2024

SWELTERING CITIES

HOT ROOFS REPORT

ACKNOWLEDGEMENT OF COUNTRY

Sweltering Cities acknowledges the Traditional Owners of the land on which we work and live, including the Gadigal, Dharug, Dharawal and Kuring-gai peoples.

Sovereignty was never ceded and this land always was, and always will be Aboriginal land. The creation of urban heat islands is one of the many results of the ongoing environmental devastation of colonisation.

CONTENTS

EXECUTIVE SUMMARY

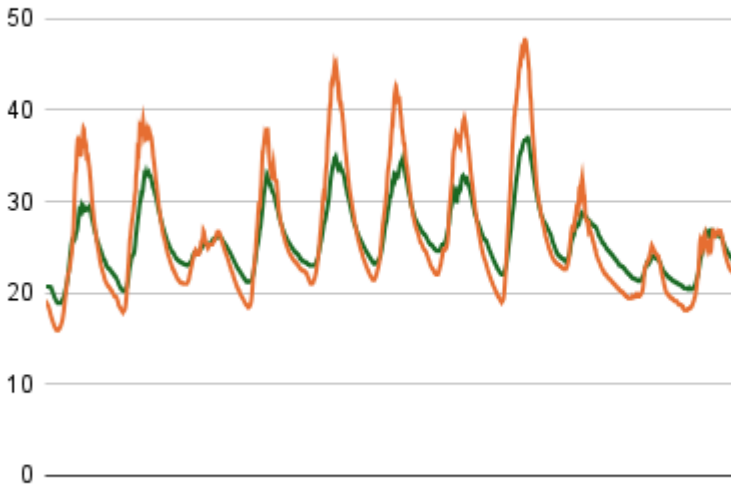
From January to March 2024 Sweltering Cities collaborated with eleven households in Western Sydney to set up thermometers around their homes to assess the impact of roof colour on both ceiling cavity and indoor temperatures. The data revealed that dark coloured roofs were hotter by up to 10°C or more on hot days compared to nearby homes experiencing similar outdoor temperatures.

Sweltering Cities' Hot Roofs project reinforces previous findings by built environment and health experts that dark roofs exacerbate internal temperatures and urban heat, including studies conducted by Professor Sebastian Pfautsch of Western Sydney University.

Western Sydney can be more than 10° hotter than surrounding rural areas or cooler coastal suburbs. The results make it clear that dark roofs are leading to hotter homes that are more dangerous to live in during summer, and more energy intensive and expensive to cool.

Results highlights:

- **Highest recorded roof cavity temperature was 49.8°**
- **The difference between the roof cavity temperatures in two homes in South West Sydney, one with a light roof and one with a dark roof, was over 11° on a hot day.**
- **People's living spaces reached up to 40°, and five homes had living spaces that reached over 30° during the study period.**
- **The newest homes, built in the 2010s, had roof cavity temperature readings over 41° which was hotter than temperatures readings outside the house at the same time.**



In this graph, the orange line represents temperature measurements from inside a dark roof, and the green line represents temperatures inside a light coloured roof. See page 12 for more information on these measurments.

We recommend that the NSW Government prioritise updating the Building Sustainability Index (BASIX) regulations to ensure that individuals, builders, or developers using any method of certification cannot design new homes in Sydney that have dark roofs. In order to address the Urban Heat Island effect and home energy efficiency impacts of existing dark roofs across the city, we recommend energy efficiency retrofit programs, local green and blue infrastructure, and providing resources for residents who live in hot homes, and access to information about energy-efficient renovation options.

Sweltering Cities will continue to advocate for planning system reform that ensures that everything we build now will be safe in a future climate and helps us reach net zero carbon emissions as soon as possible. It is essential that the hundreds of thousands of new homes being built in Sydney over the coming years will help the residents be safe and thrive in their communities.

INTRODUCTION

For people living in, working in, or even passing through the outer suburbs of Sydney (and many of Australia's cities), vast expanses of dark roofs in new developments are a common sight. The dark surfaces, heat absorbing building materials such a concrete, and treeless streets make some of these suburbs 10-15° hotter than other areas of the city. Western Sydney is home to almost 1 in 10 and is predicted to experience increasingly frequent extreme heat days as the climate warms.

Even though there is extensive evidence that dark roofs not only increase the temperature inside homes, but also on the whole street or suburbs, our planning regulations allow more and more to be installed each year. Having a dark coloured roof may be a personal choice at the point of construction, but it's one that has long reaching impacts such as potentially higher energy bills and hotter homes and streets for years or decades to come.

