Attachment 6
to
Item 2

Urban Heat Planning Toolkit

Date of meeting: 22 April 2022
Location: Council Chambers
Time: 6:30 p.m.

URBAN HEAT PLANNING TOOLKIT

2021

WSROC

TURN DOWN THE HEAT

The need for this toolkit was identified as a priority action under the *Turn Down the Heat Strategy and Action Plan (2018)*. The Turn Down the Heat Strategy was developed by 55 organisations working together to create cooler, more resilient communities.

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. WSROC has facilitated the development of this toolkit.

The toolkit has been developed by Civille in collaboration with the University of New South Wales, Atelier Ten and the University of Adelaide, and has been published by WSROC with assistance and support from a range of organisations and individuals.

WSROC would like to particularly acknowledge the support of the project delivery group, consisting of: Blacktown City Council, Cumberland City Council, Hawkesbury City Council, Liverpool City Council and the City of Parramatta Council.

This project has been assisted by the New South Wales Government and supported by Local Government NSW.

If you are looking for more information about this toolkit, please contact WSROC.

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DOCUMENT HISTORY AND STATUS

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B	Draft to project working group + workshop participants	25 September 2020	AMcA
C	Final draft for stakeholder comment	27 November 2020	AMcA, PO
D	Preliminary final for WSROC check	18 February 2021	AMcA
E	Final issue	19 March 2021	AMcA

DISCLAIMER

WSROC acknowledges Aboriginal and Torres Strait Islander peoples as the traditional custodians of the lands and waters of this place we now call Metropolitan Sydney. We pay our respect to Elders past, present and future of the Eora, Dharawal (Tharawal), Gundungurra, Dharug (Darug) and Guringai (Kuring-gai) peoples.

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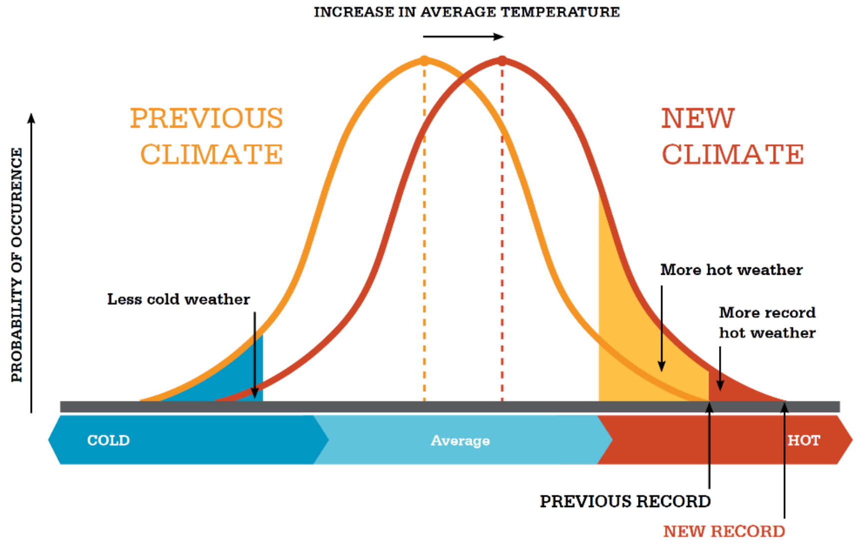
EXECUTIVE SUMMARY

Urban heat and heatwaves are significant and growing issues for Western Sydney. This toolkit has been developed to help local government strengthen their planning provisions to reduce the impacts of heat.



As the climate changes, Western Sydney is experiencing an increasing number of hot days and heatwaves. This chart, from the Climate Council (2013) shows how, as the climate warms, there will be significantly more hot weather and heatwaves.

Cities tend to be hotter than surrounding rural areas, (known as the urban heat island effect, UHI). **Western Sydney is particularly exposed to heat** due to:

- Sydney's geography and weather patterns intensify the UHI effect in the west, due to the prevalence of hot westerly winds and lack of cooling sea breezes.
- Western Sydney is urbanising rapidly, with an associated increase in hard surfaces and decrease in vegetation cover.
- This has the potential to exacerbate the urban heat island effect and worsen the local impacts of heat.

