Cool Suburbs
Assessment

Cool Suburbs Assessment NSW

Rationale Document

Acknowledgement of Country

We acknowledge Australia's First Nations Peoples as the Traditional Owners and custodians of the lands and waters on which we rely. We acknowledge their continuing connection to land, water and community, and pay respect to their Elders past and present.

We recognise and value the ongoing contribution of Aboriginal and Torres Strait Islander Peoples and communities to Australian life and how this enriches us.

REPORT FOR

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Phase 1 Final	Version 5.9	Mark Siebentritt, Malcolm Eadie, Tim Watson, Sarah Day	Mark Siebentritt	9 December 2021
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The need for the Cool Suburbs Assessment was identified as a priority action under WSROC's Turn Down the Heat Strategy and Action Plan (2018). The Turn Down the Heat Strategy was developed by 55 organisations across greater Sydney to create cooler, more resilient communities.

Cool Suburbs is also a flagship action under the Resilient Sydney Strategy (2018).

Cool Suburbs phase 1 (2022)

The Cool Suburbs prototype for phase 1 was released in 2022 and incorporated the geographic region of Western Sydney. A roadmap was developed to scale up the tool in future to expand the tool's geographic region across New South Wales (NSW) and to enhance the tool's useability and accessibility through transitioning to a web-based design.

Cool Suburbs phase 2 (2024)

This report documents phase 2 of the Cool Suburbs Assessment, presenting the assessment of credit influences across the diverse environments of NSW climate zones, acknowledging the varying impacts on urban, suburban, small town, and remote areas for development planning and design.

The phase 1 rationale document for Cool Suburbs can be found within the Resources tab in the Cool Suburbs Assessment.

The Cool Suburbs Assessment is jointly funded by the the NSW and Australian Governments.

Cool Suburbs is a collaboration between Western Sydney Organisation of Councils (WSROC) and Resilient Sydney.

Phase 1 of the Cool Suburbs Assessment (formerly 'Tool') was developed by Edge Impact in collaboration with the CRC for Water Sensitive Cities, Hydrology and Risk Consulting (HARC) and Kinesis. The development of phase 1 was supported by the Greater Cities Commission.

Phase 2 of the Cool Suburbs Assessment was developed by Edge Impact in collaboration with Netgain Advisory and Endava.

Phases 1 and 2 were supported by an expert science panel, consisting of: Monash University, Melbourne University, University of NSW and Western Sydney University.

Executive Summary

Heat is a significant and growing issue for NSW

Heat (urban heat, extreme heat, and heatwaves) is acknowledged to have cumulative and cascading impacts on our community, economy, and ecosystems (1).

Already, heat is placing significant strain on essential infrastructure including energy grids, hospitals, and transport networks (2). It's Australia's deadliest natural hazard causing more fatalities than all other natural hazards combined (3). More than half of heat-related fatalities between 2001-2018 occurred in and around buildings (68).

6% — Higher heat-related mortality risks for residents living in warm neighbourhoods.

100% — Increase in peak electricity demand when temperatures increase from 20°C to 40°C.

$6.9 bil. — In lost productivity annually due to heat stress across Australia.

Unmeasured impacts on flora and fauna. Mass deaths of flying foxes are one indicator of the scale of this impact.

Figure 1. Heatwave impacts (modified based on WSROC 2018, p.15)

These impacts are expected to increase in future as extreme heat becomes more common, and heatwaves become more frequent and intense under climate change (4). As a result, heat resilience is a significant and growing challenge for NSW.

Urban design and development is a key strategy for managing heat

Urban design offers a promising pathway to not only reduce urban heat, but also reduce energy requirements and emissions, as well as protect people, flora, and fauna from the impacts of extreme heatwaves. There is a v ast scientific literature available to inform the management of heat through design (33, 46, 16, 50, 6, 69, 70, 69, 74).

Despite this significant body of existing knowledge, much of this science has not been translated into practical tools that can support and guide decision-making in the real world. The Cool Suburbs (CS) Assessment has been specifically designed to bridge this gap between research and practice.

Cool Suburbs: Building the link between science and practice

The CS Assessment is a voluntary, industry-based performance rating tool to assess place-based urban heat resilience. It has been designed to guide practitioners to make evidence-based planning and development decisions at multiple scales (from individual lots to master planned precincts), and across development types (industrial to residential). Cool Suburbs provides a synthesis of urban heat science and practices in an easy-to-use and accessible platform with the goal of supporting improved resilience outcomes.

Who can use the tool?

Cool Suburbs has been designed for use across the six main climate zones in NSW as defined by the Australian Building Code Board (ABCB), supporting use across the state (64). The previous version of the tool was configured for Western Sydney, which was classed as Climate Zone 5 or 'Mild temperate'.

The latest iteration of the tool integrates current NSW climate zones including:

- **Climate Zone 2;** 'Hot Humid' summer conditions, covering the North Coast of NSW;
- **Climate Zone 4;** 'Hot Dry' summer conditions, covering the land area west of the Great Dividing Range; and
- **Climate Zones 5, 6, 7 and 8**; ' Mild/Warm/Hot Temperate & Alpine' summer conditions and cover the land area east of and including the Great Dividing Range with the exception of the North Coast of NSW.

Climate Zone 8 is alpine and heat is not considered to likely be a major risk for this region currently. Consequently, it was advised by the Science Panel that credit and impact scores reviewed for this climate zone should be considered in-line with Climate Zones 5, 6 and 7 as this would not negatively impact the Climate Zone.

Climate Zones 1 (high humidity summer, warm winter) and 3 (hot dry summer, warm winter) are not relevant to the NSW geographic regions and have not been included in the tool.

It is noted that the ABCB climate zones cover extremely large areas with perceivable variations in local climate. The ABCB zones were reviewed by the Science Panel as part of this project and it was found that while variations in climate exist within ABCB zones, these variations do not fundamentally change the types of design measures that would be recommended within these climate zones.

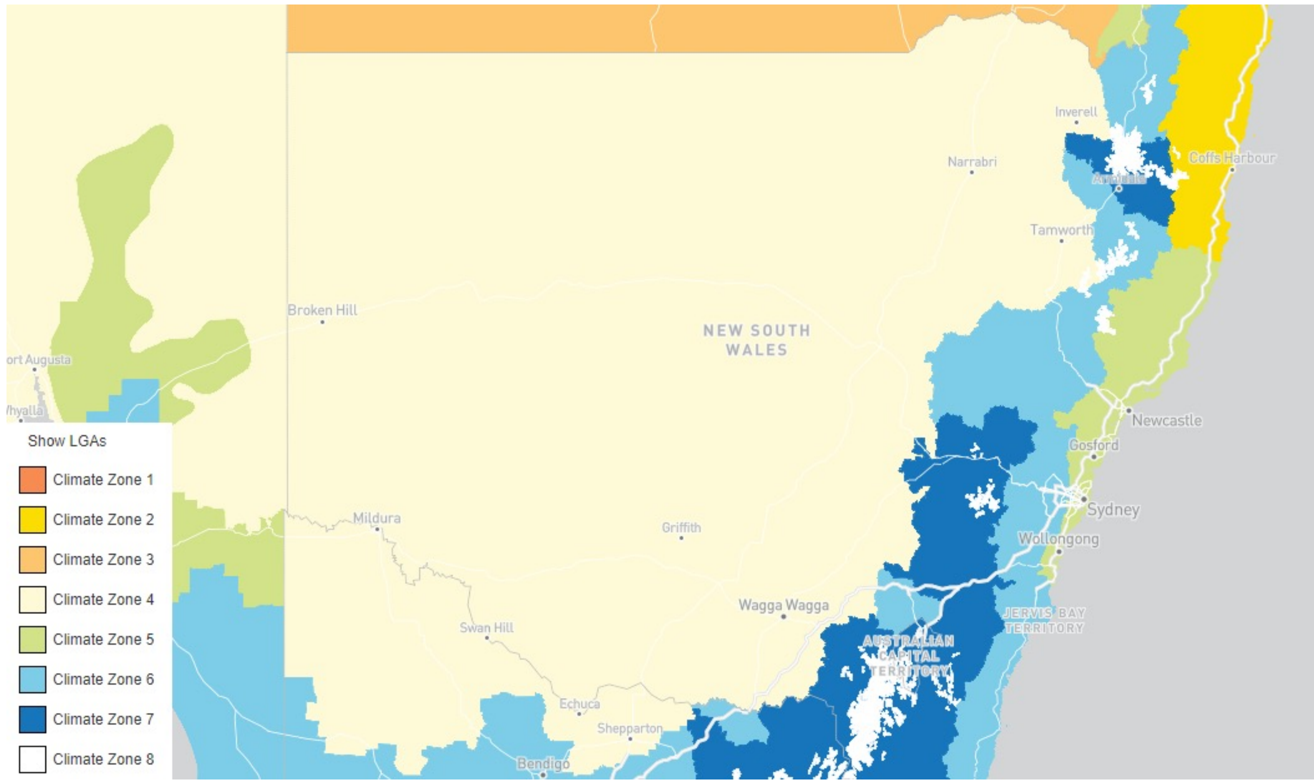

Figure 2. Australian Building Codes Board Climate Zones Map

This document

This document provides guidance about the rationale behind the development of the CS Assessment to ensure transparency regarding the science and methodology used. Transparency not only encourages academic examination and improvements to the CS Assessment over time, but also supports practitioners in building their in-depth knowledge about heat resilient design.

The design and development of the CS Assessment followed the process outlined in Figure 3.

This rationale document presents:

- Background on key concepts, including how resilience has been embedded into the design of the CS Assessment (Section 2).
- Description of the credits and criteria and how ratings are calculated (Section 3).
- Science rationale, describing the scientific basis and references for the credits and criteria (Appendix A).

Figure 3. Summary of the Cool Suburbs phase 2 development process.

01 Review of phase 1 outputs and user feedback

- Gather feedback collected from the phase 1 tool release to inform relevant updates to user pathways and practical uses.
- Conduct additional user workshops and ongoing stakeholder engagement for synthesis of feedback and translation into the phase 2 tool.

02 Update the science

- Expansion of the evidence-based research for effective interventions to contribute to urban cooling adaption and response that will include all relevant NSW climate zones.
- Translation of findings into updated metrics (where required) and an updated science rationale.

03 Tool enhancement

- Translate the existing phase 1 excel-based tool, plus all functionality updates, into a web-based tool, designed to promote user engagement and provide a development rating for resilience to extreme heat as compared to business as usual.
- Test and refine tool prototype.
- Dissemination of tool.

Contents

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Glossary of Terms

TERM	DEFINITION	REFERENCE
Adaptation	Projects and programs designed to reduce risk and help residents and organisations better cope with the impacts of heat.	(8)
Albedo	The fraction of solar radiation reflected from the surface of materials.	(9)
Awareness	Involves assessing the physical conditions in the area, and the vulnerability of residents and urban infrastructure to heat.	(8)
Blue space	In the urban planning context comprises all the areas that consist of surface waterbodies or watercourses such as ponds, lakes, rivers, and streams.	
City resilience	The capacity of individuals, communities, businesses, and systems within a city to survive, adapt and thrive no matter what kinds of chronic stresses and acute shocks they experience.	(4)
Climate hazard	Climate-related events or phenomena that may pose risks to human settlements or the environment.	(11)
Cool places	Outdoor areas that are cooler, including parks and water bodies.	(8)
Cool rooms	Rooms or spaces within a building (residential or commercial) where occupants can seek respite from heat.	(8)
Cool spaces	Existing public spaces where people can seek respite from heat indoors (including libraries, shopping centres and pools).	(8)
Deep soil	A landscaped area connected horizontally to the soil system and local ground water system beyond and is unimpeded by any building or structure above or below ground with the exception of minor structures.	(61)
Evacuation centre	Formal emergency management arrangements that provide welfare services for those affected by a disaster.	(8)
Extremely hot days	Defined by the Climate Council as temperatures 40˚C and above.	(8)

TERM	DEFINITION	REFERENCE
Green space	Open-spaced areas such as parks, lawns, community gardens and other vegetated areas.	
Heatwave	Occurs when the maximum and the minimum temperatures are unusually hot over a three-day period at a location. This is considered in relation to the local climate and past weather at the location.	(10)
Hot days	Defined by the Climate Council as days between 30˚C and 35˚C.	(8)
Reduce	Involves reducing average ambient temperatures in the built environment as much as possible.	(8)
Response	There will still be residual heat-related risk in extreme events, and therefore we also need emergency preparedness and response measures, particularly to help at-risk people in the community.	(8)
Solar Reflectance Index (SRI)	Solar Reflectance Index (SRI) is a composite measure that accounts for a surface's solar reflectance and emittance. To calculate the SRI, the material or product's emittance values and total solar reflectance must be known.	(12)
Street canyon	A place where the street is flanked by built elements, creating a canyon-like environment that can funnel wind.	
Urban Heat Island Effect (UHI)	A local climate change phenomenon whereby urban areas present higher air temperatures than their rural proximities. The difference is often 3-4˚C, but higher peak differences can reach 10 ˚C.	(8)
Urban heat mitigation	Projects and interventions that seek to reduce the root cause of urban heat (and therefore the temperature) through either an increase in green canopy, use of more building and paving reflective materials, use of irrigation and water features.	(8)
Very hot days	Defined by the Climate Council as days between 35˚C and 40˚C.	(8)

1. Introduction

1.1 Why is urban heat an issue?

Heat (urban heat, extreme heat, and heatwaves) have a major impact on the way our communities, economies, and ecosystems function. It is a major driver of mortality and morbidity in Australia, accounting for more deaths than any other natural hazard (3), and significantly impacts both physical and mental health (71)(72)(73). The economic impacts of extreme heat can be profound, ranging from reduced workforce productivity and health and safety issues, through to impacts on the built environment such as higher energy costs (6).

In cities, urbanisation exacerbates the impacts of heat through increased density, reduced green spaces, and the conversion of natural land into heat-absorbing surfaces. Factors such as material selection, wind patterns, and local topography contribute to the Urban Heat Island Effect (UHI), amplifying the accumulation of heat.

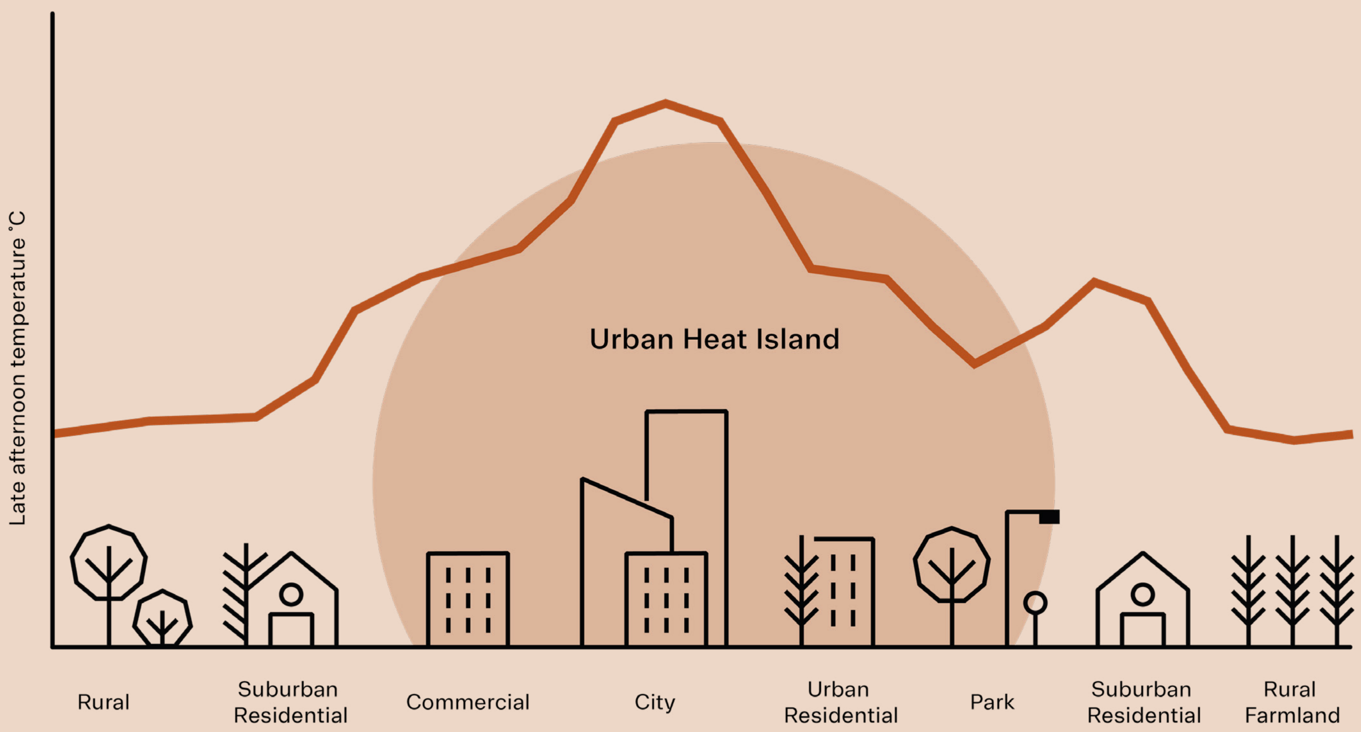

Figure 4. Urban Heat Island Effect in cities.

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In rural areas, urban heat islands may be less extreme, but an hotter overall climate combined with limited access to cooling infrastructure and water sources, as well as adverse effects on agriculture and ecosystems, increases peoples' vulnerability to heat-related impacts. Hotter temperatures affect communities of all sizes in NSW, impacting health, infrastructure, economic activity, and the natural environment

Addressing UHI through urban design measures is crucial. However, heat is a multifaceted challenge of which UHI is just one component. It is equally important to reduce the impacts of extreme heat and heatwaves, which still occur in locations where limited urban development exists. Such strategies can be achieved through comprehensive planning, infrastructure development, and adaptation strategies that protect human health when conditions become life threatening. Finally, low-carbon and renewable-based design strategies are required to minimise contributions to climate change, which if not addressed, will amplify urban heat and extreme weather events over time.

1.2 The impact of heat in New South Wales

The climate of NSW can be characterised by its variability, with diverse rainfall patterns influenced by geography and coastal factors. The Great Dividing Range contributes to rainfall distribution and temperature gradients across the state, impacting both rainfall and temperature extremes. From arid north-western regions to coastal areas, NSW experiences a range of climatic conditions, with temperature extremes posing significant impacts on health, infrastructure, and the environment (22).

Climate projections indicate a statewide increase in hot days, with significant regional variations, particularly in northwestern NSW where temperatures above 35°C could comprise up to one-third of the year by 2070. These changes are expected mainly in spring and summer, extending into autumn in the far future (22).

Weather observations across NSW indicate a steady increase in air temperatures, particularly since the 1950s, with recent decades experiencing record highs. The rate of temperature rise has accelerated, reaching 0.5°C per decade since 1990. Projections for NSW indicate continued warming in both the near future (2020–2039) and far future (2060–2079), with average temperature increases expected between 0.7°C and 2.1°C, respectively, across all regions (22).

The population of NSW is projected to grow by over 85,000 annually until 2041, with regional areas expected to see an increase of 570,000 - reaching 3.7 million by that same year (18). Many more people across the state will be at risk of adverse impacts of heat with trends of increasing frequency of hot days further inland.

Coastal areas are also experiencing fewer than 10 hot days annually, compared to over 80 in the far north-west. Vulnerable populations are at higher risk during prolonged hot spells, with implications for their health and infrastructure.

Western Sydney University's Benchmarking Heat studies have found significant temporal and spatial temperature variations that exist between different parts of each local government area (LGA) within Western Sydney (part of Climate Zone 6), and even between adjoining streets (refer to (16) (17) (18) (19)). Importantly, they found that the number of days where air temperature reached above 35°C was much greater in some locations than others (e.g., 47 days above 35°C compared to 10-25 days at two locations in Western Sydney near Parramatta).

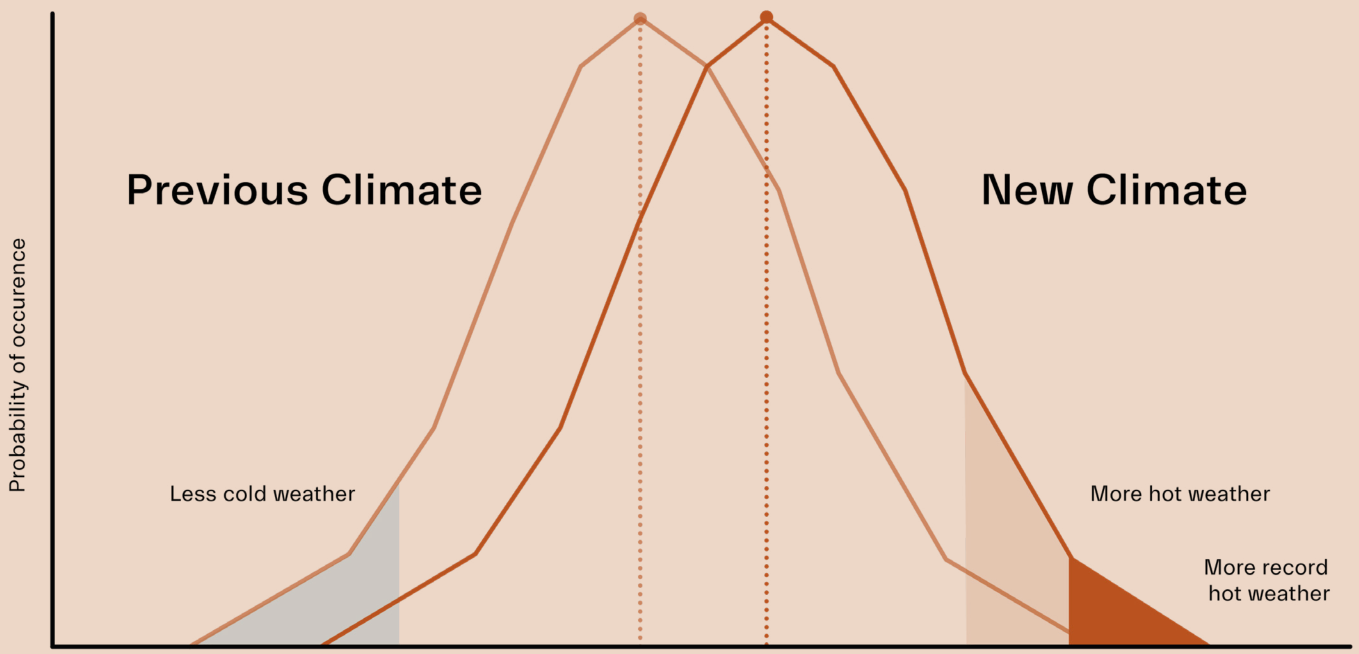

Figure 5. Overview of how as the climate warms, there will be significantly hotter weather and heatwaves. Source: Climate Council (13).