In October 2023, the NSW Government updated BASIX (the system used to set building home energy efficiency standards in NSW) to say that "for developments in coastal areas north of Wollongong (including Greater Sydney) and inland areas west of the Great Dividing Range, dark roofs (i.e. with a solar absorpance greater than 0.7) cannot be selected with the DIY method. Dark roofs can be selected in other locations in NSW." We welcomed this update and the impact it will have on cooler homes and suburbs in our increasingly hot summers. Unfortunately, the regulations apply to only some of the new houses being built, and "For the alternative thermal performance pathways of the Simulation method or the Passive House standard, dark roofs are still an option that can be modelled." The NSW Government needs to commit to this common sense update by making sure it applies to all new homes in Sydney.

In the Sweltering Cities 2022 and 2024 Summer Surveys, people have consistently told us that they think that there should be policies for lighter coloured roofs and cooler suburbs. Respondents say that it's an issue of comfort and health for them and their families, but also for their local environment and cooling down their local streets. In order to illustrate the impact on real people across Sydney, Sweltering Cities has collaborated with residents to monitor the temperatures in their own homes in order to illustrate to decision makers the urgency of acting to build more climate resilient homes.

We would like to thank all the residents who participated in the study and Professor Sebastian Pfautsch for his guidance. Their support has made this work possible.

BACKGROUND INFORMATION

Built environment and hot roofs

Sydney's urban sprawl and new housing developments have placed its built environment under immense pressure. As the city expands to the west, substantial tree cover has been lost and significant amounts of dark surfaces added in roofs, roads and pavement; all contributing to the urban heat island effect that can make Western Sydney's suburbs up to 10° hotter than cooler coastal suburbs.

Access to safe and cool homes is crucial in promoting wellbeing, quality of life and healthy communities, especially in hotter and more densely populated areas such as Western Sydney. According to the WHO Housing and Health guidelines:

"protection against outdoor heat is a key characteristic of healthy housing".

The quality of buildings and roofs are important for creating safe homes and protecting people from the heat. As dark roofs attract heat, rather than reflect it, there is a decreased thermal comfort and increased need for cooling via air conditioning. Studies have shown that cool roofs can bring down indoor temperature by an average of 4°C, and 10°C during a heatwave.

A comprehensive study of 17 building types – from low-lying residential to shopping centres – conducted by Prof. Mat Santamouris of UNSW's School of Built Environment (commissioned by the Department of Industry, Science and Resources) has shown that implementing city-scale use of light-coloured roofs or cool roof technology and pavements can reduce the maximum peak outdoor air temperature by an average of 2.1–2.5°C during summer.

This study found that **city-wide implementation of cool roofs would reduce energy bills, lower indoor temperatures, decrease urban heating and improve the health of vulnerable populations who may be at higher risk of heat related health issues.**

Cost implications

Research conducted by Professor Sebastian Pfautsch, an Associate Professor of Urban Studies at Western Sydney University, found that a dark roof resulted in higher cooling costs during summer compared to a light-coloured roof. Pfautsch suggests cooler, lighter-coloured roofs can **save up to $694 per year due to reduced electricity used on cooling.**

In the context of the 2024 Sweltering Cities Summer Survey , 61% of respondents reported that cost of living pressures have made them reluctant to turn on air conditioning and made it harder to stay safe and cool in extreme heat.

Dark roofs can also negatively impact the efficiency of solar panels. Hotter roof temperatures increase the internal resistance and reduce solar panel's ability to efficiently convert sunlight into electricity.

Heat Health

Exposure to high temperatures has a significant impact on human health. The primary cause of heat-related deaths is cardiovascular complications, especially prevalent among older people and those with pre-existing heart conditions. The heart is placed under increased strain as it works harder to cool the body down.

In Australia, the increasing prevalence of heatwaves and extreme heat events, kill more people than all other natural disasters. The increasing frequency and severity of heatwaves due to climate change are becoming a growing health concern.

Sweltering Cities Summer Survey 2024 revealed that 85% of people with a chronic illness and 90% of people with disability feel unwell on hot days. In Western Sydney, vulnerable communities, such as the elderly, individuals with disabilities or chronic illnesses and low-income households are at higher risk of heat-related health issues. They are also more likely to spend more on cooling or are forced to endure heat-related stress indoors.

These issues highlight urban heat as a significant challenge for public health and community wellbeing in Australia, particularly in its hottest suburbs. Dark roofs are significantly contributing to the problem. We now have an opportunity to look at alternative solutions that reduce heat health issues and give everyone access to safe housing.

Current Legislative Environment

The Building Sustainability Index (BASIX) is a sustainability assessment tool for all residential dwellings in NSW required by the National Construction Code.

NatHERS stand for Nationwide House Energy Rating Scheme. It provides the performance pathway to meet compliance with BASIX requirements.

