
From: Shailja Chandra
Sent: Tuesday, 14 May 2024 5:23 PM
To: Portfolio Committee 7
Cc: Sanaa Shah
Subject: Re: Inquiry into the planning system and the impacts of climate change on the environment and communities - Post hearing responses
Attachments: 2 Futureproofing-our-energy-efficiency-system-for-climate-resilience-Sweltering-Cities-and-Renew.pdf; 1 Sweltering-Cities-Hot-Roofs-report-1.4.pdf

Thank you, David,

There are no corrections to be made to the transcript.

Thank you for the opportunity to provide further information. We have enclosed the following:

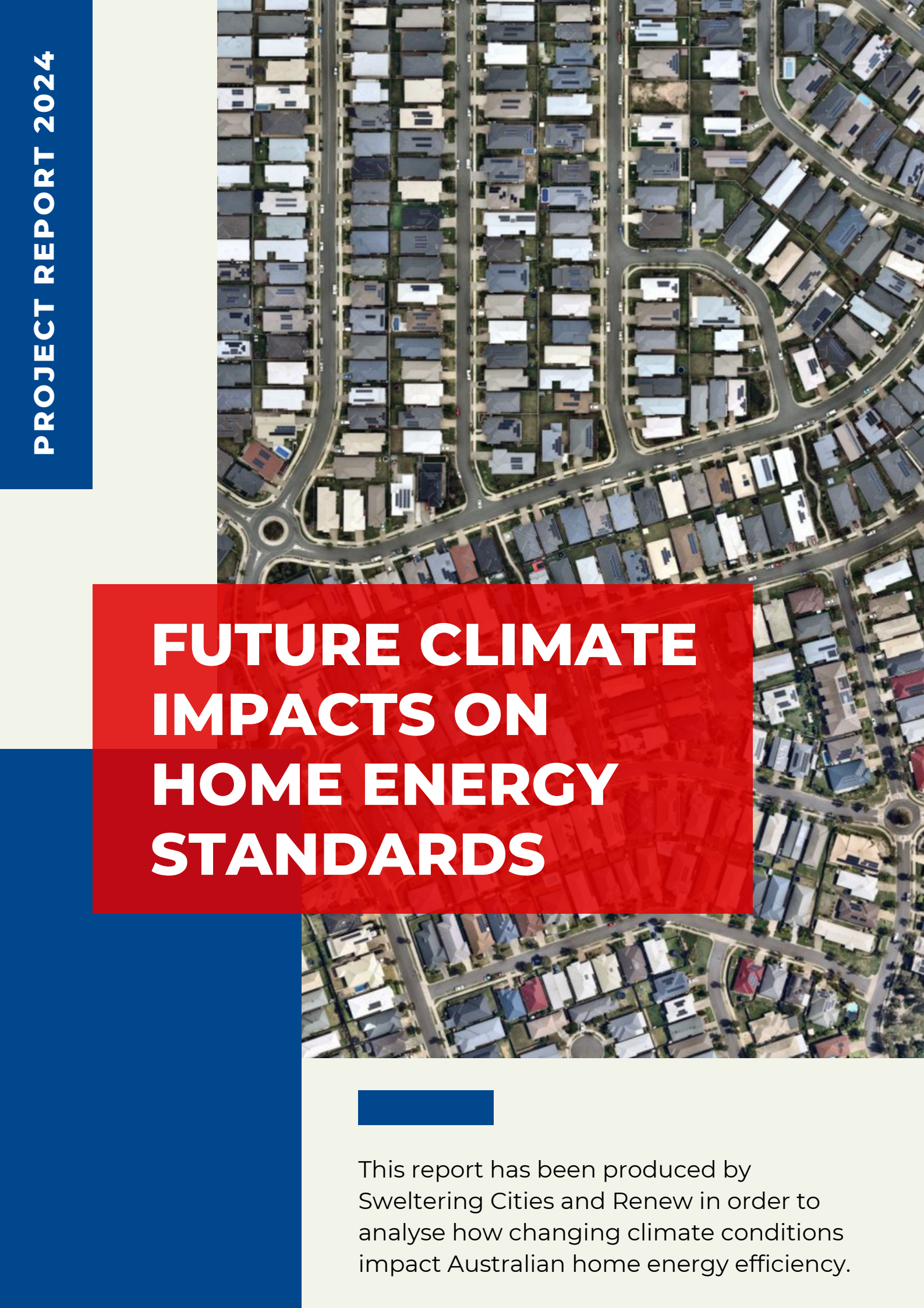
Answers to questions on notice:

In response to the question on page 26 about existing retrofit funding opportunities. - two links are enclosed:

- [NSW Government's 'NSW Climate and Energy Action' webpage](#) called 'Household energy saving upgrades', and
- [Department of Climate Change, Energy, the Environment and Water: Rebates and Assistance webpage](#)
- Copy of [Sweltering Cities' Hot Roofs report](#) as requested by the Chair Ms Sue Higginson on page 26.
- Additional information (weblinks) to support our statement that heatwaves are Australia's deadliest environmental disaster.
 - [A Lancet study](#) called Heat-related mortality: an urgent need to recognise and record
 - [AdaptNSW website](#) that states "Heatwaves are a significant hazard in Australia for both people and the environment. They have been responsible for more human deaths than any other natural hazard, including bushfires, storms, tropical cyclones, and floods."
 - A study called ['Let's talk about the weather: injuries related to extreme weather' by Australian Institute of Health and Welfare](#)
- Our [Futureproofing study](#) that was mentioned on page 26.

Additionally, I'd like to clarify that on page 27, line 8, I intended to state 'nine hottest years,' as I did on page 26, line 6, and not 'nine hottest summers.'

Kind Regards
Shailja



FUTURE CLIMATE IMPACTS ON HOME ENERGY STANDARDS

This report has been produced by Sweltering Cities and Renew in order to analyse how changing climate conditions impact Australian home energy efficiency.



ABOUT OUR PROJECT

The purpose of this project has been to explore whether the use of historical climate data to set energy efficiency standards in Australia will impact our resilience in rising temperatures and extreme heat. This is the first stage of a larger project; the scope of this work is to deliver a technical report and communications plan demonstrating the importance of this issue, potential for impact and the need for further analysis and advocacy.

This report has been prepared by Sweltering Cities and Renew with the support of Energy Consumers Australia. At a stakeholder consultation in December 2023 the technical report and analysis was presented to over 40 stakeholders for feedback. Those comments have been integrated into this final report.



THE BACKGROUND



Australian building standards require homes to meet energy efficiency standards (NatHERS). These NatHERS ratings measure how much energy is needed to heat and cool homes in a range of climate zones, setting limits for heating and cooling loads to achieve star ratings. The climate zones are designed using existing weather data: until 2022 these were based on weather data from 1970-2005; from 2022 the data is from 1990-2015.

Using past climate data for how we design our homes will reduce resilience to future climate extremes, particularly heat. Historical climate data does not accurately reflect the increasing frequency and intensity of heatwaves, and as global temperatures rise, using out of date data will lead to underestimating the severity of future heatwaves. This will result in homes that are ill-equipped to deal with extreme heat. In 2023 the Intergovernmental Panel on Climate Change (IPCC) stated that “Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020.” As the climate is hotter than the historical average, there will be a higher cooling load required to keep homes at a safe temperature. Therefore the star ratings given to new buildings and renovations underestimate how much energy the home will require, and that difference will grow over time.

The National Construction Code is the regulatory instrument used to set energy efficiency standards across Australia. The NCC is updated every three years with a focus on different areas for consideration. The next update of residential energy efficiency ratings will be in 2028.

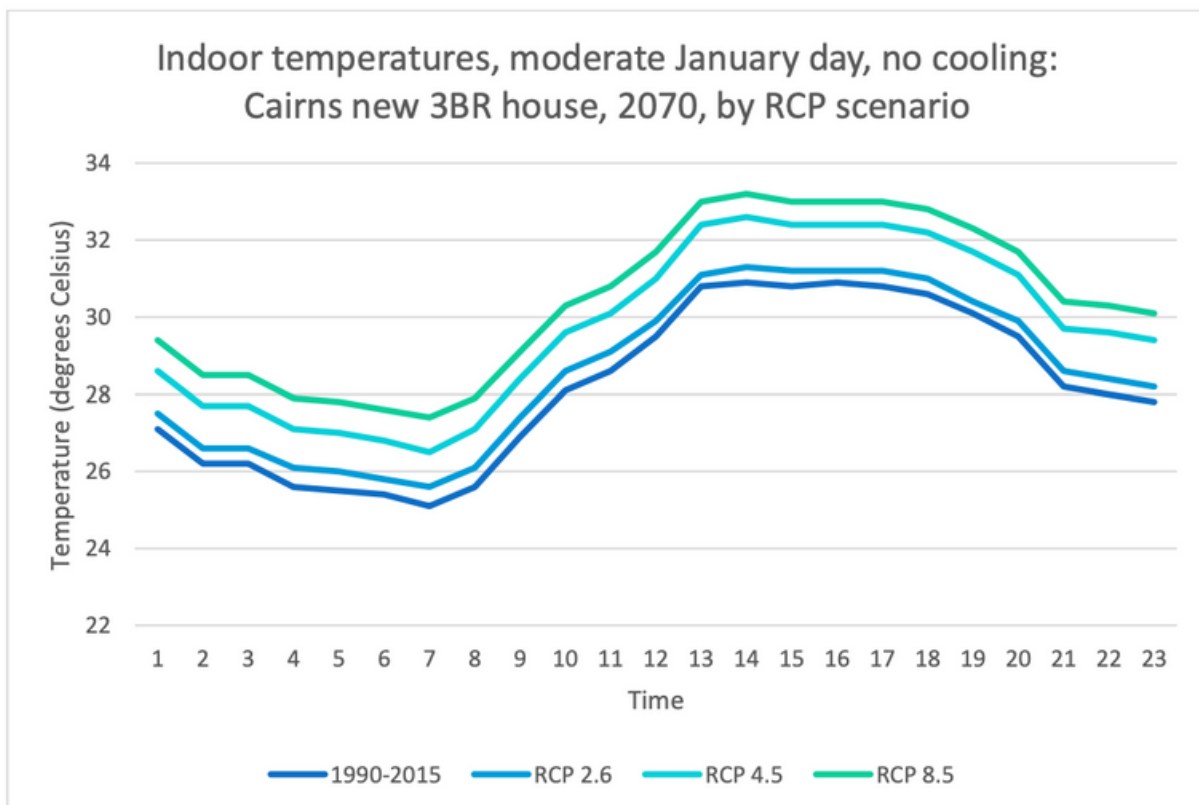
Using projected climate data provided by the CSIRO and FirstRate5 software we have analysed a new home and a poorly performing home in Melbourne, Adelaide, Cairns and Brisbane. We have compared the climate files used in the current and recently updated NCC, as well as projections for 2050, 2070 and 2090 according to Representative Concentration Pathway (RCP) scenarios. 2.6, 4.5, and 8.5. RCP 2.6 correlates to strong emissions mitigation; RCP 4.5 correlates to moderate emissions mitigation; and RCP 8.5 correlates to business as usual or no significant mitigation.

