Performance Assessment of the Cool Roof Trial in the City of Adelaide: Park 22

Technical Report

June 2023: A year after application

Delivered by:

Ehsan Sharifi (PhD)

Senior lecturer

School of Architecture and Civil Engineering

The University of Adelaide

Horace Lamb Building, North Terrace Campus, Adelaide SA 5000

(08) 83130317 – ehsan.sharifi@adelaide.edu.au

Client:

Tanya Roe

Senior Sustainability Advisor

City of Adelaide

Colonel Light Centre, 25 Pirie Street, Adelaide SA 5000

(08) 8203 7701 – t.roe@cityofadelaide.com.au

Attachment:

- CoA cool roof trial - one year data (xlsx)

Contents

Glossary

Albedo/reflectivity	The proportion of incident light reflected from a surface measured by %.
Cool material	Materials with high albedo and/or high emissivity which stay cooler than conventional materials under solar radiation.
Heat capacity	The ratio of the heat added to or removed from an object compared to the resulting temperature change.
Heat emissivity	Emissivity (or emittance) is the ratio of the heat emitted from an object or surface to that of a standard “black body” measured between 0 for the matt black body and 1.
Heat stress	Physiological stress experienced as a result of excessive heat. Heat stress occurs when the body cannot get rid of excess heat. When this happens, the body's core temperature rises and the heart rate increases.
Heatwave	Three or more days of high maximum and minimum temperatures which are unusual for that location.
Infrared IR wavelength	A proportion of light with wavelength of 700nm- 1mm (longer wavelength than visible light). Most of heat emitted from objects occur in IR range.
Mean radiant temperature (MRT)	The theoretical *uniform* surface temperature of an enclosure in which an occupant would exchange the same amount of radiant heat as in the actual *non-uniform* enclosure.
Thermal conductivity	The amount of heat per unit time per unit area which can be conducted through a plate of unit thickness of a given material.
Urban heat island	The phenomenon whereby the trapping of solar radiation and release of anthropogenic waste heat leads to higher temperatures in urban areas compared to their rural surroundings.

ST	AT	IN	RS
Surface temperature	Air temperature	Indoor air temperature	Roof space air temperature

1. Introduction

Building materials are major contributors to the development of heat islands where heat is stored in the thermal mass of the built environment (Gartland 2012). Building rooftops cover almost 20% of the urban surfaces in Australian cities. With roofs having more exposure to direct sunlight compared with other surfaces in the built environment, conventional dark roofs (with a solar reflectance of 5% to 25%) can reach a surface temperature of 50-90°C on a typical hot summer day (Green, Ledo Gomis et al. 2020, Yenneti, Ding et al. 2020). Such high temperatures result in significant stress to building occupants, air conditioning systems, energy infrastructure, building elements and potentially lead to having more intense urban heat islands in the built environment (Santamouris, Haddad et al. 2017). Having cooler roof surfaces during summer results in cooler indoor spaces, less demand for cooling energy thus, less waste heat from air-conditioning, and a longer service life for roof materials (Akbari, Cartalis et al. 2016). Cool roofs can reduce surface temperature of the rooftop by 10°C to 33°C compared to conventional roofs (Paul and Ehsan 2017, Feng, Saliari et al. 2022) (Figure 1). As a result the air temperature above the roof surface may be reduced up to 1-2°C (Virk, Jansz et al. 2015), and the indoor air temperature below the roof surface may be reduced up to 7.5°C (under metal roofs with no thermal insulation)(Anand, Gupta et al. 2014). Such temperature reduction can save 28% of energy for space cooling during summer in temperate climates, although 10% more energy may be needed for winter heating (Kolokotroni, Shittu et al. 2018).

Cool roof coating

The application of roof surface materials with higher albedo (reflectance), higher emissivity, less heat capacity and (in the case of clay materials) higher capacity to store moisture can be a logical heat stress reduction method for roofs (Rawat, Singh et al. 2022). Such so-called “cool coating” has low heat conductivity (conducts less heat into its interior), low heat capacity (stores less heat in its volume) and high albedo (solar reflectance) (Pisello, Santamouris et al. 2013). Cool roof coating is a relatively cheap, fast and efficient option to reduce the indoor temperatures (especially in the roof space) and the surface UHI effect measured by thermal imagery. However, they do not necessarily lead to cooler air temperatures outdoors, since the reflected or emitted heat can get trapped in the built environment mass, especially in very dense urban settings with tall buildings, such as central business districts (Sharifi, Sivam et al. 2016). Cool roofs can be applied on both flat and pitched surfaces. There are three main types of cool roofs (Santamouris and Kolokotsa 2016):

- Cool roof coats with high reflectance (albedo>0.65). A high-albedo roof surface with cool white coating can radiate away up to 75% of incident solar energy. This means that a high-reflectance cool roof absorbs only 300W/m^2 solar energy instead of 900W/m^2 for the best conventional rooftop covers. But when solar glare is a critical issue in CBD area, they may not be the best pick.
- High emissivity (emittance) roof surfaces radiate away heat predominantly within the infrared wavelengths (700nm - 1mm), resulting in faster energy exchange between the roof and its surrounding atmosphere. Tiles and concrete slabs have a thermal emittance of 85% and above, whereas metal surfaces have the lowest thermal emittance of 20-60% depending on the roughness of the finish, age and cleanness.
- The most efficient cool roofs have relatively high reflectance (commonly achieved by the color rather than gloss) and high emittance. The thermal emittance of a metal roof can be increased by a non-metallic coating such as paint. Such coats may have higher albedo than conventional roofs by having lighter colors and moderated shine.

Due to the thinner construction profile of metal roofs, speed of construction, availability of resources and trade, metal roofs are more common than tiled/paved roofs in South Australia. Cool roof coatings can be applied (sprayed) on a majority of conventional roof surfaces including metal, concrete and tiles. Because of the very low profile of cool roof coatings (0.25-0.45mm) there is no need for additional structural support. Normal ground and roof access is required for industrial spray guns and paint containers. Most manufacturers provide a warranty for more than 10 years (regular cleaning and maintenance is required due to dust and weather). Surface cleaning is required annually. Higher-end cool roof coating products hold up to 95% efficiency after 3 years of application and only require re-coating after 20-30 years. However, lower-end coatings require re-coating after 2-5 years and have only 56% efficiency after 1.5 years (refer to the "cool and green roof technologies for application in the City of Adelaide: Summary report May 2021").

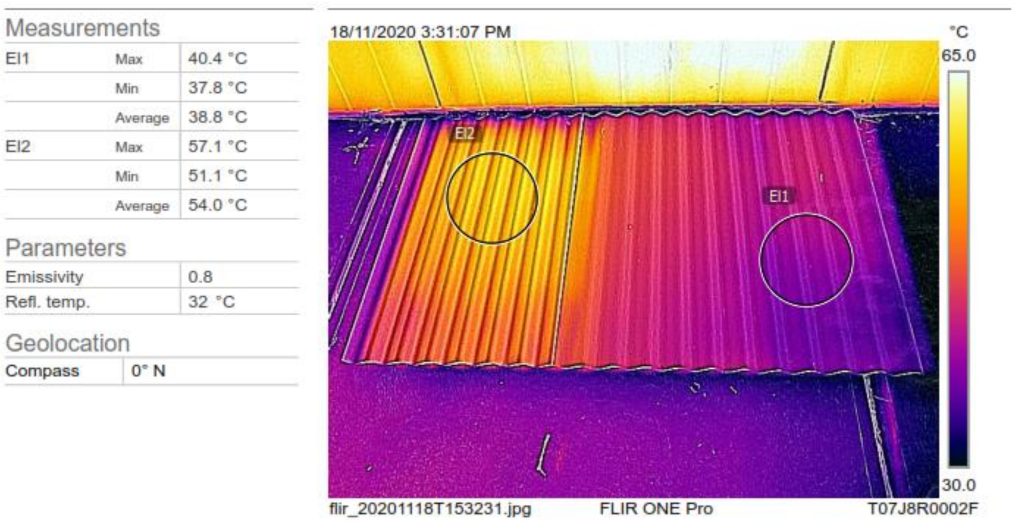


Figure 1. Surface temperature of SuperTherm® cool coating (right) vs uncoated galvanised steel (left) oriented towards North under 32°C outdoor temperature indicates up to 16.7°C cooling effect.