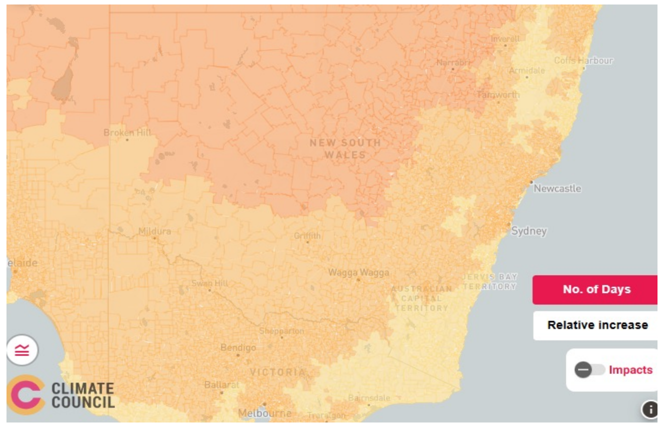

Figure 6. Climate Heat Map of NSW. Source; Climate Council, illustrating the average number of hot days and nights by 2050 and 2090 (66).

The Climate Council has recently released the Climate Heat Map of NSW (Figure 6) which is an interactive tool that provides insights into future climate trends for each suburb in Australia by visually illustrating the average number of hot days and nights by 2050 and by 2090. By 2090, Bourke is forecasted to encounter an additional 38 days over 35°C per year (under existing climate mitigation actions), Ivanhoe an additional 26 days, Penrith with 13 more days, and Dubbo with 26 additional hot days.

NSW communities already experience adverse impacts from heat, and these are expected to increase in future. Many organisations have recognised this unique risk profile (e.g., NSW OEH (5), Sydney Water & UNSW (6), Resilient Sydney (4), WSROC (8)).

Fortunately, heat has been recognised as a priority issue by national, state, and local organisations including:

Australian Government	National Health and Climate Strategy (2023) (77), National Climate Risk Assessment Report (2024) (78)
NSW Government	Adapt NSW (2015) (22), Climate Change Policy Framework (2016) (79), State Heatwave Subplan 2023 (80), and NSW State Disaster Mitigation Plan (2024) (81)
NSW Treasury	2021 Intergenerational Report (21)
WSROC	Turn Down the Heat Strategy and Action Plan (2018) (8)
Resilient Sydney	A Strategy for City Resilience 2018 (4)
Greater Sydney Commission	Greater Sydney Region Plan and District Plans (2018) (14)
Local Government	Many NSW Local Governments have adopted urban heat strategies, for example: Penrith City Council's Cooling the City Strategy and Lake Macquarie's Urban Heat Strategy

1.3 Building resilience to urban heat ('Turn Down the Heat')

The need for the CS Assessment was identified under the Turn Down the Heat Strategy and Action Plan (2018), which outlines a collaborative, multi-sector approach to tackling urban heat in Western Sydney.

A range of projects were implemented under the Turn Down the Heat Strategy. WSROC-led projects that relate to the CS Assessment, include:

Urban Heat Planning Toolkit

Developed to help local councils strengthen local planning provisions to reduce the impacts of heat. It focuses on strategies that can be implemented in both new development and redevelopment contexts, to reduce urban heat and adapt to a changing climate.

Future Proofing Residential Development in Western Sydney

This study modelled how current building standards perform under future climate scenarios. It found that current building standards use outdated climate data, which results in new developments that are both energy hungry (high emissions) and thermally unsafe.

Heat Smart Western Sydney

Identifies what processes and structures are needed for the city to respond to extreme heat and emergency events. The project assessed our current approach to heatwave management and developed a Heat Smart Resilience Framework that outlines an improved approach to heatwave management.

This second phase of Cool Suburbs is implemented under the Greater Sydney Heat Taskforce Program, which builds on the work delivered under Turn Down the Heat.

The Taskforce is a collaboration between federal, state, and local government agencies, industry organisations, and the community sector. The Taskforce's role is to establish ongoing coordinated governance arrangements to address heat risk. The Taskforce program is delivering the following initiatives that are relevant to Cool Suburbs:

- **Heat Smart City Plan**: A five-year action plan for coordinated heat risk management.
- **Heat Risk Methodology**: A holistic, place-based methodology for assessing community heat risk.
- **Heat Risk Management Guide:** Guidance for local governments on how to prepare for a heatwave.

Cool Suburbs is also a flagship action under the Resilient Sydney Strategy (4).

1.4 Limitations of past approaches to mitigating heat impacts

Mitigating heat impacts has been an objective for decision-makers in urban areas around the world for several decades. Efforts have accelerated in recent years as the impacts of heat combined with climate change become both more apparent and better understood.

Policies that have been developed to mitigate heat have often focused on single drivers. For example, cool roof initiatives have successfully reduced the temperature of buildings, investment in tree planting provides localised cooling solutions, and greater irrigation of open spaces can provide neighbourhood cooling solutions. However, focusing on single solutions or generic approaches such as these are insufficient to support precinct-scale cooling outcomes. Furthermore, approaches that focus only on reducing surface temperatures and lowering ambient temperatures will not prevent extreme heat events.

To successfully address this complex issue, an integrated approach is required that considers a range of factors including:

- The local climate context (including the effects of climate change)
- Development site condition e.g., greenfield or brownfield sites
- Development scale (e.g., masterplan)
- Development typology (e.g., building, residential home, or park)

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By considering this broad range of influences a more integrated approach can be developed and applied at multiple scales, tailored to the local climatic context.

1.5 The Cool Suburbs Assessment

The CS Assessment is a voluntary, industry-based performance (ratings) tool for place-based heat resilience. It has been designed for use by both developers and government, with the goal of supporting improved heat outcomes to ensure people can thrive in a warming environment and survive in extreme events.

Recognition of the existing credits developed in phase 1 provided the foundation for expansion of the tool across NSW climate zones.

The CS Assessment is intended to inform and guide planning and development decisions by providing a synthesis of urban heat science and practices in an easy-to-use accessible platform.

Projects receive a Cool Suburbs Star Rating, ranging from 1 to 5 stars, reflecting the extent to which a project satisfies the applicable criteria. A 5-star rating would indicate fulfillment of all applicable credits, while a 1-star rating signifies adherence to only the mandatory credits. Innovation points may be awarded in addition to a 5 star rating which is represented as a 5+ or 5++ rating.

The CS Assessment objectives include:

- Setting out a broad range of measures (represented by credits in the CS Assessment) that contribute to and guide improved place-based heat resilience;
- Identifying heat resilience measures that should be considered for different development types and scales across relevant climate conditions, supporting its use in early stages of planning and design;
- Scoring (via a rating system) the heat resilience performance of a development from a precinct to lot scale; and
- Providing guidance and assessment of planning by government and developers for existing, transforming, and new suburbs.

To support the development of the CS Assessment, an urban heat science translation task was undertaken. An expert Science Panel reviewed the most effective urban heat resilience measures focusing on holistic assessment of the tool's update. The panel considered relevant climate zones to make the tool applicable to all of NSW and adapted credits in the context of urban development in NSW. Government and industry engagement was then undertaken to help translate findings into an easy-to-use rating tool for a place (building, street, precinct, or suburb). This rationale document provides a summary of the key concepts that have been considered in developing the CS Assessment and a description of how the CS Assessment has been structured to integrate across key influences on urban heat. Appendix A summarises the science rationale that has been used to inform each of the CS Assessment Credits.

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2. Key Concepts

2.1 A resilience approach to urban cooling

Given significant historic temperature extremes, as well as projected increases under a changing climate, the impacts of heat on the community cannot be eliminated just by reducing the average (ambient) temperature.

Ensuring people have the capacity to adapt to higher and extreme temperatures, and that both community and emergency services are in place to support the most vulnerable when all else fails, is essential. As such, a resilience approach is required, based on strategies that minimise the impacts of intense shocks such as heatwaves and the ongoing stress of frequent hot and very hot weather.

This project takes a resilience approach to heat. Urban resilience is defined by Resilient Sydney as the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience (4).

Therefore, an intervention that successfully improves community resilience to heat must include measures in the built environment that:

- Mitigate urban heat (e.g., greening and high albedo roofs)
- Allow people and infrastructure to adapt to a hotter climate (e.g., development of energy efficient buildings, inclusion of PV and energy storage).
- Provide appropriate social infrastructure, including designated cool spaces (e.g., pools and air-conditioned libraries) and design for response approaches to heat-stress (e.g., provisions for emergency services and ambulances).

WSROC has developed a resilience framework for heat, which includes four steps.

1. **Awareness:** Involves assessing the physical conditions in the area, and the vulnerability of current and future residents and urban infrastructure to heat.
2. **Reduce:** Involves reducing average ambient temperatures in the built environment as much as possible through urban heat island mitigation.
3. **Adapt**: At most, we can reduce ambient temperatures at the city scale by approximately 2°C (6), so it is also important to design to help people thrive in hotter conditions and survive heatwaves. At smaller scales within the urban environment (e.g., within streets, parks and courtyards) it is possible to reduce site-specific temperatures to a much greater degree.
4. **Respond:** There will still be residual heat-related risk in extreme events, and therefore we also need to design for emergency preparedness and response measures, particularly to help at risk people in the community.

Figure 7. Urban Heat Resilience Framework. Source: (23)

Reduce

Plan & design to **reduce** urban heat.

Low carbon cities
A low carbon footprint, to mitigate climate change.

Cool cities
A reduced urban heat island effect.

Adapt

Plan and design so people can **adapt** to urban heat

Thrive

Enable people to **thrive** in a warmer climate.

Cool outdoor spaces
Parks, streets, plazas and gardens that remain useable in very hot weather

Sustainable water supply
Water available for irrigation and cooling in hot weather, even in times of drought.

Cool buildings
Public, commercial and other buildings that are comfortable in very hot weather.

Survive

Enable people to **survive** heatwaves in their home.

Cool homes
Homes that are habitable in heatwaves and comforable in very hot weather.

Robust energy systems
Reliable energy during heatwaves.

Figure 8. Urban planning and design approaches to reduce urban heat and help people adapt to urban heat. Source: (23)

2.2 Resilience in the Cool Suburbs Assessment

The CS Assessment has been developed to describe the performance of a proposed development as it relates to resilience criteria for "Reduce", "Adapt" and "Respond".

"Recovery" is also often included as a step in a resilience framework. However, the focus of the CS Assessment is on built environment measures that reduce heat and to help people adapt to heat. It is in these areas that planning and design can play the greatest role.

By combining the elements of resilience, a more thorough approach to responding to and managing the impacts of heat now and under future climate change can be developed. Initiatives recommended and rewarded through the CS Assessment can therefore:

- Reduce residual urban heat to help address increasing average temperatures.
- Support adaptation to help address periods of hot weather where reduction initiatives are ineffective.
- Ensure response elements are available, which can support community resilience towards periods of extreme heat and heat waves.

The types of measures associated with each of these elements is illustrated in Figure 9. The CS Assessment has a focus on the "reduce" and "adapt" aspects of a resilience approach. Developing cool cities will require work with other stakeholders to ensure that the broader range of awareness raising and respond measures are also implemented in current and new developments.

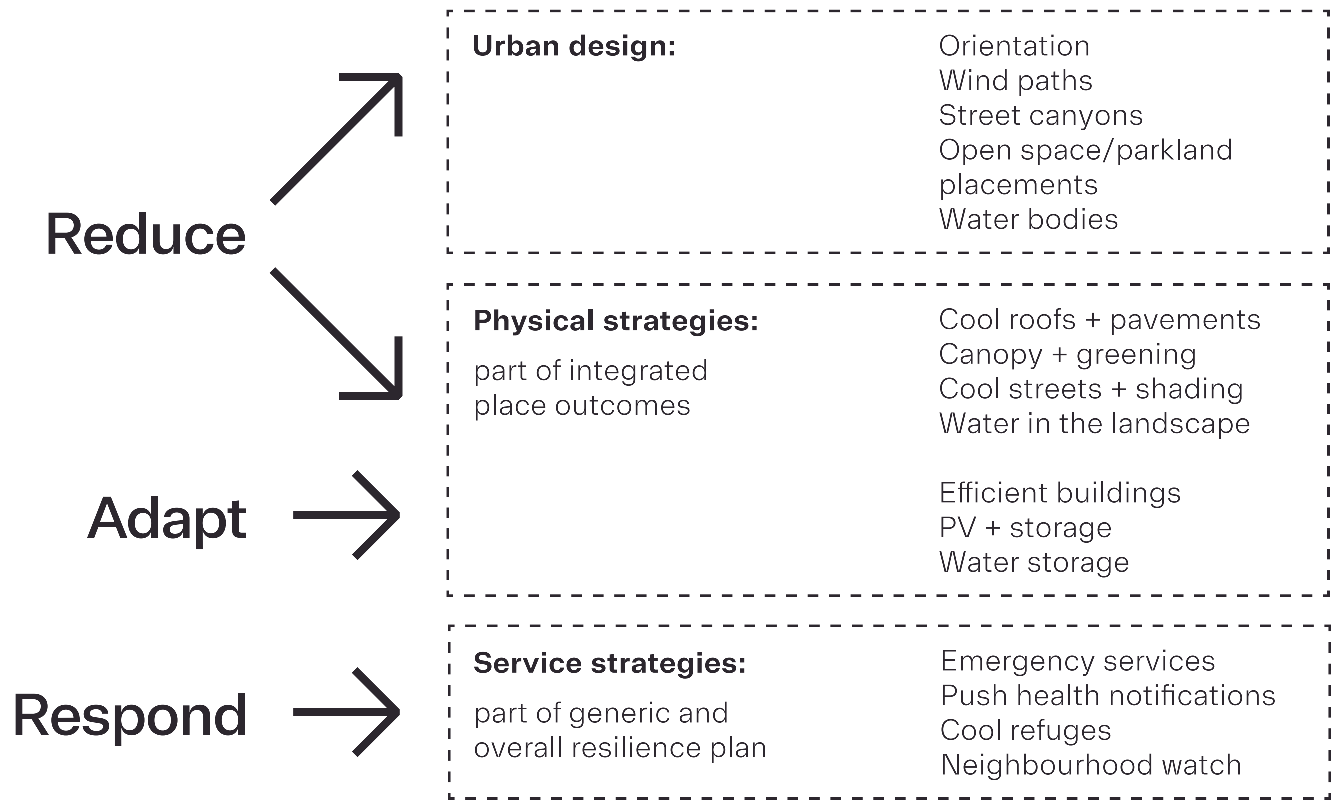

Figure 9. The resilience framework as applied to the urban heat mitigation context.

2.3 Changing how we deal with place-based heat

Through the planning and development process, a range of decisions impact upon who manages the impacts of heat, what is required and how this is achieved. This includes:

Government decision-making

Strategic decisions that guide the requirements and performance of a development or community.

Developer decision-making

Operational decisions that reflect changes in market demands, regulatory requirements, or economic outcomes.

The measures implemented or considered through these decision-making processes lead to variable outcomes that reflect regulatory landscapes and their enforcement, as well as market demands and technology. After these outcomes are implemented, governments, businesses, and local communities are required to manage their residual impacts or benefits. Cool Suburbs addresses identified risks through implementation of best practices, whilst also considering residual risk through implementation of the 'Heatwave Safe Community Guidance'.

The resilience approach underpinning the CS Assessment facilitates place-based assessment that recognises the challenges of urban heat as they play out in a community across a range of scales. The ability to specify local conditions and context for a given location (including the climate region and the physical composition) mean that the measures recommended through the CS Assessment will remain relevant and effective at addressing urban heat, regardless of the local policy context. This place-based logic is the central focus of the tool, helping to facilitate the flow of evidence-based measures to address urban heat throughout the planning and development process.

In NSW, there are a number of ways for new developments to progress through state and local government planning processes. The CS Assessment is particularly relevant to development application and assessment. It is also relevant to strategic planning, particularly within the Urban Design Credits. Examples of intervention points relevant to the CS Assessment are summarised in Table 1.

Table 1. Examples of intervention points where the CS Assessment can be applied.

DEVELOPMENT PHASE	PLANNING PROCESS INTERVENTION POINT	RELEVANT CREDIT CATEGORIES
Development control	Masterplans, parks & precinct plans	Category 1: Urban Design
		Category 2: Cool Streets
		Category 4: Cool Homes
		Category 5: Cool Buildings (Non-Residential)
Development application and assessment	Public domains	Category 1: Urban Design
		Category 2: Cool Streets
	Buildings	Category 5: Cool Buildings (Non-Residential)
	Dwellings	Category 4: Cool Homes (Residential)
	Public parks	Category 3: Cool Parks

2.4 Relationship between rating methodology and risk

The CS Assessment demonstrates that there are opportunities to address elements of heat impacts across multiple development scales.

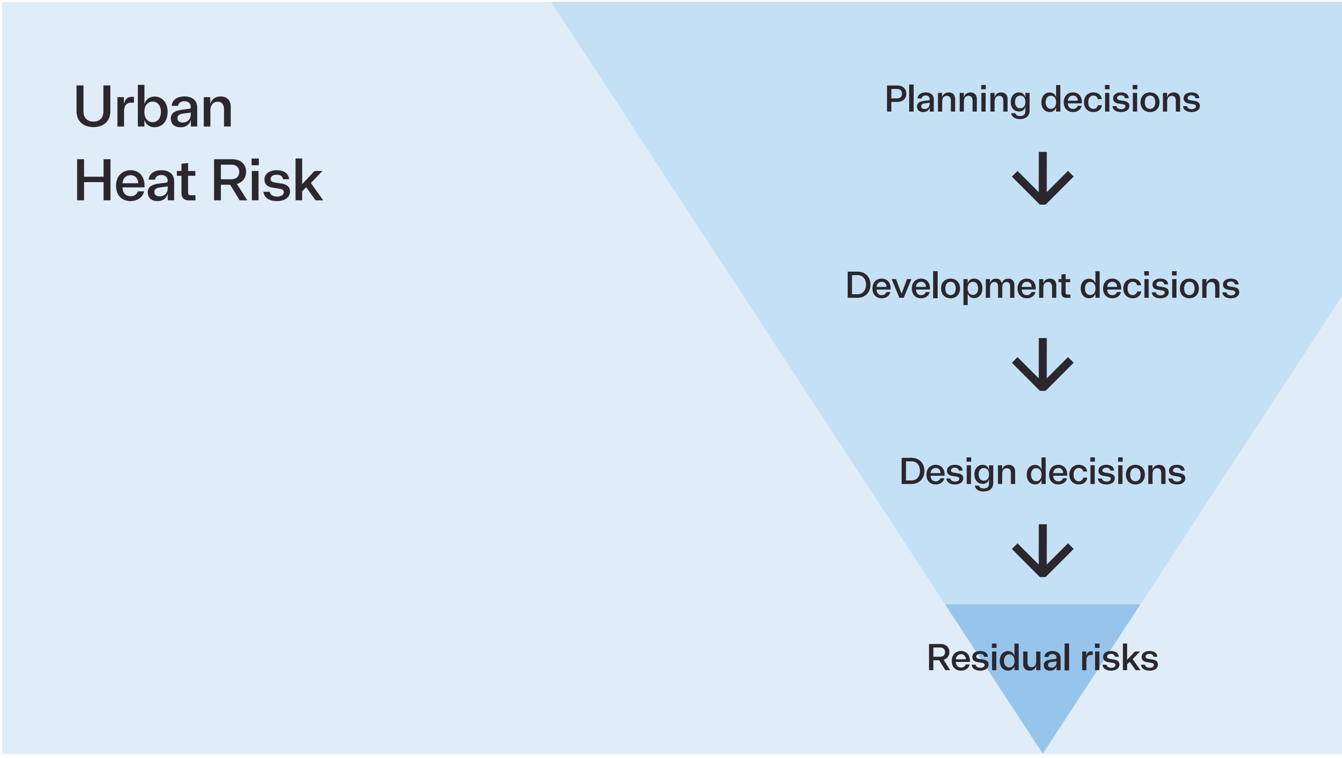

Figure 10. Heat risk can be address across the planning and development process.

In a traditional development process, where no mandated consideration or control for the risks of heat impacts are required, communities and residents ultimately bear the long-term responsibility for maintaining resilience to heat impacts (either through proactive house upgrades or risk avoidance). In this way, historic planning and design decisions determine the long-term risk exposure of communities, which will be further exacerbated by the effects of climate change.

Cool Suburbs employs a resilience framework to maximise the various opportunities for heat mitigation. The tool also considers climate change risks and their opportunity for mitigation through each stage of planning and design. Being a place-based assessment, the CS Assessment provides users with evidence-based measures to effectively reduce heat across the development process, from the master planning to the lot scale. The aim is to minimise the residual heat-related risk to communities and residents.

2.5 Science-based approach

Urban and extreme heat science is an evolving field with a rapidly expanding body of scientific evidence to guide policy and strategic action on heat resilience. Cool Suburbs has been underpinned by a robust science translation review by a respected panel of urban heat scientists (the Science Panel) from leading research institutions familiar with the climatic and place-based context across NSW.

The broader science-based best practices framework was chosen over simulation modelling because the tool aims to guide decision-making from the initial planning stages, rather than solely evaluating a final design. This makes simulation modelling impractical for most development contexts as it may not adequately support decision-making throughout the project lifecycle. However, it may be relevant to use simulation tools as supporting evidence and conversely, considering where Cool Suburbs may support simulation modelling where relevant in other planning and development processes.

The Science Panel focused on the following elements:

- **Cool Suburbs Credit Review:** Reviewed Cool Suburbs credits, ensuring the heat resilience measures included in the tool are based on latest science, as well as linked to practical application.
- **Cool Suburbs Rating Methodology:** Reviewed Cool Suburbs rating methodology, including consideration of each measure on co-dependencies and the non-linearity of urban heat performance of "bundled" measures.
- **Cool Suburbs Climate Zones:** Analysed of NSW climate zones and required modification to Cool Suburbs credits and rating methodology for each climate zone.

NAME	TITLE	DISCIPLINE	ORGANISATION
Prof. Nigel Tapper	Emeritus Professor, School of Earth Atmosphere and Environment	Urban climate	Monash University
Dr. Kerry Nice	Postdoctoral Research Fellow, Faculty of Architecture, Building and Planning	Urban climates and urban systems	University of Melbourne
Dr. Negin Nazarian	Scientia Senior lecturer	Urban climate	University of NSW
Prof. Sebastian Pfautsch	Professor of Urban Management and Planning, Urban Transformations Research Centre	Mitigating climate change impacts on cities	Western Sydney University

Table 2. Science Panel members

Headline heat resilience considerations identified and reviewed by the Science Panel were:

Extreme heat conditions (heat waves)	Extreme heat conditions are driven by macro-scale synoptic weather patterns that cause hot air from central Australia to shift eastward across the Great Dividing Range and settle over the eastern seaboard for up to several days. Local measures to mitigate and adapt to extreme heat will have minimal impact on air temperature during heat wave conditions, reinforcing the importance of a resilience approach to living with extreme heat in NSW.
Climate change	Climate change is increasing the frequency, duration, and severity of extreme heat events across NSW with the new normal hot summer day temperatures likely to be close to 50˚C by 2050 for coastal regions and above 50˚C by 2050 for inland locations, highlighting the importance of planning now for this likely future.
Ventilation	Design of the urban morphology and individual buildings for effective ventilation to displace stagnant hot air and to circulate cooler air from "cool places" like parks and waterways, to areas of high heat vulnerability is paramount.
Shade	Provision of shade to exposed hard surfaces is essential for human thermal comfort on extreme heat days.