A detailed technical report is attached to the end of this summary report.

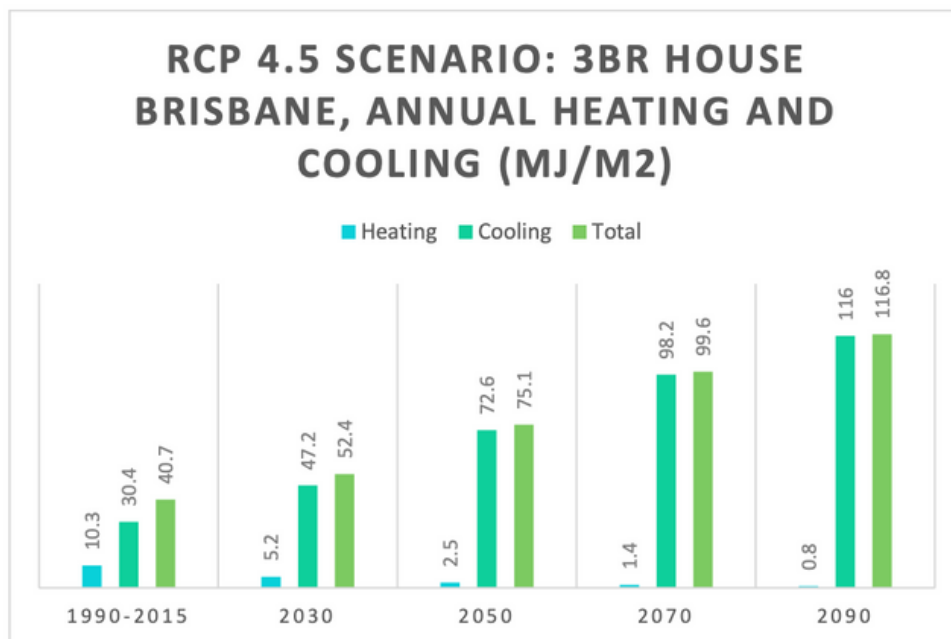
SUMMARY

Using out of date historical data to set the thresholds of energy efficiency ratings in Australia is resulting in an underestimation of the cooling required to keep homes a safe temperature in summer. This is already happening, but as the planet warms this gap will grow and homes that meet current standards for new builds will have higher indoor temperatures and require more energy to run. The biggest difference between predicted performance under historical data or future data scenarios is in hot climates and older homes.

The degree of increasing cooling load in a home will depend on the extent of climate change and successful emissions mitigation:

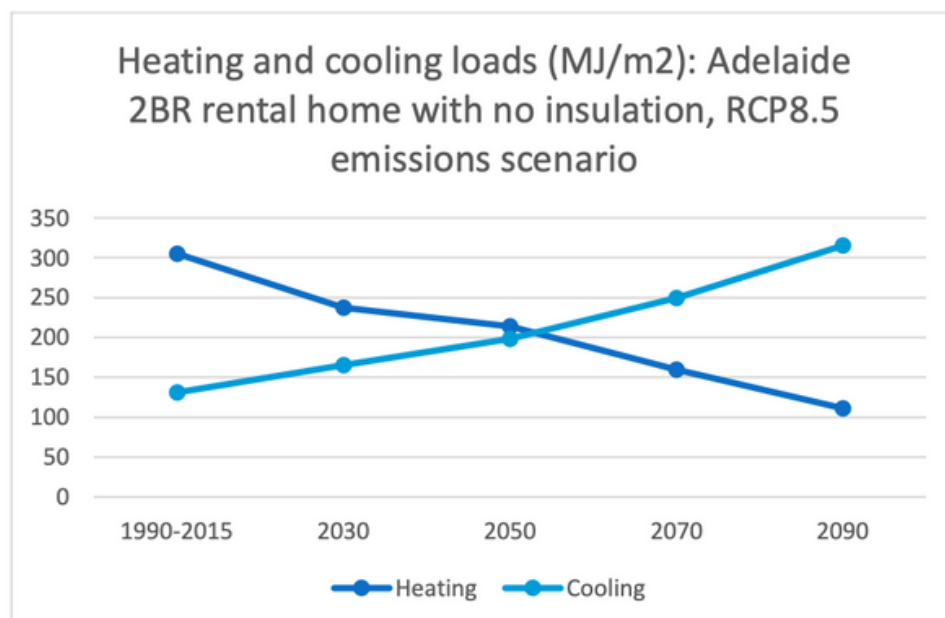


In hotter climates such as Cairns and Brisbane, this increase in temperatures means an overall increase in energy loads.



In this graph and others MJ/m2 refers to megajoule per square metre of thermal energy load, an indication of energy needed for heating or cooling

In cooler climates, reduced heating use offsets increased cooling when calculating total energy use. In the case of Adelaide, a severe climate scenario would see primary home energy use shifting from heating to cooling:



However, an overall reduction in total energy use does not negate the potential danger of high temperatures during heatwaves. These results should not be seen as a reason not to review home energy efficiency climate data. Thermal comfort during extremes should be accounted for.

What other work has been done?

This project builds upon work from organisations including the Western Sydney Regional Organisation of Councils (WSROC) and Waverley Council, researchers in Universities across Australia and government agencies.

The 2022 WSROC 'Future proofing residential development in Western Sydney' focuses on the impact of using out of date climate data on homes in Western Sydney. The graph below displays their analysis of how different climate data compares and demonstrates that the 2022 NCC update is already cooler than the current climate in Richmond, Sydney.

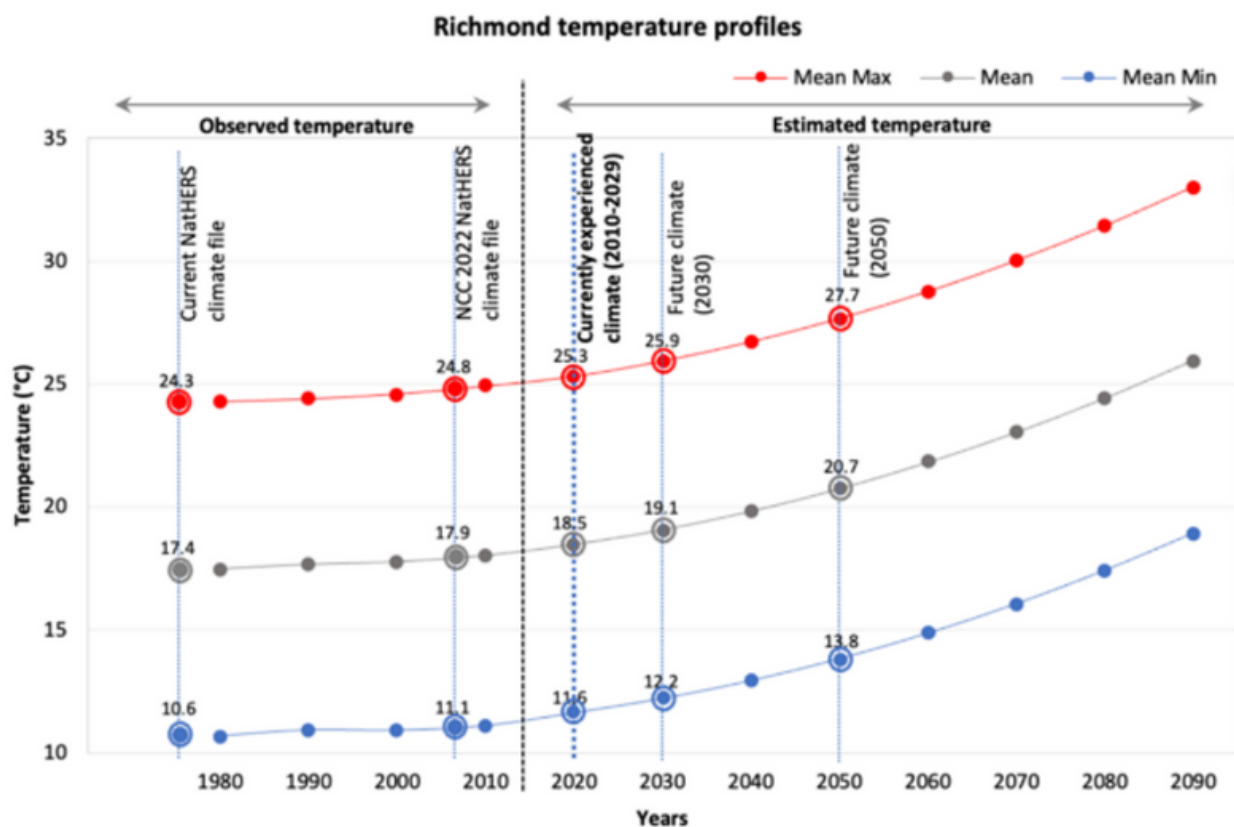


Figure 6: Richmond temperature profile presents observed mean maximum, mean and mean minimum temperatures from 1980 to 2010 and estimated temperatures from 2020 until 2090. Raw yearly temperature data is normalised by taking 20 years of running average, i.e., temperature for 1980 is derived by taking average of 1970 - 1989 (Data source: Commonwealth of Australia 2022)

The Waverley Council 'Future Proofing Residential Development to Climate Change' states that "results show it is possible the dwellings approved for construction now will be unsuitable for occupation by 2070, without extremely high levels of mechanical cooling to maintain comfortable, safe and liveable conditions." The below graph demonstrates that by 2030 most homes that are currently estimated to require more heating than cooling will all require significantly more cooling.