Western Sydney's heat challenge is widely recognised, and **Sydney's District Plans establish three key priorities related to urban heat** (Greater Sydney Commission, 2018 b, c):

1. Adapting to the impacts of urban and natural hazards and climate change
2. Reducing carbon emissions and managing energy, water and waste efficiently
3. Increasing urban tree canopy cover and delivering Green Grid connections.

WSROC's *Turn Down the Heat Strategy* (2018) includes an action to develop "Land use and design controls that prioritise resilience". This action includes three steps:

1. Develop a heat related State Environmental Planning Policy (SEPP), or modify the BASIX SEPP to address urban heat.
2. Add consistent clauses outlining urban heat standards to local Development Control Plans (DCPs) and Local Environment Plans (LEPs).
3. A systematic change to building codes and specifications to promote development that addresses and minimises UHI effects.

Urban heat has multiple interconnected impacts, including impacts on human health, urban infrastructure, the environment and the economy.

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

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

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

$6.9 billion
In lost productivity due to heat stress, annually Australia wide

Sources for each of these statistics are included on page 6

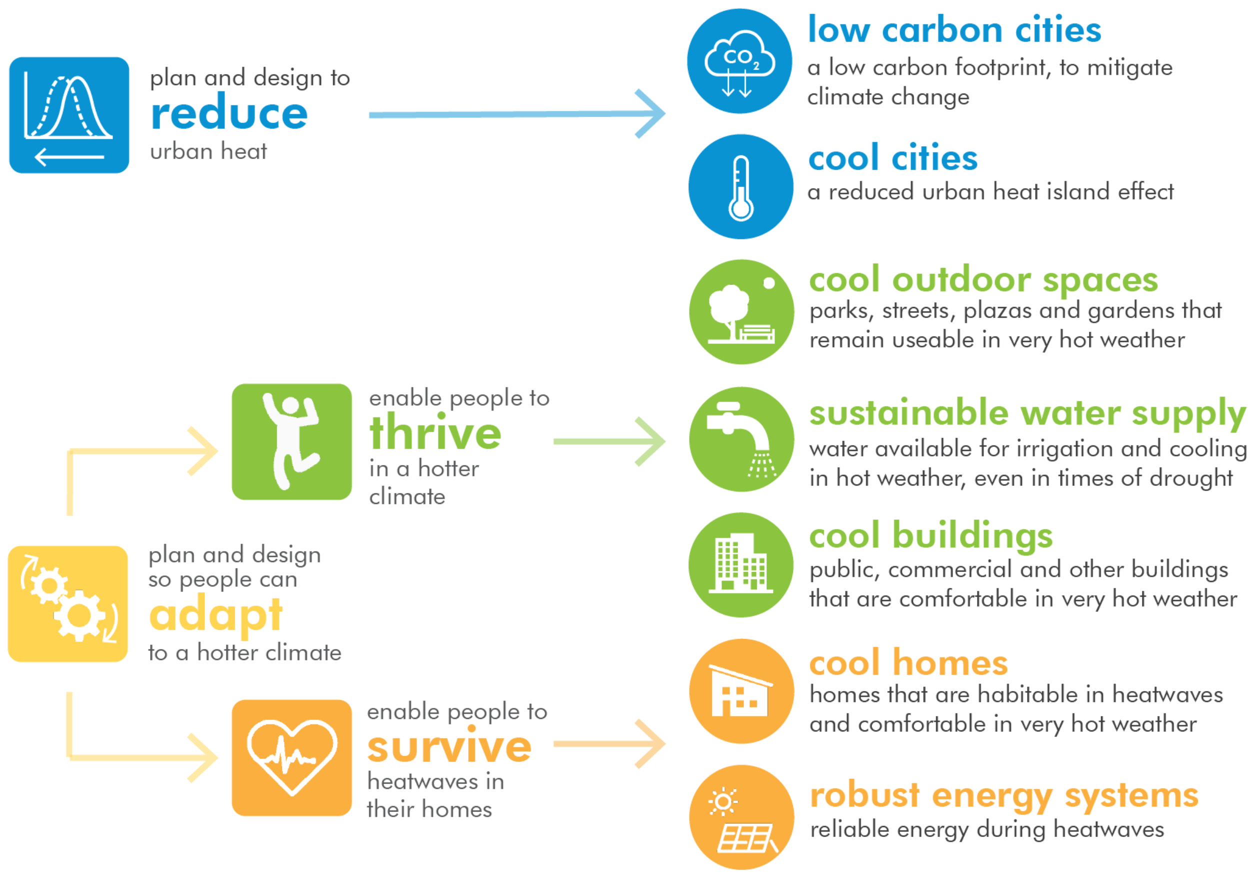
Urban heat and heatwaves can't be eliminated; we need to take a ***resilience approach****, responding with strategies that minimise the impacts of intense shocks such as heatwaves and the ongoing stress of frequent hot and very hot weather.*