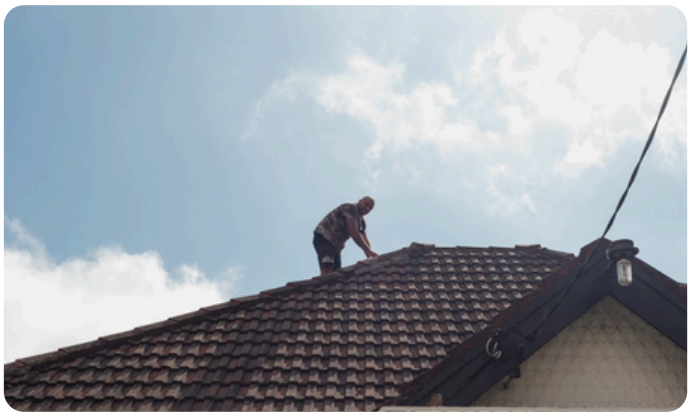
In the recent increase to BASIX standards, the second compliance pathway i.e., the BASIX DIY method, has been changed to disallow dark roofs in certain climate zones including Greater Sydney.

This means that using the DIY pathway, meeting the new, stricter BASIX standards becomes more challenging if your house has dark roofs.

However, you can still use dark roofs with the NatHERS performance pathway if you balance out the negative effects of dark roofs with other actions, like installing better windows or adding more insulation.

This approach only de-incentivises but does not fully ban dark roofs.

While some design measures can offset the negative impacts of dark roofs, their significant contribution to the urban heat island effect remain largely unaddressed.



Additionally, a recent report by Sweltering Cities in association with Renew, has found that Australia's home energy ratings and building energy efficiency regulations are based on historical climate data from 1990-2015. Using past climate data to design our homes means they are not well-prepared for future climate extremes, especially when it comes to the impacts of extreme heat.

The report finds that cooling energy loads in homes are set to increase and indoor temperatures are projected to rise for homes not using cooling, with potential serious impacts for occupant health and energy use.

The study highlights a significant gap and opportunity to take climate change into account in the National Construction Code, house energy ratings and energy efficiency standards to help build homes fit for the decades ahead.

Currently, there is no legislation to control the construction of dark roofs for all new builds and no plans on the horizon either, despite it being one of the easiest and simplest solutions that comes at no extra cost.

In August 2021, NSW Planning and Public Spaces Minister Rob Stokes announced that dark roofing will be banned in Sydney's south-west growth area in a bid to "say goodbye to the trend of having dark roofs that not only attract and retain heat and raise ambient street temperatures, but lead to astronomical electricity bills because of the need to cool homes."


'Blistering temperatures': Dark roofing banned on Sydney's urban fringe

Angus Thompson
August 23, 2021 – 4.00pm

Save Share A A A 147 View all com

Sydney Morning Herald, August 11 2021

The NSW Government's plan was abandoned after concerns from developers, reflecting "the absurdity of where developers place their preferences these days" as per Professor Sebastian Pfautsch.


Plan to ban dark roofs abandoned as NSW government walks back sustainability measures

Exclusive: Policy announced by previous planning minister shelved despite experts saying lighter roofs reduce 'heat island effect'

The Guardian, 9 April 2022

If the economic, environmental and health costs of dark roofs are not taken into account by developers, then these costs are shifted to householders and the broader community. Therefore, it is crucial for policy and legislation to place the responsibility on developers, designers as well as local and state government organisations.

Some councils encourage the use of light coloured roof, surfaces or permeable paving, however these efforts are isolated and not nationally mandated.

For example, light roof housing has already been implemented in some new developments within local councils, including in the South West and Wilton Growth Areas. Expanding this initiative across the state, rather than limiting it to certain growth areas, is required to significantly mitigate urban heat island impacts.

Well-known building rating systems such as Green Star tools reward design measures to improve thermal comfort, and reduce energy consumption and urban heat island effect, however participation in these ratings is not mandated.

One of the country's largest urban renewal projects in South Australia has demonstrated leadership in incorporating light roofs in both the renovation and refurbishment of existing properties as well as the establishment of more than 2,000 new lots. Acknowledging that in large scale developments where tree canopy takes years to grow, heat can be a big deterrent to attracting residents - the government saw it as a chance to "lead the way and encourage developers and builders to get on board with these more sustainable, energy-friendly measures".

According to the director of communications and policy at Master Builders SA, Kym Morgan, "Light-coloured roofing just makes sense, particularly out north where we know it gets hotter. It leads to significantly cooler homes and that ultimately means less time running air conditioners and lower energy bills. It also means cooler suburbs if consumers adopt lighter roofs en masse."

Dark roofs out at major SA development

10 JAN 2024 • By Reporter • 2 min read • INVESTOR STRATEGY

In an effort to avoid its $1 billion urban renewal project from becoming a "heat island", the South Australian government is cracking down on dark roofs.

Smart Property Investment, 10 Jan 2024

New designs and light roof housing in the Growth Area, [source: Camden Council]

METHODOLOGY

The Hot Roofs project was created in collaboration with health experts, and community members in Western Sydney. The study aimed to better understand the thermal effects of roof colour during summer by conducting comparisons between light and dark-coloured roofs in similar geographical area.