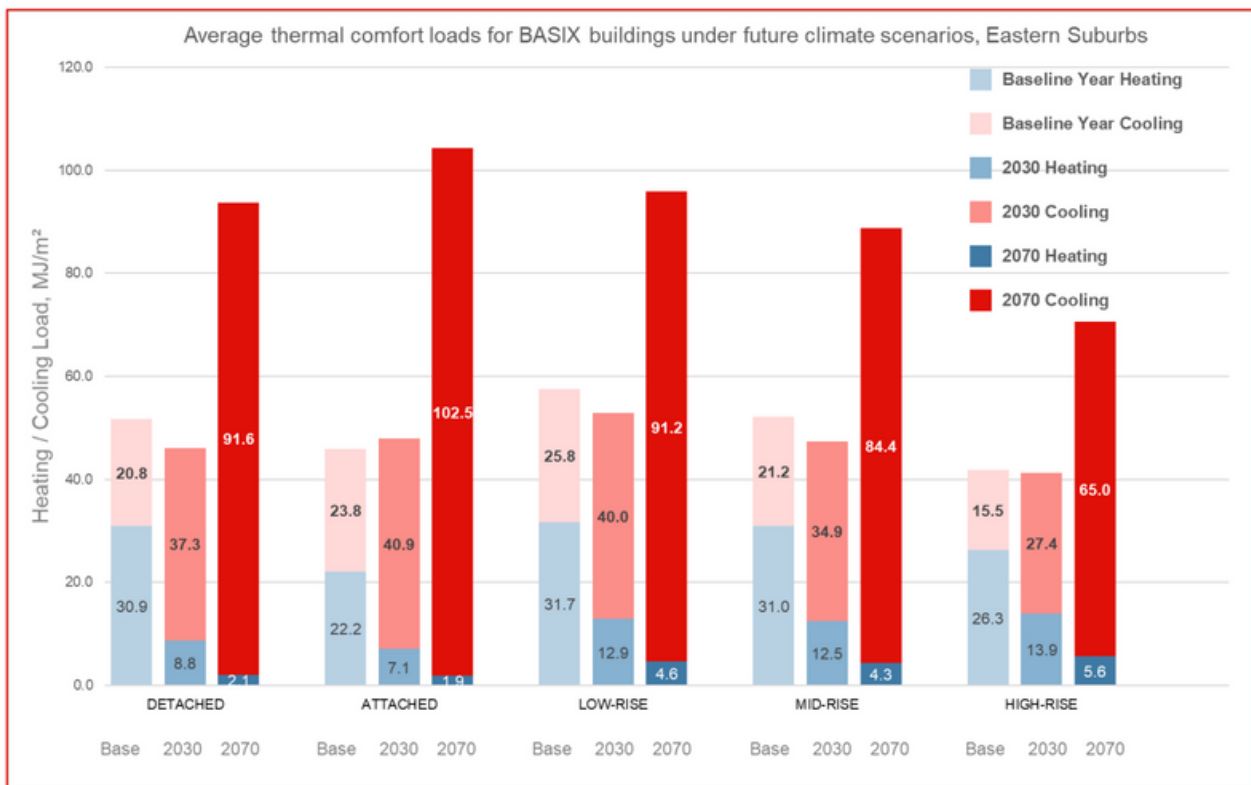


Figure 5.6 Comparison chart of average thermal comfort loads by building type, for Baseline Year, 2030 and 2070

The Waverley Report clearly states:

"Our residential dwellings need to be designed now for the 2030 climate scenario, because buildings built to the current standards will have a higher cooling load than expected when they are less than 10 years old."

IMPACTS

Health

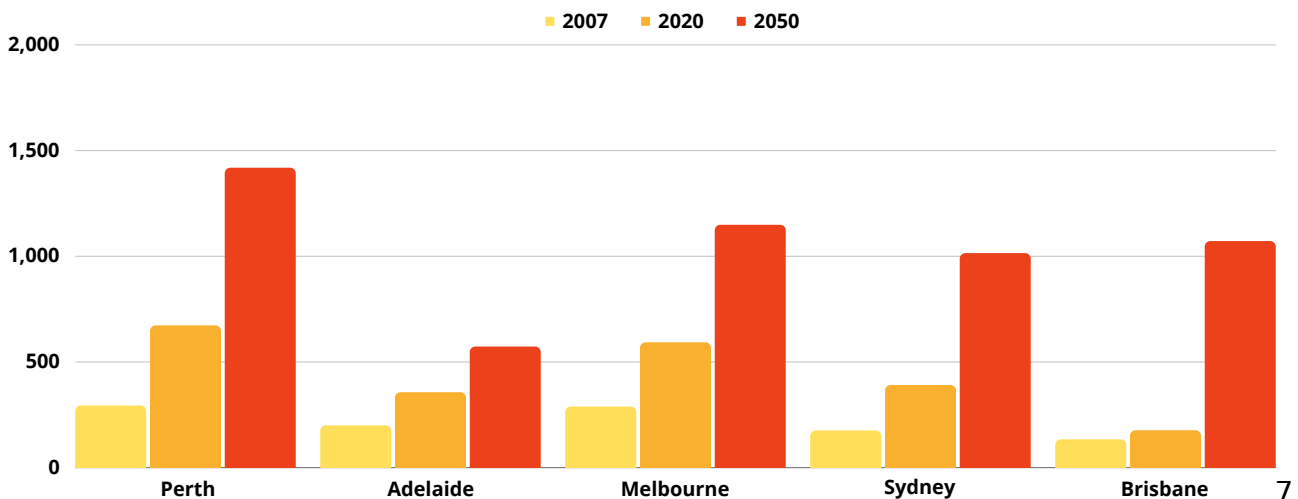
Heatwaves are the deadliest environmental disaster in Australia, they kill more people than all other disasters combined. Living in a hot home is a risk factor for heat-related disease including both physical and mental health impacts. Some of the most vulnerable cohorts are older people, young children, people with chronic illnesses and disabilities, and low-income households. Financial stress intersects with extreme heat as people struggle to afford simple measures like turning on the air con or fan, or leaving their homes to go somewhere cool.

Energy efficiency standards that use out of date climate data will result in higher than predicted internal temperatures during summer, even in homes that are built to a seven star rating now.

The health costs of extreme heat will be felt by the community and our health system. This will be especially true in Urban Heat Islands across the country, where temperatures can be 10° or more warmer than in cooler coastal suburbs or surrounding rural areas.

By updating the NCC climate data to incorporate future climate data, the Australian Government can reduce heat related illnesses and deaths in the future.

Predicted average heat deaths per year (State of the Environment report 2021)



Energy Grid

Australian energy agencies use household energy data and climate and weather predictions to estimate future energy grid demand. Using out of date climate data that underestimates the cooling load needed during summer may result in underestimations of the energy needed to power the grid during heatwaves. Using more accurate future climate data will allow government agencies, industry and other stakeholders to more accurately predict Australia's energy needs. This will likely avoid more frequent black-outs during heatwaves, which result in stress and crisis across the community and economy.

Urgent warning about energy use in one state as mercury spikes to 40C

Australians are being told to reduce their energy use during peak hours, as temperatures soar around the country to uncomfortable degrees.

Anthony Anderson, Elena Couper and Emma Cam

 3 min read December 14, 2023 - 12:07PM NCA NewsWire

Reducing carbon emissions

According to the Department of Climate Change, Energy, the Environment and Water:

Data from the department shows buildings account for around 19% of total energy use and 18% of direct carbon emissions in Australia.

Energy efficiency in buildings plays an important role for households, businesses and the wider economy. Improving energy efficiency can:

- reduce energy bills
- improve the comfort and health of occupants
- ensure energy security and affordability
- reduce the risk of blackouts by reducing peak demand
- lower carbon emissions.

Using accurate data to set energy efficiency ratings across Australia will have a significant positive impact and will support our transition to net zero carbon emissions by both reducing future energy demand and allowing for more accurate planning by government and industry.

Energy efficiency is a key component of the plan to reduce carbon emissions, and growing household energy demand for cooling will undermine efforts to meet state and federal targets.

WHAT NEXT?

We look forward to contributing this analysis to ongoing relevant federal and state strategies and processes including the National Adaptation Plan, National Climate Risk Assessment, Trajectory for Low Energy Buildings and other related frameworks.

We believe that updating the climate data in the NCC supports the sector plan for the built environment to reach 43% reduction in carbon emissions by 2030 and net zero by 2050 and state based carbon emission reduction targets.

The 2023 National Health and Climate Strategy included:

Action 6.8

Considering climate resilience in updates to the National Construction Code

The Australian Government will work with states, territories, and the Australian Building Codes Board to progress opportunities to embed sustainability and climate resilience principles in the National Construction Code, and in doing so will consider the health impacts of climate change.

We believe this includes updating the climate data used in the NCC to build in resilience to a hotter climate and will be advocating for the health impacts of climate change to be considered as per this strategy.

The next NCC update will concern commercial buildings. In that update, future climate data and high emission climate predictions will be considered. The 2028 update will cover residential buildings, and we believe that is the best opportunity to update climate data for regulations across the country. However, there may be opportunities to integrate improved climate resilience by updating regulations at other levels of government in specific jurisdictions.

Successfully advocating for an update to the climate files in the NCC will require both collaborating with government agencies, and working with industry and community stakeholders to lay out the benefits of improving energy efficiency. We look forward to kicking off this next stage of this ambitious project in 2024.

THE VISION

Australia's planning regulations support communities and businesses to be safe in a warming climate, and reduce carbon emissions in the built environment.

THE PLAN

- Produce further technical analysis that demonstrates the importance of urgent action to update climate data in the NCC
- Collaborate with stakeholders from NGOs, industry, government, and research centres on advocacy.
- Mobilise community members to demonstrate support and neutralise opposition at key moments.
- Integrating climate change forecasts into the NCC sets a precedent for planning all parts of our society using the best available science.





This report was published in January 2024.

For further information, please contact:

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Sweltering Cities is a health and climate advocacy NGO that works directly with communities impacted by extreme heat to win more liveable, sustainable, and equitable cities.

Find out more at www.swelteringcities.org



Renew is a national, not-for-profit organisation that inspires, enables and advocates for people to live sustainably in their homes and communities.

Find out more at www.renew.org.au

This report was produced with the generous support of Energy Consumers Australia.



Future home climate resilience: technical notes and analysis

Rob McLeod, Policy and Advocacy Manager, Renew

6 December 2023

Summary

This consultation paper provides the initial findings of an analysis of the future energy performance and resilience of homes under changing climate conditions.

Using CSIRO projected weather data and FirstRate5 software, we have modelled the energy use and internal temperatures of a range of case study homes across four locations: Adelaide, Melbourne, Brisbane, and Cairns. Our case studies include newly built homes (meeting current NCC standards) and older, poorly performing homes requiring retrofits.

Our findings include:

- Projected changes to energy loads for heating and cooling for each home and climate scenario in the years 2030, 2050, 2070, and 2090
- Projected changes to star ratings based on changed energy use
- Simulated indoor temperatures during hot conditions for each case study

Please see results and analysis section for findings and data.

Background context

The National Construction Code (NCC) requires new homes to meet basic energy efficiency standards and sets limits on the heating and cooling loads required to maintain comfortable indoor temperatures. Under the 2022 NCC (currently in process of implementation according to differing state and territory timelines), new homes are required to meet 7-Star NatHERS ratings as a minimum standard.

Alongside the increase to 7-Star standards, NCC2022 updated the climate data used to calculate NatHERS ratings. This weather data is made up of actual recordings across a 25-35 year period, in line with international standards. Prior to the 2022 NCC update, the weather data was from the period 1970-2005. Following the 2022 NCC update, the data used is currently from 1990-2015. Changing the weather files used resulted in changes to calculated NatHERS scores.

NatHERS measures the energy loads needed to heat and cool a home per m2. Localised weather data in 69 climate zones is used to calculate expected energy use; this allows NatHERS to take into account the different amounts of energy needed for heating and cooling in hotter and colder climates while still providing a meaningful energy efficiency rating. (For example: a 7-Star home in Hobart uses more energy than a 7-Star home in Brisbane.)