2. The cool roof trial in the City of Adelaide

The Cool Roof Trial Project has been implemented by the City of Adelaide (CoA) on Park 22 CoA Public Realm Horticulture Shed (PRHS) and building leased to the South Australian Uniting Church Netball Association (SAUCNA).

The University of Adelaide (UoA) team have installed external and internal datalogger sensors on both buildings, from January to April 2022 (pre-application) and post-application from May 2022 to June 2023 (
Figure 2).

Figure 2. Location of cool roof trial project on PRHS and SAUCNA buildings within the Park 22 on South West corner of the City of Adelaide.

This report evaluates the cooling performance of a cool roof coating trial application on the PRHS and SAUCNA Buildings located in Park 22 with in the CoA.

Case study buildings

The SAUCNA and PRHS Buildings are both single story light weight construction covered by metal roofs (Figure 3).

- The roof of SAUCNA building is facing West and East with 30° slope. It was covered by corrugated roof sheets in Coloubond® "Caulfield Green" color.
- The roof of PRHS building is facing North with 10° slope. It was covered by corrugated roof sheets in Coloubond® "Merino Cream" color.

Figure 3. The SAUCNA (top) and PRHS (bottom) buildings before the application of cool roof coating (photos taken March 2022).

Measurement criteria

Site measurements are taken by 6 x HOBO MX2303 (surface Temp.) and HOBO MX2301A (Air Temp.) sensors.

- One surface temperature unit (dual channel) and one air temperature sensor has been installed on the roof of each building under Solar Radiation Shields.
- One air temperature sensor has been installed inside the liveable space @ 1.2m above the ground for each building
- One air temperature sensor has been places in the roof space of PRHS Building (SAUCNA Building has a tall roof without ceiling).
- A benchmark air temperature sensor has been installed at the UoA North Terrace campus 1.8m above the ground surface in a permanently shaded area in the plaza on level 4 of Horace Lamb building (Figure 4).

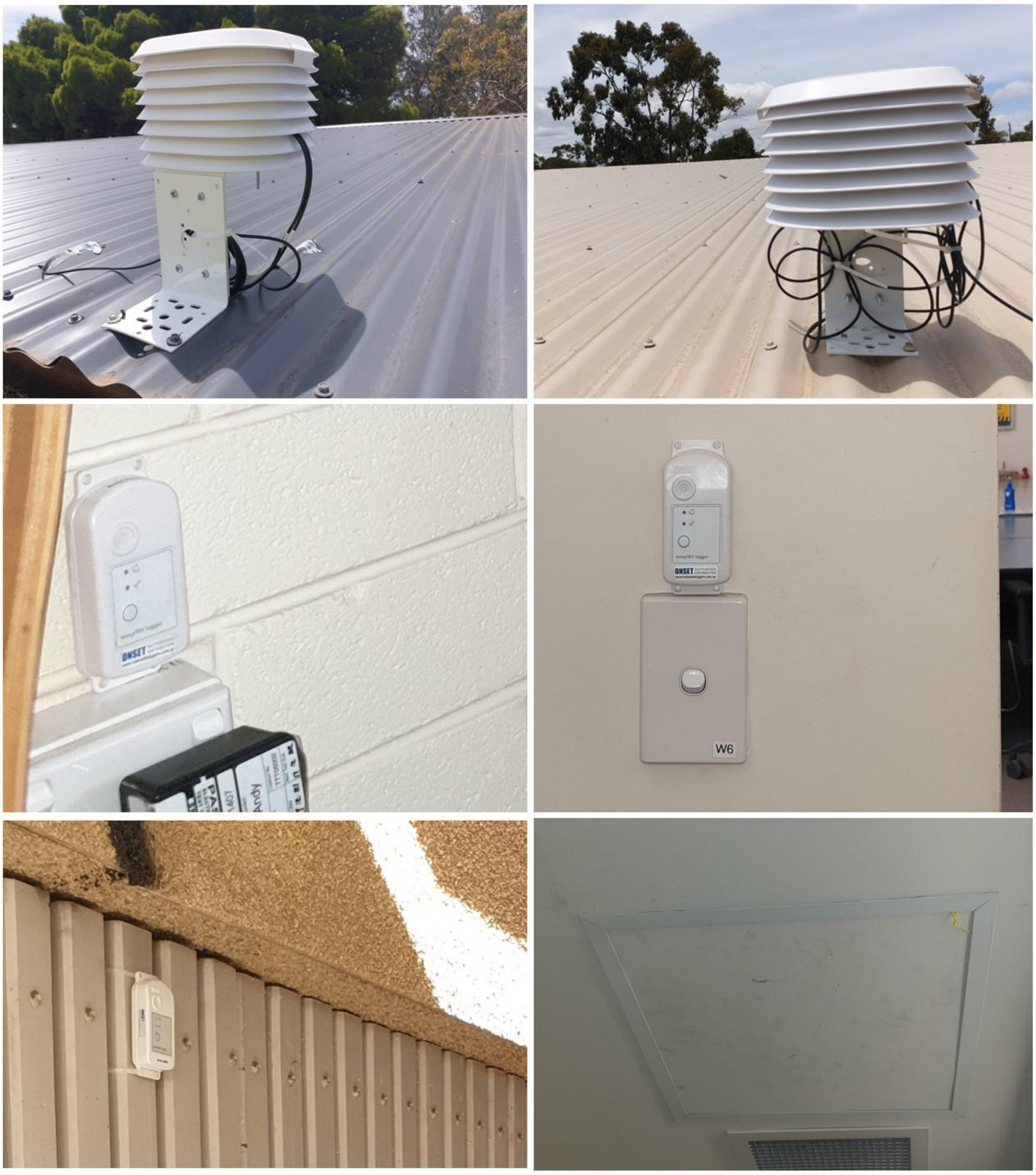


Figure 4. Sensor locations for the cool roof trail project: SAUCNA (roof top-left, indoors middle-left), PRHS (roof top-right, indoors middle-right, inside roof space bottom-right), Benchmark UoA (bottom-left).

Table 1. HOBO MX 2303 and 2301A sensor specifications

	
HOBO MX2303	HOBO MX2301A
Two External Temperature Sensors Data Logger	Temperature Humidity data Logger
Range: -40 to 100°C	Range: -40 to 70°C
Accuracy: ±0.2°C from 0 to 70°C; ±0.25°C from 70 to 100°C	Accuracy: ±0.2°C from 0 to 70°C
Resolution: 0.04°C	Resolution: 0.02°C
Response time: 3 minutes in air moving 1 m/s; 7 minutes in air moving 1 m/sec under Solar Radiation Shield	Response time: 17 minutes in air moving 1 m/s; 24 minutes in air moving 1 m/sec under Solar Radiation Shield

Applied cool roof product specifications

In May 2022, two coats of the SuperTherm® cool roof coating has been applied on the roofs of PRHS and SAUCNA buildings. Technical specifications of the product at use are presented in Table 2.

Table 2. SuperTherm® cool roof specifications

Cool roof coating	SuperTherm® Heat Block Insulation Coating
Place of manufacturing	USA
Australia distributor	NEOtech Coatings Australia
Cooling technology	Non-slippery water-based closed film thin ceramic coating High emissivity (ceramic-based) + moderate albedo (matt finish in egg shell white color).
Emissivity	0.91 (SuperTherm)
Total Solar Blocking inc. IR	0.96 (SuperTherm)
Application depth	250 microns (0.25mm) dry / 425 microns (0.425mm) wet
Application method	Sprayed, brush, roller on any surface including tile, concrete, zincalume, aluminum, steel and corrugated iron
Surface cooling benefit	Up to 20-30°C (SuperTherm)
Outdoor air-cooling benefit	Up to 1-2°C (Salamanca, Georgescu et al. 2016)
Indoor air-cooling benefit	Up to 4-8°C (SuperTherm)
Application time	Up to 400m^2/day
Maintenance	Surface cleaning (occasionally - works when dirty) re-coating after 15-20 years for maximum efficacy 73% efficiency @ 15 years (SuperTherm)
Compliance	AS/NZS 2311:2017
Warranty	20 years
https://neotechcoatings.com/coating-products/super-therm-solar-heat-block-coating/	

- The datalogger sensors were installed on 13 Jan 2022 before the cool roof coating application (data records starting from 15 Jan 2022 are included in the analysis).
- The cool roof coating was applied on both buildings in May 2022 (data related to the duration of application is removed from the analysis).
- Data has been downloaded every 2 months from all sensors, the last data was downloaded on 1 June 2023.

