

Thermal Performance Study

Thermal Performance Study on COLORBOND® Coolmax® steel in Whitehaven® 2009/2010



Figure 1 Test buildings with different roofing material (from left to right) ZINCALUME® steel, COLORBOND® Coolmax® steel in Whitehaven® and COLORBOND® steel in Surfmist®.

From November 2009 to end of March 2010, BlueScope Steel conducted a thermal performance study based on our new high solar reflectance roofing material, COLORBOND® Coolmax® steel in Whitehaven®. The test was held in Brisbane, Queensland.

The focus of the study was to determine the differences in cooling energy consumption between buildings with roofing made from COLORBOND® Coolmax® steel in Whitehaven® and other roofing materials that are amongst the leaders in solar reflectance, standard COLORBOND® steel with Thermatech® in Surfmist® and ZINCALUME® steel.

Buildings used in the study

The study involved monitoring three nominally identical transportable buildings. The buildings were modified primarily for two reasons:

1. To ensure that the differences indicated in monitoring were only as a result of the different roofing products;
2. To make the influence of the roof heat flow into the building closer in nature to that of a typical, large commercial or industrial building.

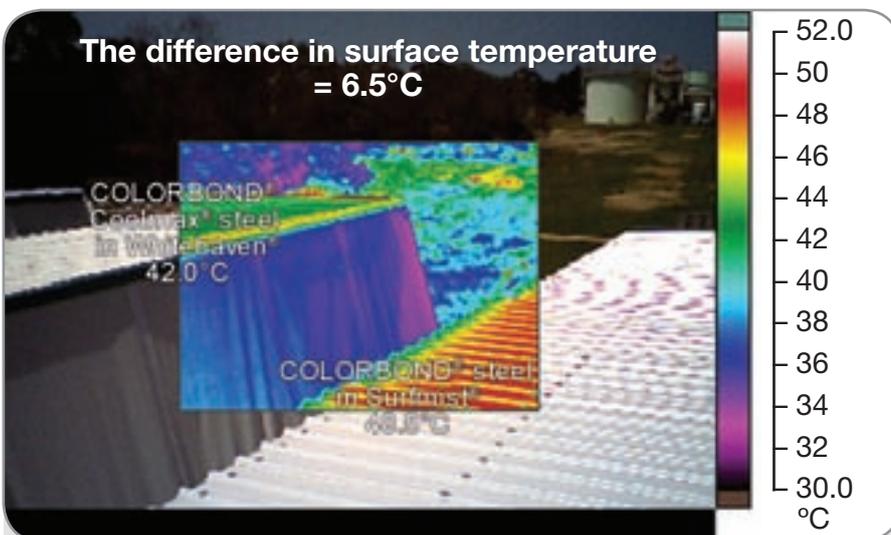


Figure 2 Thermal photography highlights the cooler temperature of roofing made from COLORBOND® Coolmax® steel in Whitehaven® relative to COLORBOND® steel in Surfmist®.



Figure 3 One of the portable buildings used in the test study.

COLORBOND® Coolmax® steel roofing is designed to provide the best thermal performance for the commercial and industrial roofing market, where by the nature of building designs, the financial and environmental benefits are usually valued more than a choice of roofing colour.

The financial benefits provided by roofing made from COLORBOND® Coolmax® steel are greater for commercial and industrial buildings as they:

- are predominately occupied during the day, resulting in greater cooling loads.
- have large roof to wall ratios, which results in more of the air-conditioning load being attributable to the roof.

The standard portable building is shown in *Figure 3*. The roofs were nominally insulated to the level required by the BCA 2009.

The building fabric cooling load imposed upon an air-conditioner will be the result of heat passing into the building through the roof, the wall, the windows, the floor and any infiltration.

Each of the standard portable buildings used in this study were modified to minimise the loading on air-conditioning from the walls, windows and floor in order to more accurately measure the impact of the roof alone.

An analysis of the heat load through the roof for conditions considered to be average for a warm day can provide an estimate of the average cooling savings whilst for a very hot day the data can provide an estimate of the buildings peak loading in order to size air-conditioning equipment.