Using past climate data for how we design our homes may reduce resilience to future climate, particularly heat. The eight hottest years on record globally have all occurred since 2015; 2023 is expected to be the hottest year on record.

Methodology

Our analysis uses [projected climate data](#) provided by the CSIRO to develop a set of case studies for the future energy performance and climate resilience of homes.

The CSIRO projected climate data use Typical Meteorological Year (TMY) climate files from 1990-2015 to develop predictive files. The files provide hourly weather data in 83 Australian locations in the years 2030, 2050, 2070, and 2090. Three climate scenarios are provided for each year and location, based on the IPCC Representative Concentration Pathway (RCP) scenarios 2.6, 4.5, and 8.5. RCP 2.6 correlates to strong emissions mitigation; RCP 4.5 correlates to moderate emissions mitigation; and RCP 8.5 correlates to business as usual or no significant mitigation.

We have used FirstRate5 energy modelling software to simulate NatHERS star ratings, heating loads, and cooling loads in each year, location, and emissions scenario for each case study. We have furthermore used FirstRate5 to simulate indoor temperatures during a nominal range of dates during a hot summer week in early January, assuming no use of cooling (free running mode). Indoor temperature simulations are not intended to provide absolute predictions about indoor heat, but rather to allow for a relative comparison between homes and scenarios.

We have selected four locations: **Brisbane, Cairns, Melbourne, and Adelaide.**

For each location we modelled two homes as case studies: a new home (compliant with current building regulations and with the exception of Adelaide meeting a 7 Star standard); and a poorly performing home, representative of many older homes lacking basic energy efficiency features such as insulation. Each home was modelled on existing floorplans; in the case of the new homes, some amendments were made to insulation, windows, and ceiling fans to ensure NCC compliance across locations.

The case studies modelled are as follows:

#	Location	Description	NatHERS star rating (1990-2015 climate data)
1	Brisbane	New detached house: 3BR	7.4
2	Brisbane	Older duplex: 2BR	1.7
3	Cairns	New detached house: 3BR	7.1

4	Cairns	Older duplex: 2BR	1.6
5	Melbourne	New detached house: 5BR	7.0
6	Melbourne	Older duplex: 2BR	1.1
7	Adelaide	New detached house: 5BR	6.6
8	Adelaide	Older duplex: 2BR	1.1

Results

Energy loads and star ratings

The following section provides the results of modelled star ratings; heating loads; cooling loads; and total heating and cooling loads. Energy loads are given in MJ/M2 of internal conditioned space.

1. Brisbane – new home

Year	RCP	Star rating	Heating	Cooling	Total
1990-2015	N/A	7.4	10.3	30.4	40.7
2030	2.6	5.7	6.2	50.3	56.5
2050		4.8	3.8	66.3	70.1
2070		5.3	5	56.1	61.1
2090		5.4	5.4	53.7	59.1
2030	4.5	6.1	5.2	47.2	52.4
2050		4.4	2.5	72.6	75.1
2070		3.6	1.4	98.2	99.6
2090		3.1	0.8	116	116.8
2030	8.5	4.9	2	64.7	66.7
2050		3.5	1.1	101.6	102.7
2070		1.9	0.1	169.8	169.9
2090		0	0	244.2	244.2

2. Brisbane – older home

Year	RCP	Star rating	Heating	Cooling	Total
1990-2015	N/A	1.7	84.5	94.2	178.7
2030	2.6	1.2	65	138.2	203.8
2050		0.6	52.9	180.3	233.2
2070		0.9	61.4	157.2	218.6
2090		1.1	62.8	148.5	211.3
2030	4.5	1.4	61.4	134.5	195.9
2050		0	44.1	199	243.1
2070		0	34.2	260.2	294.4
2090		0	26.7	304.3	331

2030	8.5	1.1	38.5	173.2	211.7
2050		0	29.7	252.9	282.6
2070		0	11.6	402.2	413.8
2090		0	6	557.4	563.4

3. Cairns – new home

Year	RCP	Star rating	Heating	Cooling	Total
1990-2015	N/A	7.1	0	111	111
2030	2.6	5.4	0	150	150
2050		5.7	0	144.7	144.7
2070		5.6	0	147.6	147.6
2090		5.6	0	145.6	145.6
2030	4.5	5.4	0	150.8	150.8
2050		4.4	0	182.5	182.5
2070		4.1	0	191.9	191.9
2090		2.1	0	269	269
2030	8.5	5	0	163.4	163.4
2050		1.9	0	279.8	279.8
2070		1.6	0	292.4	292.4
2090		0	0	362	362

4. Cairns – older home

Year	RCP	Star rating	Heating	Cooling	Total
1990-2015	N/A	1.6	2.8	289.7	292.5
2030	2.6	0	2	369.9	371.9
2050		0	1.6	349.8	351.4
2070		0	1.7	356.6	358.3
2090		0	1.7	356.8	358.5
2030	4.5	0	2	364.9	366.9
2050		0	1.4	434.7	436.1
2070		0	1	447.4	448.4
2090		0	0.4	605.9	606.3
2030	8.5	0	1.3	392.7	394
2050		0	0.4	620	620.4
2070		0	0.4	633.3	633.7
2090		0	0.2	763.9	764.1

5. Melbourne – new home

Year	RCP	Star rating	Heating	Cooling	Total
1990-2015	N/A	7	39.5	22.2	61.7
2030	2.6	7.1	31.6	29.1	60.7

2050		7.1	29.4	31.2	60.6
2070		6.9	30.5	31.9	62.4
2090		7	30.5	30.7	61.2
2030		7.1	31.7	27.9	59.6
2050	4.5	6.9	26.3	36.1	62.4
2070		6.9	19.8	42.7	62.5
2090		6.6	22.8	46	68.8
2030	8.5	7.1	26.8	33.3	60.1
2050		6.9	23.7	41	64.7
2070		5.9	18.4	63.6	82
2090		5.1	10.4	92.7	103.1

6. Melbourne – older home

Year	RCP	Star rating	Heating	Cooling	Total
1990-2015	N/A	1.1	347.2	64.6	411.8
2030	2.6	1.4	288.6	85.7	374.3
2050		1.4	275.3	91.2	366.5
2070		1.3	284.3	94.4	378.7
2090		1.3	284.4	92.9	377.3
2030	4.5	1.3	295.5	81.7	377.2
2050		1.4	253.4	105.2	358.6
2070		1.7	206.2	124	330.8
2090		1.4	223.9	140.5	364.4
2030	8.5	1.4	260.1	97.6	357.7
2050		1.4	236	120.5	356.5
2070		1.3	190.2	186.7	376.9
2090		1.2	121.6	275.4	397

7. Adelaide – new home

Year	RCP	Star rating	Heating	Cooling	Total
1990-2015	N/A	6.7	31.1	38.9	70
2030	2.6	6.7	23.9	46.9	70.8
2050		6.6	21.3	50.5	71.8
2070		6.6	23.9	48.4	72.3
2090		6.5	24.4	49.1	73.5
2030	4.5	6.5	23.5	49.8	73.3
2050		6.3	21.5	55.6	77.1
2070		6.4	16.3	58.3	75.2
2090		6.1	18.8	62.6	81.4
2030	8.5	6.6	21.9	50.4	72.3
2050		6.3	19.2	59.5	78.7
2070		5.8	13	75.4	88.4
2090		5.2	7.9	95.3	103.2

8. Adelaide – older home

Year	RCP	Star rating	Heating	Cooling	Total
1990-2015	N/A	1.1	305	131	436
2030	2.6	1.3	249.7	152.9	402.6
2050		1.4	232	166.2	398.2
2070		1.3	251.4	162	413.4
2090		1.2	254.6	167.4	422
2030	4.5	1.3	248.1	166.1	414.2
2050		1.3	232.5	182.3	414.8
2070		1.4	191.4	193.5	384.9
2090		1.2	207.9	208.6	416.5
2030	8.5	1.3	237.4	165.4	402.8
2050		1.3	213.8	198.4	412.2
2070		1.3	159.5	249.2	408.7
2090		1.2	111.1	315.1	426.2

Internal temperatures

A wide range of projected internal temperature data was calculated for each location. For each case study and climate scenario, hourly temperature data has been generated in each room across a year.

The TMY weather files used to generate the projected data are primarily used to model average annual energy use and NatHERS ratings, rather than resilience to specific heat events. The projected hourly temperatures should not be used as predictions of temperatures on specific dates, but rather how a home has been simulated to perform in given weather conditions.

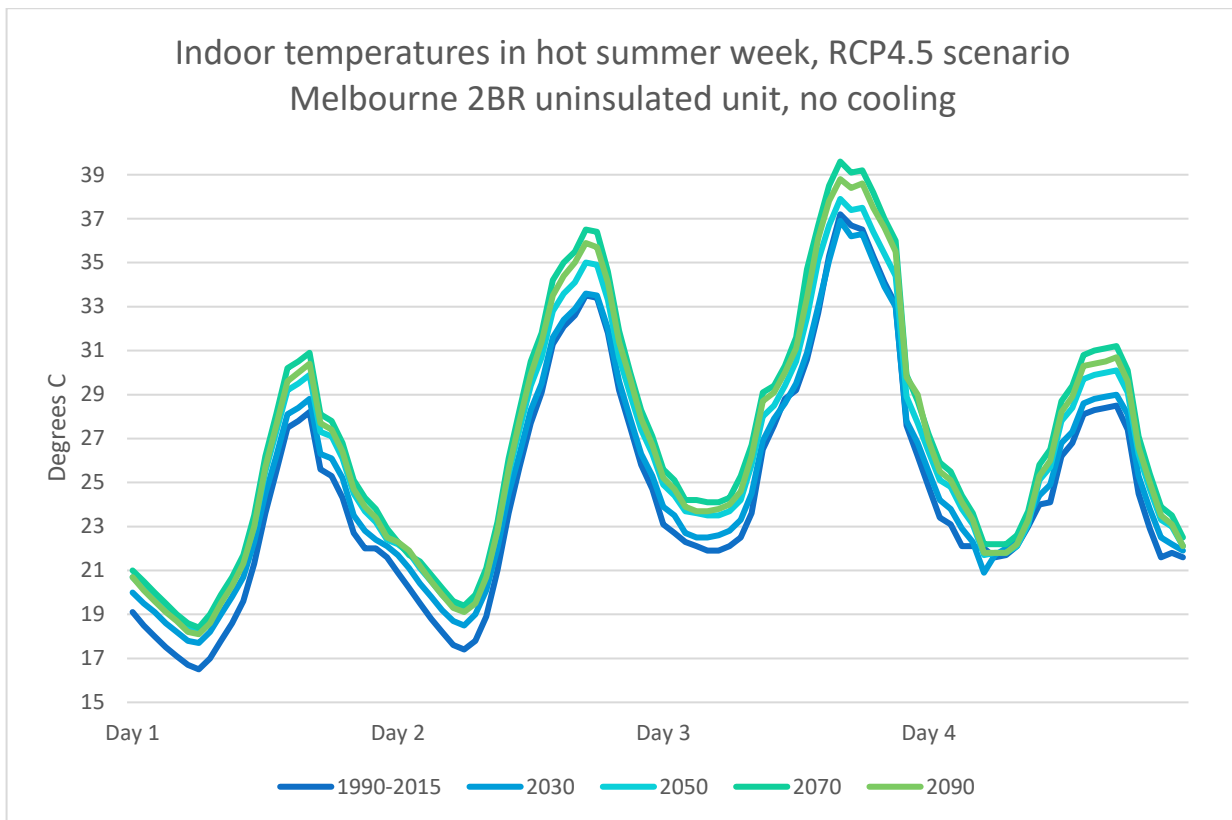
Temperature data has been calculated using ‘free running’ mode, which assumes no use of air conditioning or heating. This approach provides an insight into the resilience of buildings, however in practice heating and cooling mean that these temperatures are not experienced in many or most homes. Higher internal temperatures in free running mode indicate higher energy needs for cooling.

