathing

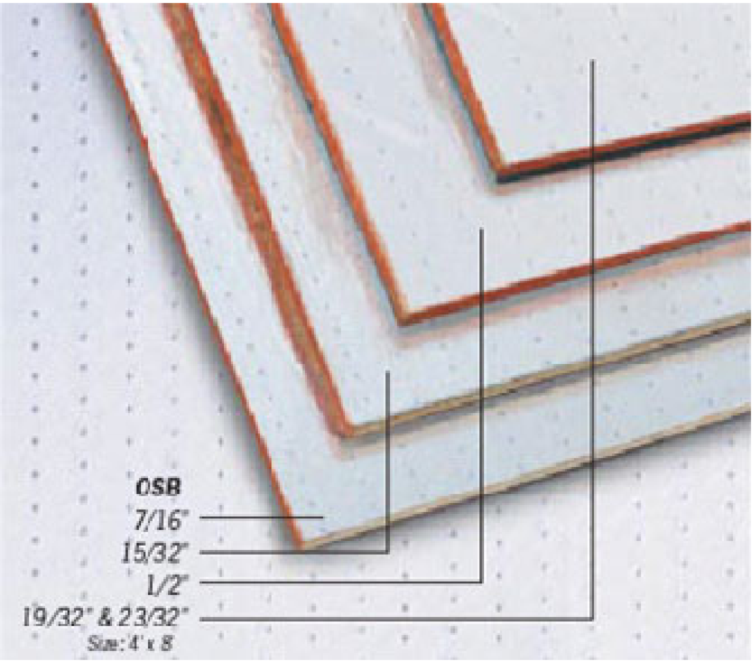
Radiant barrier sheathing is made of a thin, durable sheet of aluminum overlay laminated to OSB (or plywood). OSB is an affordable and environmentally smart wood-based structural panel made from wafers and resins.

Look for manufacturers that can show that their products do not trap moisture during jobsite exposure that may lead to deterioration of the substrate and surrounding building systems. In one product moisture vapor channels are created through the aluminum overlay and into the OSB to release trapped moisture without affecting radiant barrier performance. Releasing trapped moisture can help prevent decreased structural strength, rot, and potential mold growth in the panel and surrounding framing members.

When choosing a RB sheathing ensure perforations in the aluminum layer aren’t blocked during lamination, so roof decking and related components are protected from potential deterioration.

Perforations

Perforations must be large enough to allow passage of water vapor but spaced properly so that the openings do not affect the emissivity negatively. More on radiant barriers in this location is discussed in the section on installation.



Moisture Control Design Types

There are several types of structural radiant barriers in the market today, but when it comes to moisture control during and after construction they are not all created equal. This section will help you understand the differences in how these products are made and give you an understanding of what to look for in the design elements of a radiant barrier.

There has been a real progression in the moisture control design of structural radiant barriers over the year and below are the four types of manufacturing processes that are seen in the marketplace.

Non-Perforated Foil:

In this process the manufacturer laminates a *solid foil overlay* to the structural panel creating a finished product. The flaw in this design is that the process creates a vapor barrier on one side of the panel blocking the ability for moisture to be released from the laminated side of the panel.

Vapor Passage cont'd…

Pre-perforated Foil: In this process the manufacturer laminates a *pre-perforated foil* overlay to the structural panel creating a finished product. The flaw in this design is that the process creates a vapor barrier on one side of the panel blocking the ability for moisture to be released from the laminated side of the panel. Sound familiar? The glue fills up the pre-perforated holes in the foil blocking the release of moisture from the panel.

Post-perforated Foil: In this process the manufacturer laminates a *solid foil o*verlay to the structural panel but they don't stop there. After lamination the panel is put through a pin roller station putting small holes through the foil to allow moisture to be released through the overlay if it gets wet during construction.

Vapor Passage cont'd…

Post Incised: In this process the manufacturer laminates a *solid foil o*verlay to the structural panel. After lamination the panel is put through an incising process putting small serrations through the foil and into the wood fibers of the structural panel to optimize the free surface area to ensure moisture released through the overlay if it gets wet during construction

The faster drying materials allow the ability to design in moisture management features during the construction phase of a project to ensure a higher quality product at its completion.