Perviousness	It is essential to maintain a high percentage of site perviousness to avoid the creation of local heat islands. Retaining a high percentage of site perviousness is important for the recharge of local soil moisture stores and shallow groundwater reserves by rainfall and site stormwater. It's also essential towards supporting healthy landscapes that promote urban heat mitigation through evaporation, transpiration, and canopy shade.
Water supply security	Maintaining soil moisture during extreme heat conditions when centralised supplies of town water may be restricted is critical to ensure the survival and health of landscapes that provide shade and amenity. Secure alternative water sources are therefore essential as is Water Sensitive Urban Design (WSUD).
Energy supply security	Maintaining access to a secure and adequate energy supply to mechanically cooled "cool rooms" within private dwellings and in public buildings during extreme heat conditions is critical to ensuring public health is protected, particularly for the most vulnerable.
Urban heat metrics to measure impact	The impact of local heat resilience interventions can be measured at a range of scales (e.g., neighbourhood to local streets and allotments) using different metrics (e.g., land surface temperature, air temperature, and thermal comfort). The urban heat resilience measures (linked to the resilience framework) listed in Table 3 were developed in the CS Assessment tool for phase 1 and assessed on their appropriateness for NSW in phase 2.

Table 3. Credits and their relationship to the resilience framework outlined in Figure 7.

MEASURES (CREDITS)	REDUCE	ADAPT		RESPOND
		THRIVE	SURVIVE	
CATEGORY 1: URBAN DESIGN				
UD1: Wind Paths	✓	✓	-	-
UD2: Wind Buffering/Filtering	✓	✓	-	-
UD3: Street Canyons	✓	✓	-	-
UD4: Green and Blue Open Space	✓	✓	-	-
UD5: Retaining Existing Tree Canopy	✓	✓	-	-
UD6: Water Sensitive Urban Design (passive irrigation)	✓	✓	-	-
CATEGORY 2: COOL STREETS				
CS1: Shade	✓	✓	-	-
CS2: Irrigation	✓	✓	-	-
CS3: Cool Pavements	✓	✓	-	-
Category 3: Cool Parks				
CP1: Shade	✓	✓	-	-
CP2: Irrigation	✓	✓	-	-
CP3: Cool and/or Porous Pavements	✓	✓	-	-
CATEGORY 4: COOL HOMES				
CH1: Site Coverage	✓	✓	-	-
CH2: Site Shade	✓	✓	-	-
CH3: Site Irrigation	✓	✓	-	-
CH4: Passive Cooling	-	✓	-	-
CH5: Cool Roofs	✓	✓	-	-
CH6: Cool and/or Porous Pavements	✓	✓	-	-
CH7: Alternative Energy Supply	-	✓	✓	-
CATEGORY 5: COOL BUILDINGS (NON-RESIDENTIAL)				
CB1: Site Coverage	✓	✓	-	-
CB2: Site Shade	✓	✓	-	-
CB3: Site Irrigation	✓	✓	-	-
CB4: Passive Design	-	✓	-	-
CB5: Cool Roofs, Green Roofs and Green Walls	✓	✓	-	-
CB6: Cool and/or Porous Pavements	✓	✓	-	-
CB7: Alternative Energy Supply	-	✓	✓	-
CATEGORY 6: INNOVATIVE NEW TECHNOLOGY				
INV1: New Technologies	✓	✓	-	-
INV2: Data Collection	-	✓	-	✓
HEAT SAFE COMMUNITIES CHECKLIST	-	-	-	✓

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3. Structure of the tool

3.1 Credits and criteria

Urban heat resilience measures (called Credits in the CS Assessment) are structured as follows (Appendix A provides a detailed description):

Credit Outcome	Outlines the desired urban cooling outcomes of the Credit.
Default Credit Points	The quantum of Credit Points awarded for complying with the Credit Criteria. Default Credit Point values were set by the expert Science Panel to reflect the relative importance of the Credit compared to the other Credits in the CS Assessment. Default Credit Points are adjusted up or down in response to the development type and land use mix entered in the CS Assessment (see Section 3.5).
Credit Criteria	Explains requirements that must be met.
Evidence Requirements	Information required to demonstrate Credit Criteria have been met.
Guidance	Provides general guidance to support the development and design of compliant solutions.
Science Rationale	Provides relevant references drawn from the scientific literature to support the Credit Criteria.
Related Credits	Lists other Credits in the CS Assessment that are complementary.

3.2 Credit Categories

There are six categories of Credits in the CS Assessment as follows:

3.2.1 Category 1 Urban Design (UD) Credits

The Urban Design Credits aim to ensure urban morphology responds to the prevailing and future climatic conditions. This enables passive cooling of the local environment by removing heat through increased ventilation and vegetation cover and reducing radiant temperatures to enhance human thermal comfort.

The Urban Design Credits establish an urban morphology that optimise the urban heat benefits available from the other categories of credits listed in the CS Assessment.

3.2.2 Category 2 Cool Streets (CS) Credits

Cooling streets not only improves local thermal comfort, but reduces local ambient air temperatures, with the best results achieved where streets are aligned to channel prevailing breezes. Cooling streets can reduce the need for active cooling (air-conditioning) of local buildings, delivering energy cost savings, reduced greenhouse gas emissions, and reduced anthropogenic heating from lower usage of air-conditioning units.

The Cool Streets Credits promote provision of shade to where it is needed most for urban cooling and prioritises human thermal comfort and retention of soil moisture. This helps to achieve optimal urban cooling outcomes when applied at the local precinct and neighbourhood scales, in concert with the Urban Design Credits.

3.2.3 Category 3 Cool Parks (CP) Credits

Outdoor spaces are experienced at a human scale, where temperature variations are more pronounced than those measured at a city or precinct scale. Within the urban environment, temperatures experienced at a human scale can vary significantly from place to place at the local level. For example, the microclimate in a well-irrigated landscape under a shady tree will be different to the microclimate in a paved area with no shade and surrounding heat-reflective surfaces.

While only modest reductions can be achieved in ambient air temperatures at the city-scale, the smaller scale variability in temperatures in the urban environment mean that it is possible to create a mosaic of cool outdoor spaces that enable people to spend time outdoors, even in hot conditions.

Cool Park Credits promote provision of shade and retention of soil moisture as a priority with optimal urban cooling outcomes achieved at the local precinct and neighbourhood scales when applied in concert with the Urban Design Credits.

It's crucial to prioritise shade where it's most beneficial for human comfort. This means considering areas where shade is most needed to provide relief from the sun's heat and glare. e.g. around seating, walking paths.

3.2.4 Category 4 Cool Homes (CH) Credits

Thermally safe environments – places that remain within a range of temperatures that protect us from injury or death from overheating or over-cooling – are critical to our health and wellbeing.

Unlike most other building types, our home provides us with safety at all hours of the day and night, under all circumstances. By day, some people have the option of seeking shelter from the heat in cooler public places: shady parks, swimming pools or rivers, or inside air-conditioned buildings like libraries and shopping centres. But many people, especially the elderly or those with mobility limitations, have no choice but to shelter during the day at home. The inherent assumption within Australia's residential building standards is that a home has air-conditioning to maintain a safe indoor temperature during heat waves. However, not all homes have functional air-conditioning, not all residents can afford to run it, and air-conditioning depends on reliable power, which may be interrupted during extreme weather.

The Cool Homes Credits promote passive design principles to make homes more resilient to high outdoor ambient air temperatures and potential electricity network failures during extreme heat waves.

The Cool Homes Credits focus on protecting human health and wellbeing with avoidance of heat-related mortality as the primary goal. Since the Cool Homes Credits reduce the need for mechanical cooling, they can also contribute to local outdoor thermal comfort and modest reductions to local ambient outdoor air temperatures. If applied at scale, together with the other categories of Credits in the CS Assessment, it will reduce the overall urban heat island effect.

3.2.5 Category 5 Cool Buildings (non-residential) Credits

Cool buildings (non-residential) focuses on places of work and community hubs such as public shopping centres (malls), libraries, transport hubs (bus and rail stations) and places of worship where people who are able, can congregate for heat respite during very hot conditions. As with the Cool Homes Credits, the Cool Buildings Credits promote passive design principles to make buildings more resilient to high outdoor ambient air temperatures and potential grid failures during extreme heat events.

3.2.6 Category 6 Innovative New Technologies Credits

The Innovative New Technologies Credits have been included in the CS Assessment to recognise and promote development that pushes the envelope on urban heat performance by collaborating with research institutions to develop and/or pilot the use of new technologies. This may be through new smart digital solutions or new cool materials. These Credits are the "icing on the cake" so to speak and allow a development to achieve the highest possible Cool Suburbs rating if all other categories of Credits have also been satisfied.

3.3 Mandatory Credits

Table 4. Summary of Mandatory Credits

CREDIT CATEGORY	MANDATORY CREDITS	DEFAULT CREDIT POINTS
Urban Design	UD5: Retention of existing tree canopy	7
Cool Streets	CS1: Shade	7
Cool Parks	CP1: Shade	6
Cool Homes	CH2: Site Shade	3
Cool Buildings	CB2: Site Shade	3

3.4 Minimum effort threshold Credits

Table 5. Summary of Credits with minimum effort thresholds.

CREDIT CATEGORY	CREDITS WITH MINIMUM EFFORT THRESHOLD	APPLICABLE CLIMATE ZONES	DEFAULT CREDITS POINT DEDUCTION
Cool Streets	CS2: Irrigation	All except Climate Zone 4	-3
Cool Parks	CP2: Irrigation	All except Climate Zone 4	-3

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3.5 Scorecard Method

The CS Assessment uses a five-step process to determine the heat resilience performance of a project:

↘ **01** **Project description**
Location, project type, land use mix and planning assessment stage.

↘ **02** **Project assessment**
Self-assessment of project compliance with applicable CS Assessment Credit Criteria.

↘ **03** **Project Star Rating**
Calculation of a Cool Suburbs Star Rating based on information entered in Steps 1 and 2.

↘ **04** **Heat Impact Scores**
Calculation of heat mitigation performance scores at neighbourhood and local scales based on information entered in Steps 1 and 2.

↘ **05** **Heatwave Safe Communities Checklist**
Guidance on additional measures to respond to residual extreme heat risk.

3.5.1
Step 1: Project Description

The project proponent / assessor enters the following information in the CS Assessment to describe the project:

Development Name: Project title

Location: Suburb and Local Government Area

Climate: ABCB Climate Zone (63)

Development Type / Scale:

- Master planned Community / Large Precinct (>1000 Lots)
- Medium Precinct (101-1000 Lots)
- Small Precinct (21-100 Lots)
- Local Residential (2-20 Lots)
- Local Commercial / Industrial / Institutional (2-20 Lots)
- Local Mixed Use (2-20 Lots)
- Single Lot (Residential)
- Single Lot (Non-Residential)
- Local Street
- Local Park

Land Use Mix (% of Gross Development Area):

- Street reserves
- Parks (all other than regional)
- Residential buildings (all classes)
- Non-residential buildings

Planning Stage:

- Strategy
- Policy
- Development planning and design
- Development assessment

The CS Assessment uses the above information to determine the urban heat resilience Credit Categories to be used to rate the project (Table 6) and the associated Default Credit Points and Default Impact Scores based on Climate Zone (Tables 7 to 9). Land use mix entered in the CS Assessment is used to apply adjustment factors to the Default Credit Points and Default Impact Scores (see Sections 3.5.3 and 3.5.4).

Table 6. Relationship between development type/scale and the urban heat resilience Credits used for rating the development.

DEVELOPMENT SCALE	EXAMPLE DEVELOPMENT TYPES	APPLICABLE CREDITS CATEGORIES
Master planned Community/Large Precinct (>1000 Lots)	Master planned residential community	All
Medium Precinct (101-1000 Lots)	Medium sized residential / mixed use subdivision	All
Small Precinct (21-100 Lots)	Small sized residential / mixed use subdivision	All (except Urban Design Category)
Local Residential (2-20 Lots)	Multi-building apartment complex, retirement village, small infill residential subdivision	Cool Streets (only if internal streets) Cool Parks (only if internal POS) Cool Homes
Local Commercial/ Industrial/ Institutional (2-20 Lots)	Business / industrial Park, small commercial precinct	Cool Streets (only if internal streets) Cool Parks (only if internal POS) Cool Buildings
Local Mixed Use (2-20 Lots)	Small infill mixed use precinct (land use mix includes residential & non-residential uses)	Cool Streets (only if internal streets) Cool Parks (only if internal POS) Cool Homes Cool Buildings
Single Lot (Residential)	ABCB buildings Class 1, 2 and 3	Cool Homes only
Single Lot (Non-Residential)	ABCB buildings Class 4,5,6,7, 8 and 9	Cool Buildings only
Local Street	Streetscape renewal / upgrade	Cool Streets only
Local Park	Parkland renewal / upgrade	Cool Parks only

Table 7. Summary of Default Credit Points and Default Impact Scores for Climate Zone 2.

	DEFAULT CREDIT POINTS	NEIGHBOUR AIR TEMP. *		LOCAL AIR TEMP.*		LOCAL THERMAL COMFORT*				
		☀	☾	☀	☾	☀	☾	ST**	MT**	LT**
URBAN DESIGN CREDITS:										
UD1: Wind Paths	3	1	1	1	1	3	3	2	2	2
UD2: Wind Buffering/Filtering	2	1	1	1	1	1	1	1	1	1
UD3: Street Canyons	4	3	3	2	3	2	2	2	2	2
UD4: Green and Blue Open Space	7	1	1	1	1	1	1	2	2	2
UD5: Retaining Existing Tree Canopy	7	3	2	3	2	3	1	2	2	2
UD6: Water Sensitive Urban Design (passive irrigation)	7	1	1	1	1	1	1	1	2	2
COOL STREETS CREDITS:										
CS1: Shade	7	3	0	3	0	3	0	1	2	2
CS2: Irrigation	4	1	0	1	0	1	0	1	1	1
CS3: Cool Pavements	4	3	1	3	1	2	1	2	1	1
COOL PARKS CREDITS:										
CP1: Shade	6	3	1	3	1	3	0	2	2	2
CP2: Irrigation	6	1	0	1	0	1	0	1	1	1
CP3: Cool and/or Porous Pavements	3	2	1	2	1	2	1	2	1	1
COOL HOMES CREDITS:										
CH1: Site Coverage	2	2	1	2	1	2	1	2	2	2
CH2: Site Shade	3	3	1	3	1	3	1	2	2	2
CH3: Site Irrigation	2	1	0	1	0	1	0	1	1	1
CH4: Passive Cooling	3	1	0	1	1	3	3	2	2	2
CH5: Cool Roofs, Green Roofs and Green Walls	2	2	0	2	0	1	1	2	2	2
CH6: Cool and/or Porous Pavements	1	2	1	2	1	2	2	2	2	2
CH7: Alternative Energy Supply	2					3	3	2	2	2
COOL BUILDINGS CREDITS:										
CB1: Site Coverage	2	2	1	2	1	2	1	2	2	2
CB2: Site Shade	3	3	0	3	0	3	1	2	2	2
CB3: Site Irrigation	1	1	0	1	0	1	0	2	2	2
CB4: Passive Design	3	1	0	1	0	3	2	2	2	2
CB5: Cool Roofs, Green Roofs and Green Walls	3	2	0	2	1	2	1	2	2	2
CB6: Cool and/or Porous Pavements	1	3	1	3	1	2	2	2	2	2
CB7: Alternative Energy Supply	2					3	3	2	2	2
INNOVATIVE NEW TECHNOLOGY CREDITS:										
INV1: New Technologies	5	0	0	0	0	0	0	0	0	0
INV2: Data Collection	5	0	0	0	0	0	0	0	0	0

Please note: Impact scores are for regular hot summer conditions (max day temperature < 37˚C) and not for extreme heat conditions (max day temperature >37˚C

** Default Impact Scores for Climate Zone 2. 0 = no impact; 3 = highest impact.*
*** ST = Short term, 0-10yrs. MT = Mid-term, 10-20yrs. LT = 20+yrs. Default Temporal Impact Scores. 0 = no impact; 2 = highest impact.*

Table 8. Summary of Default Credit Points and Default Impact Scores credits for Climate Zone 4.

	DEFAULT CREDIT POINTS	NEIGHBOUR AIR TEMP. *		LOCAL AIR TEMP.*		LOCAL THERMAL COMFORT*		ST**	MT**	LT**
		☼	☾	☼	☾	☼	☾			
URBAN DESIGN CREDITS:										
UD1: Wind Paths	3	2	2	2	2	3	3	2	2	2
UD2: Wind Buffering/Filtering	2	2	2	2	2	2	2	1	2	2
UD3: Street Canyons	4	3	3	3	3	2	2	2	2	2
UD4: Green and Blue Open Space	7	3	2	3	2	2	2	2	2	2
UD5: Retaining Existing Tree Canopy	7	3	2	3	2	3	1	2	2	2
UD6: Water Sensitive Urban Design (passive irrigation)	7	3	2	3	2	3	1	1	2	2
COOL STREETS CREDITS:										
CS1: Shade	7	3	0	3	1	3	0	2	2	2
CS2: Irrigation	4	3	2	3	2	3	1	2	2	2
CS3: Cool Pavements	4	2	1	3	1	2	1	2	2	2
COOL PARKS CREDITS:										
CP1: Shade	6	3	1	3	1	3	0	2	2	2
CP2: Irrigation	6	3	2	3	2	3	1	2	2	2
CP3: Cool and/or Porous Pavements	3	2	1	2	1	2	1	2	1	1
COOL HOMES CREDITS:										
CH1: Site Coverage	2	3	2	3	2	3	1	2	2	2
CH2: Site Shade	3	3	1	3	1	3	1	2	2	2
CH3: Site Irrigation	2	2	2	2	2	2	1	2	2	2
CH4: Passive Cooling	3	0	0	1	0	3	2	2	2	2
CH5: Cool Roofs, Green Roofs and Green Walls	2	1	1	2	1	1	0	2	2	2
CH6: Cool and/or Porous Pavements	1	2	1	2	1	2	0	2	2	2
CH7: Alternative Energy Supply	2					3	3	2	2	2
COOL BUILDINGS CREDITS:										
CB1: Site Coverage	2	2	1	2	1	2	1	2	2	2
CB2: Site Shade	3	3	0	3	0	3	1	2	2	2
CB3: Site Irrigation	1	2	2	2	2	2	1	2	2	2
CB4: Passive Design	3	0	0	0	0	3	2	2	2	2
CB5: Cool Roofs, Green Roofs and Green Walls	3	2	1	2	1	1	1	2	2	2
CB6: Cool and/or Porous Pavements	1	2	1	2	1	2	1	2	2	2
CB7: Alternative Energy Supply	2					3	3	2	2	2
INNOVATIVE NEW TECHNOLOGY CREDITS:										
INV1: New Technologies	5	0	0	0	0	0	0	0	0	0
INV2: Data Collection	5	0	0	0	0	0	0	0	0	0

Please note: Impact scores are for regular hot summer conditions (max day temperature < 37˚C) and not for extreme heat conditions (max day temperature >37˚C

** Default Impact Scores for Climate Zone 2. 0 = no impact; 3 = highest impact.*
*** ST = Short term, 0-10yrs. MT = Mid-term, 10-20yrs. LT = 20+yrs. Default Temporal Impact Scores. 0 = no impact; 2 = highest impact.*

Table 9. Summary of Default Credit Points and Default Impact Scores for Climate Zones 5, 6, 7 and 8.

	DEFAULT CREDIT POINTS	NEIGHBOUR AIR TEMP. *		LOCAL AIR TEMP.*		LOCAL THERMAL COMFORT*		ST**	MT**	LT**
		☼	☾	☼	☾	☼	☾			
URBAN DESIGN CREDITS:										
UD1: Wind Paths	3	1	1	1	1	3	3	2	2	2
UD2: Wind Buffering/Filtering	2	1	1	1	1	2	2	1	2	2
UD3: Street Canyons	4	3	3	2	3	2	2	2	2	2
UD4: Green and Blue Open Space	7	3	3	3	3	2	2	2	2	2
UD5: Retaining Existing Tree Canopy	7	3	2	3	2	3	1	2	2	2
UD6: Water Sensitive Urban Design (passive irrigation)	7	3	2	3	2	3	1	1	2	2
COOL STREETS CREDITS:										
CS1: Shade	3	3	0	3	0	3	0	1	2	2
CS2: Irrigation	2	2	1	2	1	2	0	1	2	2
CS3: Cool Pavements	2	2	1	3	1	2	1	2	2	2
COOL PARKS CREDITS:										
CP1: Shade	6	3	1	3	1	3	0	2	2	2
CP2: Irrigation	6	3	2	3	2	3	1	2	2	2
CP3: Cool and/or Porous Pavements	3	2	1	3	1	2	1	2	1	1
COOL HOMES CREDITS:										
CH1: Site Coverage	2	2	1	2	1	2	1	2	2	2
CH2: Site Shade	3	2	1	2	1	2	1	2	2	2
CH3: Site Irrigation	2	2	1	2	1	2	1	2	2	2
CH4: Passive Cooling	3	1	0	1	0	3	2	2	2	2
CH5: Cool Roofs, Green Roofs and Green Walls	2	2	1	2	1	0	0	2	2	2
CH6: Cool and/or Porous Pavements	1	2	1	2	1	2	0	2	2	2
CH7: Alternative Energy Supply	2					3	3	2	2	2
COOL BUILDINGS CREDITS:										
CB1: Site Coverage	2	2	1	2	1	2	1	2	2	2
CB2: Site Shade	3	2	1	3	2	3	1	2	2	2
CB3: Site Irrigation	1	2	0	2	0	2	1	2	2	2
CB4: Passive Design	3					3	2	2	2	2
CB5: Cool Roofs, Green Roofs and Green Walls	3	2	1	2	1	2	1	2	2	2
CB6: Cool and/or Porous Pavements	1	2	1	2	1	2	1	2	2	2
CB7: Alternative Energy Supply	2					3	3	2	2	2
INNOVATIVE NEW TECHNOLOGY CREDITS:										
INV1: New Technologies	5	0	0	0	0	0	0	0	0	0
INV2: Data Collection	5	0	0	0	0	0	0	0	0	0

Please note: Impact scores are for regular hot summer conditions (max day temperature < 37˚C) and not for extreme heat conditions (max day temperature >37˚C

** Default Impact Scores for Climate Zone 2. 0 = no impact; 3 = highest impact.*
*** ST = Short term, 0-10yrs. MT = Mid-term, 10-20yrs. LT = 20+yrs. Default Temporal Impact Scores. 0 = no impact; 2 = highest impact.*

3.5.2
Step 2: Project Assessment

Cool Suburbs currently relies on self-assessment. The assessor of the project will determine if the project satisfies the Credit Criteria for each of the applicable Credits by referring to the Evidence Requirements, Guidance and Science Rationale information provided for each applicable Credit.