The project was completed through citizen science, by placing temperature monitors (image on right) in the homes of eleven participants. The citizen science approach entails connecting community to science and collaborating through collection of data.

Participants were selected with both light and dark coloured roofs, and in close proximity to other homes in the project. Participants were required to host three temperature monitors in their homes for two months in summer. The monitors were installed from 3rd - 5th January and collected from 27th - 28th February.

The ‘tempmate’ temperature monitors digitally record real-time temperature data every 10 minutes, they were placed in protective cylinders.

Each participant received three monitors, for three different locations: inside the roof space, indoors in a living area, and outside (under cover).

Inside roof space

Indoors living area

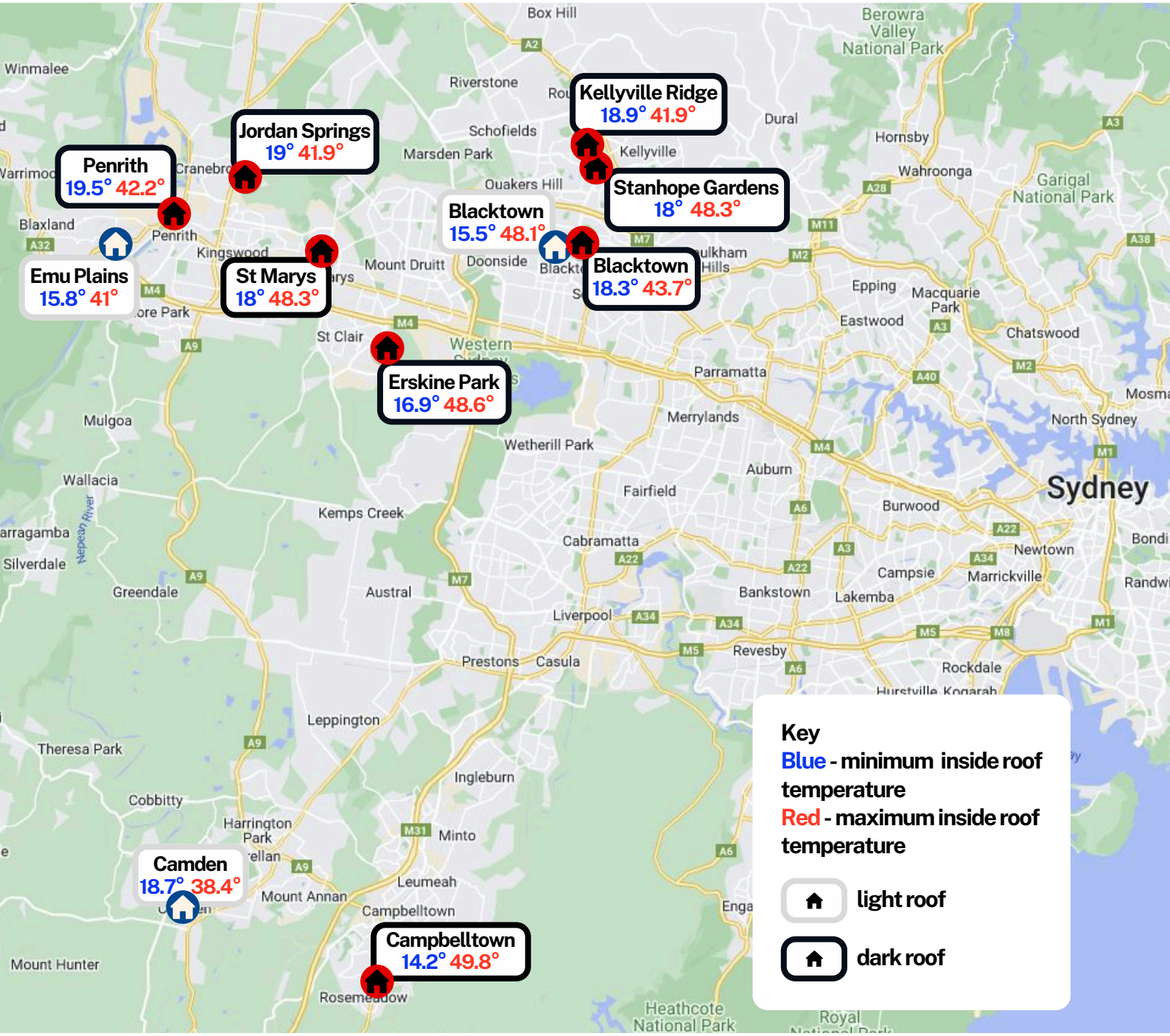
Outside

With help from Professor Sebastian Pfautsch, the raw data (temperature readings automatically recorded every 10 minutes for the duration of the project) was condensed into the daily minimum, maximum and mean temperature.