Heatwaves will become more frequent and intense as our climate changes. Therefore, we need to improve the city's resilience to urban heat. A resilience approach involves not only reducing urban heat, but also helping people adapt to a hotter climate, and being prepared to respond in extreme events. It also involves recovery after such events.

This toolkit is part of a suite of projects being delivered by WSROC to improve Western Sydney's resilience to urban heat. All these projects follow a standard resilience framework, shown on the right.

This toolkit focuses on strategies that can be implemented in new development and redevelopment. Therefore, it focuses on the steps where planning and design are most relevant: **reducing** urban heat (Step 2) and helping people **adapt** to a hotter climate (Step 3). The diagram below expands on Steps 2 and 3, with adaptation broken down into two main objectives: enabling people to **thrive** in a warmer climate; and enabling people **survive** heatwaves, particularly in their homes. The toolkit identifies seven ways to address these objectives (below right).

Resilience framework for urban heat



Planning and design strategies for urban heat resilience

***Local planning provisions** are important mechanisms to influence built environment outcomes, and improved controls have the potential to reduce the impacts of urban heat. But this is also a new and complex space.*

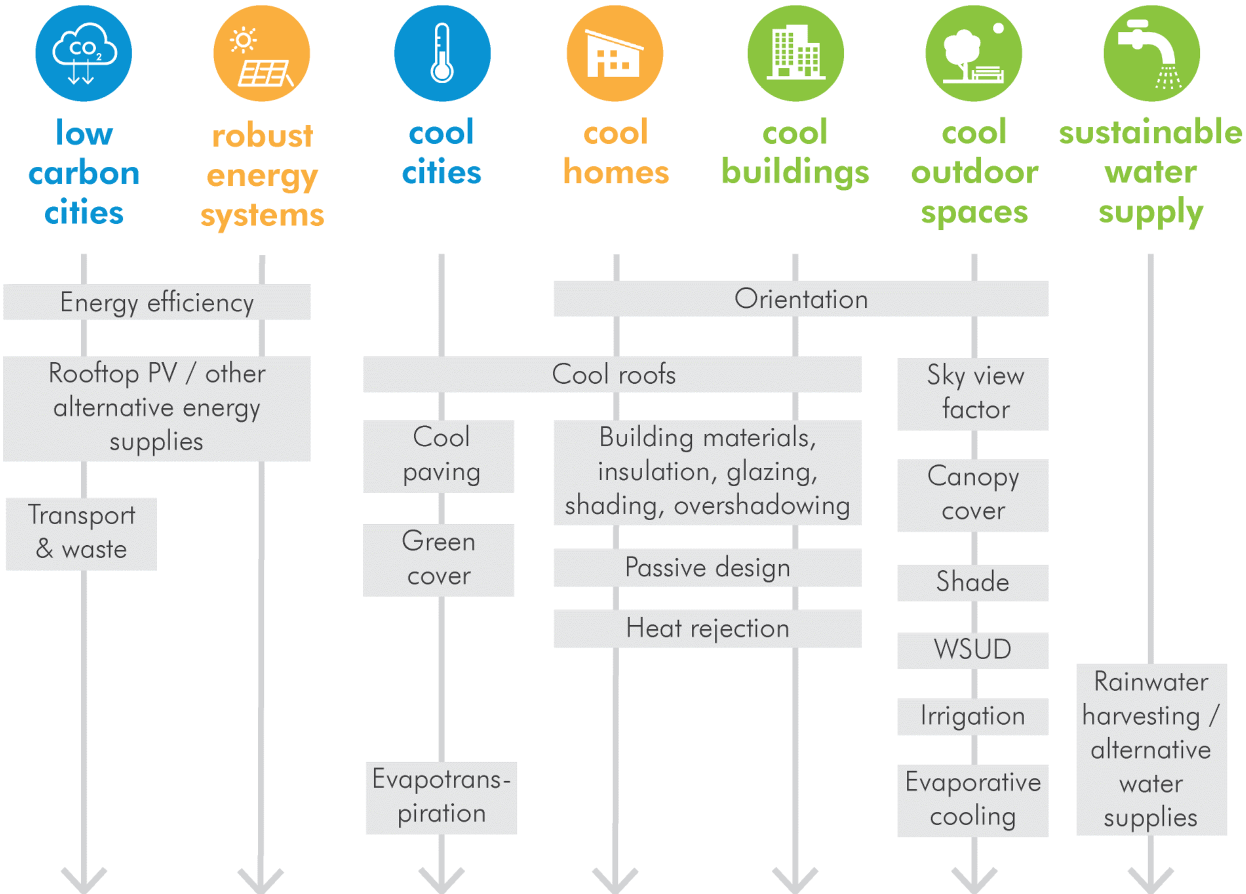
Key challenges are:

- Local planning provisions have a limited role - a significant proportion of development bypasses local provisions, utilising other approval pathways.
- Key aspects of building design are regulated by national codes and state regulations, which prevail over any local provisions, but are not doing enough to address urban heat.