A selection of findings is presented below for the purposes of discussion. Further scenarios and data can be provided on request.

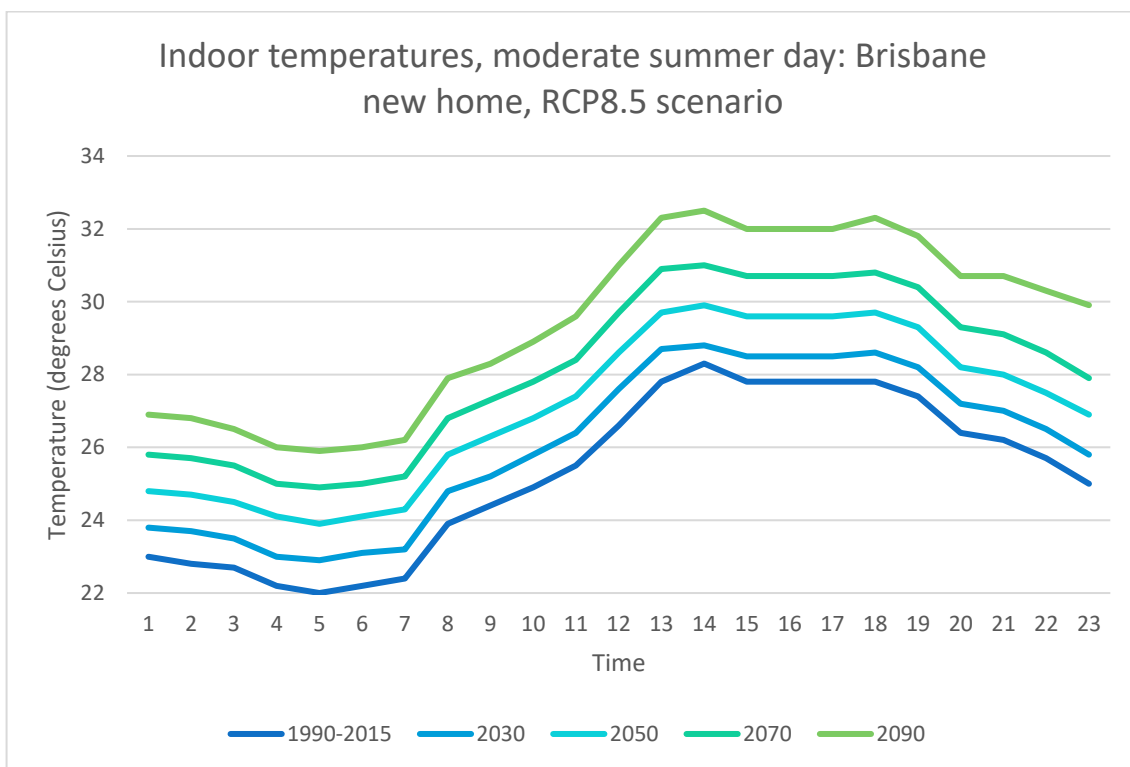
1. Daily temperatures in hot conditions

Hotter outdoor temperatures increase the internal temperature of homes in all locations and scenarios. Examples of selected hot weather temperatures are as follows.

Melbourne uninsulated unit, four days during January including heatwave conditions: maximum indoor temperatures modelled to increase by approx. 2-3 degrees depending on scenario and date.



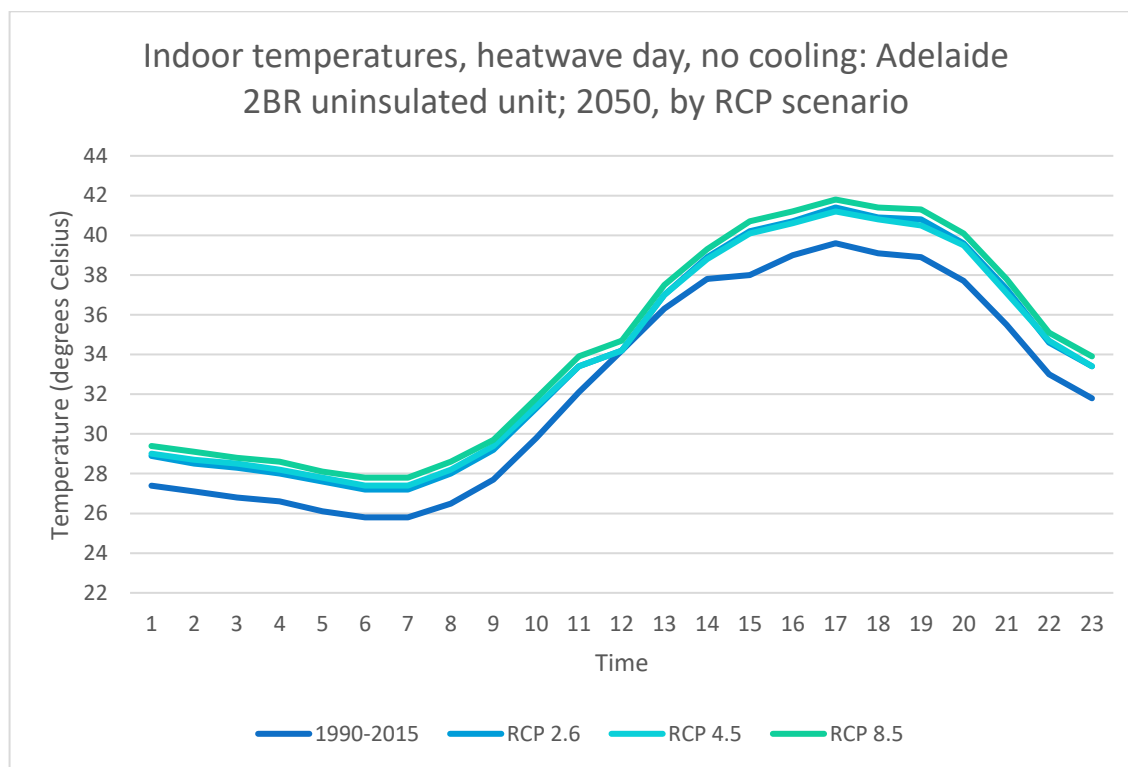
Brisbane new home, one day during January (max temperature 29 degrees in 1990-2015), RCP8.5 scenario: indoor temperatures modelled to increase over time, up to four degrees by 2090 under severe climate scenario.



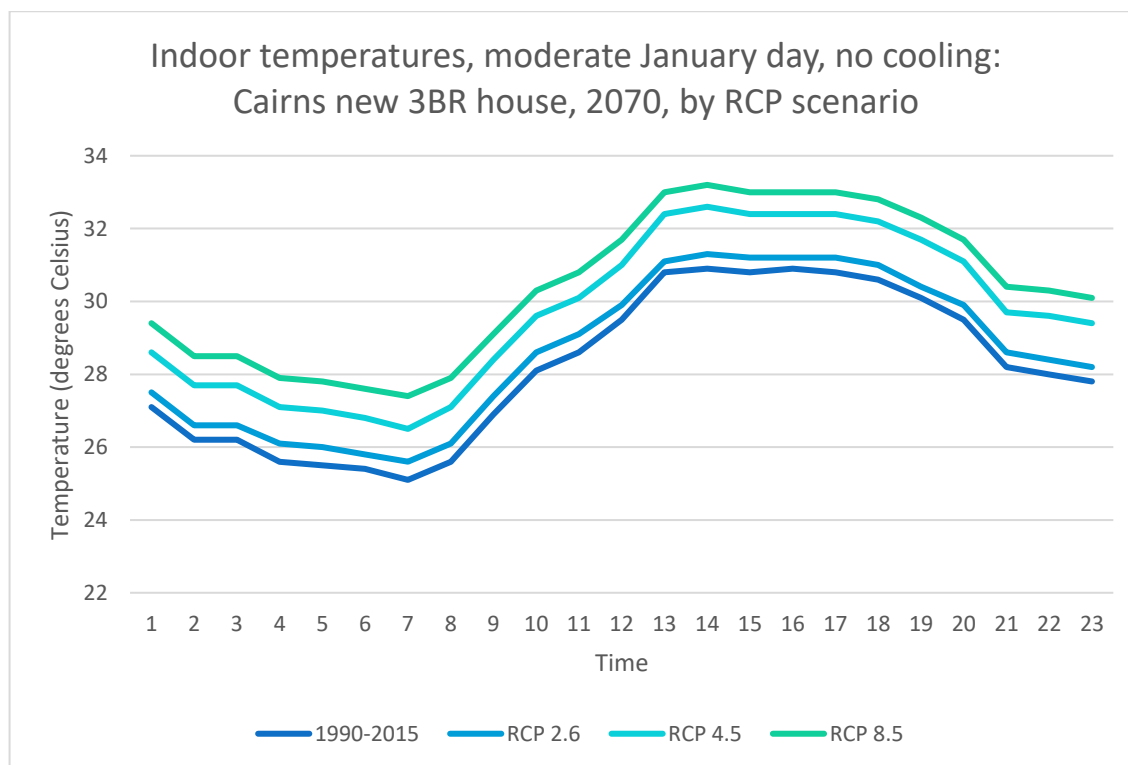
2. Impact of climate mitigation and RCP scenarios

Comparing internal temperatures in the same year and case study home across different RCP scenarios allows for an analysis of the projected impact of emissions mitigation.