Monitoring the study

The monitoring systems used in this study include:

- control equipment for the air-conditioner.
- electrical consumption devices linked to a data logger.
- temperature measurement devices linked to a data logger.

All monitoring equipment used in this study was independently designed and built. The data logger and temperature sensors were calibrated by a NATA accredited laboratory to ensure accuracy.

Controlling air-conditioner cycling

Accurate control and measurement of electrical consumption of the air-conditioner was required in order to assess the associated impact from the different roofing materials. This is particularly crucial when comparing COLORBOND® Coolmax® steel in Whitehaven® with COLORBOND® steel in Surfsmist®, as the differences are relatively smaller than a comparison between very solar reflective and solar absorbent roofing materials.

The equipment was independently calibrated and found to produce identical output temperatures across the range of 10–30°C. A system was put in place to measure relative results of room temperature to an accuracy of +/- 0.1°C. The room temperature probe was linked so that the air-conditioner would switch on at 21°C and switch off at 20°C.

Monitoring electrical use

The total amount of electricity consumed each day provided an estimate of the electrical savings for the building, which can be easily scaled to buildings of different sizes as a function of the square meterage of roof area. Additionally, in very hot weather, the number of hours that the installed air-conditioner could not keep the room temperature controlled is indicative of the impact the roofing material has on the required air-conditioner sizing.

Temperature measurements

The portable buildings were set up to log particular temperatures both within and outside the building. The following temperature measurements were taken:

- **Room temperature** – the accurate equipment used to control the cut-in/cut-out of the air-conditioners measures room temperature. The temperature probes were placed just above head height in identical positions within each building.
- **Roofing temperature** – Type K thermocouples were placed in similar positions beneath the roof sheeting.
- **Internal ceiling temperature** – Type K thermocouples were placed in similar positions on the internal surface of the ceiling lining.
- **Roof cavity temperature** – Type K thermocouples were placed in similar positions located just above the ceiling lining.
- **External wall temperature** – Type K thermocouples were placed in similar positions located on the southern facing wall.
- **External shaded temperature** – Type K thermocouples were placed in a partially shaded position (shade cloth) about 50mm from the southern facing wall. This provided an indication of the outdoor temperature.

A Bureau of Meteorology site at Archerfield in Brisbane is located approximately 10 kilometres from the study site. This enabled access to solar radiation data, wind speed and guidance to outdoor temperatures.

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A summary of key findings

COLORBOND® Coolmax® steel in Whitehaven® could provide savings on cooling energy costs of up to 7.5%

Commercial buildings will derive the largest energy savings from COLORBOND® Coolmax® steel as they have high cooling requirements due to predominant daytime occupation and because they are often thermally influenced by a roof that dominates the exterior. For these buildings, specifying a roof made from COLORBOND® Coolmax® steel in Whitehaven® over COLORBOND® steel in Surfemist® could result in cooling energy savings of up to 7.5%.

COLORBOND® Coolmax® steel in Whitehaven® has a 9% higher solar reflectance than COLORBOND® steel in Surfemist®. Based on independent roof studies of the solar reflectance of roofing contained in a report by the US Environmental Protection Agency (<http://www.epa.gov/hiri/resources/compendium.htm>), we calculate this difference could result in cooling energy savings of up to 7.5%. Savings will vary and depend upon the level of insulation, location of air-conditioning ducts, building shape and function.

Our analysis is based on the typical difference in solar reflectance of about 60% going from a dark absorptive roof to a light reflective roof – resulting in savings of up to 50% typically reported in public domain (some studies report savings of up to 70%). COLORBOND® Coolmax® steel in Whitehaven® has a 9% higher solar reflectance than COLORBOND® steel in Surfemist® – evidence BlueScope.