HOT ROOFS MAP

Eleven homes were monitored across Western Sydney, with a combination of dark and light roof colours, and varied materials (e.g. tiles, metal). The map shows the location of the homes, and the minimum and maximum roof temperatures recorded (Jan - Mar 2024).

Link to interactive map



RESULTS

The results section present a comparison of temperatures of Western Sydney homes with light-coloured roofs (e.g., light beige, light grey) versus dark-coloured roofs (e.g., dark brown, dark charcoal). The data reveals that homes with light-coloured roofs consistently maintained lower temperatures during the data collection period than the homes with dark roofs. The data collected includes mean, maximum, and minimum temperatures in three locations; the roof, inside the house and outside.

The below table summarises the data recorded from every house. Including the roof, inside and outside temperatures. The maximum and minimum temperature, and the mean temperature recorded in each location.

Participant and Suburb	Roof colour, Material	Tempera-ture (°C)	Roof	Inside	Outside
John **Emu Plains**	**Light** Beige, Metal	Mean	25.5	23.4	25.3
		Maximum	41.0	27.7	35.9
		Minimum	15.8	20.6	19.1
Helen **Camden**	**Light** Grey, Steel	Mean	26.3	25.9	24.1
		Maximum	38.4	41.0	39.6
		Minimum	18.7	21.9	15.6
Angela **St Marys**	**Dark** Brown, Aluminium	Mean	27.6	25.0	N/A*
		Maximum	48.3	30.2	N/A*
		Minimum	18.0	19.8	N/A*
Dane **Penrith**	**Dark** Charcoal, Concrete	Mean	25.3	25.4	23.9
		Maximum	42.2	31.3	39.0
		Minimum	19.5	22.5	16.0
Tilak **Jordan Springs**	**Dark** Grey, Concrete	Mean	25.8	24.7	24.7
		Maximum	41.9	33.1	41.4
		Minimum	19.0	19.4	14.7

** Outside temperature readings for Angela unavailable due to instrument failure

Suburb	Roof colour, Material	Tempera-ture (°C)	Roof	Inside	Outside
Deborah **Campbelltown**	**Dark** Black, Tiles	Mean	26.7	24.0	23.1
		Maximum	49.8	30.9	36.6
		Minimum	14.2	18.4	14.2
Phillip (House) **Blacktown**	**Light** Red, Tiles	Mean	26.9	26.5	25.2
		Maximum	48.1	37.4	42.4
		Minimum	15.5	19.6	15.7
Phillip (Granny Flat) **Blacktown**	**Dark** Tiles	Mean	28.4	26.4	24.6
		Maximum	43.7	33.8	44.0
		Minimum	18.3	21.9	13.9
Anoop **Stanhope Gardens**	**Dark** Brown, Tiles	Mean	27.4	26.5	25.3
		Maximum	45.6	40.0	43.1
		Minimum	18.2	19.7	15.7
Sanaa **Kellyville Ridge**	**Dark** Grey, Concrete Tiles	Mean	27.2	28.7	24.0
		Maximum	41.9	37.4	39.8
		Minimum	18.9	22.6	14.9
Kim **Erskine Park**	**Dark** Red, Concrete Tiles	Mean	28.3	26.1	25.4
		Maximum	48.6	34.0	42.9
		Minimum	16.9	21.0	17.0

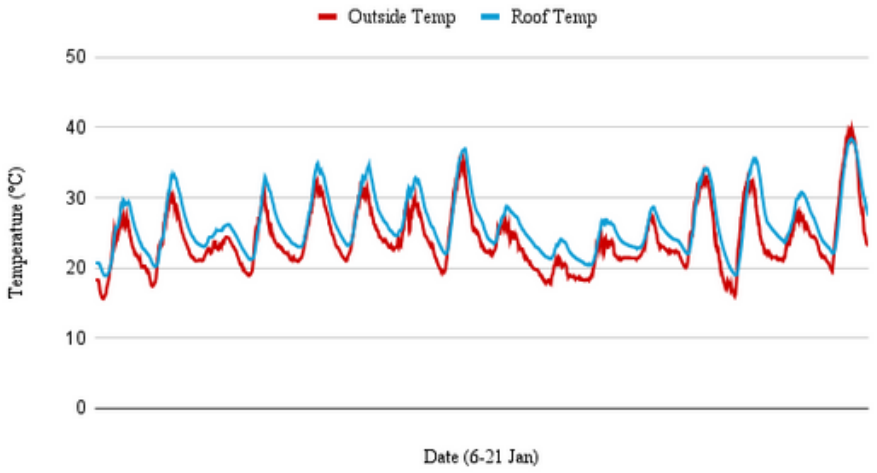
CASE STUDIES

South West Sydney: Camden (light) and Campbelltown (dark)

Not far from each other in South West Sydney, Deborah's home in Campbelltown and Helen's home in Camden registered similar outdoor temperatures on hot days, but vastly different indoor roof temperatures. On the 21st of January, the highest temperature recorded inside Deborah's roof in Campbelltown was **11.4°C higher** than that inside the light grey roof in Camden, even though the outdoor temperature was slightly cooler in Campbelltown.