Foil Faced Structural Sheathing

In fact, radiant barrier sheathing requires less time and labor to install than loose radiant barriers because the radiant barrier is already applied to the sheathing material. No special tools or additional construction steps are required.

The radiant barrier side of the roof sheathing is placed face down, toward the interior of the attic. There must be at least a 3/4" air space between the aluminum layer and other products such as insulation **in a vaulted ceiling configuration.**

Radiant Barriers and Composite Shingle Roofs

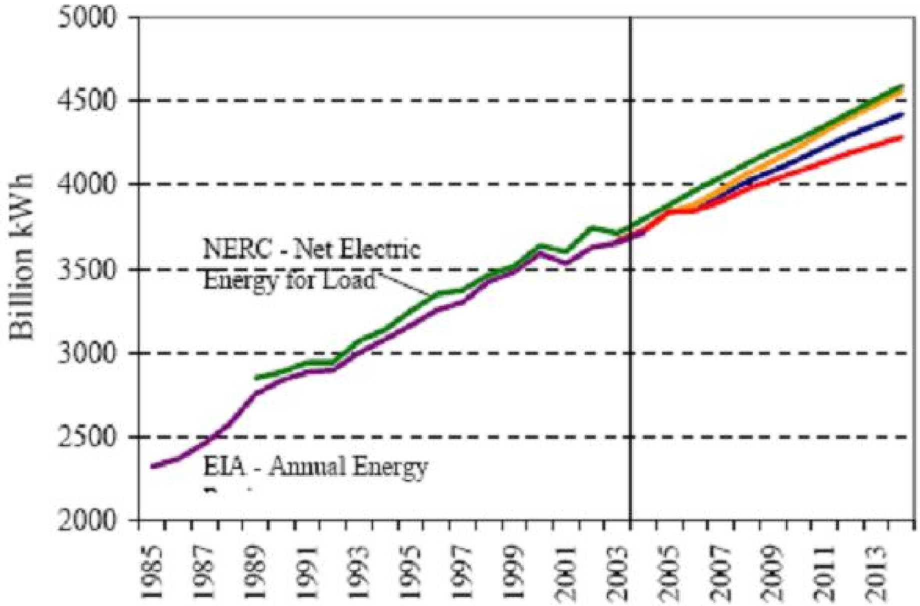
A study done by the Florida Solar Energy Center, which measured the temperatures of roof shingles above roof mounted radiant barriers on hot, sunny summer days, found that peak temperatures with a radiant barrier were only 2-5° F higher than the temperature of shingles under the same conditions without a radiant barrier.

A common misconception when structural radiant barriers were introduced was that the heat would melt the composite shingles. Numerous studies have shown that the shingles had a slight increase in temperature then dissipated the heat to the outside air. This is due to the inability of the radiant barrier roof sheathing, the felt paper and the shingles to store more heat.

Because roof shingles are designed to withstand temperatures in the area of 160-190°F an added 2-5°F will not adversely affect the shingles. However, this should be verified with the shingle manufacturer.