COLORBOND® Coolmax® steel may help reduce peak cooling load, which may reduce upfront HVAC equipment costs

Specifying COLORBOND® Coolmax® steel in Whitehaven® may either allow the capacity of the cooling equipment to be downsized or will help it cope on hot days. Based on calculated reduced heat flows, specifying COLORBOND® Coolmax® steel in Whitehaven® over COLORBOND® steel in Surfemist® and ZINCALUME® steel has the potential to save approximately \$0.57/m² and \$1.70/m² of roofing respectively on the cost of HVAC cooling equipment (see Figure 5). The actual benefit may be greater when air-conditioning ducts run within the roof space or near the roof as the impact of heat and infiltration on ducting is not taken into account, but any savings may vary and depend upon

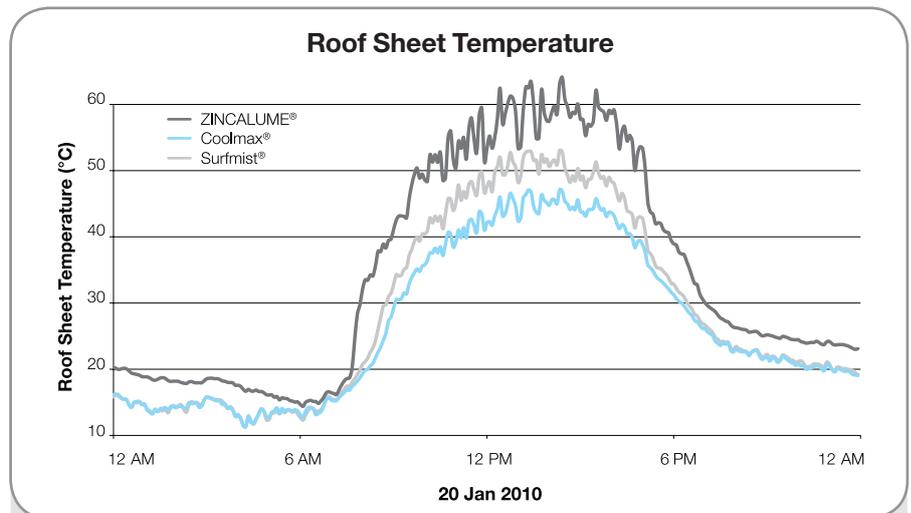


Figure 4 Roof sheet temperature on a typical warm sunny day.

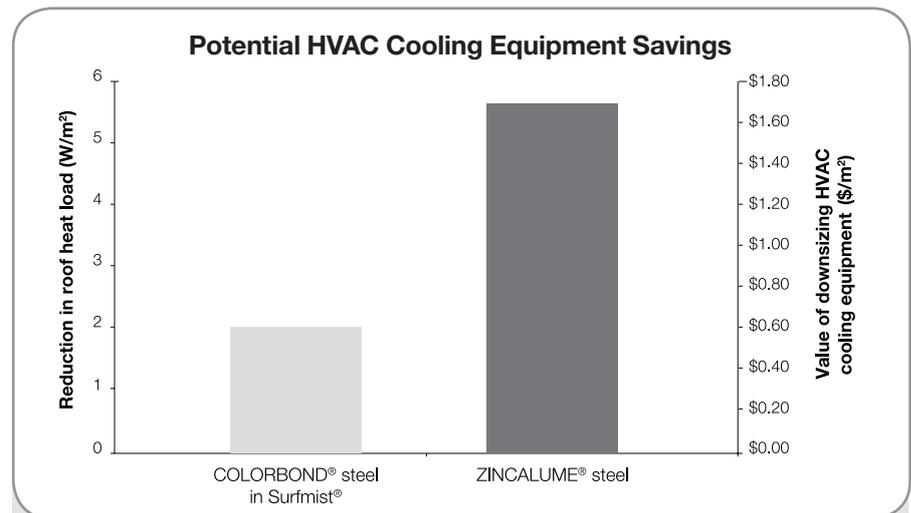


Figure 5 Potential HVAC Cooling Equipment Savings by specifying COLORBOND® Coolmax® steel over other roofing materials (On basis of theoretical heat flow through for R3.2 roof on hot day, 1=1000 W/m², tout = 34°C, wind=0.5m/s, cooling equipment valued at \$300/kW).

the particular circumstances of your building, including building location, level of insulation, location of air-conditioning ducts, building shape, building function and environmental factors.

Heat flows based on simple heat balance equations for a typical hot day.

Australian Building Code Board Regulation Impacts Statement quotes 2008 values ranging from \$200/kW to \$300/kW (ABCB RIS 2009-04).