3. Calibration of sensors with BoM

Daily Weather Observations for Adelaide was obtained from the official station at the Australian Bureau of Meteorology (BoM) IDCJDW5081 locate at West Terrace (Ngayirdapira), SA, for the duration of the study (Jan 2022 – June 2023).

The hourly BoM data is sufficient for the performance analysis of the cool roof. However, since the data sampling and calculation methods at BoM weather station cannot be controlled by the research team, a HOBO MX2301A sensor was installed at UoA campus. Sampling methods and temperature recording intervals is identical to the sensors that are used on SAUCNA and PRHS buildings.

The benchmark sensor (BNCH) at the UoA is calibrated with 9am and 3pm daily data of the BoM station in winter and summer under clear sky. The benchmark sensor is then used as a point of reference for all the other sensors in this project.

The BNCH sensor data is calibrated in 5 consecutive sunny days in winter (2-7 July 2022) and 11 consecutive sunny days in summer covering a heatwave period (3-13 Jan 2023). Figure 5 indicates that both calibration models are highly accurate with R^2>0.95 and *p*<0.001. However, to get a common calibration model, these two models are combined in Figure 6, resulted in having one calibration equation for the whole data with R^2=98 and *p*<0.001 (more accurate than both winter and summer models).

Clear Sky cold (2-7 July 2022)	Clear Sky hot (3-13 Jan 2023)

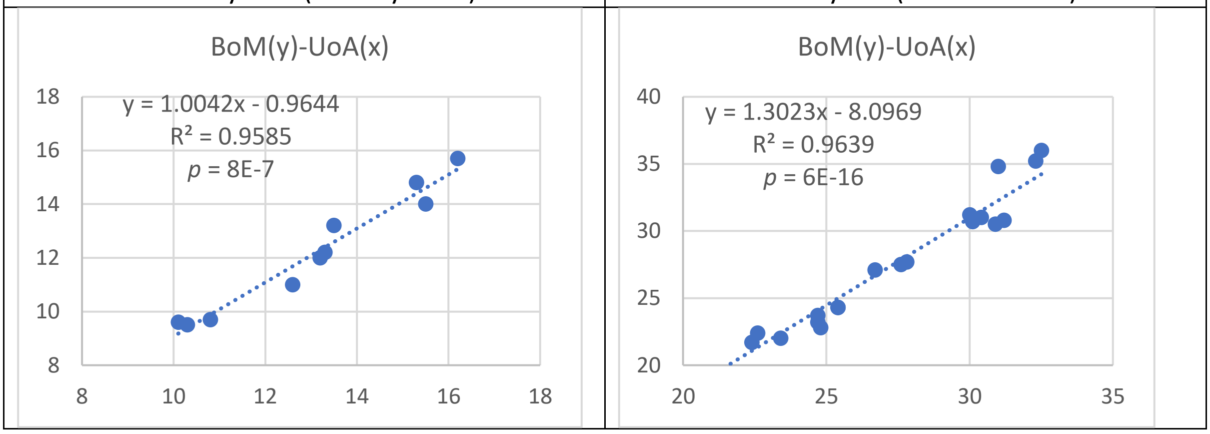


Figure 5. Sensor calibration in cold winter (left) and hot summer (right) under clear sky (p<0.001 for both models)

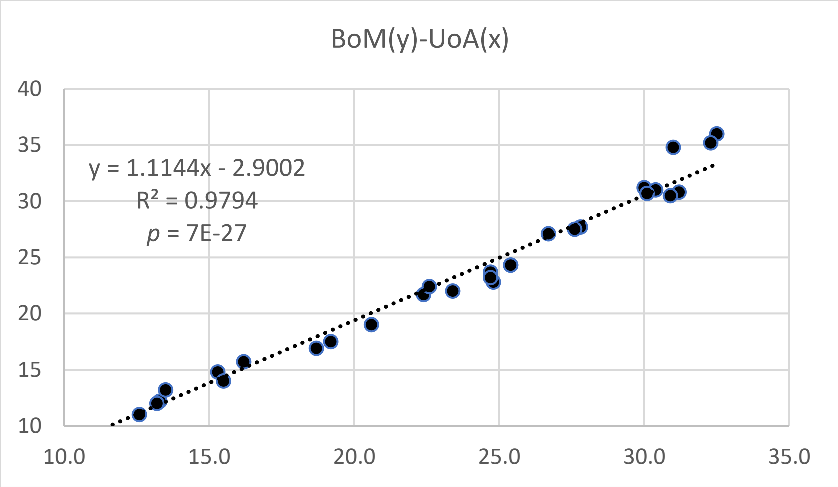


Figure 6. Full spectrum (winter-summer) data calibration in 16 days covering 12<T<36 between 9am and 3pm 2022-23.

Therefore, the Equation 1 is being used to calibrate the BNCH sensor and consequently all the other sensors in the project. In the rest of this report, we have used the calibrated data as benchmark.

Equation 1. BoM = 1.1144 x UoA BNCH - 2.9002

4. Cooling performance evaluation: before vs after application

Table 3 indicates that both buildings have experienced lower surface temperatures after the application of cool coating. None of the roofs surpass the surface temperature of 56.2°C during summer after the application of cool coating, while SAUCNA had experience 70.4°C before the application of cool coating. Figure 7 indicates an average cooling impact of 10.5°C surface temperature for SAUCNA and 8°C for PRHS after the application of the cool roof coating.

Table 3. Surface temperature variation on SAUCNA and PRHS roofs from Jan-April 2022 and Jan-April 2023 (before and after application).

	SAUCNA		PRHS	
	Before application (°C)	**After Application (°C)**	**Before application (°C)**	**After Application (°C)**
Maximum Surface Temp. recorded	70.4	53.4	57.2	56.2
Average (3 months) Surface Temp.	26.6	20.9	24.4	16.4

The SAUCNA Building with the darker pre-application roof, facing West, experienced the highest variation of 17°C in the maximum recorded surface temperature, while the PRHS with a lighter pre-application roof facing North has a surface temperature reduction of only 1.0°C in the maximum surface temperature. This may indicate the better performance of the lighter pre-application color on PRHS that kept it from overheating even before the application of the cool roof coating.

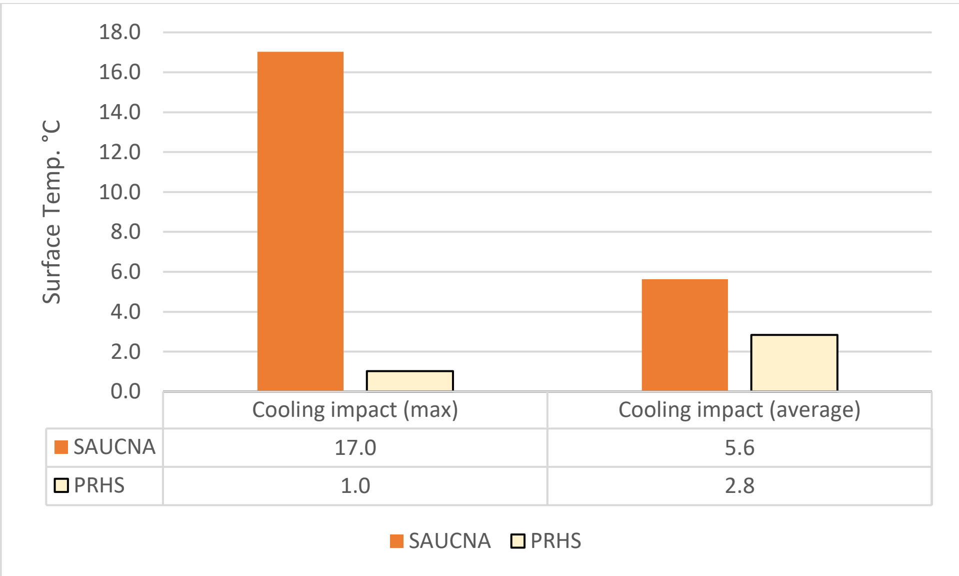


Figure 7. Long-term moderated (day-night) variations in surface temperate after cool coating application.