All Credits claimed must have the required documented evidence to justify the claim. Additionally, all Mandatory Credits applicable to the project must be satisfied in order to achieve a Cool Suburbs Star Rating.

3.5.3
Step 3: Cool Suburbs Star Rating

A project's Cool Suburbs Star Rating is calculated on a scale between 1 to 5 stars with 1 star representing a project that meets only the applicable Mandatory Credits and 5 stars representing a project that satisfies all applicable Credits. Star bands are linearly distributed within that range.

An important aspect of the Cool Suburbs Star Rating calculation is the adjustment factors applied to the Default Credit Points in Tables 9-11 based on the land use mix information entered in the CS Assessment. The rules in the CS Assessment to adjust Default Credit Points for calculation of the Cool Suburbs Star Rating are as follows:

1. Urban Design Credits and Innovation Credits (where applicable): No adjustment
2. Cool Street, Cool Parks, Cool Homes and Cool Building Credits (where applicable): Adjustment factors are based on % land cover entered in the CS Assessment relative to a default land cover of 25%. For example, if street reserves land cover is entered in the CS Assessment as 40% of gross development area, the adjustment factor that will be applied to the Default Credit Points for the Cool Streets Category Credits is 40/25 = 1.6.

The assessment includes two innovation credits. These are awarded in addition to the maximum five-star rating and reward innovative practices that go beyond commonly recognised improvements. These innovation credits can be awarded to a development that has achieved a five-star rating for a final rating of 5++.

3.5.4
Step 4: Cool Suburbs Heat Impact Scores

The CS Assessment calculates the project's Heat Impact performance relative to the performance of an "ideal" development of the same type that satisfies all applicable Credits. For example, a Heat Impact performance score of 85% means the project achieves 85% of the heat mitigation benefit had it satisfied all applicable Credits.

The CS Assessment calculates Heat Impact performance based on the following metrics:

- Day / Night Neighbourhood Air Temperature
- Day / Night Local Air Temperature
- Day / Night Local Human Thermal Comfort

The CS Assessment uses the Default Heat Impact Scores from Tables 7-9 based on the project's applicable Credits and Climate Zone. Similar to the calculation of the Cool Suburbs Star Rating (Section 3.5.3), the same adjustment factors are applied to the Heat Impact Scores from Tables 7-9 to reflect the project's land use mix.

3.5.5
Step 5: Cool Suburbs Best Practice Heate Safe Communities Checklist

The CS Assessment features a Heatwave Safe Communities Checklist that covers key elements of what should be included in a development to ensure that the residual risk from acute urban heat events is managed appropriately, particularly in relation to vulnerable communities. These initiatives are provided for guidance only and will not have any implication on the overall Cool Suburbs Star Rating or Heat Impact (benefit). The key response elements, outcomes, criteria, and guidance are provided in Table 10 below.

Table 10 - Heatwave Safe Communities Checklist

RESPOND ELEMENTS	OUTCOME	CRITERIA	GUIDANCE	REF.
RES1: Vulnerability mapping (for existing communities only)	Improved understanding of the distribution of at-risk members of the community to guide investment in heat mitigation measures.	Spatial vulnerability mapping undertaken using ABS statistics such as the SEIFA index. In large greenfield developments, consideration should be given to SEIFA index of surrounding communities.	Vulnerable members of the community are most at risk from extreme heat due to a range of socio-economic or physiological factors. Mitigation measures such as cool spaces should be readily accessible in areas with higher levels of vulnerable groups (e.g., low-income, over 65, young children). Heat risk assessments are an emerging space. Land surface temperature is a commonly used proxy for exposure, since this data is relatively available. However, impact on human health is better reflected in University Thermal Comfort Index (1), which includes a more complex interplay between temperature, humidity, wind speed, land cover and shading. *Note; Table 11 below has been provided to outline relevant indices, themes and indicators.	(1) (24) (25)
RES2: Community awareness and decision support	Provide information that supports the community to make safe decisions that reduce their heat risk, with a focus on extreme conditions.	Integration of design elements that inform communities about local climate conditions and encourages actions to reduce risk. For example, the installation of temperature or UV displays in public spaces, signage promoting hydration in hot weather, or alerting to the likelihood of hot metal play equipment at certain temperatures.	Low awareness of extreme heat and its health impacts can result in individuals not taking action to protect themselves or their families. The aim of this element is to provide information on the severity of location-based conditions through technology. You can find more information here in the NSW health community resource (updated in 2023) https://www.health.nsw.gov.au/environment/beattheheat/Pages/community-resources.aspx The HeatWatch App (released in 2023, currently being trialled), is a collaboration between the University of Sydney and NSW Health. The app provides personalised heat-health risk alerts with accompanying evidence-based cooling and hydration advice based on a user's physiological characteristics (e.g., age, health status, medications), location, and weather data https://heatwatch.sydney.edu.au/	–
RES3: Drinking water access	Ensure that the community has access to fresh drinking water in all public spaces to reduce likelihood of heat-related illness.	Provision of safe drinking water in all public parks and spaces.	Hydration is essential for maintaining health in extreme heat. Water is essential for the body's primary cooling mechanism (sweating), supporting kidney function, and can be used by first responders to assist individuals experiencing heat-related illness by drinking or wetting the skin.	(26)

Table 10 - Heatwave Safe Communities Checklist recommendations (continued)

RESPOND ELEMENTS	OUTCOME	CRITERIA	GUIDANCE	REF.
RES4: Cool Spaces	Designated cool indoor spaces where at-risk people can find relief from heat are included in the project design.	A designated Cool Centre has been provided in the project design that offers an accessible space for at-risk people who seek shelter from extreme heat. The centre can be any publicly accessible space and should have adequate cooling systems, as well as back-up power supplies in the case of a black out.	Minimum facility requirements for Cool Centres: • Reasonable capacity (minimum 50m^2 floor space available, with minimum 2.0m^2 per person available) - Accessibility - Sealed/paved access to entry - Disabled access available - Parking and drop-off zones should be close to the centre entrance - Vehicle access to main door - Emergency service pickup point • Bathroom facilities - Male and female toilets - Parent room - Disabled facilities available • Communications - Hardline telephone - Internet connectivity - Mobile connectivity • Electricity - Connection available to plug in backup power generator • Ventilation - Air-conditioning available - Low risk of failing at maximum summer temperatures for its location. - Ceiling or portable fans • Water supply - Drinking water supply available • Kitchen - Area for food preparation, including a refrigerator	(82) (83)
RES5: Safe transport routes	To support safe travel during extreme heat events.	Provision of targeted measures to improve heat safety along known active transport routes. This includes adequate shading and water provision at transport stops.	While active transport is not recommended during extreme heat events, many vulnerable groups may rely on such routes and services to access cool spaces away from their residences. Provision of shade and water supports safer travel during these times.	(28) (29)

Table 11 — RES1 Indicators

INDICES	THEMES	INDICATORS
Exposure	Heat exposure	• University Thermal Comfort Index (1) / Land Surface Temperature (2) • Vegetation cover (3) (4)
Sensitivity	Socio economic status	• Low socio-economic demographic (3) (5) (6) (10)
	Physiological	• Under 5 or over 65 years of age (3) (6) • Existing medical condition (3) (6) (9) • Need for assistance (incl. disability) (4) (5)
	Behavioural	• Outdoor workers (3) (7) (9)
Adaptive capacity	Location	• Distance to health and emergency services (4) (11) • Proximity to cool centres (4) (10)
	Mobility	• No motor vehicle (5) (7) (8) (11) (12)
	Awareness	• New arrival to area (7)(11) • CALD (7) (11) (13) • Education (10) (11) • Internet access (11)
	Tenancy type	• Owning / renting (10) (11) (14)

Cool Suburbs Assessment NSW – Rationale Document

Appendix

A

Cool Suburbs Assessment Credits

This Appendix provides an overview and science rationale for each Credit in the Cool Suburbs Assessment. A list of cited references is included in the References section in Appendix B.

Cool Suburbs Assessment NSW – Rationale Document

Urban Design Credits

Urban design shapes our neighbourhoods and suburbs creating pattern and form, known as urban morphology. The Urban Design (UD) Credits aim to ensure urban morphology responds to current and future climatic conditions and supports passive cooling with the goal of improving human comfort.

UD1: Wind paths

3 DEFAULT CREDIT POINTS

Outcome

Channelling of breezes to lower local air temperature by removing stagnant, heated air and improve outdoor thermal comfort.

Criteria

> 75% of the development's total street length (including lanes) is oriented (+/- 30˚) to the dominant prevailing summer breezes.

Guidance

Wind rose (wind speed and direction) data is available from the Bureau of Meteorology.

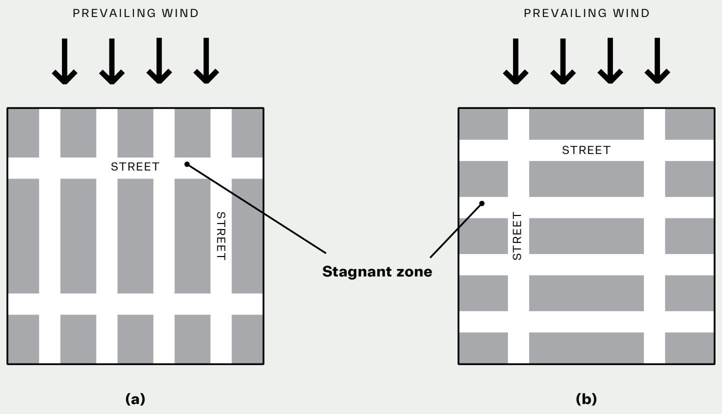

Figure UD1-1 The pattern of street canyon for ventilation: (a) Recommended, (b) Not recommended (Source: Ng, 2009, as cited in He, et al 2019).

In the street pattern in Fig. UD1-1(b), most areas are stagnant zones and wind speeds are consistently very low. Comparatively, the wind speeds in the streets shown in the Fig. UD1-1(a) are higher because of the increase of urban permeability, and reduction in amount of stagnant area.

Evidence Requirements

Plan(s) showing the length and orientation of each street relative to the dominant prevailing summer wind direction.

Science Rationale

Orienting streets (street canyons) to channel the prevailing cooling summer winds displaces pockets of stagnant hot air and improves thermal comfort. The research (33) shows ventilation efficiency lies in adjusting street canyons parallel to prevailing wind, as shown in Figure UD1-1 (a).

Related credits

UD2 – Wind Buffering / filtering

UD3 – Street Canyons

UD4 – Green and Blue Open Space

All of the Cool Street Credits

UD2: Wind Buffering/ Filtering

2 DEFAULT CREDIT POINTS

Outcome

Buffering hot summer winds at the development boundary reduces local air temperatures and improves outdoor thermal comfort.

Criteria

50m minimum width urban forest corridor to >75% of the development boundary that is perpendicular (+/- 30o) to the dominant prevailing hot summer winds.

Guidance

Urban forest corridor cross-section shall incorporate a minimum of three large shade trees (12m diameter canopy/tree at maturity).

Evidence Requirements

Plan and cross-sections showing length, width and vegetation composition of urban forest corridor relative to the development boundary and direction of dominant prevailing hot summer wind.

Science Rationale

Hot summer winds emanate from central Australia. Buffering hot summer winds at the development boundary through an urban forest corridor enhances the cooling benefits from other urban cooling measures implemented within the development.

Related credits

All other Credits

UD3: Street Canyons

4 DEFAULT CREDIT POINTS

Outcome

Street canyons configured to promote shade and ventilation to reduce local air and surface temperatures and improve outdoor thermal comfort.

Criteria

> 75% of street canyons (excluding lanes) have an aspect ratio (H:W) less than 1.0.

Guidance

Urban design should prioritise shallow street canyons (aspect ratio < 1.0) to allow for solar access to the public realm in winter, space for street tree planting, ventilation, and nocturnal cooling.

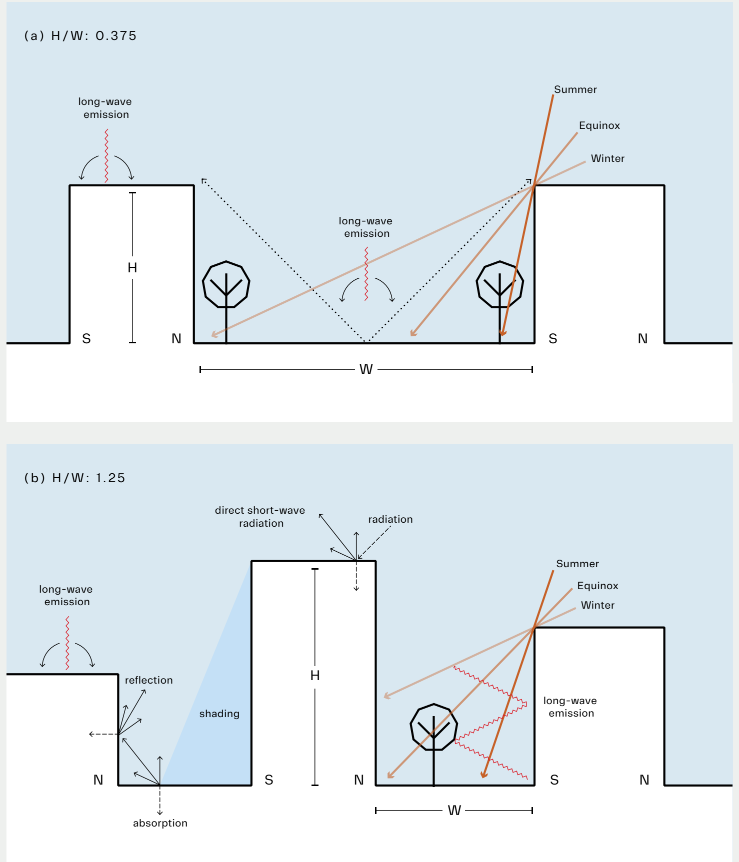

Figure UD3-1 Street canyon solar access and heat fluxes. (Images adapted from (34)

Evidence Requirements

Sections through each street canyon showing aspect ratio (H:W).

Street layout plan showing the length of streets with aspect ratio less than 1.0 and total length of all streets.

Science Rationale

Research (33) (31) (32) shows better ventilation and nocturnal cooling performance primarily corresponds to lower building height, lower compactness, and wider streets.

Related credits

UD1 – Wind Paths

All Cool Streets Credits

UD4: Green and Blue Open Space

7 DEFAULT CREDIT POINTS

Outcome

Green and blue open space designed and positioned to reduce local air and surface temperatures and improve outdoor thermal comfort.

Criteria

Site perviousness:

The development site has > 60% pervious surfaces

> 50% of pervious surfaces are deep soil area.

And;

Green and blue open space placement:

Green and blue open spaces are located upwind of heat sensitive land uses such as schools, community centres, public transport hubs, hospitals, and child / aged-care facilities.

Guidance

Consider the prevailing summer wind direction and locations of heat sensitive land uses when positioning parks and water bodies.

Irrigated green space provides the best cooling benefit (see also UD6, CP2)

Downwind cooling effect of urban parks extends to about one park width (37).

Distributed smaller water bodies orientated perpendicular to the dominant prevailing summer wind direction will provide greater urban cooling benefit than a single large linear water body oriented parallel to the prevailing summer wind direction.

Downwind cooling benefits of green space and water bodies will be greatest if located upwind of street canyons designed for efficient ventilation (see also UD1 and UD3).

Evidence Requirements

Landscape plan showing the total area of pervious surfaces and deep soil area relative to the gross development area.

Landscape plan showing the location and dimension of green and blue open spaces relative to heat sensitive land uses.

Science Rationale

Research (36) (16) on the influence of land surface type on air temperatures shows:

Increasing the area of green open spaces and tree canopy leads to cooling.

When provided in equal proportions, warming from hard surfaces exceeds cooling from open space.

Open space and tree canopy cover can reduce summer night-time air temperatures.

With reference to Figure UD4-1, effective cooling can only be achieved if the ratio of open space to hard surfaces is 2:1 or greater.

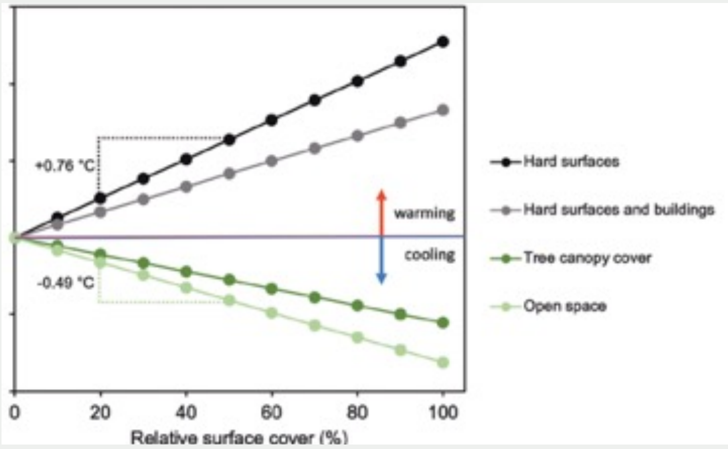

Figure UD4-1 Predicted changes in mean summer air temperature along a gradient of different surface cover types and tree canopy (Source: Pfautsch, S., Tjoelker, A R. (2020)).

Research (38) shows smaller distributed water bodies placed perpendicular to prevailing winds will create the most efficient urban canopy layer cooling per m^2 of water body surface area.

Related credits

UD1 – Wind Paths

UD2 – Wind Buffering / Filtering

UD4 – Retention of existing tree canopy

UD5 – Water sensitive urban design (passive irrigation)

All Cool Park Credits

UD5: Retaining Existing Tree Canopy

7 DEFAULT CREDIT POINTS

Outcome

Retaining existing tree canopy cover to provide shade, lower surface radiative temperatures, promote ventilation and improve Human Thermal Comfort

Criteria

Retain existing trees:

- Retain in-situ existing trees that are ecologically or culturally significant or have trunk diameter >300mm and are in good condition and are locally appropriate.

And

- Tree Canopy Cover (measured as % of Gross Development Area):

At maturity, the development's overall tree canopy cover exceeds the existing tree canopy cover or exceeds *40% tree canopy cover, whichever is the greater.

* Replace with the local council's urban tree canopy target if > 40%.

Guidance

- Tree species selection to suit in-situ soil conditions and resilience to high heat stress having regard to projected future extreme heat days due to climate change (refer to Adapt NSW's Regional Climate Change Snapshot Reports for a summary of projected changes to extreme heat days, temperatures and summer rainfall in your region).
- Guidance on the best tree species for a given geography based on various planting factors including future climate is available on the https://www.whichplantwhere.com.au website.
- A variety of suitable tree species is preferred to increase the urban canopy roughness through different tree heights and foliage types.
- Evergreen trees should be used for areas that will benefit from year-round shade.
- Deciduous trees should be used where sunlight is desirable in winter.
- Trees should be clustered with occasional breaks in canopy rather than evenly spaced.
- The placement of new trees should consider their ability to channel breezes and provide shade to hard surfaces and locations of highest communal use during the hottest times of the day, particularly pedestrian pathways and playgrounds.
- Provide active management of younger trees to support crown development.
- Ensure a secure water supply is available during

extended dry periods to provide at least the minimum sustaining irrigation needs of each tree species (see also UD6, CS2, CP2, CH3, CB3).

- Inadequate irrigation will lead to reduced plant transpiration and cooling potential (31).
- Access to deep soils (a landscaped area connected horizontally to the soil system and local ground water system beyond and is unimpeded by any building or structure above or below ground) supports healthy trees. Recommended minimum deep soil areas (assuming 600mm and 1000mm accessible soil depth for clay and sandy loam soils respectively):
- Small Trees (6 metre canopy diameter at maturity): 14m² in sandy loam soils; 23m² in clay soils.
- Medium Trees (8m diameter canopy at maturity): 18m² in sandy loam soils; 30m² in clay soils.
- Large Trees (≥12m diameter canopy at maturity): 26m² in sandy loam soils; 43m² in clay soils.

Evidence Requirements

- A baseline tree survey covering species (including ecological and/or cultural significance), size, condition, and canopy cover.
- Landscape plan showing retained trees, proposed tree planting and planned mature canopy cover as % of gross development area.

Science Rationale

- A lack of vegetation and tree canopy cover is a key defining feature of developed urban areas and a major contributor to the UHI effect (46).
- Trees provide cooling through both transpiration and shade. Shade is critical for improved Human Thermal Comfort during hot sunny conditions (39, 40).
- Tree canopy shade reduces the amount of heat absorbed by surfaces during the day, which in turn results in cooler air temperatures at the beginning of the night and less emission of heat during the night (36).
- Trees are an effective urban heat mitigation solution for several reasons:
- A vast range of tree species enables the selection of trees that best fit with the climate and environment of the location (e.g., soil type, water availability, light availability, etc.).
- Tree roots have an advantage over the shallow roots of grasses and shrubs when it comes to accessing deep-water sources. They can draw water from these depths into the topsoil, enabling them to continue evapotranspiring for longer periods compared to understorey plants.
- Trees provide multiple benefits in addition to urban cooling, including reduced stormwater runoff volumes, air quality benefits (depending on tree species selection), carbon uptake and storage, habitat, and building and neighbourhood energy savings (39).

Related credits

UD1 – Wind Paths

UD2 – Wind Buffering/Filtering

UD4 – Green and Blue Open Space

UD6 – Water Sensitive Urban Design

CS1 – Shade

CP1 – Shade

CH2 – Site Shade

CB2 – Site Shade

UD6: Water Sensitive Urban Design (passive irrigation)

7 DEFAULT CREDIT POINTS

Outcome

Water sensitive urban design delivers passively irrigated, multi-functional landscapes that reduce surface radiative temperatures, promote ventilation, and improve Human Thermal Comfort.

Criteria

- Passively irrigated landscapes make up > 50% of the project's gross landscape area (excluding sports courts and fields and undisturbed natural areas).

And

- > 50% of the aggregate WSUD treatment area (excluding constructed wetlands) incorporate shade trees.

Projects in Climate Zone 4 only are excluded from having to satisfy the passive irrigated landscapes criterion.

Guidance

- Passively irrigated landscapes (59)(75) maintain healthy vegetation and soil moisture accentuating urban cooling and Human Thermal Comfort (HTC) benefits.
- WSUD should be combined with increased tree canopy cover to maximise cooling via both evapotranspiration and shading.
- Provision of tree canopy cover within WSUD assets should prioritise areas of high solar exposure (e.g. hard surfaces in street reserves).
- Aim for many, smaller, distributed WSUD assets at regular intervals throughout the urban environment to retain stormwater in the urban landscape and promote widespread infiltration into soils to maintain soil moisture stores.
- Reference examples of WSUD solutions for commercial, industrial, and housing developments can be found in Sydney Water's Urban Typologies and Stormwater Management Solutions (41).