- Urban heat is an issue that cuts across many aspects of urban planning and design, and therefore provisions to address urban heat also need to balance multiple other objectives.

This toolkit identifies various design measures to reduce the impacts of urban heat, identifying how each measure works, summarising key evidence and noting limitations. Several case studies are included.

The toolkit also identifies how to include these measures in local planning provisions. Three broad types of recommendations are made:

1. **New LEP and DCP provisions.** To raise the prominence of urban heat in LEPs and DCPs, it is recommended that specific urban heat provisions should be included. The recommended provisions include cool roof targets, which address an issue not covered elsewhere in existing planning provisions.
2. **Improvements to existing provisions.** Where LEP and DCP provisions need to meet multiple objectives including addressing heat, it is more appropriate to build on existing provisions. Recommendations are made to improve many existing provisions including landscape, tree and Water Sensitive Urban Design (WSUD) provisions.
3. **Topics beyond local planning controls.** For example, BASIX governs energy efficiency and thermal performance for residential development. The toolkit provides a strong case for including consideration of cooling initiatives in the BASIX tool.



Planning and design measures for urban heat resilience

The toolkit recommends new and updated local planning provisions for consideration by councils. It identifies that local provisions can play a key role in creating cool cities and cool outdoor spaces, and a supporting role to many other objectives.