Daily surface temperature analysis

It is worth noting that annual weather conditions change every year so simply comparing annual changes before and after application may give deviation from real thermal performance of the material. Therefore, further analysis is done for a cool, a moderate and a hot day before and after installation for both buildings:

BoM weather data was reviewed for before and after application of the cool roof coating and 6 days with clear sky are selected, representing slightly cool (14<airT<20°C), moderate (18<airT<28°C) and hot (22<airT<36°C) for before and after the application of the cool roof coating.

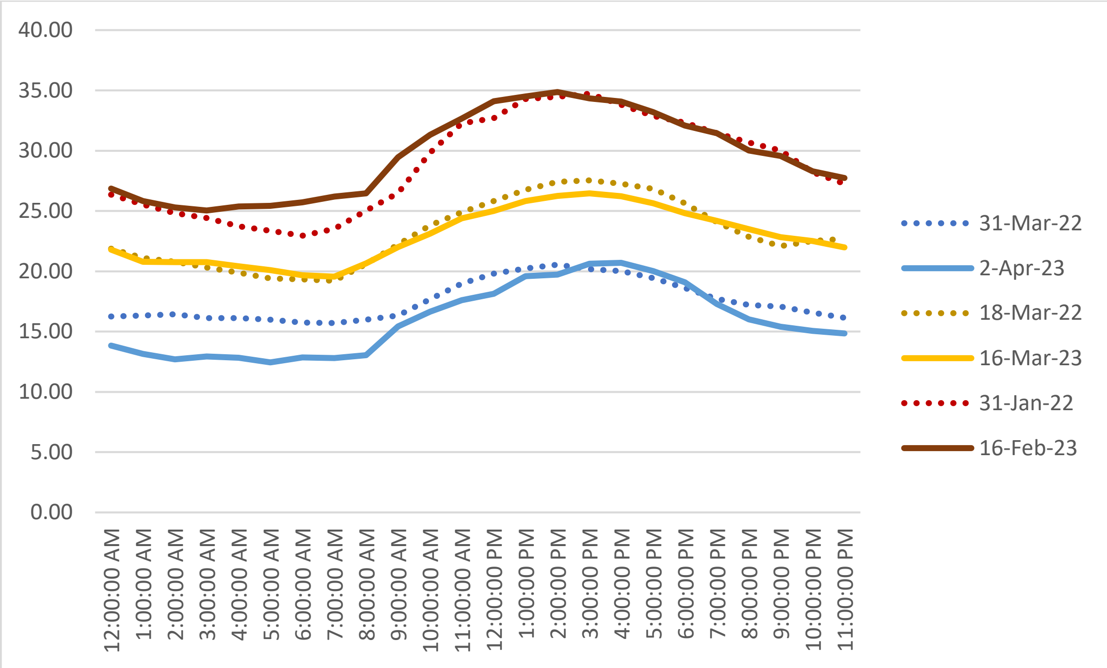
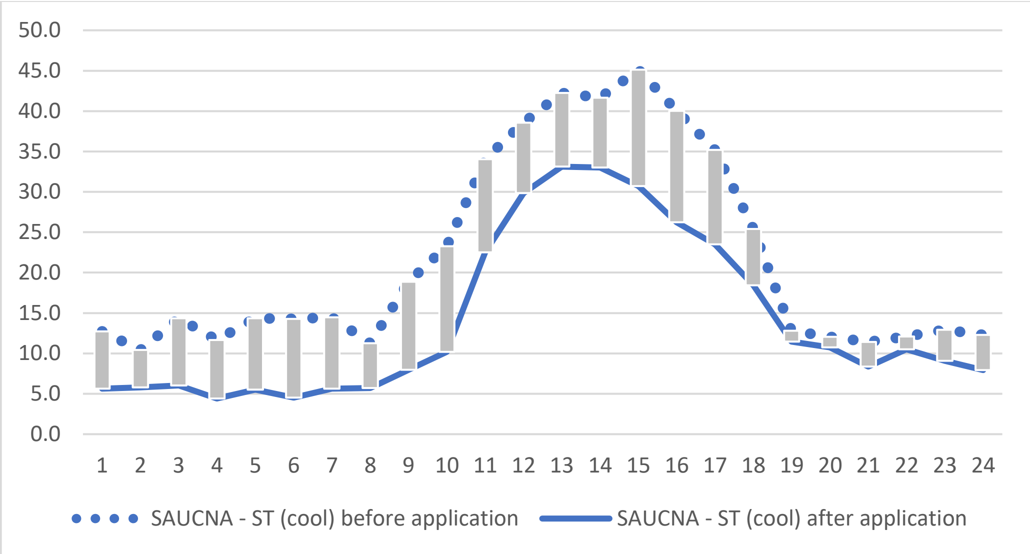


Figure 8. Air temperature profile of representative cool, moderate and hot days in 2022 and 2023 before and after cool roof coat application (calibrated UoA data with BoM official weather station).

Impact of cool coating in a slightly cool sunny day (autumn/spring)

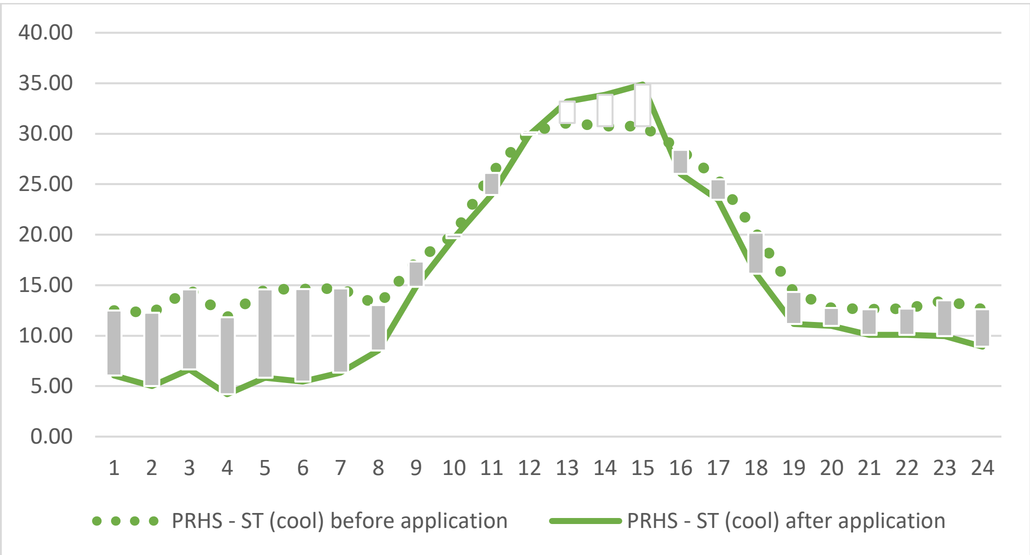
Figure 9 shows a maximum surface temperature cooling of 14.4°C and a daily average cooling of 7.7°C after the application of the cool roof coating on a previously dark green corrugated steel roof of the SAUCNA building, on a relative cool sunny day of autumn.



max ST variation (°C)	14.4
average daily ST variation (°C)	7.7
average daytime ST variation (7am-9pm) (°C)	8.1

Figure 9. Daily variation of surface temperature of SAUCNA Building on a cool sunny day.

The maximum surface temperature reduction on a cool sunny day was 9.2°C with a daily average cooling of 3.4°C for PRHS after the application of the cool roof coating (Figure 10).