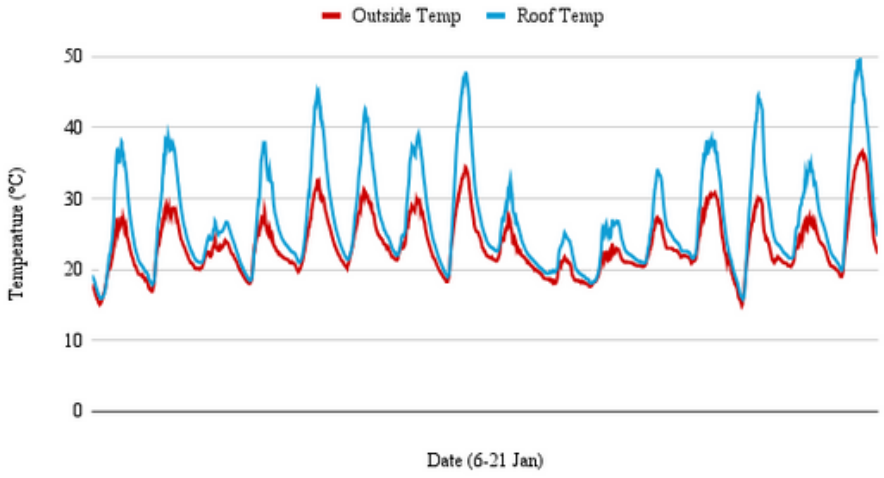
Deborah was surprised by how hot it was inside her roof since she had installed some additional energy efficiency measures including 'whirly-birds' to vent hot air and additional insulation.

Light roof in Camden



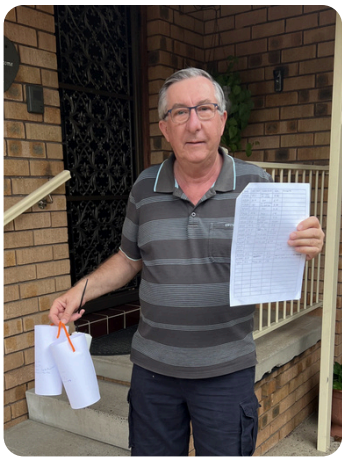
In the house with the light coloured roof, the temperature inside the roof cavity is consistently similar to the outside temperature.

Dark roof in Campbelltown



In the house with the dark coloured roof, the roof cavity temperature frequently exceeded the outside temperature. In fact, on multiple days in this week it was over 10° hotter inside the roof than outside.

Western Sydney: Emu Plains (light) and St Mary's (dark)

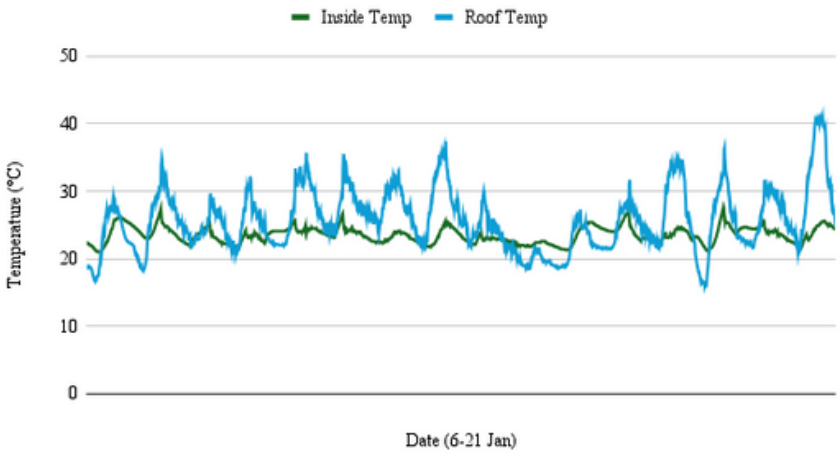


Participant John holding temperature monitors

The suburbs of Emu Plains and St Mary's are around 12km apart and sit on either side of Penrith, a suburb famous for reaching 48.9° in January 2020. St Mary's has recorded ground temperatures of over 50°. This region of Sydney is projected to get double as many over 35° hot days than the historical average by 2050 (The Australia Institute, 2018).