Key role for local provisions:

cool cities **cool outdoor spaces**

When it comes to a **cool city** and cool **outdoor spaces**, local planning provisions can be improved in three key areas:

1. Local provisions can include new standards for **building exteriors**, to reduce their contribution to urban heat. This toolkit identifies cool roof provisions as a high priority, as this could be a straightforward addition. A cool roof standard can be readily defined, appropriate materials are already available that meet this standard, and there are few competing considerations. Cool façade controls and heat emissions from HVAC systems are secondary priorities, relevant in high density areas.
2. Local provisions for **landscaped areas** can be improved to better address urban heat. There is tension here with competing objectives, but potential to refine and strengthen existing provisions for total landscaped area, deep soils and trees. Irrigation and shade requirements could also be considered, and local provisions could also encourage measures such as green roofs and walls. This toolkit makes several recommendations, including example provisions.
3. Local provisions for **water sensitive urban design** can be improved to include a greater emphasis on reducing runoff and retaining water in the landscape. This should include harvesting rainwater and stormwater as a sustainable supply for irrigation, filtering and storing runoff in vegetated stormwater treatment systems, and encouraging infiltration where appropriate.

Supporting role for local provisions:

low carbon cities **robust energy systems**

sustainable water supplies **cool buildings**

In other aspects of urban heat, local planning provisions need to play more of a supporting role, for example:

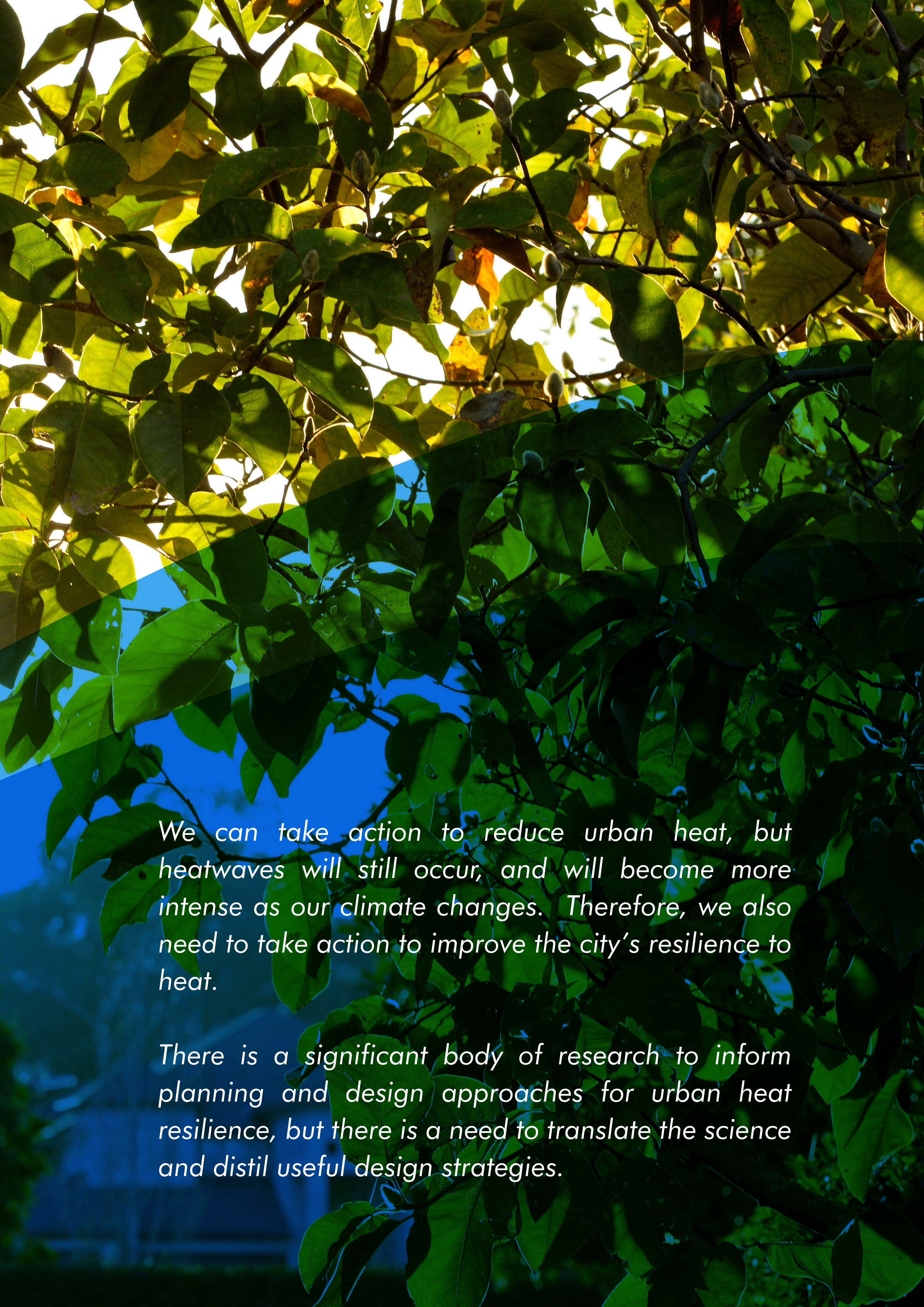
- Local planning provisions can support **low carbon cities** and **robust energy systems**, but the most important strategies to reduce the city's carbon emissions and improve the reliability of the grid need to be driven from a higher strategic level - for example in regional energy, transport and waste strategies. Local planning provisions can support these strategies but can't drive significant change on their own.
- Similarly, large-scale **sustainable water supplies** (stormwater harvesting, wastewater recycling) need higher-level strategic planning. Local planning provisions can encourage the use of rainwater tanks (at least for non-residential development) or can play a supporting role by establishing requirements for dual reticulation in new development.
- There are also other important aspects of urban heat mitigation (e.g. orientation, sky view factor) that are more important to consider at a larger scale or more strategic level, e.g. at precinct planning stage.