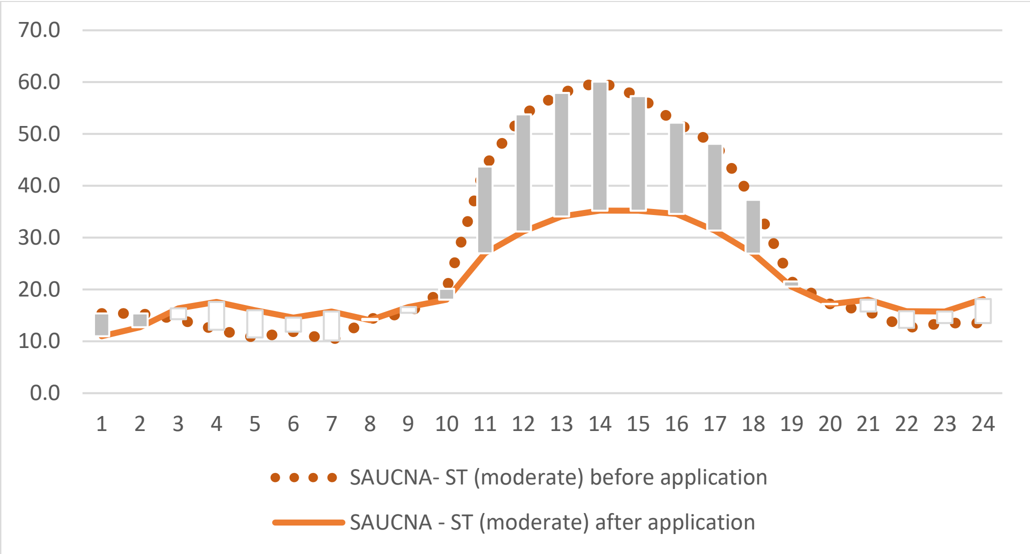


max ST variation (°C)	9.2
average daily ST variation (°C)	3.4
average daytime ST variation (7am-9pm) (°C)	1.3

Figure 10. Daily variation of surface temperature of Building 2 (Horticulture) on a cool sunny day.

Impact of cool coating in a moderate sunny day (summer/autumn)

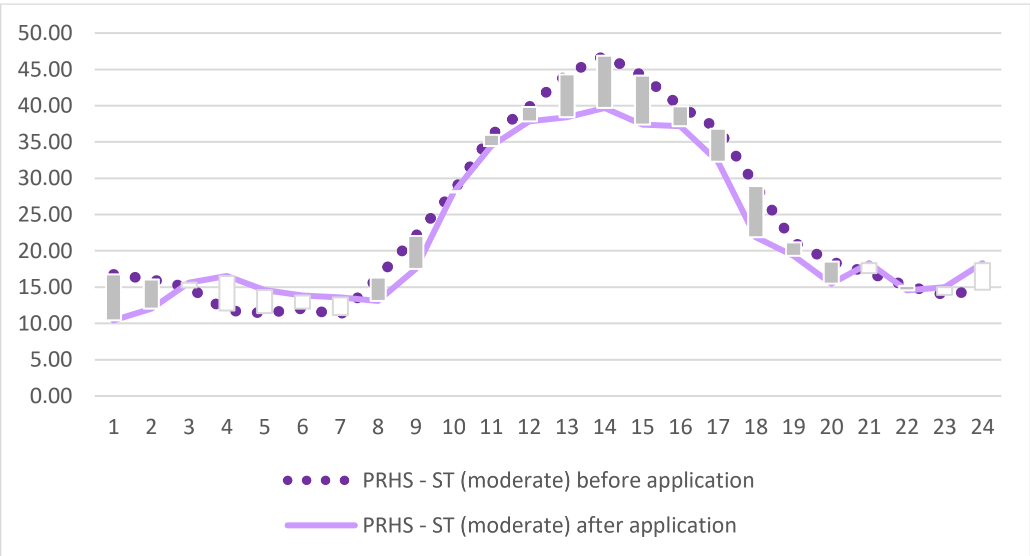
Figure 11 shows a maximum surface temperature variation of 24.9°C and a daily average cooling of 5.5°C after the application of the cool roof coating on a previously dark green corrugated steel roof of the SAUCNA building, on a moderate sunny day of autumn.



max ST variation (°C)	24.9
average daily ST variation (°C)	5.5
average daytime ST variation (7am-9pm) (°C)	10.1

Figure 11. Daily variation of surface temperature of SAUNCA Building on a moderate sunny day.

On a moderate sunny day, the maximum surface temperature reduction was 7.2°C for the PRHS with a daily average cooling of 1.8°C after the application of the cool roof coating (Figure 12).

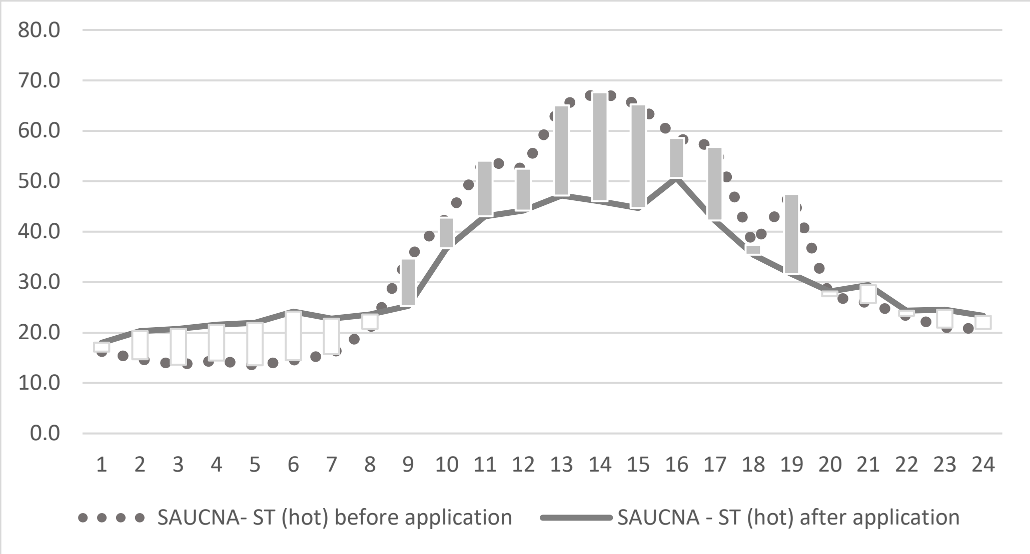


max ST variation (°C)	7.2
average daily ST variation (°C)	1.8
average daytime ST variation (7am-9pm) (°C)	3.3

Figure 12. Daily variation of surface temperature of Building 2 (Horticulture) on a moderate sunny day.

Impact of cool coating in a hot sunny day (summer)

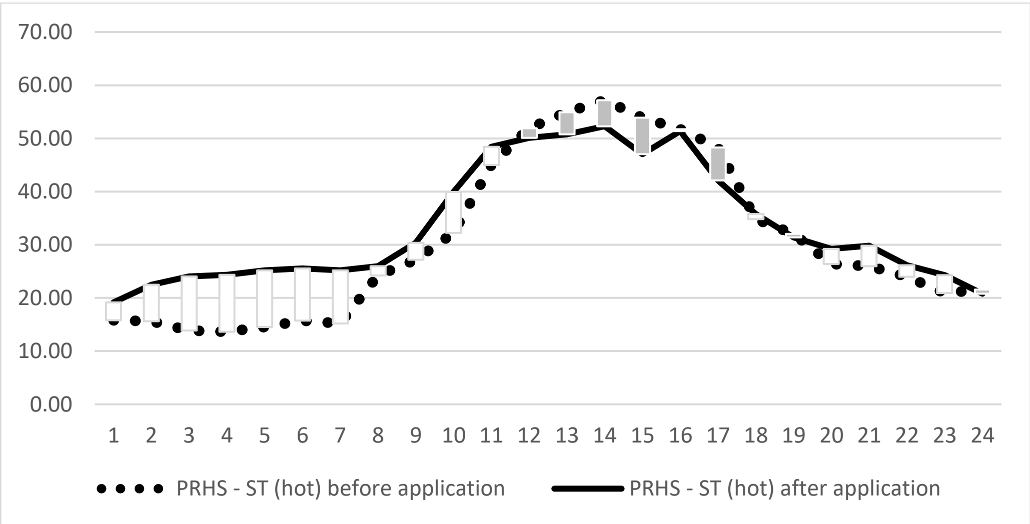
Figure 13 shows a maximum surface temperature variation of 21.6°C after the application of the cool roof coating on a previously dark green corrugated steel roof, on a hot sunny day of summer. The daily average cooling is 3.1°C. It is worth noting that roof surface temperature had reached 67.7°C on 31 Jan 2022, while it does not surpass 57.2°C after the application of the cool coating.



max ST variation (°C)	21.6
average daily ST variation (°C)	3.1
average daytime ST variation (7am-9pm) (°C)	8.5

Figure 13. Daily variation of surface temperature of SAUCNA Building on a hot sunny day.