Radiant Barriers and Insulation

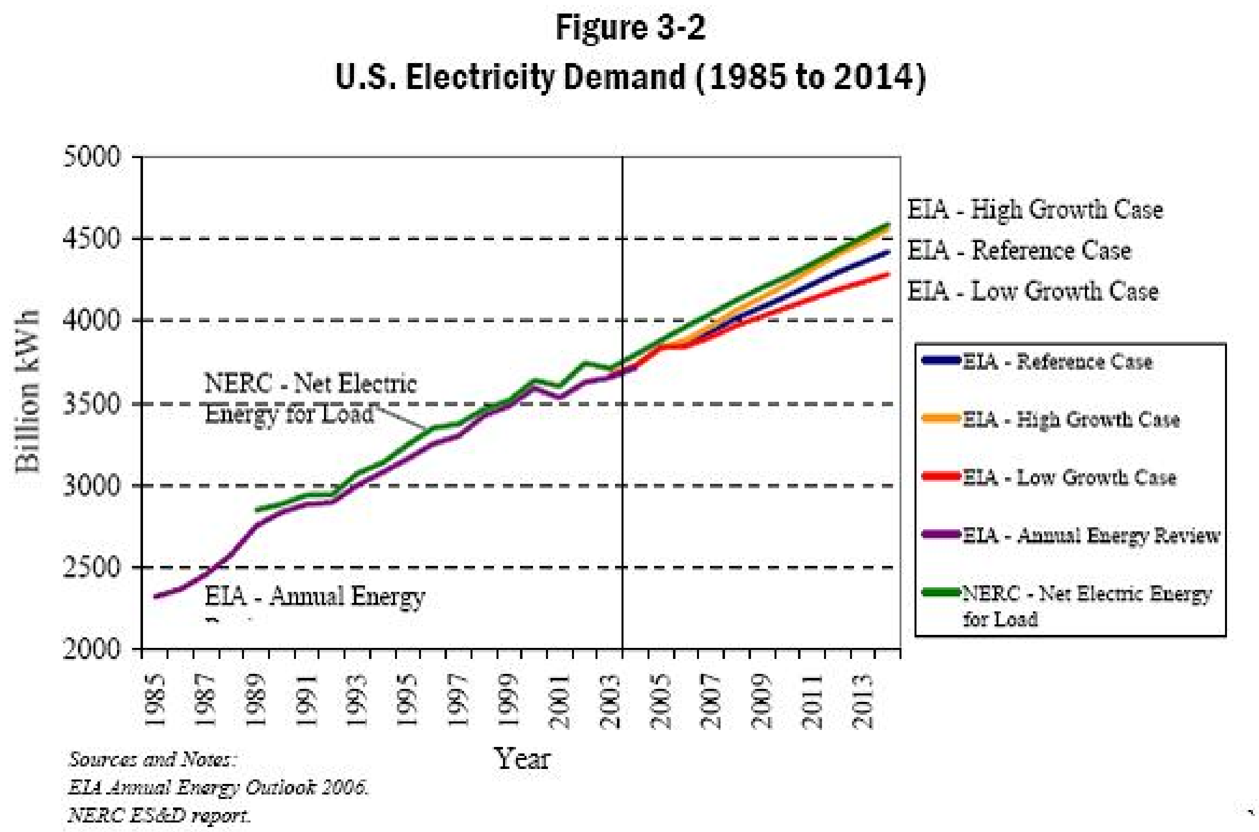
Insulation and radiant barriers work together to reduce attic and interior heat gains. Insulation works by trapping the air within it and reducing heat transfer by air movement or conduction. The radiant barrier reduces the amount of heat that will enter the attic. By reducing the attic temperature in the summer the insulation doesn't have to work as hard in preventing the heat from entering the conditioned space.