Limited role for local provisions - other mechanisms are needed:

cool homes

This toolkit identifies **cool homes** as a crucial element in addressing the impacts of urban heat, as cool homes enable people to survive heatwaves, even when mechanical cooling or relocating to a cooler space is unachievable. At present, thermal comfort in homes is covered by the BASIX SEPP, and this would prevail over any competing local provisions. The only real avenue to improve the thermal performance of Western Sydney homes is to improve the standards in BASIX. BASIX also covers energy efficiency and alternative water supplies in residential development, restricting any role for local planning provisions in these areas. However, local planning provisions can cover these aspects for non-residential buildings.

PART I
WHY THIS TOOLKIT HAS BEEN PREPARED



We can take action to reduce urban heat, but heatwaves will still occur, and will become more intense as our climate changes. Therefore, we also need to take action to improve the city's resilience to heat.

There is a significant body of research to inform planning and design approaches for urban heat resilience, but there is a need to translate the science and distil useful design strategies.

1 INTRODUCTION TO THIS TOOLKIT

Relevant strategic plans have identified that improving resilience to urban heat is a priority for Western Sydney. Furthermore, local land use planning and design has been identified as one important way to improve urban heat resilience.

This toolkit is intended for local governments in Western Sydney, principally to assist them to develop land use, planning and design controls that prioritise resilience to urban heat. Particular focus given to clauses that can be added to, or modified within LEPs and DCPs. This will establish consistent urban heat standards for new development. Figure 1 shows the scope of the toolkit in relation to typical stages in the planning and development process. It also shows the intended scope of WSROC's "Cool Suburbs Tool" – this tool is currently being developed and is intended to complement this toolkit with more focus on design.

This toolkit is organised into four parts, as shown in Table 1. While the focus is local government, the first two parts have broad relevance to a wider audience. Part II in particular takes a broad approach to identifying planning and design principles and strategies related to urban heat resilience, before Part III turns to applying these to local planning provisions.

Similarly, while the focus is on local land use planning and design, the toolkit, particularly Parts I and II, have broader relevance. Local councils in Western Sydney are tackling urban heat on multiple fronts, for example Western Sydney councils have been involved in urban heat research partnerships, demonstration projects, community outreach, advocacy and industry engagement. Even though this toolkit is focused on planning and design, much of its content, particularly Part II, could be applied to other aspects of councils' work.