On a similar hot day the maximum surface temperature cooling for PRHS roof was lower than the SAUCNA building at 6.9°C. The average daily temperature even increased by 2.7°C after the application of the cool roof coating. Figure 14 shows that such increase in daily surface temperature is mainly impacted by having higher temperature at nighttime compared with its original light color roof.



max ST variation (°C)	6.9
average daily ST variation (°C)	-2.7
average daytime ST variation (7am-9pm) (°C)	-0.1

Figure 14. Daily variation of surface temperature of PRHS Building on a hot sunny day.

5. Impact of cool roof application on indoor and outdoor air temperature

Average outdoor air temperature variations Jan-April

The outdoor air temperature sensors were installed under the Solar Radiation Shield at 200mm above the roof surface of both buildings (Figure 4).

Table 4 shows both buildings have experienced 1.4°C lower average air temperature at 200mm above their roof surface after the application of cool coating (Figure 15). The air temperature above none of the roofs surpass 42.0°C.

Table 4. Air temperature variation on SAUCNA and PRHS roofs from Jan-April 2022 and Jan-April 2023 (before and after application).

	SAUCNA		PRHS	
	Before application (°C)	**After Application (°C)**	**Before application (°C)**	**After Application (°C)**
Average (3 months) Air Temp.	22.4	21.0	22.5	21.1
Maximum	36.8	42.0	36.7	40.5

However, the maximum air temperature above both surfaces were lower before the application of cool coating that is due to generally lower temperatures in the summer of 2022 compared to summer 2023.

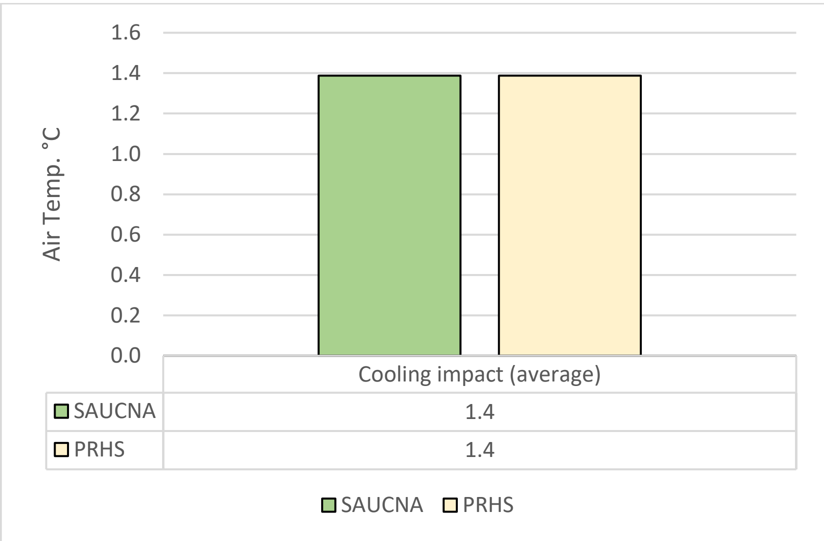


Figure 15. Long-term moderated (day-night) variations in air temperate 200mm above the roof surface before and after cool coating application.

Average indoor air temperature variations Jan-April

The indoor air temperature sensors were installed at 1.2m above the ground surface inside the habitable area of both buildings. Table 5 shows for both SAUCNA and PRHS buildings have experienced lower air temperatures after the application of cool coating. An average 1.2°C lower indoor air temperature is recorded in SAUCNA, and 0.9°C in PRHS (Figure 15). The indoor air temperature of none of the buildings surpass 32.5°C.

Table 5. Air temperature variation in SAUCNA and PRHS habitable rooms from Jan-April 2022 and Jan-April 2023 (before and after application).

	SAUCNA		PRHS	
	Before application (°C)	**After Application (°C)**	**Before application (°C)**	**After Application (°C)**
Average (3 months) Air Temp.	25.1	23.8	23.6	22.7
Maximum	30.7	32.5	30.1	29.3

The lower indoor temperature before the application of cool coating may be due to the impact of running air-conditioning units.

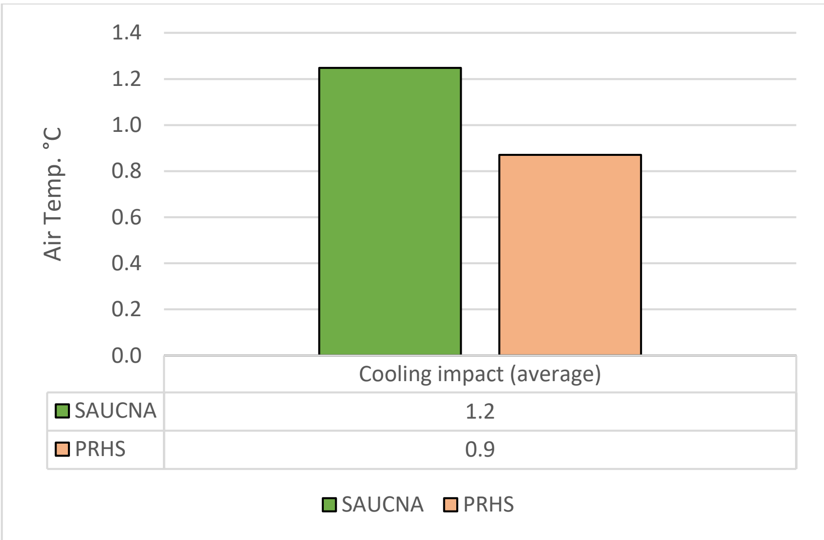


Figure 16. Long-term moderated (day-night) variations in indoor air temperate of SAUCNA and PRHS before and after cool coating application.

Average roof space cooling

An additional air temperature sensor was installed inside the roof space of PRHS Building. The SAUCNA building does not have a ceiling.

Table 6 indicates a relatively steady cooling effect of 1.1°C inside the roof space of PRHS Building that translate to lower and higher temperatures occurred after the application of cool coating. It is worth noting that due to the insulation being below the metal roof sheets, it is expected to have a steady air temperature inside the roof space, closer to indoor temperature than the roof surface temperature. A comparison between Table 6 and Figure 16 underlines such similarity.

Table 6. Long-term moderated (day-night) variations in air temperate inside the roof space of PRHS before and after cool coating application.

Air T Inside the Roof Space	PRHS	
	Before application	After Application
Maximum	33.2	31.7
Minimum	19.0	17.6
Average	24.3	23.2
Cooling impact (max)	1.6	
Cooling impact (min)	1.4	
Cooling impact (average)	1.1	

6. Cooling performance of cool coating during the Heatwave of Dec 2022

Adelaide has a relatively cold and wet 2022 and 2023. Yet, between 25 and 27 Dec, a summer heatwave resulted in maximum air temperature of 40.7°C being recorded at the Adelaide West Terrace/Ngayirdapira weather station ID:023000 (BoM 2023).

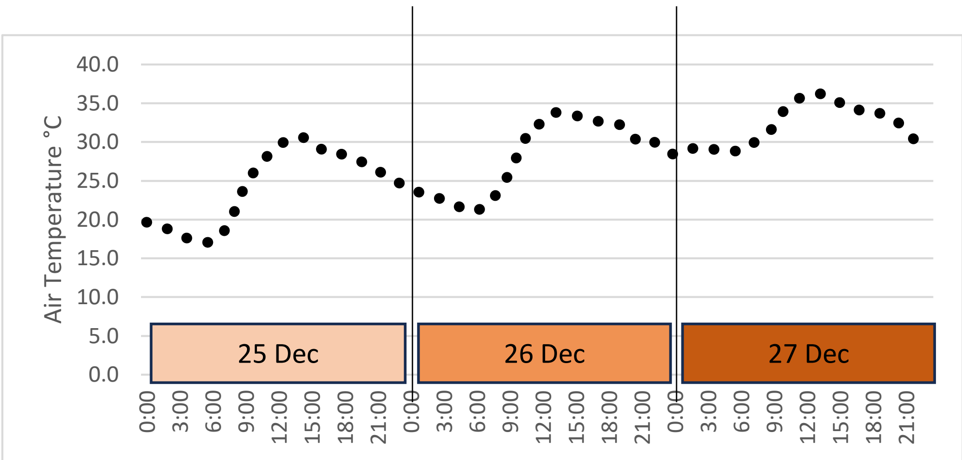


Figure 17. Air temperature profile of 25-27 Dec 2022 heatwave in Adelaide.