COLORBOND® Coolmax® steel translates to cooler room temperatures

A roof made from COLORBOND® Coolmax® steel reduces the surface temperature of your roof which translates to a cooler room temperature. During the study it was found that the insulated roof

made from COLORBOND® Coolmax® steel reduces the internal temperature of the room by up to 2°C when compared to ZINCALUME® steel.

Scaling: 60% change in solar reflectance = up to 50% savings in cooling costs. 9% change in solar reflectance = up to 7.5% savings in cooling costs (or 15% of 50%).

COLORBOND® Coolmax® steel creates a cooler roof

Over the months of monitoring the insulated roof made from COLORBOND® Coolmax® steel was consistently cooler. The external surface temperature of the roof sheet was up to 6.5°C and 18°C cooler compared to the roof made from COLORBOND® steel in Surfemist® and ZINCALUME® steel.

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Key additional benefits of COLORBOND® Coolmax® steel in Whitehaven®

The following statements are based on existing BlueScope Steel reports and referenced information from the public domain.

COLORBOND® steel is excellent at maintaining its solar reflectance

COLORBOND® Coolmax® steel in Whitehaven® is designed to maintain all the qualities of COLORBOND® steel. One such quality is the product's excellent resistance to dirt retention and maintenance of solar reflectance. As an example, COLORBOND® steel in Surfsmist® samples exposed over a decade at the Rockhampton exposure site retained 95% of their initial solar reflectance.

Reference: Adams JC & Stark GK, The benefits of light coloured steel roofing, BlueScope Steel Research, BSR/S/2005013, August 2005.

COLORBOND® steel is more likely to retain its solar reflectance over white post-applied solutions

In a US study by Oak Ridge National Laboratory (ORNL) metal roofing, pre-painted metal was found to retain almost 95% of its initial solar reflectance over three years. By comparison, some membrane roofing products and white coatings displayed a 40% and 25% drop respectively in solar reflectance over the same exposure period. (Miller 2004)

http://www.coolmetalroofing.org/elements/uploads/casestudies/TMI_CaseStudy_26.pdf

Specifying COLORBOND® Coolmax® steel over lower solar reflectance roofing materials may help mitigate the impact of Urban Heat Islands

Elevated temperature from Urban Heat Islands, particularly during summer, can affect a community's environment and quality of life. According to the USA EPA, impacts include:

- increased energy consumption.
- elevated emissions of air pollutants and greenhouse gases.
- impaired water quality.

For more information on Urban Heat Islands and their effects visit <http://www.epa.gov/heatisland/about/index.htm> or watch the video featuring a Senior Research Scientist from BlueScope Steel at colorbond.com/coolmax

A cool roof can favourably impact the lifespan of the roofing materials

A cooler roof keeps the entire roofing system cooler and less prone to thermal stresses. This can favourably impact the lifespan of the materials that comprise the roofing system.

<http://www.consumerenergycenter.org/coolroof>

Cool roofs can reduce the roof surface temperature by up to 38°C, thereby reducing the heat transferred into the building below. This helps to reduce energy costs, improve occupant comfort, cut maintenance costs, increase the life cycle of the roof, and may reduce Urban Heat Islands along with associated smog.

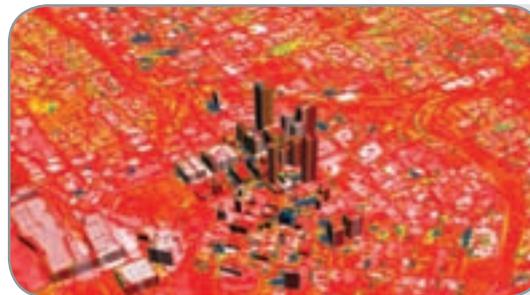


Figure 6 Dense development using dark, high mass materials cause cities to heat. Increased temperatures cause increased air-conditioner loads on buildings and air pollution.

Photograph by NASA Goddard Space Flight Center Scientific Visualization Studio.

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For more information on COLORBOND® Coolmax® steel, steel roofing solutions or any of the information contained in this study paper visit colorbond.com/coolmax or call BlueScope Steel on 1800 022 999.