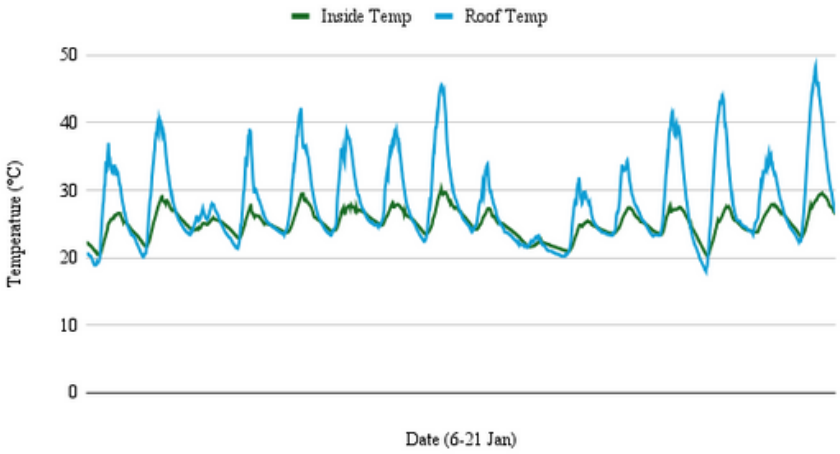
The highest temperature recorded inside the dark brown roof in St. Mary's was 48.3° compared to 41° in the light beige roof in Emu Plains on 21 Jan.

Light coloured roof in Emu Plains



Whilst there is significant variation in the roof cavity temperature in the light coloured roof in the Emu Plains house, it is slower to change in comparison to the dark coloured roof cavity temperature inside the St Mary's house.

Dark coloured roof in St Marys



The graph above illustrated that the temperature inside the dark coloured roof varied widely with the temperature. Quick temperature changes indicate that the roof provided limited protection from outside temperatures.

CASE STUDIES

New Housing Developments: Jordan Springs & Kellyville Ridge

The newest homes in our study were in Jordan Springs and Kellyville Ridge.

Both of these houses are part of new developments in Western Sydney and were built between 2010-2015 with dark roofs. Some residents and consumers may assume that homes built to the current standards would provide a high level of protection from extreme heat. However, the roof cavities in both houses recorded temperatures over 40°, higher than the maximum outdoor temperature.

These results demonstrate that existing planning regulations for thermal comfort and energy efficiency aren't sufficient in protecting the inside of our homes from extreme external temperatures.

As further similar developments are approved, light roof housing could mitigate urban heat island impacts and lead to cooler, healthier homes.

Tilak, Jordan Springs

Sanaa, Kellyville Ridge

"If there was more information available when we were building our house, I definitely would have chosen a different roof colour" -Tilak

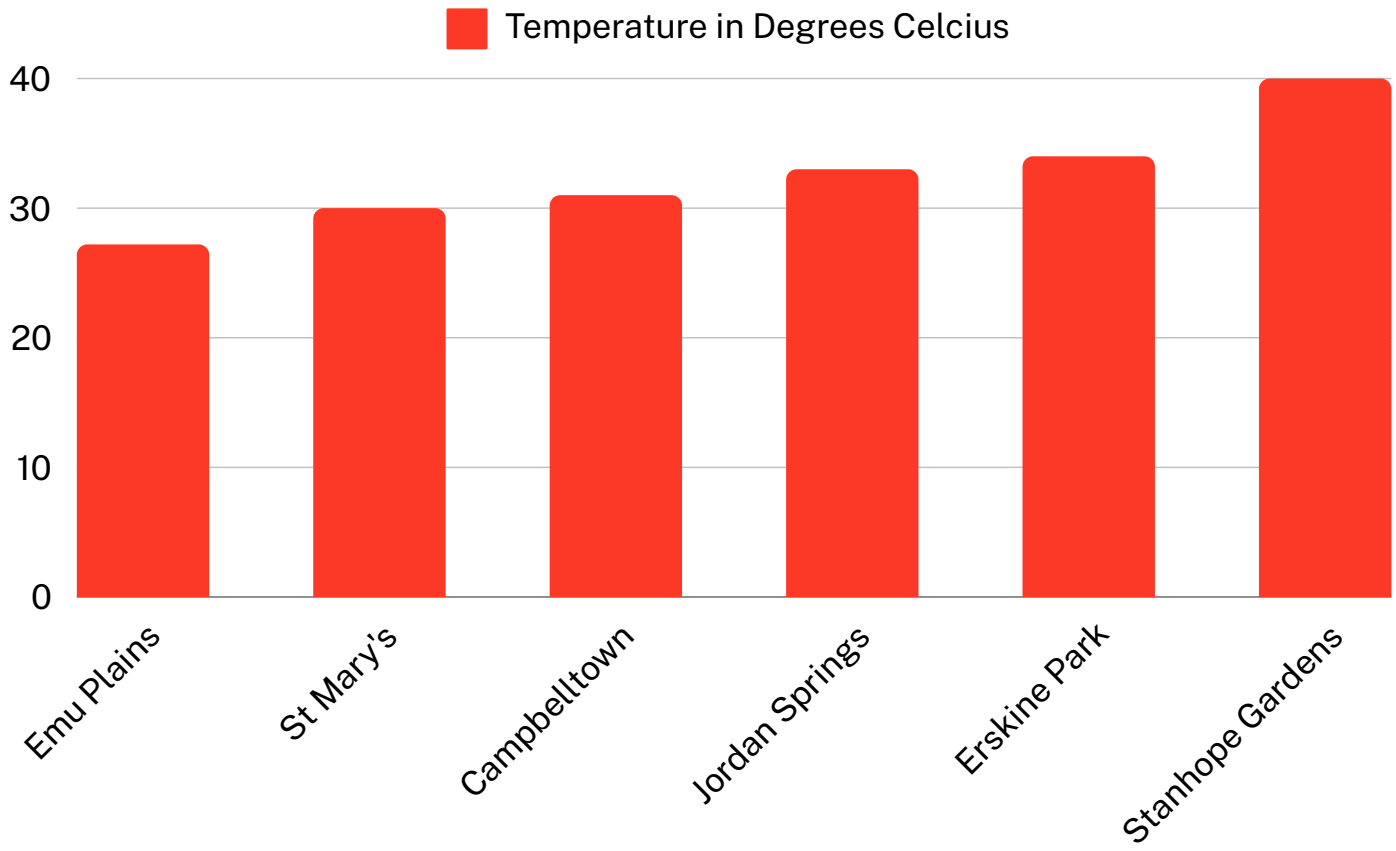
	Jordan Springs			Kellyville Ridge		
	Roof: Dark, Tiles			Roof: Dark Grey, Concrete Tiles		
	Inside	Outside	Roof	Inside	Outside	Roof
Mean	24.7	24.7	25.8	28.7	24.0	27.2
Max	33.1	41.4	41.9	37.4	39.8	41.9
Min	19.4	14.7	19.0	22.6	14.9	18.9