Adelaide uninsulated unit, internal temperatures during heatwave conditions, one day in early January; comparison of 1990-2015 temperatures with 2050 temperatures in each RCP scenario:



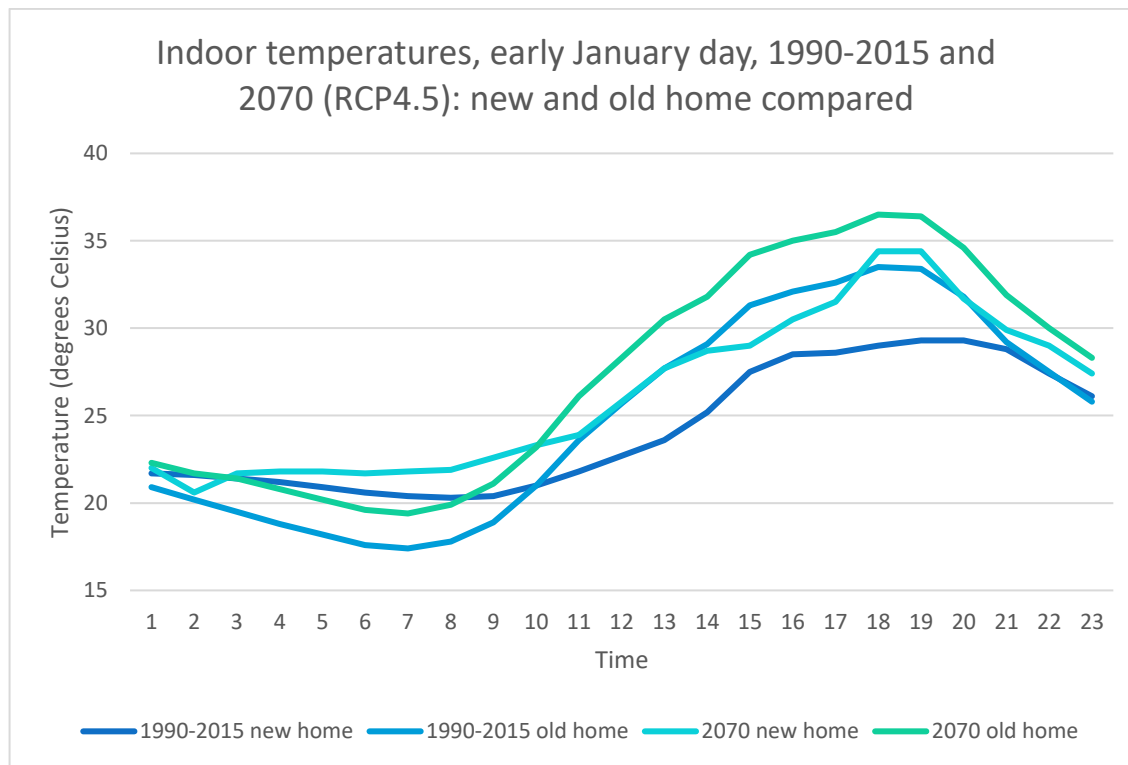
Cairns new home, one day in early January, 1990-2015 and 2070 across RCP scenarios:



In the case of the Cairns new home case study, an RCP8.5 scenario was modelled to experience internal temperatures close to 2 degrees hotter during the afternoon than an RCP2.6 scenario in 2070.

3. Impact of building design and energy efficiency

A significant difference was modelled in internal temperatures between new homes (NCC compliant) and older homes.



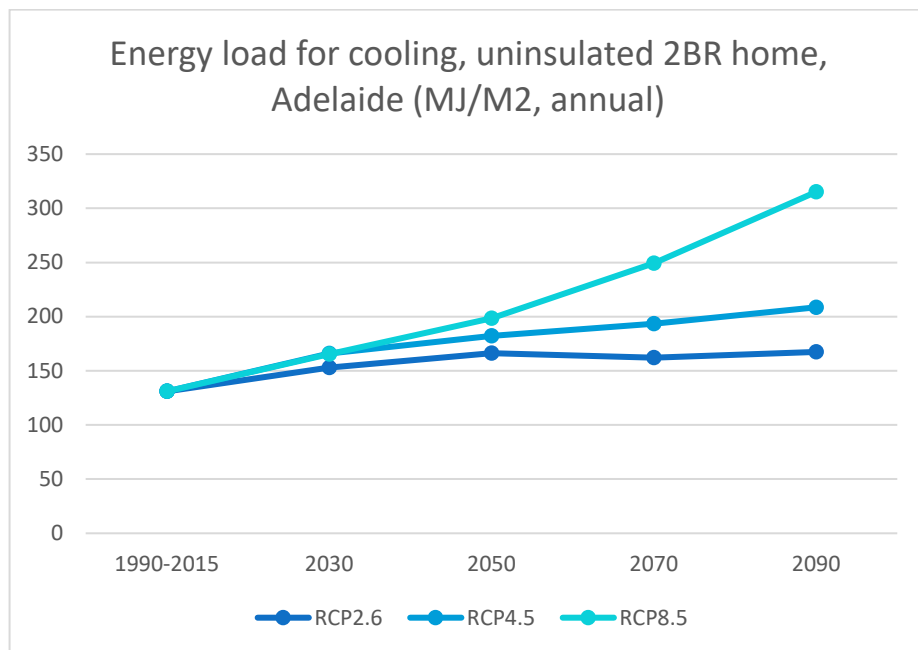
In the case of this scenario, the internal temperatures of a 7-Star home built in 2023 were modelled to be similar (or slightly higher at peak) in 2070 than those of an uninsulated 1.1-Star home under 1990-2015 climate conditions.

Analysis and discussion

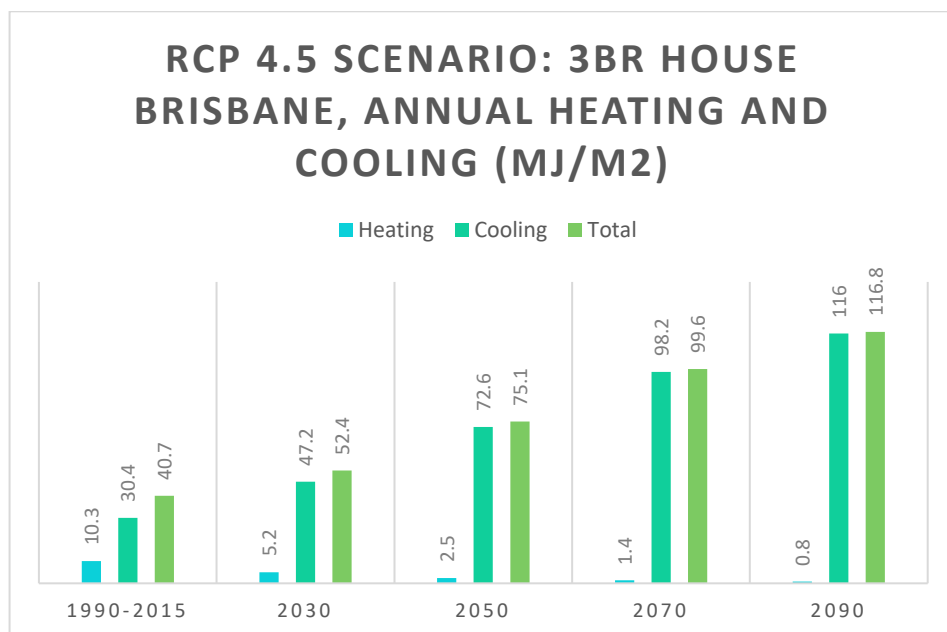
Increased cooling loads

A key trend is that energy loads required for cooling to maintain comfortable internal temperatures are projected to increase as temperatures rise. Because current data includes years as far back as 1990, significant differences were found between the performance of homes according to currently used data and expected energy use in 2030.

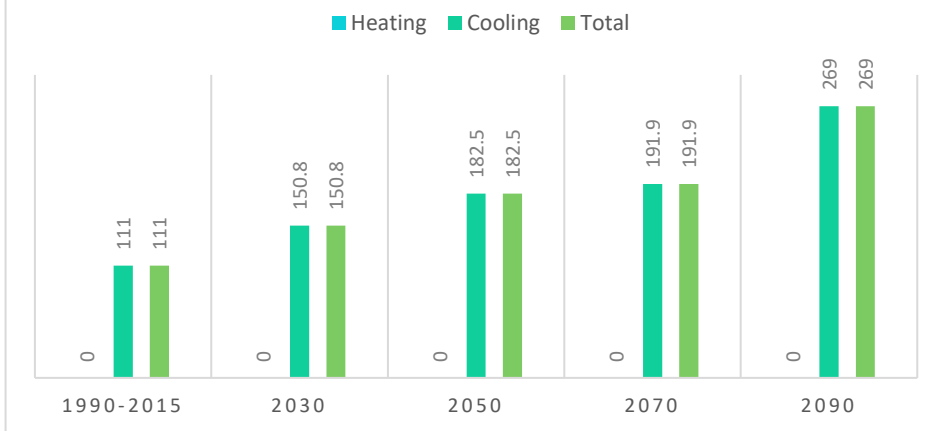
The level of increase varies according to the extent of climate change and successful emissions mitigation:



In hotter climates such as Cairns and Brisbane, this increase means an overall increase in energy loads.

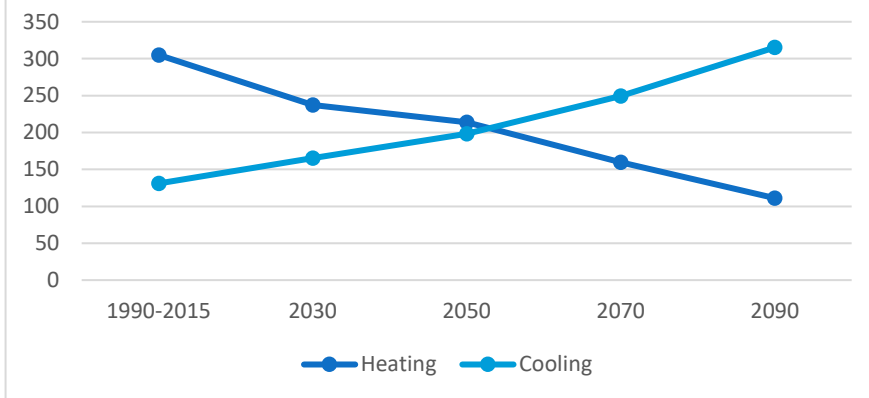


RCP 4.5 SCENARIO: 3BR HOUSE CAIRNS, ANNUAL HEATING AND COOLING (MJ/M2)