Trends in the Energy Industry

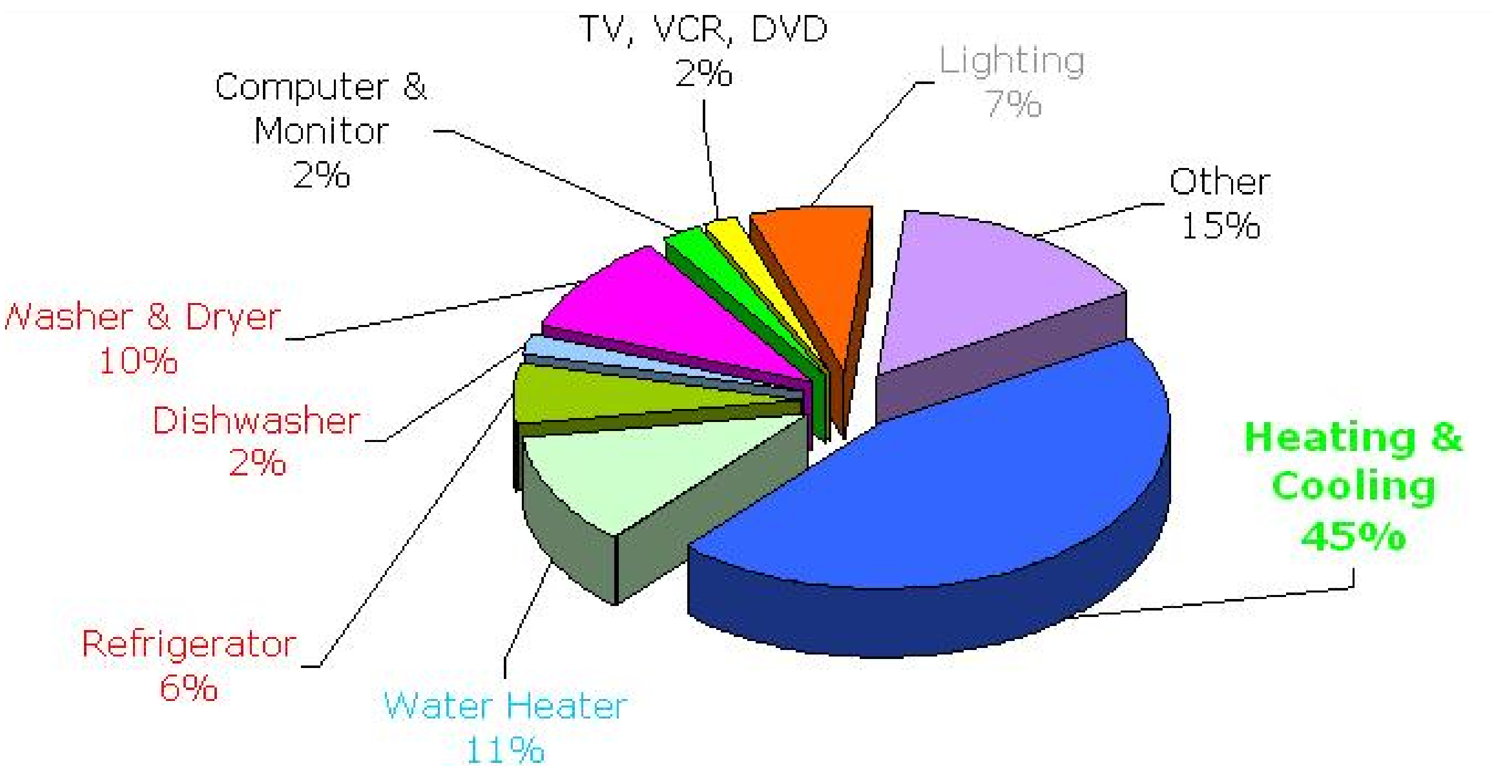
Energy Prices

As energy prices continue to rise along with a growing awareness of environmental costs of energy usage, building owners are looking for technologies that will lower their heating and cooling costs.



Residential Energy Usage

The average U.S. household uses a total of 30 kilowatt hours a day during the summer and 50 kilowatt hours a day during the winter. Forty-five percent of this electrical energy use is for heating and cooling, as shown in the chart below.



Energy Savings

In 2001 the Oak Ridges National Laboratory published a fact sheet on radiant barriers in which they summarized energy savings tests. The majority of these tests were done on buildings with high cooling loads in warm humid areas. Test results showed that with R-19 insulation in the attic space, radiant barriers can reduce summer heat gain by 16-42%. According to the Department of Energy this translates to a 8-12% reduction in annual utility bills.

In another study, done by the Florida Solar Energy Center, the installation of a radiant barrier resulted in peak energy use reduction three times greater than if attic insulation was increased. In this study, homes were given attic retrofits of radiant barriers fastened to roof decking or roof trusses, and energy use reduction and peak energy use reduction were monitored. Although homes where insulation increased from R-19 to R-30 showed lower cooling loads by 3.4kWh/day, the peak demand reduction was only 5%. With installation of a radiant barrier this peak demand reduction was in the order of 15%. This is due to reduced heat flow into the attic, which in turn reduces the amount of heat energy affecting the air conditioning equipment, ductwork, and insulation when installed in the attic.

Energy Savings Vary

There are many factors to consider when calculating energy savings such as the pitch of the roof, ventilation rate, location of the A/C equipment and ductwork, orientation of the home, insulation levels, window area and efficiency, number of occupants, and on and on. However, on the whole the Florida Solar Energy Center recommends the use of a radiant barrier saying it will provide an 8-12% annual savings on air conditioning costs for buildings in the southeast United States.

Lowered A/C Run Time

One of the indirect benefits of radiant barriers is reduced A/C runtime. In 1995, a study was done by Lawrence Berkeley National Laboratories which compared attic and ceiling temperatures, duct temperatures and flows, and A/C electricity consumption of a **new** unoccupied home in Austin, Texas before and after installing a radiant barrier on the roof sheathing. The house studied was built in 1995 to the then current "Good Cents" home specifications published by the Lower Colorado River Authority (LCRA) and had relatively low envelope leakage.