Evidence Requirements

Engineering + landscape plans showing the area of passively irrigated landscapes as % of gross landscape area

Landscape plans showing planned mature canopy cover of trees planted within WSUD assets as a % of aggregate WSUD treatment area (excluding wetlands).

Written agreement is provided with the future asset manager confirming a commitment to continuation of WSUD asset management after asset handover.

Science Rationale

Implementation of WSUD and greening generally occurs at the household and street scale (the micro-scale) through planting of street trees, construction of WSUD elements like biofiltration systems, and creation of open space (40). These micro-scale implementations will influence the micro-climate. When WSUD features and urban greening is widespread across the neighbourhood, it will have an influence on the local climate. This is presented conceptually in Figure UD6-1, which shows the widespread implementation of WSUD and urban greening at the micro-scale, and the anticipated benefits at the local-scale. When several neighbourhoods begin to support cooling through these and other mitigation approaches, this is when the city-

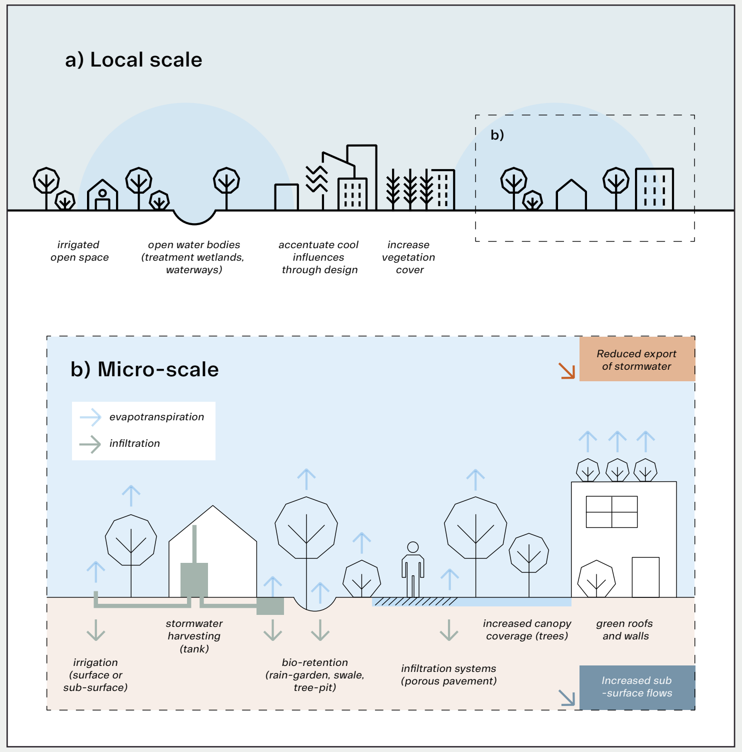

Figure UD6-1 Schematic representation of widespread WSUD elements at the micro-scale in the restoration of a more natural water balance, along with increased vegetation cover. This enhances urban evapotranspiration and shading resulting in local-scale cooling effects that can improve Human Thermal Comfort (Source: Modified after Oke (2009)).

WSUD aims to reintegrate stormwater back into the urban landscape to help restore the water balance and influence the urban climate by modifying the urban radiation budget and surface energy balance (42). This in turn drives the environmental parameters that influence Human Thermal Comfort. Figure UD6-2 theorises the key processes involved in developing urban micro-climates during warm summertime conditions between a conventional (water limited) urban landscape (Figure UD6-2, a and c) and a water sensitive urban landscape (Figure UD6-2, b and d), which each exert environmental influences on Human thermal Comfort (HTC).

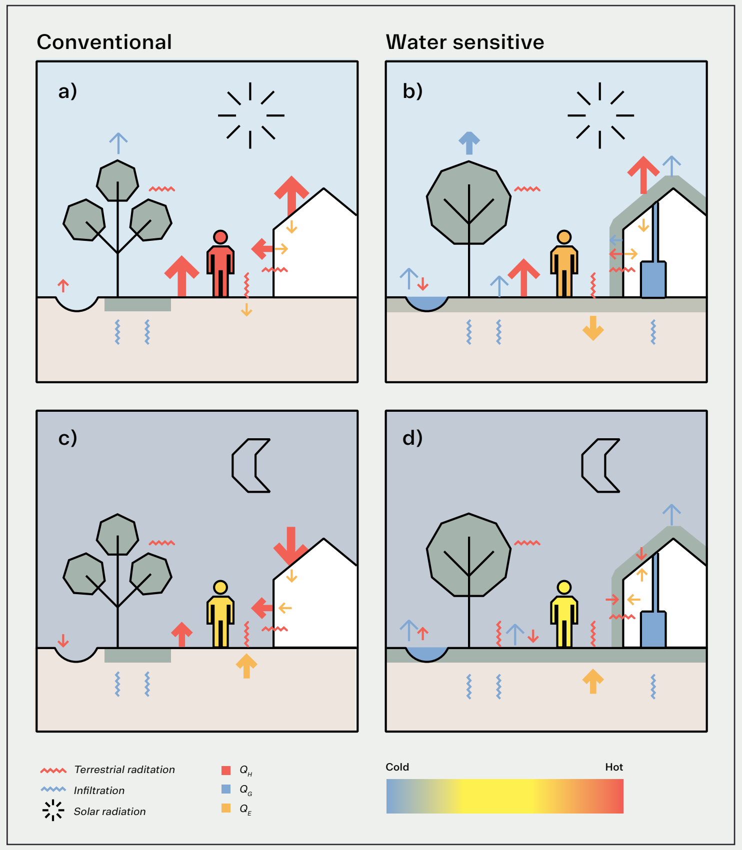

Figure UD6-2 Generalisation of key processes in the formation of urban micro-climates during summer for conventional (water limited) urban landscapes (a and c) and water sensitive urban landscapes (b and d) (Source: Modified after Oke (2009)).

With respect to Figure UD6-2, during the day when aiming to limit heat stress, promoting shading, and limiting atmospheric heating is important for creating a more comfortable thermal environment. The water sensitive scenario (along with healthy vegetation) serves to increase shading, evapotranspiration and reduce surface temperatures, thereby reducing QH (sensible heat flux or the loss of energy by the surface by heat transfer to the atmosphere) and radiative loadings on pedestrians, as well as supporting an overall reduction in QG (ground heat flux) (Figure UD6-2 b). This is in contrast to a more conventional urban landscape (Figure UD6-2a) where water is limited, and vegetation health is compromised. Under this arrangement, QH dominates, and intense surface heating and reduced shading supports higher radiative loading on the human body. This also increases energy demand for cooling, increasing QF (anthropogenic heat flux). At night, promoting long-wave cooling and ventilation can create more comfortable thermal environments. Furthermore, the water sensitive scenario (having generally stored less heat during the day) is less conducive to supporting urban canopy layer warming (Figure UD6-2d) than the conventional urban layout (Figure UD6-2c).

Related credits

All Credits

Cool Streets Credits

Cool streets play an important role in providing amenity and recreation as well as traditional transport functions. Tree canopy cover, passive irrigation of soft landscapes, and cool pavement technologies can all contribute to creating "cool lines" in urban landscapes, for people to move outdoors even in hot conditions.

CS1: Shade

7 DEFAULT CREDIT POINTS

Outcome

Shade (natural and built) within street reserves lowers surface radiative temperatures, promotes ventilation, and improves Human Thermal Comfort.

Criteria

Tree canopy cover at maturity (measured as % of street reserve):

LAND USE CATEGORY	CANOPY COVER TARGET (MINIMUM)
EXISTING RESIDENTIAL STREETS	
With overhead powerlines	40%
With underground powerlines	50%
EXISTING INDUSTRIAL STREETS	
With overhead powerlines	35%
With underground powerlines	45%
NEW RESIDENTIAL STREETS	
With underground powerlines	70%
NEW INDUSTRIAL STREETS	
With underground powerlines	60%
All other local street types	Use local controls

Note: Targets exclude intersections. For existing streets, the above targets only apply if greater than the existing (pre-refurbishment) tree canopy cover, otherwise no-net loss of tree canopy cover is the acceptable target.

And

Shading of high use spaces:

>80% shade cover (measured in plan) of footpath or shared use spaces within street reserves.

On-grade carparks: One medium tree (8m diameter canopy at maturity) per four car parking spaces. The tree is to be in a planted within a deep soil zone of >13 m^2 – the equivalent of a car parking bay area.

Guidance

- Selection and placement of shade solutions within streets should consider peak-use times to ensure shade maximises solar UV protection when it is needed most.
- Tree species selection to suit in-situ soil conditions and resilience to high heat stress having regard to projected future extreme heat days due to climate change (refer to Adapt NSW's Regional Climate Change Snapshot Reports for a

summary of projected changes to extreme heat days, temperatures and summer rainfall in your region).

- A variety of suitable tree species is preferred to increase the urban canopy roughness through different tree heights and foliage types.
- Guidance on the best tree species for a given geography based on various planting factors including future climate is available on the https://www.whichplantwhere.com.au website.
- Use evergreen trees for areas that will benefit from year-round shade.
- Use deciduous trees where sunlight is desirable in winter.
- Consideration of safety is paramount with species selected to minimise risk to public safety.
- Access to deep soils supports healthy trees. Recommended minimum deep soil areas:
  - Small Trees (6 metre canopy diameter at maturity): 14m^2 in sandy loam soils; 23m^2 in clay soils.
  - Medium Trees (8m diameter canopy at maturity): 18m^2 in sandy loam soils; 30m^2 in clay soils.
  - Large Trees (≥12m diameter canopy at maturity): 26m^2 in sandy loam soils; 43m^2 in clay soils.
- Ensure a secure water supply is available during extended dry periods to provide the minimum sustaining irrigation needs of each tree species (see CS2).
- Provide active management of younger trees to support crown development.
- Develop and apply long term strategies to transition from built shade to an increased proportion of natural shade as canopy increases in size and density.
- If installing shade sails as part of built shade solutions, make sure to choose fabric that has a UV Effectiveness (UVE) rating of 80% or more.
- A test if shade is high quality or not on a clear day is the amount of blue sky you can see (sky view factor) while underneath it. The less blue sky you can see, the better protection from solar UV radiation.

Cool Suburbs Assessment NSW – Rationale Document

Evidence Requirements

Landscape plan showing canopy cover at maturity as % of street reserve area for all streets.

Science Rationale

- Street reserves and on-grade carparks will often have a high percentage of heat absorbing surfaces such as bitumen, concrete and paving. Without shade, these surfaces can heat to very high surface temperatures on hot summer days increasing mean radiant temperature and reducing Human Thermal Comfort.
- Studies (42) have shown shade from street trees can modify street micro-climates to improve the comfort of pedestrians and lower local air temperatures. Percentage canopy cover, street orientation and aspect ratio (W:H) interplay to determine the magnitude of urban heat benefits.
- A study of microclimatic variation across the City of Parramatta during the summer of 2018/19 showed a street with 30% tree canopy cover experienced only 5 days of local air temperatures greater than 40˚C whereas a nearby street where canopy cover was just over 10% the local air temperatures soared above 40˚C on 13 days (18).
- A study comparing the micro-climate of two residential streets with similar aspect ratio (H:W) in East Melbourne, where one street had very little tree canopy cover (12%) and the other had a good tree canopy cover (45%), showed during hot summer conditions the local air temperature in the street with more trees was 0.2-0.6 ˚C cooler than the street without many trees (42). The street with more trees was also up to 0.9 ˚C cooler during the morning as the trees delayed surface heating. Moreover, heat stress (Human Thermal Comfort) was lower in the street with trees.

Related credits

UD5 – Retention of existing tree canopy

UD6 – Water Sensitive Urban Design

CS2 – Irrigation

INV2 – Data collection and Analysis

CS2: Irrigation

4 DEFAULT CREDIT POINTS

Outcome

Irrigated street reserve landscapes reduce local surface temperatures, cool local air temperatures, and improve local thermal comfort.

Criteria

- A secure water supply is provided for irrigating street reserve landscapes commensurate with seasonal water requirements determined from local site conditions.

And

- Passively irrigated landscapes make up > 50% of the street reserve gross landscape area.

For Climate Zone 4 only, the above Credit Criteria will be deemed satisfied if the Minimum Effort Criteria listed below is satisfied.

Minimum effort criteria

Water cart irrigation is provided for at least the minimum period required for effective street tree establishment and ongoing water cart irrigation is provided to sustain street tree health during periods of extended dry and extreme heat.

Failure to satisfy the Minimum Effort Criteria will incur a 3 Credit Point penalty.

Guidance

- An alternative water source such as passive irrigation (59) (75), harvested stormwater runoff and reticulated recycled water should be used wherever possible as the primary irrigation water source with potable (town) water as a backup.
- Irrigation rates guided by local best practice for species and soil profile determined by an appropriately qualified person such as arborist, terrestrial ecologist, landscape architect or irrigation consultant.
- Over-irrigation does not always mean more urban cooling, can be detrimental to tree/plant health, and can increase humidity in hot humid climates leading to reduced human thermal comfort.
- A smart irrigation system which relies on rain and/or soil moisture sensors and night scheduling provides the most efficient irrigation management and avoids over or under watering.
- Drip irrigation lines (above or sub-surface) are preferred.

Evidence Requirements

Engineering and landscape plans detailing the source(s) of secure water for landscape irrigation and showing irrigation infrastructure, watering regime (scheduling and application rates) and the area of passively irrigated landscape as % of street reserve gross landscape area.

In cases where ownership of the street reserve asset will transfer from a developer to the local council, written agreement is provided from the local council confirming a commitment to continuation of the streetscape irrigation regime after asset handover.

Science Rationale

- As cities increasingly experience hot weather events, it is important to ensure green spaces and tree canopies are receiving sufficient water to continue to thrive (44).
- Vegetation that is water stressed has higher surface temperatures than irrigated vegetation; inadequate irrigation will lead to reduced plant transpiration (and subsequent cooling) when it is most required (31).
- Research (59) shows on hot summer days, un-shaded and un-irrigated / browned-off turf can potentially reach land surface temperatures (LST) equivalent to asphalt roads and dark roofs, whereas irrigated turf can be 20°C cooler.

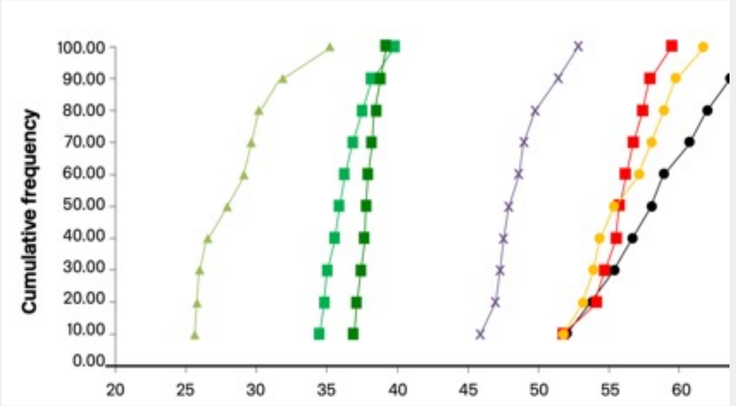

Figure CS2-1 Designing for a cool city—Guidelines for passively irrigated landscapes. Melbourne, Victoria: Cooperative Research Centre for Water Sensitive Cities). (Source: Cooperative Research Centre for Water Sensitive Cities (2020)).

Additional Practical evidence

- An investigation of the impact of irrigation on urban cooling for the suburb of Mawson Lakes in Adelaide showed during a heatwave event a 10% increase in irrigated pervious cover led to a 0.25˚C reduction in daily average temperature (38). The amount of cooling tapers off at high irrigated pervious covers and/or high levels of irrigation as the maximum amount of cooling is reached.
- An investigation of the cooling effects of nocturnal irrigation at two Melbourne botanic gardens showed the cooling effects from nocturnal irrigation of garden and lawn areas intensify during heatwaves compared with the non-heatwave periods (45). At some garden sites, nocturnal irrigation was associated with 0.5˚C — 1˚C of cooling during non-heatwave conditions. However, the cooling associated with nocturnal irrigation was greater (2˚C — 4˚C) during heatwave conditions.

Related Credits

UD6 — Water Sensitive Urban Design

CS1 — Shade

INV1 — New Technologies

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CS3: Cool Pavements

4 DEFAULT CREDIT POINTS

Outcome

Cool pavements reduce local surface and air temperatures and enhance Human Thermal Comfort.

Criteria

Cool pavements with an initial Solar Reflectance (SR) > 50% applied to > 75% of street reserve hard surfaces.

Guidance

There are a range of strategies for designing pavements that reduce urban heat impacts, including:

- Use of 'cool materials' — those that are more reflective and store less heat.
- Use of lighter pigments in mixing asphalts, concretes and pavers can increase solar reflectance by 30%.
- Incorporating a thin coating of a reflective layer to assist in the reflectance of the material. This must be considerate of driver safety and pedestrian comfort - its use can lead to glare and discomfort for drivers and some thermal discomfort for pedestrians at times of peak daytime sunlight.
- Choosing materials with a low emissivity rating, meaning they will be less prone to embodying heat.

Evidence Requirements

Pavement design report + plans specifying cool pavements (type and solar reflectance) and showing coverage of cool pavements within each street reserve as % of total street reserve hard surfaces.

Asset Management Plan detailing activities and funding source for ongoing maintenance and future renewal of cool pavements.

In cases where ownership of the street reserve asset will transfer from a developer to the local council, written agreement is provided from the local council confirming a commitment to continuation of Asset Management Plan after asset handover.

Science Rationale

- Standard and common materials used in roads and pavements absorb heat, retain heat and radiate heat, instead of reflecting the heat and energy (46). The standard solar reflectance of concrete and other common paving materials is 25-40%. When these low solar reflectance materials are used, the surface temperatures can reach 65˚C in summer impacting the immediate ambient air temperatures significantly. Because these materials store heat, the effect of this absorption can remain long after peak direct sunlight.

- Reflective materials reflect solar radiation rather than absorbing it. High emissivity materials heat up more readily in response to external temperature changes and as such contribute more readily to the ambient air temperature than low emissivity materials. Emissivity is less easily modified than reflectivity as most common building materials have a high emissivity.

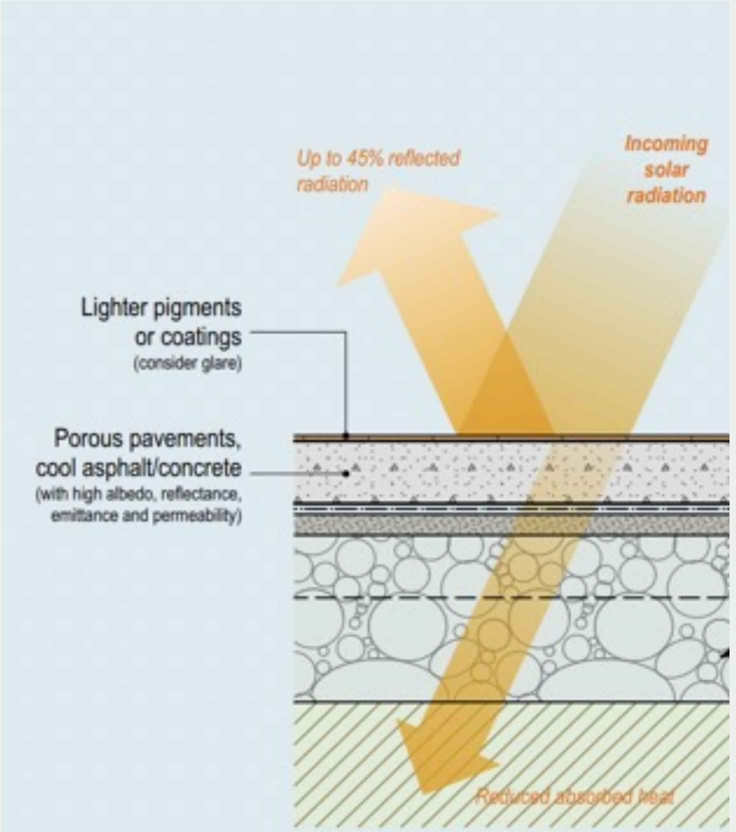

Figure CS3-1 Typical section through a cool pavement. (Source: Source: Osmond P and Sharifi E (2017)).

Related Credits

INV1 – New Technologies

Cool Parks Credits

Air temperatures in outdoor spaces can vary significantly. The microclimate under a shady tree will be different to the microclimate in a paved area with no shade.With this in mind, the Cool Parks Credits promote urban design features to create a mosaic of cool outdoor spaces where people can spend time outdoors, even in hot conditions.

CP1: Shade

6 DEFAULT CREDIT POINTS

Outcome

Shade (natural and built) lowers surface radiative temperatures, promotes ventilation, and improves Human Thermal Comfort.

Criteria

Retain existing trees:

- Existing trees that are ecologically or culturally significant or have a trunk diameter >300mm and that are in good condition and are locally appropriate are retained in-situ.

And

Tree canopy cover (at maturity):

- Parks < 5ha without sports courts and fields: >45% tree canopy cover.
- Parks < 5ha with sports courts and fields: >45% tree canopy cover applied to the park area excluding sports courts and fields.
- Parks > 5ha: No net-loss of tree canopy cover compared to existing (baseline).

And

Shading of high use spaces (e.g. children's playgrounds and BBQ/eating areas):

- >70% shade cover (measured in plan).

Guidance

- Urban parks cool more effectively if they contain scattered trees and receive irrigation.
- Prioritise provision of canopy shade for parks where daytime cooling is the priority (e.g., parks within city centres, commercial areas and low-rise residential developments).
- Prioritise more open green areas (shade trees planted to park edges) for parks where night-time cooling is the priority (e.g., parks in higher density residential areas).
- A heterogeneous tree canopy planted in groves is preferred to a homogeneous tree canopy planted in continuous rows.
- In the right positioning, well shaded and irrigated parks can provide down-wind cooling effects beyond the park boundaries (see also UD4 and UD6).
- Trees have the greatest urban cooling effect when they are positioned to shade hard surfaces during the hottest times of the day.
- Selection and placement of shade solutions within parks should consider peak-use times to ensure shade maximises solar UV protection when it is needed most.