Figure 18 illustrates the relative performance of the cool roof coating during the heatwave of Dec 2022. As expected, surface temperatures are noticeably higher than the benchmark air temperature. However, the maximum recorded surface temperature is 53.79°C on PRHS roof, only 17°C higher than the air temperature around.

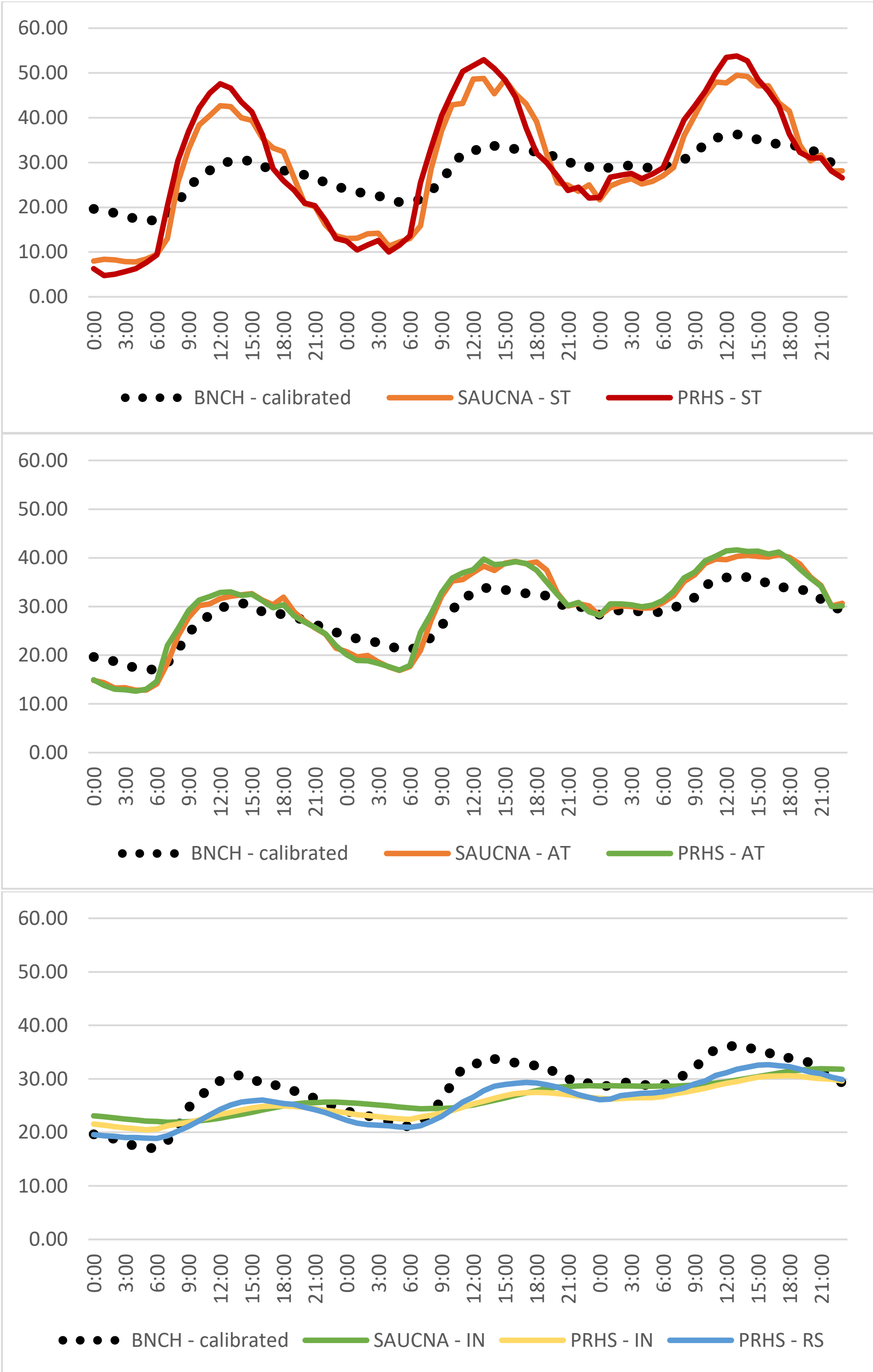


Figure 18. Impact of the cool roof coating on roof surface temperature (top graph), air temperature 200mm above the roof surface (middle graph) and indoor air temperature (bottom graph) during heatwave of Dec 2022.

The maximum air temperature 200mm above the roof surfaces was 41.62°C (middle graph in Figure 18), that stays within 1°C of the ambient temperature around.

This means that even during the heatwave, these cool roofs do not contribute much to the urban heat island effect.

The indoor temperatures in both buildings were below 36°C all the time during the heatwave. Given that 36°C is still significantly higher than comfortable indoor temperatures in Adelaide (<29), it is unlikely that any air conditioning was operational during the studies heatwave days in 2022.

7. Thermal imagery of roof surfaces

The thermal images of roof surfaces before and after application indicate up to 20.5°C cooling effect on SAUNCA Building and relatively lower cooling impact of 10.3°C on PRHS Building.

Surface cooling compared to surrounding ground covers

Figure 19 (right) shows the roof of SAUNCA Building (Sp2) was 7.6°C hotter than the surrounding paved area (Sp6) before the application, while it was 11.6°C cooler than the same paved area after the application. This indicates 19.2°C surface cooling compared to the surrounding surfaces.

Meanwhile, the roof of PRHS (left) Building (Sp2) was 5.6°C hotter than the ground grass cover (Sp5), whereas it was only 1.3°C cooler than the same ground surface after application, resulting in 6.9°C cooling impact relative to the adjacent ground cover.