The home:

- living area 1530 ft2
- slab on grade with flat ceilings
- roof pitch of 6 in 12
- brown composite asphalt shingles
- R-38 ceiling insulation
- R-6 duct insulation
- both the air handler and duct system were located in the attic
- air infiltration measures

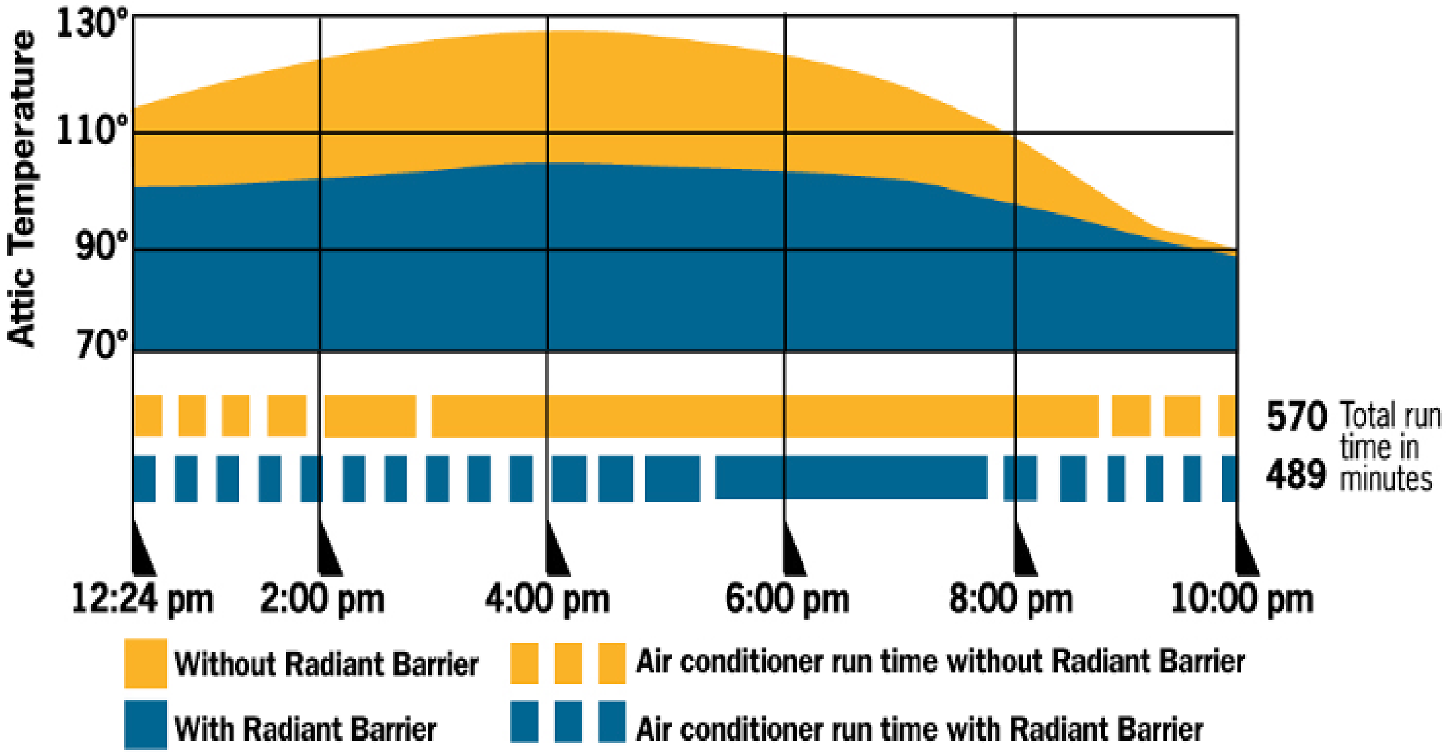
Lowered A/C Run Time cont'd…

The home was monitored from July 15 to 23, 1995 with the radiant barrier being installed on July 20. Based on weather data throughout the monitoring period, July 19 and 22 were selected as the dates to compare the pre- and post-radiant barrier data because of similar weather.