- ree species selection to suit in-situ soil conditions and resilience to high heat stress having regard to projected future extreme heat days due to climate change (refer to Adapt NSW's Regional Climate Change Snapshot Reports for a summary of projected changes to extreme heat days, temperatures and summer rainfall in your region).
- Access to deep soils (a landscaped area connected horizontally to the soil system and local ground water system beyond and is unimpeded by any building or structure above or below ground) supports healthy trees. Recommended minimum deep soil areas (assuming 600 to 1000mm accessible soil depth for clay and sandy loam soils respectively):
  - Small Trees (6 metre canopy diameter at maturity): $14m^2$ in sandy loam soils; $23m^2$ in clay soils.
  - Medium Trees (8m diameter canopy at maturity): $18m^2$ in sandy loam soils; $30m^2$ in clay soils.
  - Large Trees (≥12m diameter canopy at maturity): $26m^2$ in sandy loam soils; $43m^2$ in clay soils.
- A variety of suitable tree species is preferred to increase the urban canopy roughness through different tree heights and foliage types.
- Guidance on the best tree species for a given geography based on various planting factors including future climate is available on the https://www.whichplantwhere.com.au website.
- Use evergreen trees for areas that will benefit from year-round shade.
- Use deciduous trees where sunlight is desirable in winter.
- Consideration of safety is paramount with species selected to minimise risk to public safety.
- Ensure a secure water supply is available during extended dry periods to provide the minimum sustaining irrigation needs of each tree species.
- Provide active management of younger trees to support crown development.
- Develop and apply long term strategies to transition from built shade to an increased proportion of natural shade as canopy increases in size and density.
- If installing shade sails as part of built shade solutions, make sure to choose fabric that has a UV

Effectiveness (UVE) rating of 80% or more.
- A test if shade is high quality or not on a clear day is the amount of blue sky you can see (sky view factor) while underneath it. The less blue sky you can see, the better protection from solar UV radiation.

Evidence Requirements
- A baseline tree survey covering species (including ecological and/or cultural significance), size, condition, and canopy cover.
- Landscape plan(s) showing retained trees and proposed trees with planned mature canopy area provides as % of gross park area (excluding sports courts and fields).

Science Rationale
- High quality built and natural shade can reduce exposure to solar UV radiation by up to 75% (57).
- Common surfaces used in playgrounds can climb to temperatures of up to 60C during the day. Providing shade can reduce the temperature of these surfaces by 20C (58).
- Radiant temperatures in parks that have well-irrigated trees can be 2-4°C cooler than adjacent un-vegetated or build up areas; the extent and proportion of tree plantings can have a 1-2°C impact on the actual temperature.
- Trees deliver greater cooling effect and enhance human comfort more than other urban green approaches (shrubs, grass) (39). Existing established trees provide the greatest benefit for heat minimisation and should be prioritised in planning.
- Trees that are water stressed will lead to reduced plant transpiration and reduced cooling potential (31).

Related Credits

UD2 — Wind buffering / filtering

UD4 — Green and blue open Space

UD5 — Retention of existing tree canopy

UD6 — Water Sensitive Urban Design

CS2 — Irrigation

INV2 — Data collection and Analysis

CP2: Irrigation

6 DEFAULT CREDIT POINTS

Outcome

Irrigated parks reduce local surface temperatures, cool local air temperatures, and improve local thermal comfort.

Criteria

A secure water supply is provided for irrigating park landscapes commensurate with seasonal water requirements determined from local site conditions.

And

Passively irrigated landscapes make up > 50% of the park landscape area (excluding turf areas, sports fields and undisturbed natural areas).

For Climate Zone 4 only, the above Credit Criteria will be deemed satisfied if the Minimum Effort Criteria listed below is satisfied.

Minimum effort criteria

Water cart irrigation for at least the minimum period required for effective tree establishment after planting and ongoing water cart irrigation to sustain tree health during periods of extended dry and extreme heat.

Failure to satisfy the Minimum Effort Criteria will incur a 3 Credit Point penalty.

Guidance
- An alternative water source such as passive irrigation (59) (75), harvested stormwater runoff and reticulated recycled water should be used wherever possible as the primary irrigation water source with potable (town) water as a backup.
- Irrigation rates guided by local best practice for species and soil profile determined by an appropriately qualified person such as arborist, terrestrial ecologist, landscape architect or irrigation consultant.
- Over-irrigation does not always mean more urban cooling, can be detrimental to tree/plant health, and can increase humidity in hot humid climates leading to reduced human thermal comfort.
- A smart irrigation system which relies on rain and/or soil moisture sensors and night scheduling provides the most efficient irrigation management and avoids over or under watering.
- Drip irrigation lines (above or sub-surface) are preferred.

Evidence Requirements

Engineering and landscape plans detailing the source(s) of secure water for landscape irrigation and showing irrigation infrastructure, watering regime (scheduling ad application rates) and the area of passively irrigated landscape as % of gross landscape area (excluding turf areas, sports fields, and undisturbed natural areas).

Written agreement is provided with the future asset manager confirming a commitment to continuation of the park irrigation regime after asset handover.

Science Rationale

- As cities increasingly experience hot weather events, it is important to ensure green spaces and tree canopies are receiving sufficient water to continue to thrive (44).
- Vegetation that is water stressed has higher surface temperatures than irrigated vegetation; inadequate irrigation will lead to reduced plant transpiration (and subsequent cooling) when it is most required (31).
- Research (59) shows on hot summer days, un-shaded and un-irrigated / browned-off turf can potentially reach land surface temperatures (LST) equivalent to asphalt roads and dark roofs, whereas irrigated turf can be 20˚C cooler.

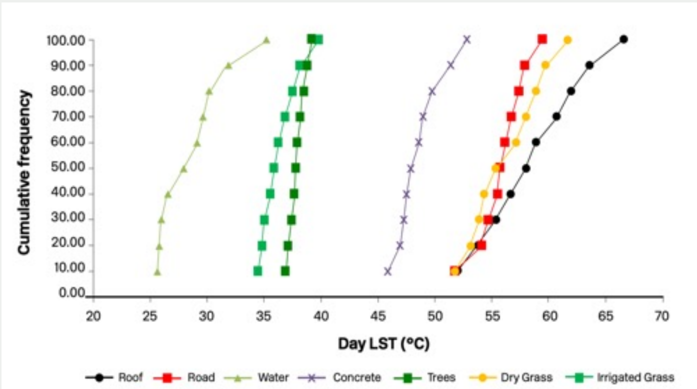

Figure CP2-1 Designing for a cool city—Guidelines for passively irrigated landscapes. Melbourne, Victoria: Cooperative Research Centre for Water Sensitive Cities). (Source: Cooperative Research Centre for Water Sensitive Cities (2020)).

- An investigation of the impact of irrigation on urban cooling for the suburb of Mawson Lakes in Adelaide showed during a heatwave event a 10% increase in irrigated pervious cover led to a 0.25˚C reduction in daily average temperature (38). The amount of cooling tapers off at high irrigated pervious covers and/or high levels of irrigation as the maximum amount of cooling is reached.

Related Credits

UD6 — Water Sensitive Urban Design

CP1 — Shade

INV1 — New Technologies

Cool Suburbs Assessment NSW — Rationale Document

CP3: Cool and/or Porous Pavements

3 DEFAULT CREDIT POINTS

Outcome

Cool and/or porous pavements reduce local surface temperatures and local air temperatures and enhance Human Thermal Comfort.

Criteria

Cool pavements with an initial Solar Reflectance (SR) > 50% or porous pavements, or a combination of both applied to > 75% of total park hard surfaces.

Guidance

There are a range of strategies for designing park hardscapes that reduce urban heat impacts, including:

- Use of 'cool materials' — those that are more reflective and store less heat.
- Use of lighter pigments in mixing asphalts, concretes and pavers can increase solar reflectance by 30%.
- Incorporating a thin coating of a reflective layer to assist in the reflectance of the material. This must be considerate human comfort - its use can lead to glare some and thermal discomfort for park users and pedestrians at times of peak day-time sunlight.
- Choosing materials with a low emissivity rating, meaning they will be less prone to embodying heat.

Permeable pavements should consider the following in their design:

- Permeable paving allows for the drainage, infiltration, and evaporation of water more effectively through urban surfaces, which can be achieved via the use of non-traditional pavements (made from plastic, metal, or concrete) filled or interspersed with permeable materials (vegetation, gravel) laid over a permeable base.
- Maximum impact occurs when permeable pavements are designed in conjunction with the principles of cool pavements described above, namely highly reflective materials and materials less prone to storing heat.
- Foam based concrete is more permeable than traditional concrete; permeable natural resins used in place of traditional masonry binders can be adopted for low impact areas.
- Porous pavements and surface coverings adjacent to garden beds and tree plantings will enhance surface water absorption and therefore water access for these plants.

Evidence Requirements

Landscape plan specifying cool pavements (types and solar reflectance) and/or porous pavements (type, porosity, and hydraulic conductivity) and showing the coverage of cool and/or porous pavements as % of total park hard surfaces.

Asset Management Plan detailing activities and funding source for ongoing maintenance and future renewal of cool and porous pavements.

Written agreement is provided with the future asset manager confirming a commitment to continuation of Asset Management Plan after asset handover.

Science Rationale

Standard and common materials used for park hardscapes absorb heat, retain heat and radiate heat, instead of reflecting the heat and energy (46). The standard solar reflectance of concrete and other common paving materials is 25-40%. When these low solar reflectance materials are used, the surface temperatures can reach 65˚C in summer impacting the immediate ambient air temperatures significantly. Because these materials store heat, the effect of this absorption can remain long after peak direct sunlight.

More reflective materials (SR> 50%) reflect the solar radiation rather than absorbing it. High emissivity materials heat up more readily in response to external temperature changes and as such contribute more readily to the ambient air temperature than low emissivity materials (47). Emissivity is less easily modified as most common building materials have a high emissivity.

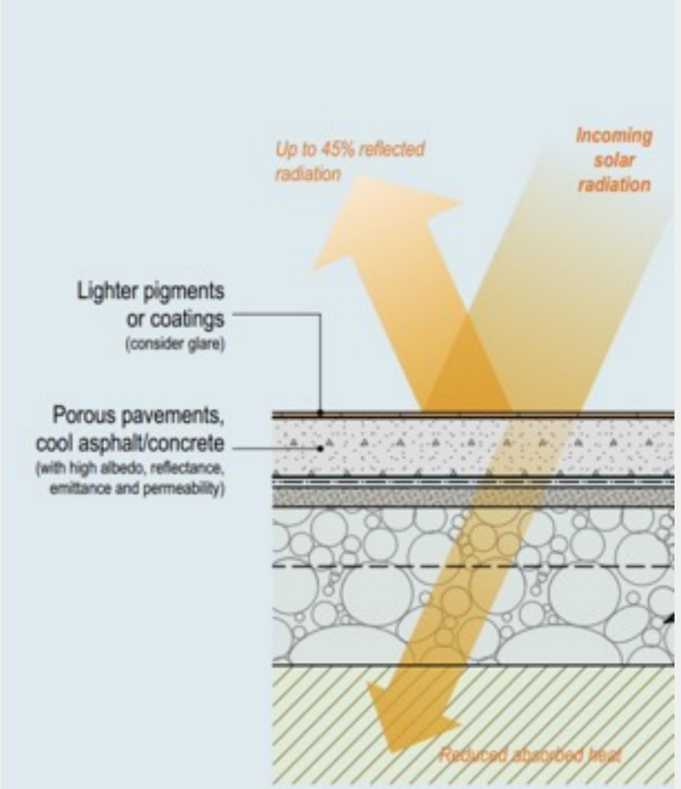

Figure CP3-1 Typical section through a cool pavement. (Source: Osmond P and Sharifi E (2017)).

Evaporative cooling from porous and permeable surfaces may decrease surface temperature by up to 20˚C. Incorporating porous surfaces in conjunction with highly reflective materials with low emissivity will reduce local temperatures, increase cooling effect in summer and reduce surface runoff. It has the additional benefit of increased soil moisture benefitting verge plantings (46).

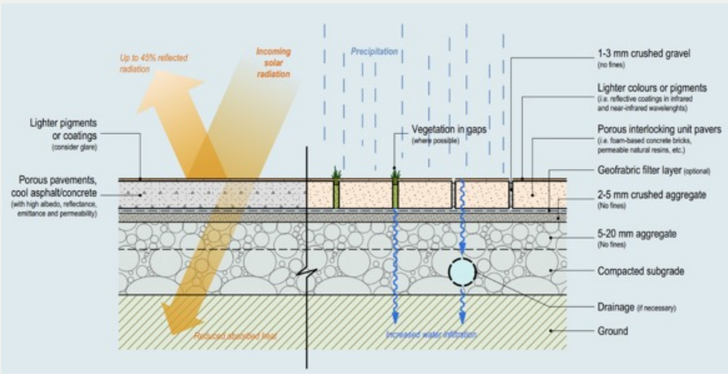

Figure CP3-2 Typical section through a porous pavement (Source: Osmond P and Sharifi E (2017)).

Related Credits

INV1 – New Technologies

Cool Suburbs Assessment NSW – Rationale Document

Cool Homes Credits

Homes that can stay within a safe temperature range are critical for human health and wellbeing. To reduce reliance on air conditioning as a cooling solution, Cool Homes Credits promote passive design principles to make homes more resilient to high outdoor temperatures and potential power outages during extreme heat.

CH1: Site Coverage

2 DEFAULT CREDIT POINTS

Outcome

Site cover provides for permeable deep soil areas for shade and evapotranspiration from site landscapes to reduce mean radiant temperatures and air temperatures and improve thermal comfort.

Criteria

Site layout provides the following minimum deep soil area (% of site area)

- Detached dwellings:
  - Lot areas up to 300m^2: 20% deep soil area (minimum dimension 3m)
  - Lot areas 300m^2 to 600m^2: 25% deep soil area (minimum dimension 3m)
  - Lot areas greater than 600m^2: 30% deep soil area (minimum dimension 3m)
- Attached dwellings:
  - Lot areas up to 150m^2: 15% deep soil area (minimum dimension 3m)
  - Lot areas 150m^2 to 300m^2: 20% deep soil area (minimum dimension 3m)
  - Lot areas greater than 300m^2: 25% deep soil area (minimum dimension 3m)
- Multi-dwelling housing:
  - Lot areas up to 1000m^2: 20% deep soil area (minimum dimension 3m)
  - Lot areas 1000m^2 to 3000m^2: 25% deep soil area (minimum dimension 3m)
  - Lot areas greater than 3000m^2: 30% deep soil area (minimum dimension 3m)
- Apartments:
  - Lot areas up to 650m^2: 10% deep soil area (minimum dimension 3m)
  - Lot areas 650m^2 to 1500m^2: 15% deep soil area (minimum dimension 3m)
  - Lot areas greater than 1500m^2: 20% deep soil area (minimum dimension 3m)

Guidance

Site layout should, where practicable, provide for deep soil areas to support tree canopy shade to the eastern and western facades of the dwelling/ building.

Site layout (across multiple lots) should seek to achieve larger contiguous private open space areas oriented to channel cooling summer winds.

Evidence Requirements

Site landscape plan showing location and extent of deep soil areas as % of total site (allotment) area.

Science Rationale

Research (36) (16) on the influence of land surface type on air temperatures shows:

- Increasing the area of green spaces and tree canopy leads to cooling.
- When provided in equal proportions, warming from hard surfaces exceeds cooling from green space.
- Open space and tree canopy cover can reduce summer night-time air temperatures.
- With reference to Figure UD4-1, effective cooling can only be achieved if the ratio of open space to hard surfaces is 2:1 or greater.

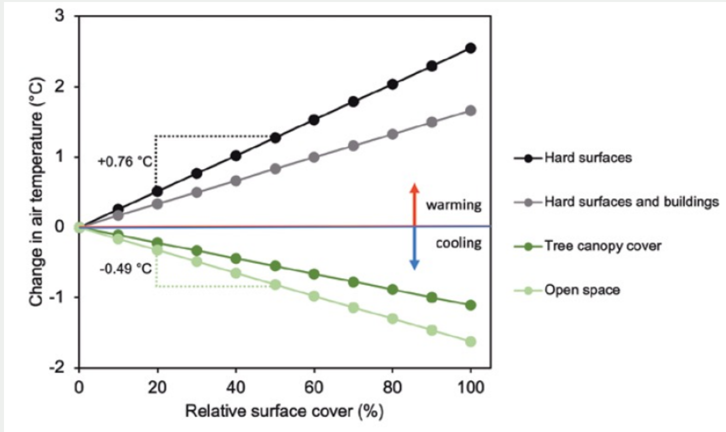

Figure CH1-1 Predicted changes in mean summer air temperature along a gradient of different surface cover types and tree canopy (Source: Pfautsch, S., Tjoelker, A R. (2020)).

Related Credits

UD1 — Wind Paths

UD5 — Water Sensitive Urban Design

CH2 — Site Shade

CH3 — Site Irrigation

CH4 — Passive Cooling

CH7 — Porous Pavements

CH2: Site Shade

3 DEFAULT CREDIT POINTS

Outcome

Shade (natural and built) moderates internal air temperatures, improves indoor and outdoor human thermal comfort and reduces the use of mechanical space conditioning and its impact on outside air temperatures.

Criteria

Passive shading of dwellings:

FAÇADE ORIENTATION	ACCEPTABLE SOLUTIONS
North	Fixed or adjustable horizontal shading above window (and extending past window on each side)
East and West	* Planting: Deciduous tree (Climate Zones 7&8), Evergreen tree (Climate Zones 2,4,5, and 6). And/or Fixed or adjustable vertical louvres or blades; deep verandas or pergolas with deciduous vines and double glazed and/or "low-e" glazed windows.
North-East and North-West	Adjustable shading or pergolas with deciduous vines to allow winter solar heating (or verandas to exclude it for Climate Zone 2) and double glazed and/or "low-e" glazed windows.
South-East and South-West	* Planting: Deciduous tree (Climate Zones 7&8), Evergreen tree (Climate Zones 2,4,5, and 6).

** Planting to achieve the minimum tree planting rates and tree canopy targets in the table following.*

DEVELOPMENT CATEGORY	TREE CANOPY TARGET (MIN % OF SITE AREA)	TREE-PLANTING RATE*
DETACHED DWELLINGS^		
Less than 300 m²	20%	For every 200 m² of site area, or part thereof at least one small tree
300 m² — 600 m²	25%	For every 250 m² of site area, or part thereof at least one medium tree
Greater than 600 m²	30%	For every 350 m² of site area, or part thereof at least 2 medium trees or one large tree
ATTACHED DWELLINGS^		
Less than 150 m²	15%	At least one small tree
150 m² — 300 m²	20%	For every 200 m² of site area, or part thereof at least one small tree
Greater than 300 m²	25%	For every 225 m² of site area, or part thereof at least one medium tree
MULTI DWELLING HOUSING^		
Less than 1,000 m²	20%	For every 300 m² of site area, or part thereof at least one medium tree
1,000m²–3,000 m²	25%	For every 200 m² of site area, or part thereof at least one medium tree
Greater than 3,000 m²	30%	For every 350 m² of site area, or part thereof at least 2 medium trees or one large tree
APARTMENTS**		
Less than 650 m²	15%	For every 350 m2 of site area or part thereof, at least one small tree is to be planted in the deep soil area
650 m² — 1,500 m²	15%	For every 350 m2 of site area or part thereof, at least one medium tree is to be planted in the deep soil area
Greater than 1,500 m2	*20%*	For every 575 m2 of site area or part thereof, at least 2 medium trees or one large tree is to be planted in the deep soil area

**The tree-planting rate: the number of trees that need to be planted within a deep soil area to achieve a set target.*

Tree size categories:

- Small tree — minimum 6m mature canopy diameter
- Medium tree — minimum 8m mature diameter
- Large tree — minimum 12m mature diameter.

^For these development types, the canopy and deep soil target are the same. In these situations, tree canopy will not cover the entire deep soil area. Proponents should meet the deep soil target as a priority and are encouraged to plant more trees than prescribed in the tree-planting rate, where possible.

Guidance

https://www.yourhome.gov.au/passive-design/shading

Shading, particularly windows and other forms of glazing, can have a significant impact on summer comfort and energy costs.

Appropriate shading designs and structures can help to block unwanted sun in summer while still allowing solar access in winter.

Shading can be fixed (for example, eaves, and evergreen trees) or adjustable (for example, external louvres, pergolas with adjustable shade cloth, blinds and deciduous trees).

On north-facing façades, the easiest shading solution is eaves that are wide enough to block high-angle sun in summer but admit low-angle sun in winter. Horizontal shade projections above glazing can also work well.

On east-and west-facing façades, vertical shade structures or deep pergolas work well, particularly if they are adjustable, allowing winter sun in when needed.

More shading is suitable for hot humid climates, and less shading may be suitable for cold temperate climates.

Trees and planted pergolas and trellises can provide good shading and can also improve cooling, air quality and visual appeal of a home.

Tree species selection to suit in-situ soil conditions and resilience to high heat stress having regard to projected future extreme heat days due to climate change (refer to Adapt NSW's Regional Climate Change Snapshot Reports for a summary of projected changes to extreme heat days, temperatures and summer rainfall in your region).

A variety of suitable tree species is preferred to increase the urban canopy roughness through different tree heights and foliage types.

Guidance on the best tree species for a given geography based on various planting factors including future climate is available on the https://www.whichplantwhere.com.au website.

Use evergreen trees for areas that will benefit from year-round shade.

Use deciduous trees where sunlight is desirable in winter.

Consideration of safety is paramount with species selected to minimise risk to public safety.

Access to deep soils supports healthy trees. Recommended minimum deep soil areas:

- Small Trees (6 metre canopy diameter at maturity): $14m^2$ in sandy loam soils; $23m^2$ in clay soils.
- Medium Trees (≥8m diameter canopy at maturity): $18m^2$ in sandy loam soils; $30m^2$ in clay soils.
- Large Trees (≥12m diameter canopy at maturity): $26m^2$ in sandy loam soils; $43m^2$ in clay soils.

The placement of trees should also consider their ability to channel breezes.

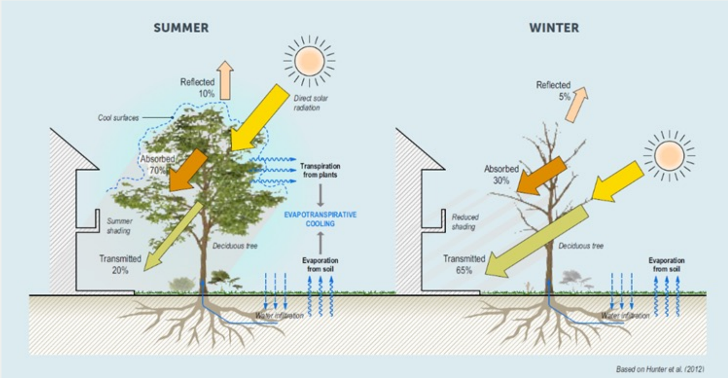

Figure CH2-1 Cooling effect of a tree in a sunny day in summer and winter (Source: Osmond P and Sharifi E (2017)).

Care should be taken when locating trees close to residential buildings if located within bushfire and/or cyclone hazard areas. In these areas an alternative shade solution should be considered.

Science Rationale

Radiant heat from the sun passes through glass and is absorbed by building elements and furnishings which then re-radiate it inside the dwelling. Re-radiated heat has a longer wavelength and cannot pass back out through the glass as easily thereby heating the air within the house.

In most climates, solar gain is desirable for passive winter heating but must be avoided in summer.

Shading glass is the best way to reduce unwanted heat gain, as unprotected glass is often the greatest source of heat entering a home.

Shading uninsulated and dark-coloured walls can also reduce the heat load on a building. However, fixed shading that is inappropriately designed can block beneficial winter sun.