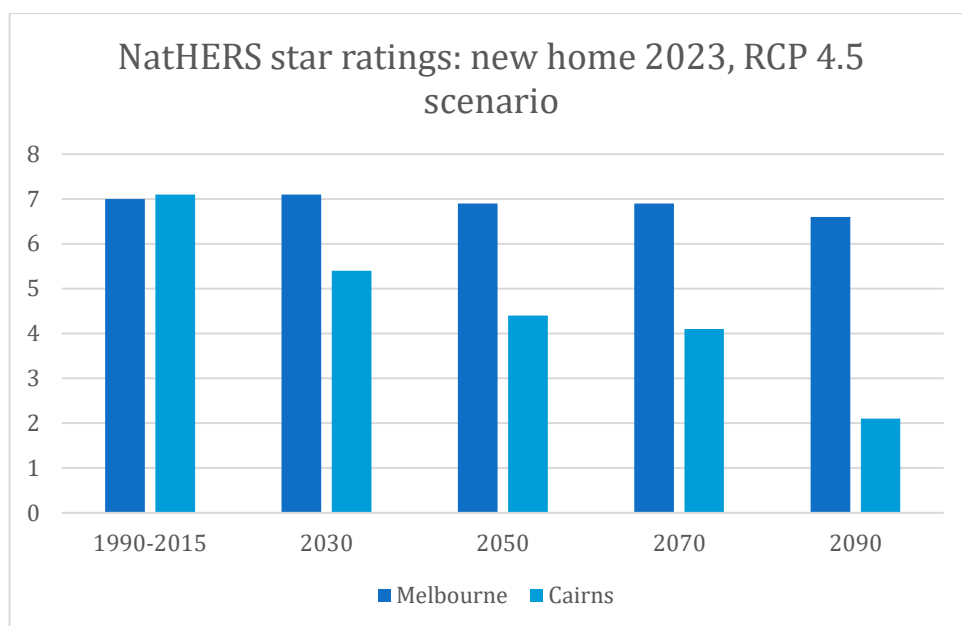


In cooler climates, reduced heating use offsets increased cooling when calculating total energy use. In the case of Adelaide, a severe climate scenario would see primary home energy use shifting from heating to cooling:

Heating and cooling loads (MJ/m2): Adelaide 2BR rental home with no insulation, RCP8.5 emissions scenario



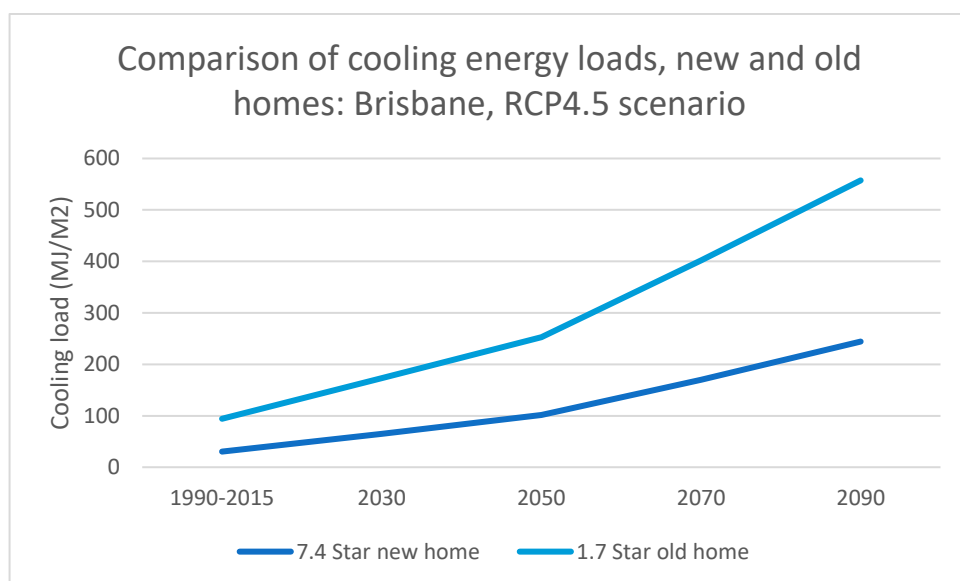
NatHERS star ratings are calculated according to total energy loads (heating and cooling combined). As such, applying 2022 NatHERS star rating bands to future climate scenarios led to significant decreases in hotter climates; however, the reduction in heating requirements in colder climates offset those increases in colder climates and led to smaller effects on NatHERS ratings:



In the case of poorly performing homes in Brisbane and Cairns, a star rating of zero was expected as soon as 2050 and 2030, respectively.

Impact of design and energy efficiency

Building design and energy efficiency ratings were found in our modelling to have an increasing impact on overall energy use (and particularly cooling loads) in a range of scenarios. While further analysis should be undertaken of this effect, this indicates the importance of home retrofits and building standards.



Resilience to extreme temperatures

A core consideration is that overall annual energy use does not necessarily correspond to resilience to extreme temperatures. Designing to minimise annual energy loads may at times be in tension with maximising resilience in extreme heat conditions; this appears to be particularly the case in colder climates where heating loads are expected to decrease. Nonetheless, our initial analysis indicates that improved energy efficiency can be consistent with resilience to heatwave conditions; in our view this is a critical area for further technical analysis.

Next steps and further work

The case studies suggest further opportunities for technical analysis, including:

- Assessment of further building types, including apartments
- Assessment across all NatHERS climate zones
- Detailed assessment of the impacts of design choices and optimisation of design for future climate
- Assessment of impacts of specific design principles in Climate Zones 1 & 2 (northern Australia)
- Specific analysis of heatwave resilience (alongside analysis using annualised energy data)
- Analysis of impacts on energy grids, peak demand and DER integration
- Analysis of the potential impacts of home retrofits for existing homes
- Analysis of further impacts of land use change and changed urban heat island effects

Our initial analysis and case studies indicate that the impact of increasing temperatures on home resilience and energy use is a significant public policy issue. The technical analysis forms part of a broader project to understand and communicate the required policy response. Further discussion of this element of the project will be held during stakeholder consultations.

Comments and feedback

Please email Rob McLeod at rob.mcleod@renew.org.au

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.

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EXECUTIVE SUMMARY

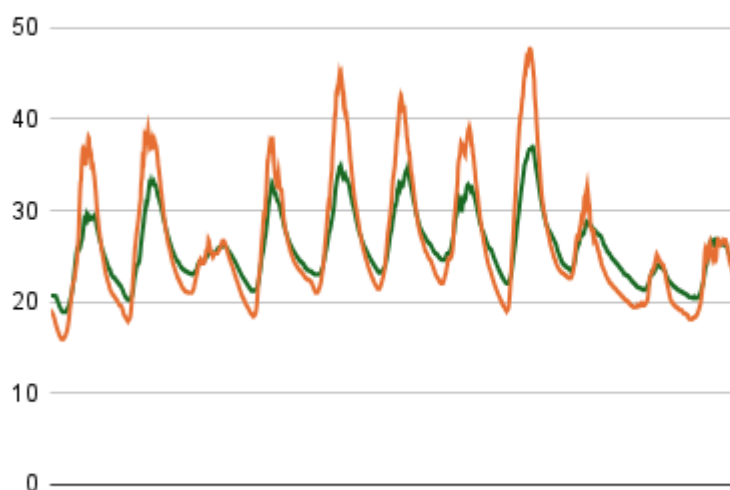
From January to March 2024 Sweltering Cities collaborated with eleven households in Western Sydney to set up thermometers around their homes to assess the impact of roof colour on both ceiling cavity and indoor temperatures. The data revealed that dark coloured roofs were hotter by up to 10°C or more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

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 as 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 absorptance 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.



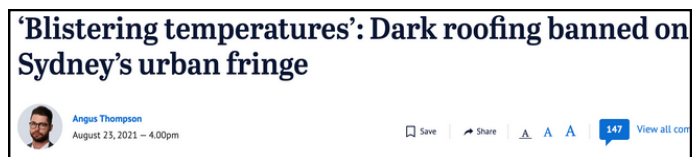
Additionally, a recent report by Sweltering Cities in association with Renew, has found that Australia's home energy ratings and building energy efficiency regulations are based on historical climate data from 1990-2015. Using past climate data to design our homes means they are not well-prepared for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



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.



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]

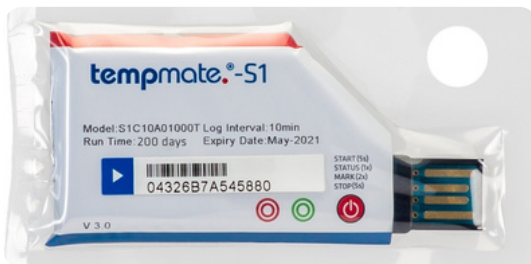
METHODOLOGY

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



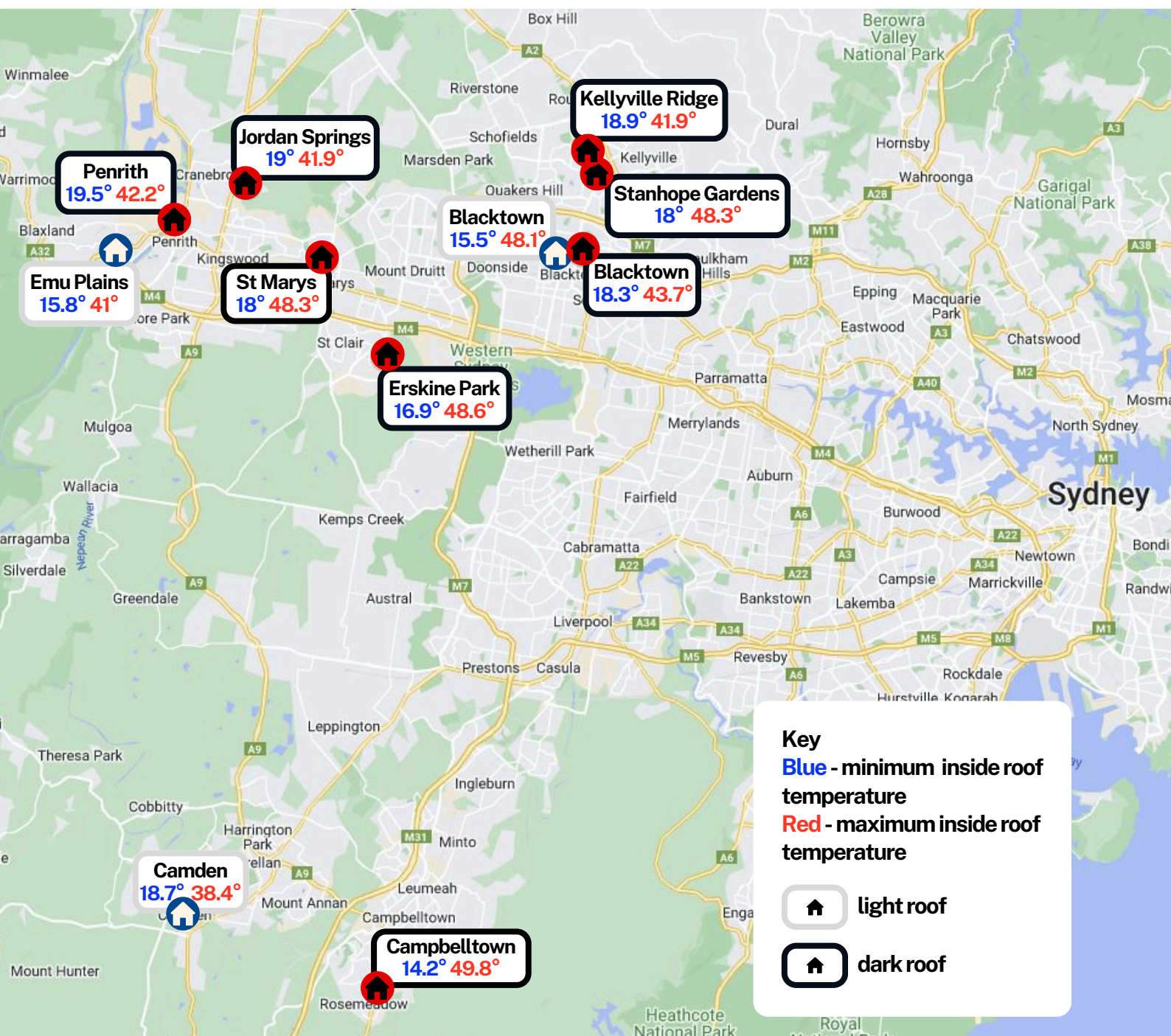
Outside

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	Temperature (°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