Extensive data analyses were performed to quantify the energy consumed on July 22 with the radiant barrier compared to July 19 without the radiant barrier. The analyses showed that the A/C energy consumption was 16% less on July 22 as compared to July 19, and that 80% of this decrease was attributable to reduced radiant heat gain by the duct system and air handler as a result of the radiant barrier installation.

Lowered A/C Run Time cont'd…

In addition, the radiant barrier reduced the cooling load by up to 15%, and the A/C ran for a total of 81 minutes less throughout the day than on July 19. These results are quite significant, especially given the fact that the home had R-38 ceiling insulation.



Installation and Applications

Applications – Gable End

Radiant barrier sheathing is used in both new construction and remodeling. As structural sheathing in new construction, it is an ideal way to include a radiant barrier without incurring extra labor costs. In addition to roof sheathing applications, radiant barrier sheathing panels should be used on the gable ends to create an energy efficient attic system. Just as in the Roof sheathing application the foil faces into the attic space on the gable ends.

Applications - Roof and Wall

For roof sheathing installation, place the panels with the foil side facing down on the rafters or trusses, toward the attic air space.

For exterior wall applications, the foil surface should face out, toward the exterior of the home. Using furring strips to create a separation between the foil and the siding is considered best practice. This gives the sheathing the required air space between the exterior finish and the wall.

Handle radiant barrier sheathing panels as you would other APA-rated sheathing panel products; protecting them from moisture and rain before and during construction.

Studies

Case Study – Centex Homes

Huntingdon Engineering and Environmental, Inc. conducted a study in which 20 to 30 temperature measurements were made in 7 pairs of houses built by Centex Homes (Smith 1994) in the Houston, TX area. The houses were selected in matched pairs with similar floor plans, roof pitch, shingle color, attic ventilation, and attic insulation; the only substantial difference being that one house in each pair had radiant barrier roof sheathing while the other house had traditional sheathing.

Exterior and interior temperature measurements were made on September 19 and 20, 1994. Overall, outside ambient air temperatures ranged from 82°F to 89°F. Measurements within pairs of homes had no more than 4°F difference in outdoor ambient air temperature during the test.

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Case Study – Centex Homes cont'd…

This study showed attic surface temperature reductions of the insulation in the attics with radiant barrier sheathing to be in the range of 17° to 29.9°F, as compared to the homes without a radiant barrier. Ambient attic air temperature reductions were on the order of 12°F to 21°F. In addition, A/C coil temperatures were measured for three of the homes.

The homes with the radiant barrier exhibited A/C coil temperature reductions in the range of 22°F to 27°F. These temperature reductions indicate that an attic radiant barrier reduces the ceiling cooling load and direct air conditioning cooling load for homes during the cooling season.

Kenetech Study

Kenetech Resource Recovery, Inc. conducted a study evaluating the annual energy use and cost of a home in Austin, TX. Savings were sufficient to provide a payback on the initial cost of the product in about 2 years.

A large portion of the savings was due to a significant reduction in heat transfer through the ductwork. This study estimated a 40+% rate of return on the investment.