Tree canopy shade reduces the amount of heat absorbed by surfaces during the day, which in turn results in cooler air temperatures at the beginning of the night and less emission of heat during the night (36). In hot dry climates this effect is relatively large, and it is at night when the cooling benefits of tree canopy shade on ambient air temperature become most apparent.

Trees that are water stressed will lead to reduced plant transpiration and reduced cooling potential (31).

Related Credits

CH1 — Site Coverage

CH3 — Site Irrigation

CH4 — Passive Cooling

Cool Suburbs Assessment NSW — Rationale Document

CH3: Site Irrigation

2 DEFAULT CREDIT POINTS

Outcome

Irrigated site landscapes reduce local surface temperatures, cool local air temperatures, and improve local thermal comfort.

Criteria

A secure water supply is provided for irrigating site landscapes commensurate with seasonal water requirements determined from local site conditions.

Guidance

- An alternative water source such as passive irrigation (59) (75), harvested roofwater or reticulated recycled water should be used wherever possible as the primary irrigation water source with potable (town) water as a backup.
- Irrigation rates guided by local best practice for species and soil profile determined by an appropriately qualified person such as arborist, terrestrial ecologist, landscape architect or irrigation consultant.
- A smart irrigation system which relies on rain and/or soil moisture sensors and night scheduling provides the most efficient irrigation management and avoids over or under watering.
- Drip irrigation lines (above or sub-surface) are preferred.

Evidence Requirements

A site landscape water management plan which achieves water efficiencies and supports the continued achievement of objectives outlined in CH2.

Science Rationale

- As cities increasingly experience hot weather events, it is important to ensure green spaces and tree canopies are receiving sufficient water to continue to thrive (44).
- Vegetation that is water stressed has higher surface temperatures than irrigated vegetation; inadequate irrigation will lead to reduced plant transpiration (and subsequent cooling) when it is most required (31).
- Research (59) shows on hot summer days, un-shaded and un-irrigated / browned-off turf can potentially reach land surface temperatures (LST) equivalent to asphalt roads and dark roofs, whereas irrigated turf can be 20˚C cooler.

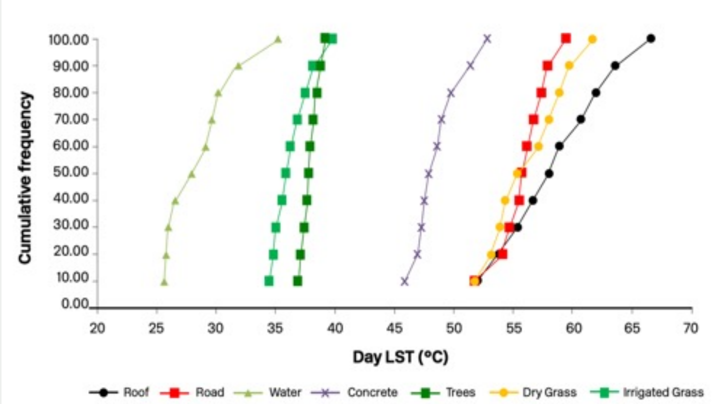

Figure CH3-1 Designing for a cool city—Guidelines for passively irrigated landscapes. Melbourne, Victoria: Cooperative Research Centre for Water Sensitive Cities). (Source: Cooperative Research Centre for Water Sensitive Cities (2020))

- An investigation of the impact of irrigation on urban cooling for the suburb of Mawson Lakes in Adelaide showed during a heatwave event a 10% increase in irrigated pervious cover led to a 0.25˚C reduction in daily average temperature (38). The amount of cooling tapers off at high irrigated pervious covers and/or high levels of irrigation as the maximum amount of cooling is reached.

Related Credits

UD6 — Water Sensitive Urban Design

CH1 — Site Cover

CH2 — Site Shade

CH4 — Passive Cooling

INV1 — New Technologies.

CH4: Passive Cooling

3 DEFAULT CREDIT POINTS

Outcome

Residential buildings use passive design to maintain a comfortable internal temperature thereby minimising impact on the external environment.

Criteria

Residential dwelling design incorporates:

- Cross-ventilation to all bedroom and communal living spaces (lounge / living areas)
- A "cool refuge" space being a bedroom or similar sized space located on the southern side of the dwelling and away from unshaded east or west facing facades and provided with wall and ceiling insulation to minimum NCC requirements, cross ventilation for venting heat at night and fitted with a ceiling fan.
- If the local council or building authority has an alternative more stringent criterion for a cool refuge space use that criterion in lieu of the above.

Guidance

- Homes that adopt passive design minimise their impact on their surrounding environment by reducing energy requirements in heating and cooling and by minimising their contribution to the external environment through excess heat loss/ heat production generated by mechanical cooling systems (the exhaust from an air-conditioner unit).
- Passive cooling principles require consideration of the floor plan and building form, local climate, house positioning, thermal mass considerations, appropriate materials and positioning for windows, shading, insulation, and buffer zones.
- It is important to design homes for the local environment, i.e., prevailing winds/ breezes, tree type and positioning, proximity to other dwellings and climate.
- To maximise heat loss during hot seasons, passive design considers air movement, breezes, evaporation, earth coupling and reflection of radiation. Solution should be considerate of local climatic conditions.
- Solutions may include breeze capture, access to cool night air, convective air movement, solar chimneys, evaporative cooling (i.e., from a water source), earth coupling.
- Fans should be positioned strategically to circulate cooler air and expel heated air

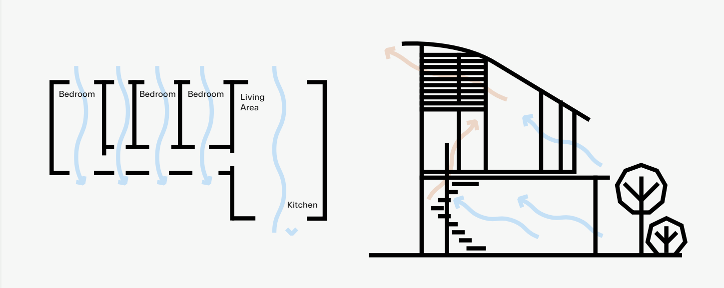

Figure CH4-1 Capturing breezes, using convection properties and solar chimneys are all effective natural cooling systems in the right climate.

Evidence Requirements

Dwelling design plans and sections showing provision for cross-ventilation and "cool refuge" space.

Science Rationale

All buildings in Australia require some cooling in warmer months (48). The type of passive cooling options available depend predominately on climate. Consideration of passive cooling should occur at the preliminary design stage as it can determine orientation, materials used, height, levels, and other significant design components.

Related Credits

All other Cool Homes Credits

Cool Suburbs Assessment NSW – Rationale Document

CH5: Cool Roof Materials

2 DEFAULT CREDIT POINTS

Outcome

Cool roof materials reflect more solar radiation and emit more heat to improve indoor thermal comfort and reduce air temperatures (night-time).

Criteria

100% of roofing materials installed have an initial Solar Reflectance Index (SRI) as follows:

- For roof pitched <45° an initial SRI > 80
- For roof pitched >45° an initial SRI > 40

Roofs that are 'downslope' from the publicly accessible places, such as in hilly areas, scenic areas or which are in view from taller adjacent buildings should avoid reflective white or very light-coloured finishes that could cause glare.

Guidance

Incorporating high reflectance and high emittance materials in the roofing design generates lower temperatures compared to dark roofing material.

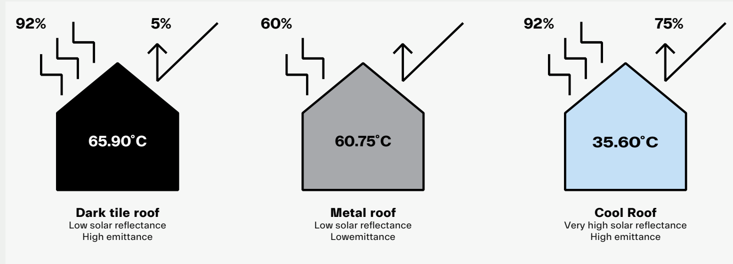

Figure CH5-1 Reflectance and emittance of different roof materials (Source: Osmond P and Sharifi E (2017)).

Evidence Requirements

Dwelling design plans and sections showing roof material specification with compliant SRI.

Science Rationale

- Building roofs make up almost 20% of the urban surfaces in Australian cities. Rooftops are generally more exposed to direct sunlight compared with other urban surfaces. Thus, during a typical sunny day, rooftops retain more heat load than other urban elements.
- Most rooftop materials are heavy and dark and therefore store significant heat. Conventional roof surfaces (with a solar reflectance of 5% to 25%) can reach a surface temperature of 65- 90°C on a typical hot summer day and cause significant stress to building occupants, cooling systems, energy infrastructure, roofing materials and urban microclimates.
- Cool roofs adopt high reflectance (>65%) and high emissivity (>85%) surfaces to deflect up to 75% of solar radiation energy. The impact of this can be 33°C cooler surface temperatures and decreased indoor temperatures (46). This can save 18-34%

energy on air-conditioning — but can require increased heating in winter months.

On a city-scale, maximum near-surface temperature decrease of 0.50°C occurred when albedo was increased from 0.50 to 0.70, or 0.25°C per 0.1 albedo increase (47).

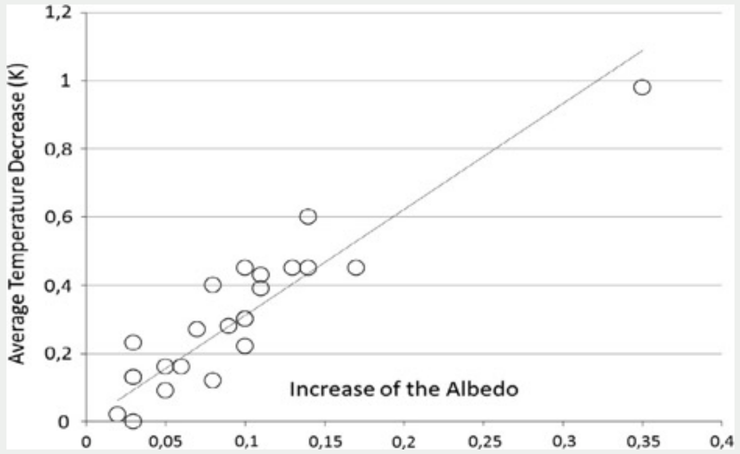

Figure CH5-2 Correlation between the possible albedo change in roof materials and the corresponding decrease of the average ambient temperature in urban areas. (Source: Santamouris M (50)).

Related Credits

CH4 — Passive Cooling

INV1 — New Technologies

Cool Suburbs Assessment NSW — Rationale Document

CH6: Cool and/or Porous Pavements

1 DEFAULT CREDIT POINTS

Outcome

Cool, porous and/or permeable pavements reduce local surface temperatures and local air temperatures and enhance Human Thermal Comfort.

Criteria

Cool pavements with an initial Solar Reflectance (SR) > 50% or porous pavements, or a combination of both applied to >50% of site landscape hard surfaces.

Guidance

There are a range of strategies for designing site landscape hard surfaces that reduce urban heat impacts, including:

- Use of 'cool materials' — those that are more reflective and store less heat.
- Use of lighter pigments in mixing asphalts, concretes and pavers can increase solar reflectance by 30%.
- Incorporating a thin coating of a reflective layer to assist in the reflectance of the material. This must be considerate human comfort - its use can lead to glare some and thermal discomfort for park users and pedestrians at times of peak daytime sunlight.
- Choosing materials with a low emissivity rating, meaning they will be less prone to embodying heat.

Permeable pavements should consider the following in their design:

- Permeable paving allows for the drainage, infiltration, and evaporation of water more effectively through urban surfaces, which can be achieved via the use of non-traditional pavements (made from plastic, metal or concrete) filled or interspersed with permeable materials (vegetation, gravel) laid over a permeable base.
- Maximum impact occurs when permeable pavements are designed in conjunction with the principles of cool pavements described above, namely highly reflective materials and materials less prone to storing heat.
- Foam based concrete is more permeable than traditional concrete; permeable natural resins used in place of traditional masonry binders can be adopted for low impact areas.
- Porous pavements and surface coverings adjacent to garden beds and tree plantings will enhance surface water absorption and therefore water access for these plants.

Evidence Requirements

Site landscape plan specifying cool pavements (types and solar reflectance) and/or porous pavements (type, porosity and hydraulic conductivity) and showing the coverage of cool and/or porous pavements as % of total site landscape hard surfaces.

Science Rationale

Standard and common materials used in pavements absorb heat, retain heat and radiate heat, instead of reflecting the heat and energy (47) (46). The standard solar reflectance of concrete and other common paving materials is 25-40%. When these low solar reflectance materials are used, the surface temperatures can reach 65˚C in summer impacting the immediate ambient air temperatures significantly. Because these materials store heat, the effect of this absorption can remain long after peak direct sunlight.

More reflective materials reflect the solar radiation rather than absorbing it. High emissivity materials reflect heat more readily in response to external temperature changes and as such result in a lower ambient air temperature than low emissivity materials. Emissivity is less easily modified as most common building materials are inherently high emissivity.

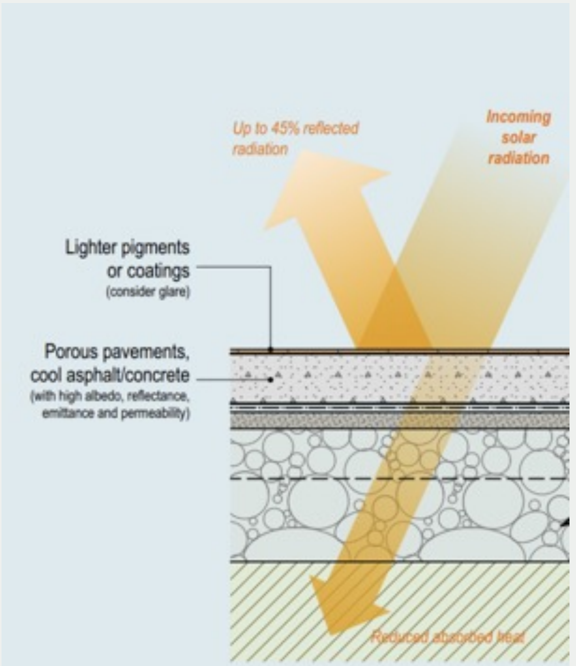

Figure CH6-1 Typical section through a cool pavement (Source: Osmond P and Sharifi E (2017)).

Evaporative cooling from porous and permeable surfaces may decrease surface temperature by up to 20˚C (46). Incorporating porous and/or permeable surfaces in conjunction with highly reflective materials with high emissivity will reduce local temperatures, increase cooling effect in summer and reduce surface runoff. It has the additional benefit of increased soil moisture benefitting adjacent garden beds.

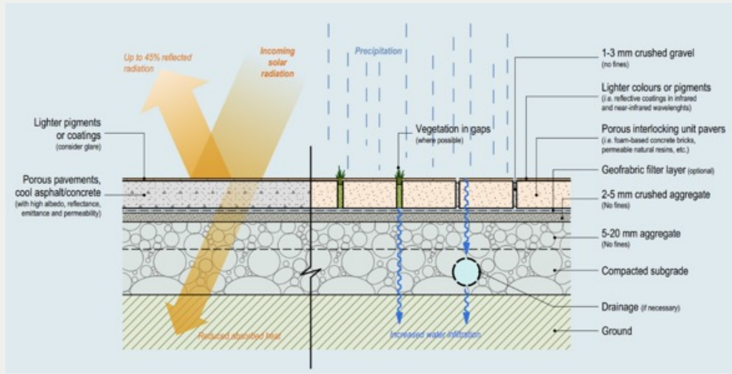

Figure CH6-2 Typical section through a porous pavement (Source: Osmond P and Sharifi E (2017)).

Related Credits

UD5 — Water Sensitive Urban Design

CH4 — Passive Cooling

CH6 — Cool and/or Porous Pavements

INV1 — New Technologies

CH7: Alternative Energy Supply

2 DEFAULT CREDIT POINTS

Outcome

The dwelling generates and stores sufficient renewable energy onsite to balance its predicted energy use over a year.

Criteria

Dwelling has installed (or designed for install) a solar PV array, inverter, and battery system with the following minimum capacity:

- Homes up to 150m: 5kW PV system
- Homes between 150m - 250m: 7.5kW PV system
- Homes between 250m - 350m: 10kW PV system

Guidance

- The solar PV system shall be designed by a Clean Energy Council accredited designer and installed by an accredited installer.
- Solar panels to be installed to face between East, through North to West orientations.
- PV array panels to be installed at roof pitch or at latitude tilt angle (or on trackers as desired).
- Design documentation to be submitted that proves the PV system is not shaded by neighbouring buildings or trees across the year.

Evidence Requirements

Dwelling design plans showing provision for compliant sized solar PV and battery storage system.

Science Rationale

Australia has the most solar coverage of any continent on earth – making solar the most plausible renewable energy source to use on a home (51). With solar panel efficiency increasing and prices decreasing dramatically, installing solar is accessible and can have a considerable impact on energy purchasing costs.

An increased reliance on air conditioning in recent years has caused a rise in peak demand (which refers to the maximum amount of electricity demanded by a location) (49). During a heatwave, the grid is under the greatest pressure due to widespread use of air conditioning systems. The increased uptake of household and business solar PV is having a positive reduction effect on the instances of blackouts during heatwaves; however, batteries are required to maintain the load post peak solar radiation. Without renewable storage options, the peak demand is simply delayed until later in the day when solar radiation is reduced but cooling is still required.

Related Credits

CH4 – Passive Cooling

CH5 – Cool roofs materials

INV1 – New Technologies

Cool Suburbs Assessment NSW – Rationale Document

Cool Buildings Credits

Cool buildings focus on workplaces, community hubs and places of worship where people can gather for shelter from very hot conditions. As with Cool Homes, Cool Buildings Credits promote passive design principles to make buildings more resilient to high outdoor temperatures and potential power outages during extreme heat.

CB1: Site Coverage

2 DEFAULT CREDIT POINTS

Outcome

Site cover provides for permeable deep soil areas for shade and evapotranspiration from site landscapes to reduce mean radiant temperatures and air temperatures and improve thermal comfort.

Criteria

> 20% of site (allotment) area provided as deep soil area (3m minimum dimension)

Guidance

Site layout should, where practicable, provide for deep soil areas to support tree canopy shade to the eastern and western facades of the /building and to ground surface hardstand areas.

Evidence Requirements

Site landscape plan showing location and extent of deep soil areas as % of total site (allotment) area.

Science Rationale

Research (36) (16) on the influence of land surface type on air temperatures shows:

- Increasing the area of green spaces and tree canopy leads to cooling.
- When provided in equal proportions, warming from hard surfaces exceeds cooling from green space.
- Open space and tree canopy cover can reduce summer night-time air temperatures.
- With reference to Figure UD4-1, effective cooling can only be achieved if the ratio of open space to hard surfaces is 2:1 or greater.

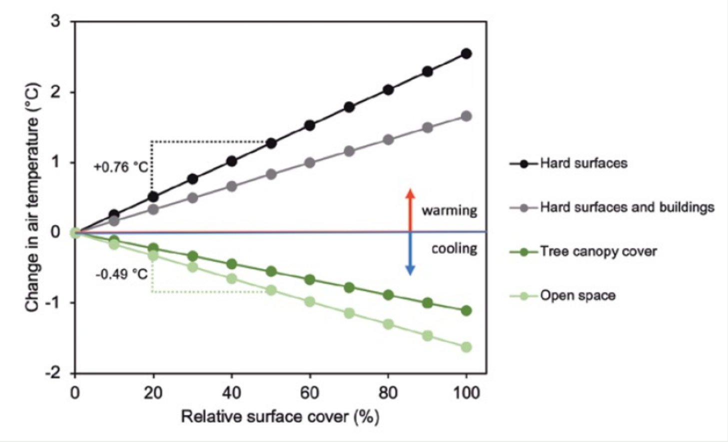

Figure CB1-1 Predicted changes in mean summer air temperature along a gradient of different surface cover types and tree canopy (Source: Pfautsch, S., Tjoelker, A R. (2020)).

Related Credits

UD1 – Wind Paths

UD5 – Water Sensitive Urban Design

CB2 – Site Shade

CB3 – Site Irrigation

CB4 – Passive Design

CB7 – Porous Pavements

Cool Suburbs Assessment NSW – Rationale Document

CB2: Site Shade

3 DEFAULT CREDIT POINTS

Outcome

Shade (natural and built) moderates internal air temperatures, improves indoor and outdoor human thermal comfort and reduces the use of mechanical space conditioning and its impact on outside air temperatures.

Criteria

Fixed and/or adjustable external shading devices installed to all external windows and openings (other than south facing) to achieve > 80% restriction of average daily summer solar radiation on external glazing / openings.

And

Site tree canopy cover (at maturity) > 25% of site (allotment) area.

And

Shade cover (measured in plan) to > 50% of external on-grade hard stand areas.

Guidance

- Shading, particularly windows and other forms of glazing, can have a significant impact on summer comfort and energy costs.
- Appropriate shading designs and structures can help to block unwanted sun in summer while still allowing solar access in winter.
- Shading can be fixed (for example, eaves, and evergreen trees) or adjustable (for example, external louvres, pergolas with adjustable shade cloth, external blinds and deciduous trees).
- On north-facing façades, the easiest shading solution is horizontal overhangs/eaves over windows that are wide enough to block high-angle sun in summer but admit low-angle sun in winter. Horizontal shade projections above glazing can also work well.
- On east-and west-facing façades, vertical shade structures work well, particularly if they are adjustable, allowing winter sun in when needed.
- More shading is suitable for hot humid climates, and less shading may be suitable for cold temperate climates.
- If installing shade sails as part of built shade solutions, make sure to choose fabric that has a UV Effectiveness (UVE) rating of 80% or more.
- A test if shade is high quality or not on a clear day is the amount of blue sky you can see (sky view factor) while underneath it. The less blue sky you can see, the better protection from solar UV radiation.
- Trees and planted pergolas and trellises can provide good shading and can also improve indoor and outdoor cooling, air quality and visual appeal

of the building.

- Tree species selection to suit in-situ soil conditions and resilience to high heat stress having regard to projected future extreme heat days due to climate change (refer to Adapt NSW's Regional Climate Change Snapshot Reports for a summary of projected changes to extreme heat days, temperatures and summer rainfall in your region).
- Guidance on the best tree species for a given geography based on various planting factors including future climate is available on the https://www.whichplantwhere.com.au website.
- The placement of trees should also consider their ability to channel breezes.
- A variety of suitable tree species is preferred to increase the urban canopy roughness through different tree heights and foliage types.
- Deciduous trees should be used where sunlight is desirable in winter; evergreen trees should be used where year-round shade is preferable.
- Access to deep soils supports healthy trees. Recommended minimum deep soil areas:
  - Small Trees (6 metre canopy diameter at maturity): 14m^2 in sandy loam soils; 23m^2 in clay soils.
  - Medium Trees (8m diameter canopy at maturity): 18m^2 in sandy loam soils; 30m^2 in clay soils.
  - Large Trees (12m diameter canopy at maturity): 26m^2 in sandy loam soils; 43m^2 in clay soils.
- Care should be taken when locating trees close to buildings if located within bushfire and/or cyclone hazard areas. In these areas an alternative shade solution should be considered.