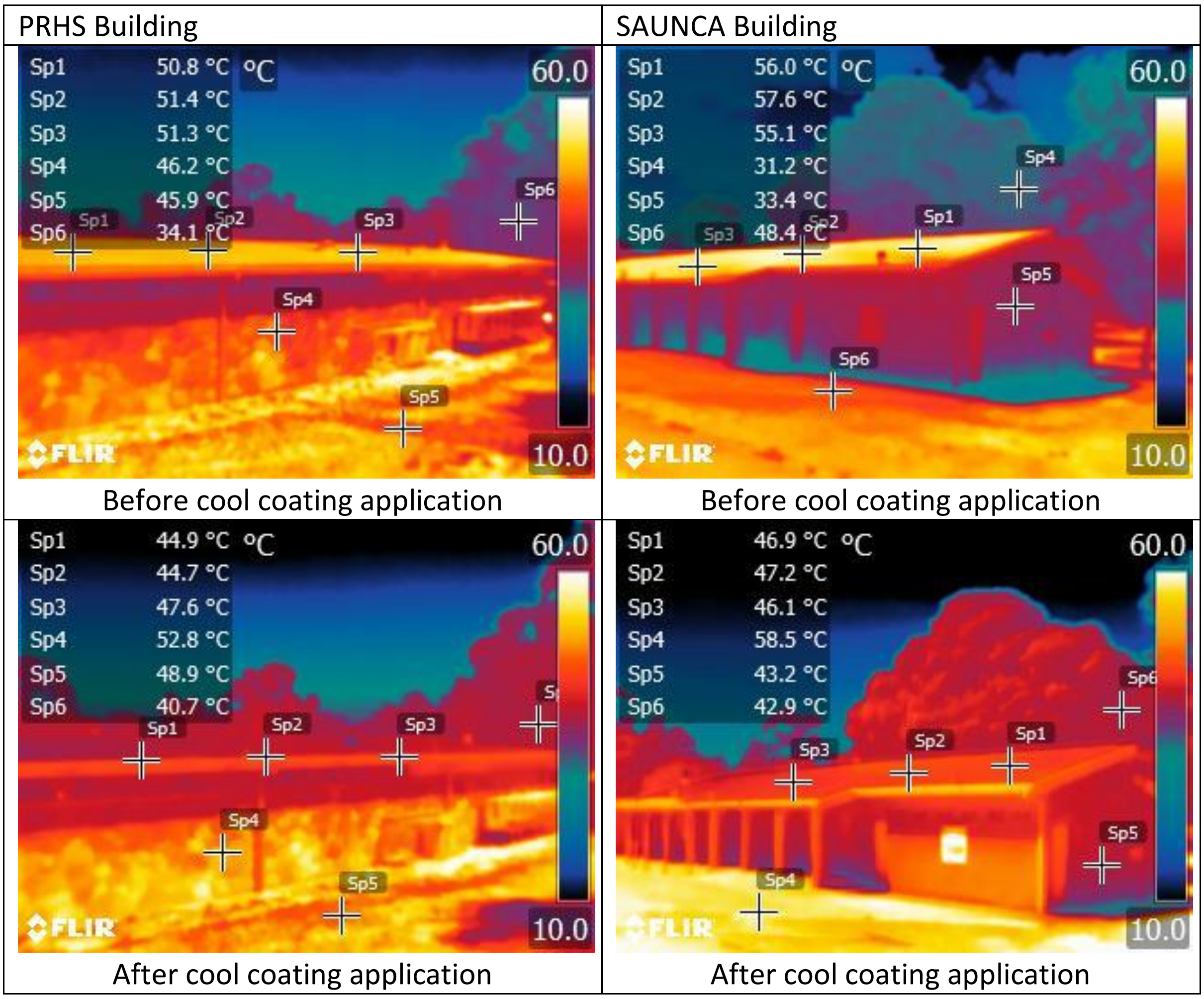


Figure 19. Thermal images of PRHS and SAUCNA buildings before and after the application of cool roof coating.

Surface cooling compared to surrounding tree canopy

Figure 19 (right) also shows the roof of SAUNCA Building (Sp2) was 26.3°C hotter than the adjacent tree canopy (Sp4) before the application, while it was only 4.3°C hotter than the same tree (Sp6) after the application. This indicates a 22°C surface cooling compared to the surrounding evergreen tree canopy.

Meanwhile, PRHS roof (left) (Sp2) was 17.3°C hotter than the adjacent tree (Sp6) , whereas it was only 6.9°C hotter than the same tree canopy after the cool coating application, indicating a likely 10.4°C cooling impact relative to the adjacent tree canopy.

Surface cooling compared to masonry building walls

Finally Figure 19 (right) indicates the roof of SAUNCA Building (Sp2) was 24.2°C hotter than the building wall (light painted brick – Sp5) before the application, while it was only 4.0°C hotter than the same wall surface after the application. This indicates a likely 20.2°C surface cooling compared to the surrounding vertical surfaces.

Meanwhile, PRHS roof (left) was 5.2°C hotter than the building wall (stacked stone – Sp4) before the application, whereas it was only 5.2°C cooler than the same wall surface after the application, resulting in 10.4°C cooling impact relative to the adjacent tree.

Table 7. Cooling performance of cool roof coating via thermal imagery (FLIR E8) when compared to different surfaces

Compared with	PRHS Building	SAUNCA Building
Surrounding ground cover	6.9°C	19.2°C
Vertical building wall	10.4°C	20.2°C
Adjacent tree canopy	10.4°C	26.3°C

Table 1 summaries the measured cooling impact of the cool roof coating relative to surrounding ground covers, walls and tree canopies. It is worth noting that thermal imagery has been undertaken on a few days of +36°C between 12-2pm. Therma images may be used to better visualise the cooling impact of the roof coating in comparison to the surrounding vegetation, vertical and paved areas.

8. Summary of findings

- The cool roof coating is shown to reduce the surface temperature of conventional dark roof facing west up to 17°C.
- The cool roof coating resulted in an average air temperature reduction of 1.2°C at 200mm above the roof surface and 1.1°C inside the roof space with insulation below the metal roof sheets and 1.4°C indoor space cooling.
- The cooling impact of the cool roof coating is the highest in warm and sunny weather conditions. With metal having high thermal conductivity and thin profile on roofs, the cooling impact of the coating is reduced in colder ambient temperatures and under cloudy sky.
- This is beneficial since there will be less cooling penalty in colder months of the year than the benefit on the hotter months.
- The cool coating can effectively maintain the indoor air temperature up to 6°C lower than the outdoor air temperature during heatwaves.

Limitations and potential for further studies

- Due to the start of the project pre-application data was not collected in cold weather conditions of winter.
- 2022 was a relatively cool and wet year in Adelaide. Results may differ in other years.
- The two case study buildings for the cool roof trial were facing West and North, one with dark and the other with light corrugated steel profiles. Their performance results may be skewed by their orientation, slope and construction styles.
- Complimentary small scale (1:10) experiment of pitched/flat roof with multiple orientation may expand the findings.

List of Figures

List of tables

References

Akbari, H., C. Cartalis, D. Kolokotsa, A. Muscio, A. L. Pisello, F. Rossi, M. Santamouris, A. Synnefa, N. H. Wong, M. J. J. o. C. E. Zinzi and Management (2016). "Local climate change and urban heat island mitigation techniques–the state of the art." **22**(1): 1-16.
Anand, Y., A. Gupta, A. Maini, A. Gupta, A. Sharma, A. Khajuria, S. Gupta, S. Sharma, S. Anand and S. K. Tyagi (2014). "Comparative Thermal Analysis of Different Cool Roof Materials for Minimizing Building Energy Consumption." Journal of Engineering **2014**: 685640.
BoM. (2023). "Historical weather observations and statistics." 2023, from http://www.bom.gov.au/climate/data-services/station-data.shtml.
Feng, J., M. Saliari, K. Gao and M. Santamouris (2022). "On the cooling energy conservation potential of super cool roofs." Energy and Buildings **264**: 112076.
Gartland, L. M. (2012). Heat islands: understanding and mitigating heat in urban areas, Routledge.
Green, A., L. Ledo Gomis, R. Paolini, S. Haddad, G. Kokogiannakis, P. Cooper, Z. Ma, B. Kosasih and M. Santamouris (2020). "Above-roof air temperature effects on HVAC and cool roof performance: Experiments and development of a predictive model." Energy and Buildings **222**: 110071.
Kolokotroni, M., E. Shittu, T. Santos, L. Ramowski, A. Mollard, K. Rowe, E. Wilson, J. P. d. B. Filho and D. Novieto (2018). "Cool roofs: High tech low cost solution for energy efficiency and thermal comfort in low rise low income houses in high solar radiation countries." Energy and Buildings **176**: 58-70.
Paul, O. and S. Ehsan (2017). "Guide to urban cooling strategies."
Pisello, A. L., M. Santamouris and F. J. A. i. b. e. r. Cotana (2013). "Active cool roof effect: Impact of cool roofs on cooling system efficiency." **7**(2): 209-221.
Rawat, M., R. J. E. Singh and B. Environment (2022). "A study on the comparative review of cool roof thermal performance in various regions." **3**(3): 327-347.
Salamanca, F., M. Georgescu, A. Mahalov, M. Moustaoui and A. Martilli (2016). "Citywide Impacts of Cool Roof and Rooftop Solar Photovoltaic Deployment on Near-Surface Air Temperature and Cooling Energy Demand." Boundary-Layer Meteorology **161**(1): 203-221.
Santamouris, M., S. Haddad, F. Fiorito, P. Osmond, L. Ding, D. Prasad, X. Zhai and R. Wang (2017). "Urban Heat Island and Overheating Characteristics in Sydney, Australia. An Analysis of Multiyear Measurements." **9**(5): 712.
Santamouris, M. and D. Kolokotsa (2016). Urban climate mitigation techniques, Routledge.
Sharifi, E., A. Sivam and J. Boland (2016). "Resilience to heat in public space: a case study of Adelaide, South Australia." Journal of Environmental Planning and Management **59**(10): 1833-1854.
Virk, G., A. Jansz, A. Mavrogianni, A. Mylona, J. Stocker, M. J. E. Davies and Buildings (2015). "Microclimatic effects of green and cool roofs in London and their impacts on energy use for a typical office building." **88**: 214-228.
Yenneti, K., L. Ding, D. Prasad, G. Ulpiani, R. Paolini, S. Haddad and M. Santamouris (2020). "Urban Overheating and Cooling Potential in Australia: An Evidence-Based Review." Climate **8**(11): 126.