Roaring River Study

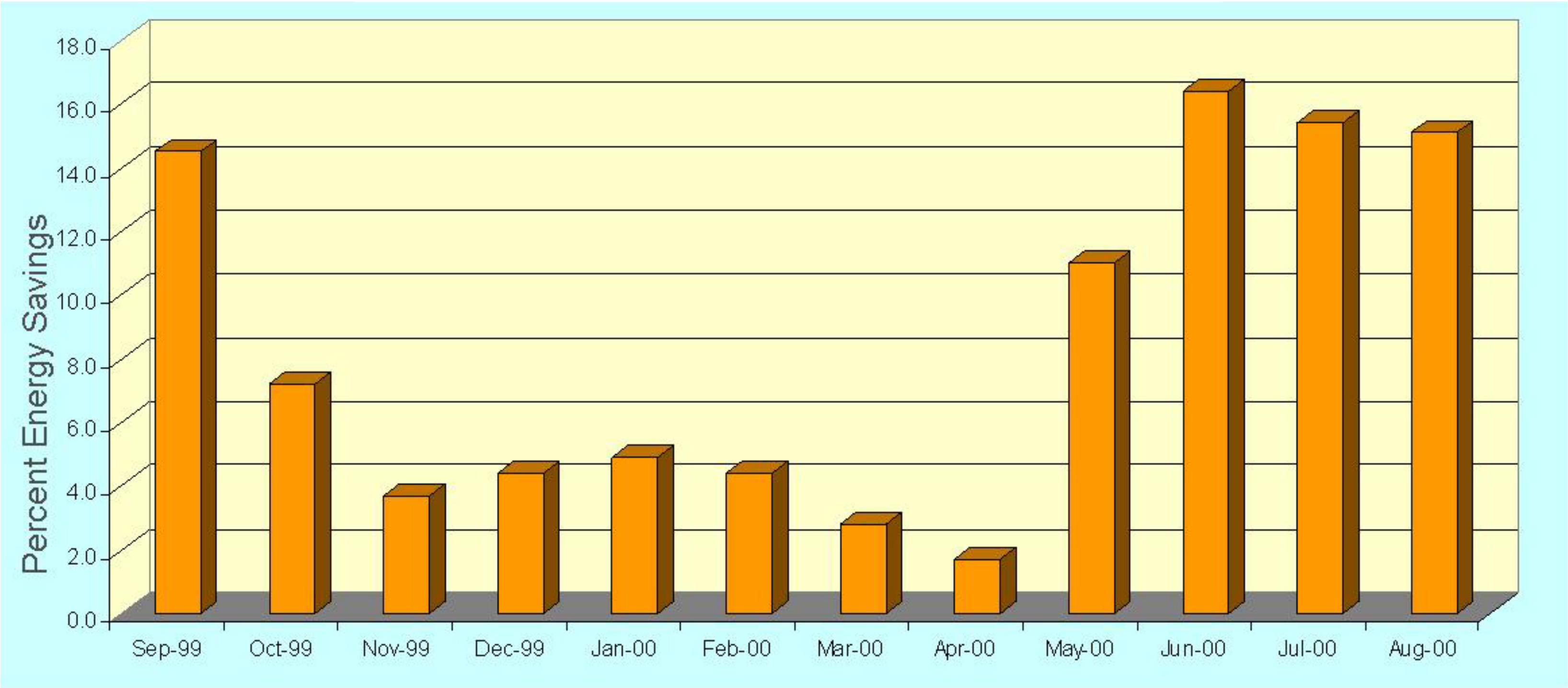
From September 1999 through August 2000 a study was done to determine the energy savings for homeowners when using radiant barrier roof sheathing. For this study the energy consumption of two unoccupied manufactured homes located in Roaring River, N.C. was monitored for a year. The two homes were identical except one had radiant barrier roof sheathing and the other had regular OSB roof sheathing. Both of the homes were Horton model E200, one of the most energy efficient models available at the time. Each home had R-30 blown in fiberglass insulation above the ceiling and R-11 insulation in the walls and R-22 insulation below the floors.

The homes were heated and cooled via identical electric heat pumps with all ductwork located in the crawl space and the air handler located within the conditioned space. In addition to being monitored for electric energy consumption temperatures were monitored at various locations within the homes, the attic spaces and the outdoors. The results of this study indicate that savings attributable to radiant barrier roof sheathing occurred in every month, varying with average daily high and low temperatures as shown in the following figure.

Roaring River Study cont'd…

The data indicated that radiant barrier sheathing yielded savings of up to 16.4% during the summer months and was up to 4.9% during the winter months. Thus, it can be concluded that radiant barrier sheathing reduces attic heat gain in the warmer months and attic heat loss in the cooler months.

Roaring River, NC – Radiant Barrier Study



Average temperature **26°** **89°**

Roaring River Study cont'd…

It is important to note that the three months with the lowest energy savings April, March, and November had average daily high temperatures (66.1° F, 66.5° F and 66.0° F respectively) very close to the reference temperature of 65 ° F used to calculate both heating degree days (HDD) and cooling degree days (CDD). HDD and CDD use 65° F as the reference temperature because it is the theoretical outdoor temperature at which no heating or cooling is required for a structure. It stands to reason that energy savings will be lower in months when average daytime temperatures are close to 65F.

FSEC Studies

In the late 1980s, FSEC published a comprehensive, detailed report about radiant barrier technology. This report is one of the most, if not the most, comprehensive text on radiant barriers. It is a definitive resource that presents research by the authors as well as others. Topics addressed include the effects of ceiling insulation level, horizontal versus roof/rafter mounting, dust accumulation, and surface degradation, among others.