Evidence Requirements

Site plans and sections showing shade solutions and site tree canopy cover at maturity (as % of site area).

Science Rationale

Radiant heat from the sun passes through glass and is absorbed by building elements and furnishings which then re-radiate it inside the dwelling. Re-radiated heat has a longer wavelength and cannot pass back out through the glass as easily thereby heating the air within the house.

In most climates, solar gain is desirable for passive winter heating but must be avoided in summer.

Shading glass is the best way to reduce unwanted heat gain, as unprotected glass is often the greatest source of heat entering a home.

Shading uninsulated and dark-coloured walls can also reduce the heat load on a building. However, fixed shading that is inappropriately designed can block beneficial winter sun.

Tree canopy shade reduces the amount of heat absorbed by surfaces during the day, which in turn results in cooler air temperatures at the beginning of the night and less emission of heat during the night (36). In hot dry climates this effect is relatively large, and it is at night when the cooling benefits of tree canopy shade on ambient air temperature become most apparent.

Trees that are water stressed will lead to reduced plant transpiration and reduced cooling potential (31).

Related Credits

CB1 – Site Coverage

CB3 – Site Irrigation

CB4 – Passive Design

CB5 – Cool roofs, green roofs and green walls.

Cool Suburbs Assessment NSW – Rationale Document

CB3: Site Irrigation

1 DEFAULT CREDIT POINTS

Outcome

Irrigated site landscapes reduce local surface temperatures, cool local air temperatures, and improve local thermal comfort.

Criteria

A secure water supply is provided for irrigating site landscapes commensurate with seasonal water requirements determined from local site conditions.

Guidance

- An alternative water source such as passive irrigation (59) (75), harvested roofwater or reticulated recycled water should be used wherever possible as the primary irrigation water source with potable (town) water as a backup.
- Irrigation rates guided by local best practice for species and soil profile determined by an appropriately qualified person such as arborist, terrestrial ecologist, landscape architect or irrigation consultant.
- A smart irrigation system which relies on rain and/or soil moisture sensors and night scheduling provides the most efficient irrigation management and avoids over or under watering.
- Drip irrigation lines (above or sub-surface) are preferred.

Evidence Requirements

A site landscape water management plan which achieves water efficiencies and supports the continued achievement of objectives outlined in CB2.

Science Rationale

- As cities increasingly experience hot weather events, it is important to ensure green spaces and tree canopies are receiving sufficient water to continue to thrive (44).
- Vegetation that is water stressed has higher surface temperatures than irrigated vegetation; inadequate irrigation will lead to reduced plant transpiration (and subsequent cooling) when it is most required (31).
- Research (59) shows on hot summer days, un-shaded and un-irrigated / browned-off turf can potentially reach land surface temperatures (LST) equivalent to asphalt roads and dark roofs, whereas irrigated turf can be 20˚C cooler.

Cool Suburbs Assessment NSW – Rationale Document

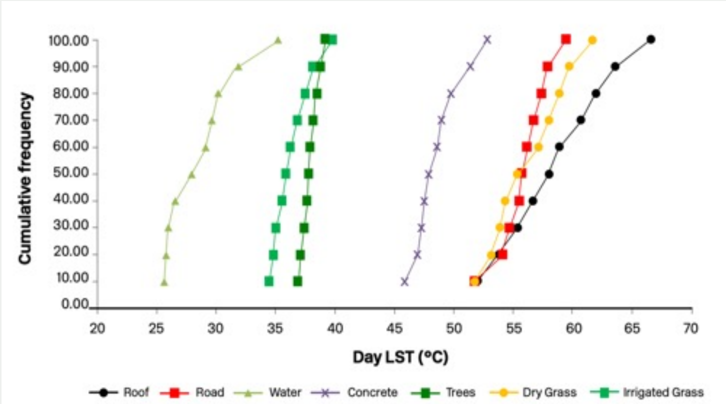

Figure CB3-1 Designing for a cool city–Guidelines for passively irrigated landscapes. Melbourne, Victoria: Cooperative Research Centre for Water Sensitive Cities). (Source: Cooperative Research Centre for Water Sensitive Cities (2020)).

- An investigation of the impact of irrigation on urban cooling for the suburb of Mawson Lakes in Adelaide showed during a heatwave event a 10% increase in irrigated pervious cover led to a 0.25˚C reduction in daily average temperature (38). The amount of cooling tapers off at high irrigated pervious covers and/or high levels of irrigation as the maximum amount *of cooling is reached.*

Related Credits

UD6 — Water Sensitive Urban Design

CB1 — Site Cover

CB2 — Site Shade

CB4 — Passive Cooling

INV1 — New Technologies

CB4: Passive Design

3 DEFAULT CREDIT POINTS

Outcome

Buildings use passive design to maintain a comfortable internal temperature thereby minimising impact on the external environment.

Criteria

Building design incorporates:

- Cross-ventilation to all habitable workspaces
- A "cool refuge" space being a bedroom sized space located on the southern side of the building and away from unshaded east or west facing facades and provided with wall and ceiling insulation to minimum NCC requirements, cross ventilation for venting heat and fitted with a ceiling fan.

Guidance

- Buildings that adopt passive design minimise their impact on their surrounding environment by reducing energy requirements in heating and cooling and by minimising their contribution to the external environment through excess heat loss/ heat production generated by mechanical cooling systems (the exhaust from an air-conditioner unit).
- Passive cooling principles require consideration of the floor plan and building form, local climate, building positioning and orientation, thermal mass considerations, appropriate materials and positioning for windows, shading, insulation, and buffer zones.
- It is important to design buildings for the local environment, i.e., prevailing winds/ breezes, tree type and positioning, proximity to other dwellings and climate.
- To maximise heat loss during hot seasons, passive design considers air movement, breezes, evaporation, earth coupling and reflection of radiation. Solution should be considerate of local climatic conditions.
- Solutions may include breeze capture, access to cool night air, convective air movement, solar chimneys, evaporative cooling (i.e., from a water source), earth coupling.

Evidence Requirements

Building design plans and sections showing provision for cross-ventilation and "cool refuge" space.

Science Rationale

All buildings in Australia require some cooling in warmer months (48). The type of passive cooling options available depend predominately on clim`ate. Consideration of passive cooling should occur at the preliminary design stage as it can determine orientation, materials used, height, levels, and other significant design components.

Related Credits

CB1 — Site Coverage

CB2 — Site Shade

CB5 — Cool Roofs, Green Roofs and Green Walls

CB5: Cool Roofs, Green Roofs and Green Walls

3 DEFAULT CREDIT POINTS

Outcome

Building roof and wall(s) reflect solar radiation, reduce surface temperatures and/or enhance evapotranspiration.

Criteria

100% of roofing materials with an initial Solar Reflectance Index (SRI):

- For roof pitched <45°: initial SRI > 80
- For roof pitched >45°: initial SRI > 40

Roofs that are 'downslope' from the publicly accessible places, such as in hilly areas, scenic areas or which are in view from taller adjacent buildings should avoid reflective white or very light-coloured finishes that could cause glare

Or:

An irrigated green roof to 100% of the available roof area with minimum 80% foliage cover of freely transpiring plants which does not include succulents.

And (in addition to one of the above)

A vertical garden / green wall with potted foliage covering at least 60% of the East and West facing exterior walls (unless the wall is shaded — see CB2)

Guidance

Cool Roofs:

- Incorporating high reflectance and high emittance materials in the roofing design generates lower temperatures compared to dark roofing material.

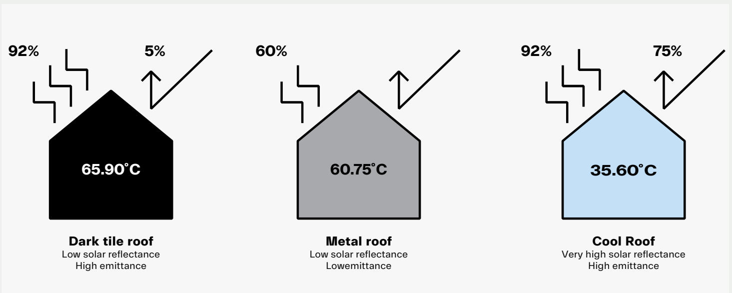

Figure CB5-1 Reflectance and emittance of different roof materials (Source: Osmond P and Sharifi E (2017)).

- Solar glare causing discomfort is not as critical an issue for rooftops compared to high reflectance materials at ground surface which can impact people using a given area.

Green Roofs:

- Green roofs must have a drought resilient irrigation supply (rainwater, recycled water).
- Green roofs must be properly designed to ensure building integrity is not compromised by the additional weight.

Green Walls:

- Green walls lower the ambient air temperature by a) enabling evapotranspiration and b) cooling the air that passes between the support system and the building wall.
- Green walls or vertical gardens are distinct from a green façade as they feature multiple plantings across a wall, whereas a green façade will generally feature a small number of vines/creeper root systems spreading a thin covering over a wall. Green facades are not eligible for this credit.
- Green walls must be carefully designed in consideration of sunlight, (drought resilient) irrigation, plant type(s) and fertilisation.
- Green walls can provide a visually pleasing aspect to a building and improve the human experience in an urban setting.

This credit only applies to green walls (plant-trough based or wall bound), not ground based (façade). Source: https://efb-greenroof.eu/green-wall-basics/

Evidence Requirements

Building design plans and sections showing design specifications for cool roof materials or green roof and green wall.

Science Rationale

- Conventional roof surfaces (with a solar reflectance of 5% to 25%) can reach a surface temperature of 50-90°C on a typical hot summer day and cause significant stress to building occupants, cooling systems, energy infrastructures, roofing materials and urban microclimates (46).
- Cool roofs adopt high reflectance (>0.65) and high emissivity (>85%) surfaces to deflect up to 75% of solar radiation energy. The impact of this can be surface temperatures 33°C cooler and decreased indoor temperatures. This can save 18-34% energy on air-conditioning — but can require increased heating in winter months.

- On a city-scale, maximum near-surface temperature decrease of 0.50˚C occurred when albedo was increased from 0.50 to 0.70, or 0.25˚C per 0.1 albedo increase (47).

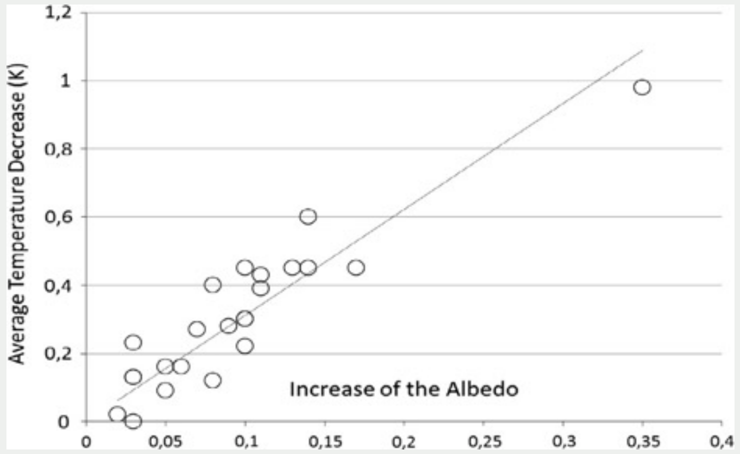

Figure CB5-1 Correlation between the possible albedo change in roof materials and the corresponding decrease of the average ambient temperature in urban areas. (Source: Santamouris M (2012))

- Green roofs and walls reduce a building's heating and cooling requirements (52). Green walls directly shade the building surface from direct light, thereby reducing heat gain, while green roofs and cool roofs reduce heat transfer through the roof and reduce ambient temperatures on the roof surface.
- Green roofs and walls facilitate evapotranspiration, providing a cooling effect.
- Green walls planted on a support system which is separated from the main wall will provide passive cooling; as the hot air moves up (by convection) between the building surface and the vegetation, it is cooled.
- Green roofs and green walls can reduce stormwater run-off and improve water quality.
- Green roofs present a relatively high heat island mitigation potential, particularly when applied at a city-wide scale; the difference between green roofs and reflective roofs is dependent on many factors, but both have a significant impact (50). A green roof and a green wall can lead to energy savings for the building of a significant magnitude.

Related Credits

CB4 — Passive Design

CB8 — Alternative Energy Supply

INV1 — New technologies

CB6: Cool and/or Porous Pavements

1 DEFAULT CREDIT POINTS

Outcome

Cool, porous and/or permeable pavements reduce local surface temperatures and local air temperatures and enhance Human Thermal Comfort.

Criteria

Cool pavements with an initial Solar Reflectance (SR) > 50% or porous pavements, or a combination of both applied to >50% of site landscape hard surfaces.

Guidance

There are a range of strategies for designing site landscape hard surfaces that reduce urban heat impacts, including:

- Use of 'cool materials' — those that are more reflective and store less heat.
- Use of lighter pigments in mixing asphalts, concretes and pavers can increase solar reflectance by 30%.
- Incorporating a thin coating of a reflective layer to assist in the reflectance of the material. This must be considerate human comfort - its use can lead to glare some and thermal discomfort for park users and pedestrians at times of peak daytime sunlight.
- Choosing materials with a low emissivity rating, meaning they will be less prone to embodying heat.

Permeable pavements should consider the following in their design:

- Permeable paving allows for the drainage, infiltration, and evaporation of water more effectively through urban surfaces, which can be achieved via the use of non-traditional pavements (made from plastic, metal, or concrete) filled or interspersed with permeable materials (vegetation, gravel) laid over a permeable base.
- Maximum impact occurs when permeable pavements are designed in conjunction with the principles of cool pavements described above, namely highly reflective materials and materials less prone to storing heat.
- Foam based concrete is more permeable than traditional concrete; permeable natural resins used in place of traditional masonry binders can be adopted for low impact areas.
- Porous pavements and surface coverings adjacent to garden beds and tree plantings will enhance surface water absorption and therefore water access for these plants.

Evidence Requirements

Site landscape plan specifying cool pavements (types and solar reflectance) and/or porous pavements (type, porosity, and hydraulic conductivity) and showing the coverage of cool and/or porous pavements as % of total site landscape hard surfaces.

Science Rationale

Standard and common materials used in pavements absorb heat, retain heat and radiate heat, instead of reflecting the heat and energy (47) (46). The standard solar reflectance of concrete and other common paving materials is 25-40%. When these low solar reflectance materials are used, the surface temperatures can reach 65˚C in summer impacting the immediate ambient air temperatures significantly. Because these materials store heat, the effect of this absorption can remain long after peak direct sunlight.

More reflective materials reflect the solar radiation rather than absorbing it. High emissivity materials reflect heat more readily in response to external temperature changes and as such result in a lower ambient air temperature than low emissivity materials. Emissivity is less easily modified as most common building materials are inherently high emissivity.

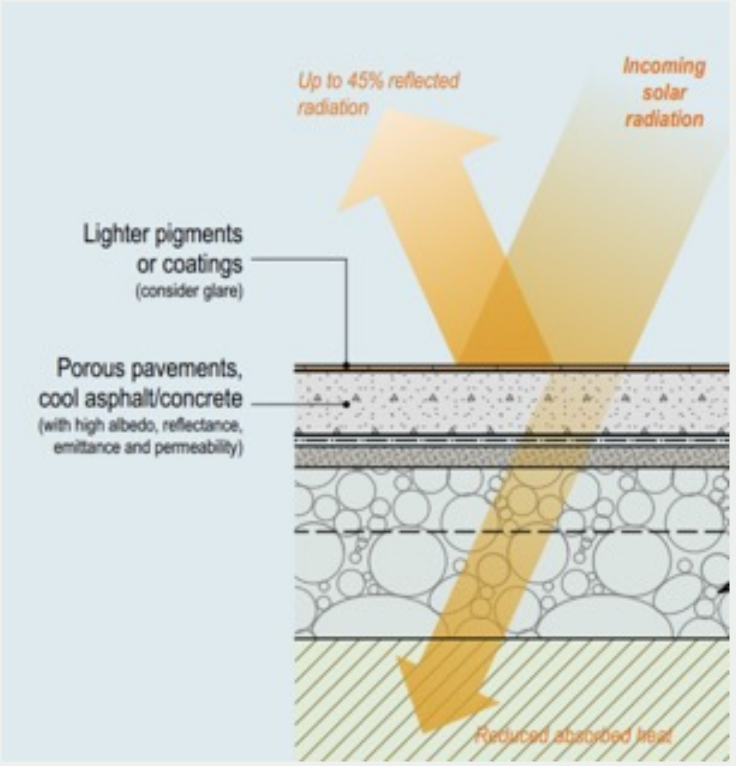

Figure CB6-1 Typical section through a cool pavement (Source: Osmond P and Sharifi E (2017)).

Cool Suburbs Assessment NSW – Rationale Document

Evaporative cooling from porous and permeable surfaces may decrease surface temperature by up to 20˚C (46). Incorporating porous and/or permeable surfaces in conjunction with highly reflective materials with high emissivity will reduce local temperatures, increase cooling effect in summer and reduce surface runoff. It has the additional benefit of increased soil moisture benefitting adjacent garden beds.

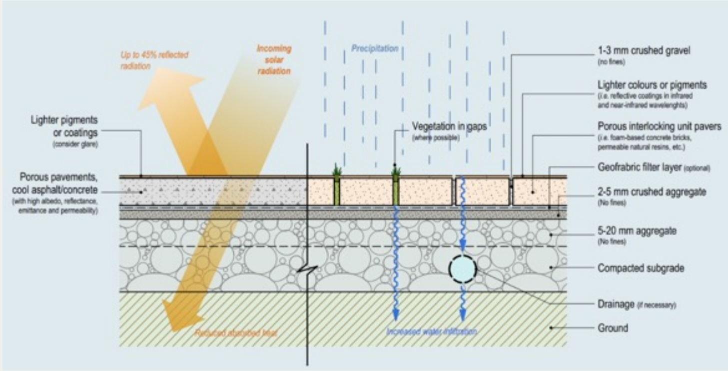

Figure CB6-2 Typical section through a porous pavement (Source: Osmond P and Sharifi E (2017)).

Related Credits

CB1 – Site Coverage

CB3 – Site Irrigation

CB5 – Cool Roofs and Green Roofs and Green Walls

CB6 – Cool and/or Porous Pavements

INV1 – New Technologies

CB7: Alternative Energy Supply

2 DEFAULT CREDIT POINTS

Outcome

The building uses or generates enough renewable energy onsite to balance its predicted energy use over a year.

Criteria

The building has installed (or designed for install) a solar PV array, inverter and battery system of sufficiently capacity to provide enough renewable energy to balance its predicted energy use over a year.

If the building cannot support a sufficiently large system, a supply contract is in place to facilitate the purchase of off-site renewables-sourced electricity, in addition to an onsite backup solution.

This credit cannot be obtained if 100% of electricity is being supplied from an external source — there must be demonstrated capacity to store electricity onsite with an appropriately sized battery system or a back-up generator system, to avoid loss of power (and capacity to cool the building) during an outage or grid failure.

Guidance

- This credit is designed to reduce GHG emissions in cities and to establish buildings which are energy-secure during power outages.
- The PV system shall be designed by a Clean Energy Council accredited designer and installed by an accredited installer.
- Solar panels to be installed to face between East, through North to West orientations.
- PV array panels to be installed at roof pitch or at latitude tilt angle (or on trackers as desired).

Evidence Requirements

Building design plans showing provision for compliant sized solar PV and battery storage system.

Documentation that proves the PV system is not shaded by neighbouring buildings or trees across the year.

Evidence of supply contract for any purchased off-site renewables-sourced electricity.

Science Rationale

- Australia has the most solar coverage of any continent on earth — making solar the most plausible renewable energy source to use on a home (51). With solar panel efficiency increasing and prices decreasing dramatically, installing solar is accessible and can have a considerable impact on energy purchasing costs.
- Electricity accounts for about 53% of the energy used in Australian households but contributes 87% of total household GHG emissions (48).

- An increased reliance on air conditioning in recent years has caused a rise in peak demand — the maximum amount of electricity demanded by a location (state/ region/ neighbourhood) (49).
- During a heatwave (three or more consecutive days of unusually high temperatures) the grid is under the greatest pressure.
- Increasing uptake of household and business solar PV is having a positive reduction effect on the instances of blackouts during heatwaves, however batteries are required to maintain the load post peak solar radiation — without renewable storage options, the peak demand is simply delayed until later in the day

Related Credits

GB4 — Passive Cooling

GB5 — Cool Roofs, Green Roofs & Green Walls

Innovative New Technology

Innovative New Technologies Credits recognise developments that advance urban heat performance through use of new technologies. These Credits allow a development to achieve the highest Cool Suburbs rating, if all other Credit have been satisfied.

INV1: New Technologies

5 DEFAULT CREDIT POINTS

Outcome

Demonstration of innovative new urban cooling technologies as "proof of concept."

Criteria

Partnership with a university or research institution to test within the development an innovative new urban cooling technology as "proof of concept".

Guidance

This Credit rewards development that commits to advancing development of new technologies for urban cooling by partnering with universities in the development and testing of such new technologies and providing real world applications as demonstrations to facilitate evidence gathering for proof of concept and industry knowledge exchange.

Evidence Requirements

Documentation proving the partnership with a university or research institution to develop and test innovative new urban cooling technologies at "proof of concept" stage.

Science Rationale

N/A

INV2: Data Collection and Analytics

5 DEFAULT CREDIT POINTS

Outcome

A network of temperature sensors and data loggers providing continuous near surface (2m) air temperature data which is analysed and provided in near real time to citizens to inform individual and community decisions and behaviours that enhance resilience to urban heat.

Criteria

The development has installed a network of temperature sensors and data loggers providing continuous near surface (i.e., 2m) air temperature data.

And;

The data collected is made available to community members and other key stakeholders.

Guidance

This Credit rewards development that commits to precinct scale data collection and analysis to build the evidence base for urban cooling outcomes realised from portfolios of urban cooling interventions employed at different scales within the development.

An example of a sensor network would consist of continuous air temperature sensors/loggers deployed and maintained:

- Along all streets at a minimum of 1/100m of street verge length (evenly spaced) and on both sides of the street
- Within allotment rear yards at min 1/100m of street block long axis (evenly spaced)
- Within open space (parks) at minimum 5/ha and positioned to cover the range of use areas
- Within carparks at minimum 2/ha and positioned to cover shaded and unshaded areas

Evidence Requirements

Technical report(s) demonstrating compliance with the Credit Criteria.

Science Rationale

N/A

Cool Suburbs Assessment NSW – Rationale Document

B

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A list of cited references in the Cool Suburbs Assessment Science Rationale.

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Cool Suburbs Assessment

About WSROC

The Western Sydney Regional Organisation of Councils' (WSROC) mission is to build collaboration between local governments across Greater Western Sydney, promoting Western Sydney, its people, and places, through advocacy, business improvement, strategic leadership, research, and partnerships.

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