CASE STUDIES

Hot rooms

Since the Covid-19 pandemic, more people than ever are working from home. The Australian Bureau of Statistics says that 37% of people reported working from home at least once in the last week in their August 2023 workplace survey. As we compiled the data from the participants across Sydney, we were struck by how high the inside temperatures in living areas were. The high temperatures were not only in older homes with dark roofs, but also in new homes, including the newest homes in our study in Jordan Springs and Kellyville Ridge.

This graph illustrates the maximum temperatures recorded by temperature monitors placed in indoor living areas (loungeroom, study, bedroom). The two highest were 34° in Emu Plains and 40° in Stanhope Gardens.



SafeWork NSW recommends an indoor temperature of 20 - 26° for sedentary work (such as work on a computer). They warn that "Thermal discomfort can seriously impact a worker's overall morale and work performance. Prolonged exposure can lead to fatigue, lowered concentration and productivity." Studies related to workplace productivity and heatwaves often focus on construction, agriculture and manufacturing workplaces. The results in our study show that people who work from home, or study at home, will also be impacted if their work space is reaching high temperatures. People may also feel the financial pressure of cooling their homes in the middle of the day during the week, when in the past they may have been in an office or at a study location.

RECOMMENDATIONS

Update regulations for new builds

- Update all compliance pathways in BASIX and the National Construction Code to stop the new installation of dark roofs in hot suburbs, and not just de-incentivise them.
- Update energy efficiency standards with future climate data so that the homes built now are safe in a future, hotter climate.
- Place responsibility on developers, designers and councils via policy instruments to prevent communities from bearing the cost impacts.
- Introduce legislation to stop the installation of dark, absorbent pavings in urban areas.
- Add new green and blue infrastructure in hot suburbs.

Retrofitting existing homes to be cooler and more energy efficient

In homes with dark roofs, and especially suburbs with a high Urban Heat Island effect, there will be the need to retrofit homes to mitigate the impacts of a hot roof. The NSW Government should make funding available for simple retrofitting measures such as those listed below.

Owners undergoing major maintenance retrofit have various energy efficiency retrofit solutions at their disposal. Depending on the scope of the retrofit and budget considerations, these options may include:

- Replacing the roof with a lighter colour.
- Adding extra insulation and roof sarking (additional thin membranes under roofs) in the roof cavity to maintain comfortable internal temperatures.
- Install a roof cavity ventilation system e.g. a whirly bird to maintain comfortable internal temperatures.
- Utilise heat-reflective roof paints with a high Total Solar Reflectance percentage to reflect the sun's radiation, minimise internal temperature and reduce urban heat island effect.
- Incorporate green roofs to maintain comfortable internal temperatures and minimise urban heat island effect, although they may not always be financially feasible for residential properties.

CONTACT US

Thank you to all of the household participants who made this project possible, including John, Helen, Angela, Dane, Tilak, Deborah, Phillip, Laura, Sonia, Anoop, Sanaa and Kim, as well as their families and other residents.

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