FSEC Studies cont'd…

Fairey et al. presents a basic heat transfer model to show that "for all practical purposes, the percentage reduction in ceiling heat transfer that is attributable to an attic radiant barrier system will not be a function of the ceiling insulation level…..All other things being equal, the percentage reduction in ceiling heat transfer for attic radiant barrier systems as compared to standard attics should remain constant regardless of ceiling insulation level."

This is because, in effect, for a summer environment, the heat gain of the attic is reduced at the plane of the roof mounted radiant barrier which is always above the insulation, so the net heat flow is reduced before it passes through the insulation. Readers are cautioned however, that ceiling heat transfer reductions do not necessarily translate into real reductions in cooling energy use.

Summary of Studies

A summary of these and other studies was able to determine that in general, ceiling heat flow reductions in summer correspond to cooling energy savings of up to 17%.

In addition, studies showed that the energy savings achieved by roof mounted radiant barriers increase significantly when HVAC ducts are installed in the attic.

Much of the early radiant barrier research studied the effects of roof-deck or rafter-mounted versus horizontal installation. Many of these studies showed that the horizontal configuration performed better than the roof-deck or rafter-mounted installations. However, these studies neglected to cover the interior attic gables with a radiant barrier which likely accounted for the performance differences. Later work at the Florida Solar Energy Center demonstrated that as long as the interior gable walls were covered with the radiant barrier, roof-deck and rafter-mounted radiant barriers provide equivalent ceiling heat gain reductions, as compared to a horizontal installation.

Summary of Studies cont'd…

In addition it is well documented that horizontal application of radiant barriers is susceptible to dust covering the surface of the barrier and lowering its effectiveness. For this reason, and the fact that the horizontal configuration does not reduce the radiant heat gain of attic mounted A/C equipment or ducts, properly installed roof deck or rafter mounted radiant barriers (including gables) are preferred.

Summary

Summary

Without a doubt radiant barriers, most effective in areas with high cooling loads, will lower the cooling energy costs of a home. They work to prevent radiant heat on the roof from entering living space below. They are additionally effective when the HVAC ductwork is located in the attic where they will lower attic temperatures and keep ductwork cooler and subsequently reduce A/C run-time.

It is important to note that to achieve the most effective temperature control in an attic space, radiant barrier sheathing must also be installed in the gable ends.

References

Fairey, Philip. *Radiant Energy Transfer and Radiant Barrier Systems in Buildings*, FSEC Publication DN-6, May 1994. Accessed on October 29, 2008 http://www.harmonyfl.com/lih/documents/EH245.pdf

Medina, Mario A. *Radiant Barriers: Performance Revealed*, homeenergy.org, 2000. Accessed on October 31, 2008

http://www.rimainternational.org/tech_pdfs/RB-Revealed.pdf

O'Neal, Dennis N. *An Evaluation of Placement of Radiant Barriers and their Effectiveness in Reducing Heat Transfer in Attics*, Texas A&M University. Accessed on October 31/2008 http://www.rimainternational.org/tech_pdfs/An_Evaluation_of_Placement_of_Radiant_Barriers.pdf

References cont'd…

Parker, D.S., Sherwin, J. R. and Anello, M. T., FPC *Residential Monitoring Project: New Technology Development - Radiant Barrier Pilot Project*, Florida Solar Energy Center 2001. Accessed on October 31, 2008

http://www.fsec.ucf.edu/en/publications/html/FSEC-CR-1231-01-es/

Swinton. M.C. *Radiant Barriers and Reflective Insulation*, National Research Council of Canada. 1991, Accessed on October 31, 2008

http://irc.nrc-cnrc.gc.ca/pubs/cp/wal5_e.html

Vrazel, Matthew *Energy Savings and other Performance Attributes of LP TechShield® Radiant Barrier Products* LP Technology Center, TN. Sept. 2008

Resources

Oak Ridge National Laboratory
http://www.ornl.gov/sci/roofs+walls/radiant/rb_01.html

Florida Solar Energy Center http://www.fsec.ucf.edu/en/publications/html/FSEC-EN-15/

Reflective Insulation Manufacturers Association http://www.rimainternational.org/

California Energy Commission http://www.energyvideos.com/bld.php?P=CA&A=5&S=rad

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