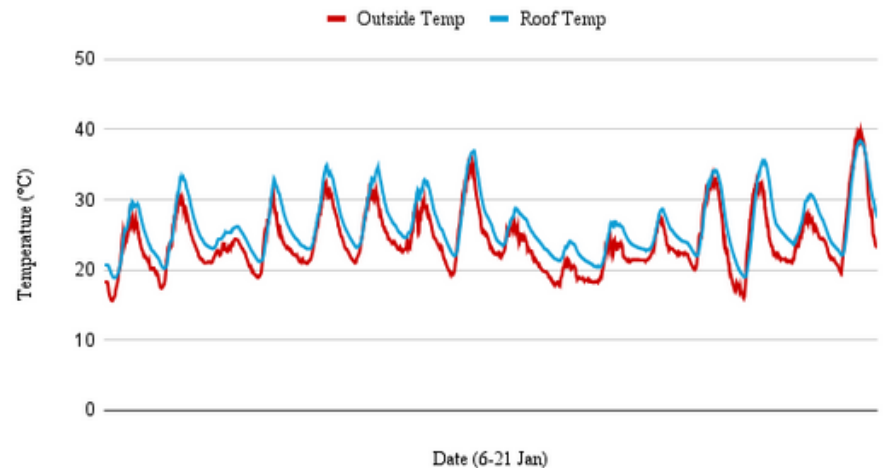
South West Sydney: Camden (light) and Campbelltown (dark)

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.

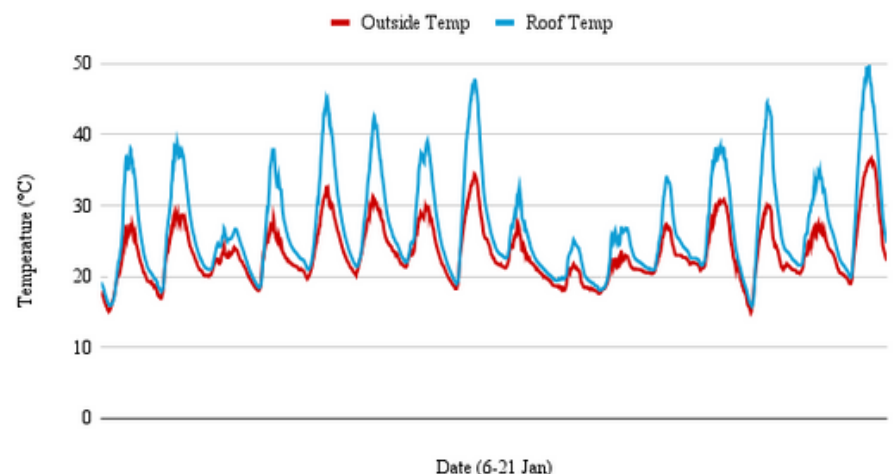


Light roof in Camden



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.

CASE STUDIES

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

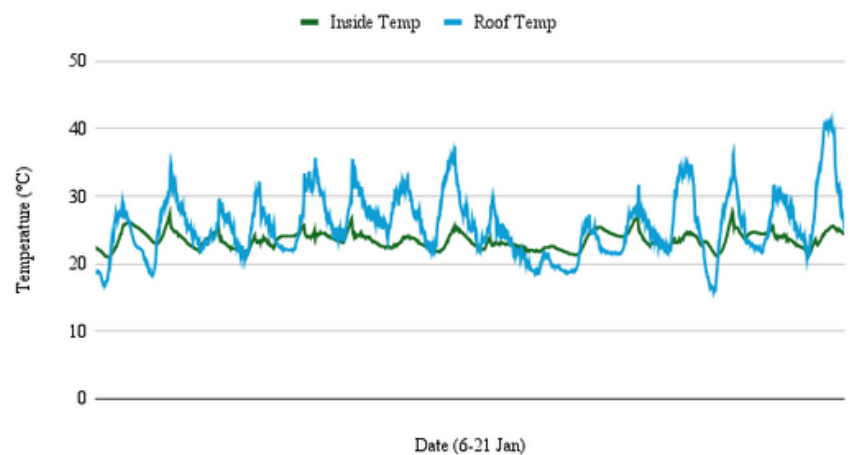
The suburbs of Emu Plains and St Mary's are around 12km apart and sit on either side of Penrith, a suburb famous for reaching 48.9° in January 2020. St Mary's has recorded ground temperatures of over 50°. This region of Sydney is projected to get double as many over 35° hot days than the historical average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



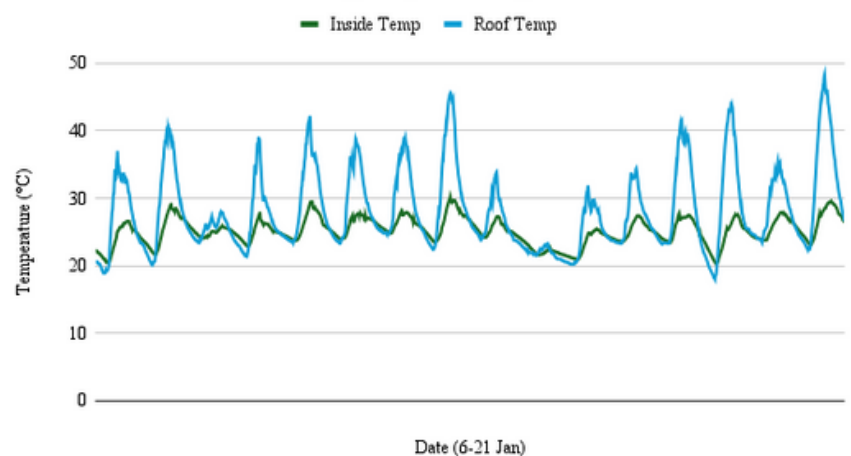
Participant John holding temperature monitors

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

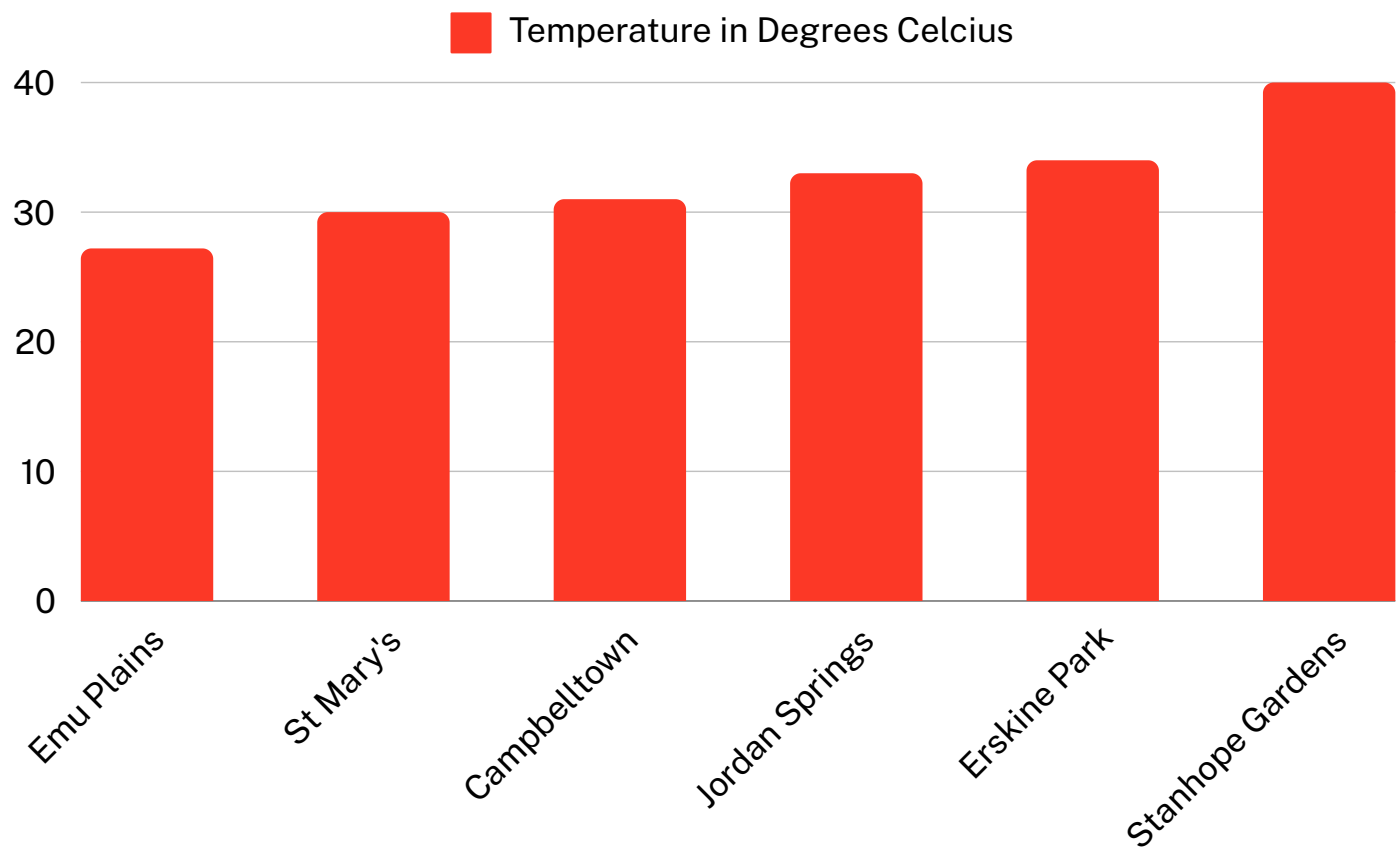
	Jordan Springs			Kellyville Ridge		
	Roof: Dark, Tiles			Roof: Dark Grey, Concrete Tiles		
	Inside	Outside	Roof	Inside	Outside	Roof
Mean	24.7	24.7	25.8	28.7	24.0	27.2
Max	33.1	41.4	41.9	37.4	39.8	41.9
Min	19.4	14.7	19.0	22.6	14.9	18.9

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 (lounge, 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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