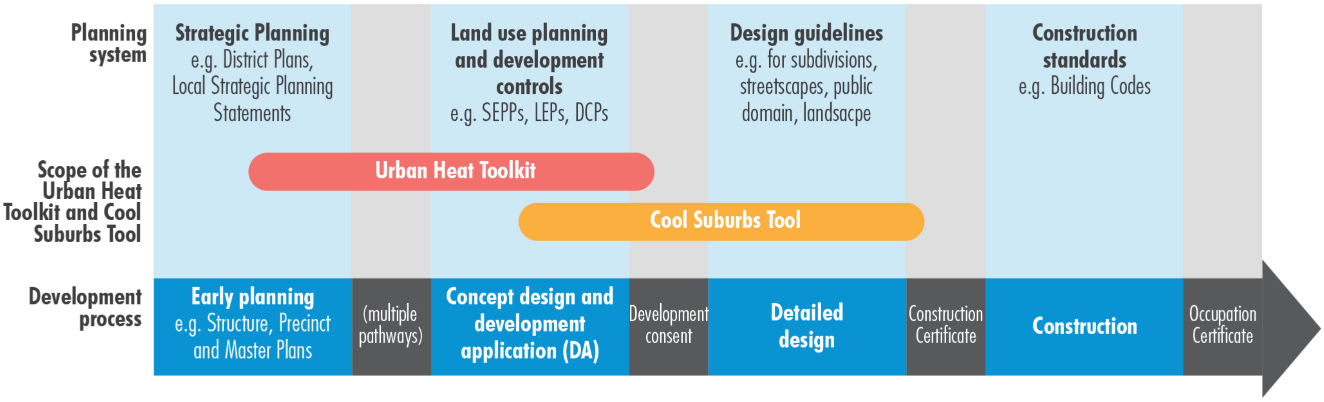


Figure 1: Scope of the Urban Heat Toolkit and Cool Suburbs Tool in terms of stages in the planning and development process

Table 1: Structure of this toolkit

PART I	PART II	PART III	PART IV
Part I provides relevant background information, outlining the purpose of this toolkit and the strategic drivers behind it.	Part II introduces a resilience framework and a series of design strategies for urban heat, translating resilience principles into a planning and design framework for urban heat, and then translating relevant research findings to present a set of design strategies that respond to each part of the framework.	Part III focuses on applying the design strategies to local planning provisions. Importantly, it also discusses the challenges and limitations of local planning provisions, identifying where these can and cannot play a role.	Part IV presents supporting information including references, a glossary of terms and example local planning clauses.

2 URBAN HEAT IS AN IMPORTANT ISSUE FOR WESTERN SYDNEY

2.1 SYDNEY IS HOT AND GETTING HOTTER

Sydney experiences hot temperatures in summer. The former NSW Office of Environment and Heritage (2014) and the Greater Sydney Commission (2018a) have both defined "hot days" as those where the temperature reaches above 35°C, and the Greater Sydney Commission (2018a) has recommended the number of hot days as a performance measure for addressing urban heat.

A changing climate is increasing temperatures globally, although the effects are not evenly distributed. The former NSW Office of Environment and Heritage (OEH, 2014) has presented a snapshot of the expected temperature changes in Sydney to 2070:

- In the period from 2020-2039, maximum temperatures are projected to increase by 0.3-1.0°C, while minimum temperatures are projected to increase by 0.4-0.8°C.
- By 2070, maximum temperatures are projected to increase by 1.6-2.5°C and minimum temperatures by 1.4-2.5°C.

These increasing temperatures are contributing to an increasing number of hot days and record temperature events in Sydney. Heatwaves (periods of three or more consecutive days of high maximum and minimum temperatures which are unusual for that location) are becoming more frequent, longer and hotter.

Figure 2 illustrates how a relatively small increase in average ambient temperatures (from "previous climate" to "new climate") can lead to a surprisingly large effect on the number of hot days and record hot days. At the extreme end of the temperature range, the effects are pronounced.

Addressing climate change is therefore an important aspect to minimise the impacts of urban heat.

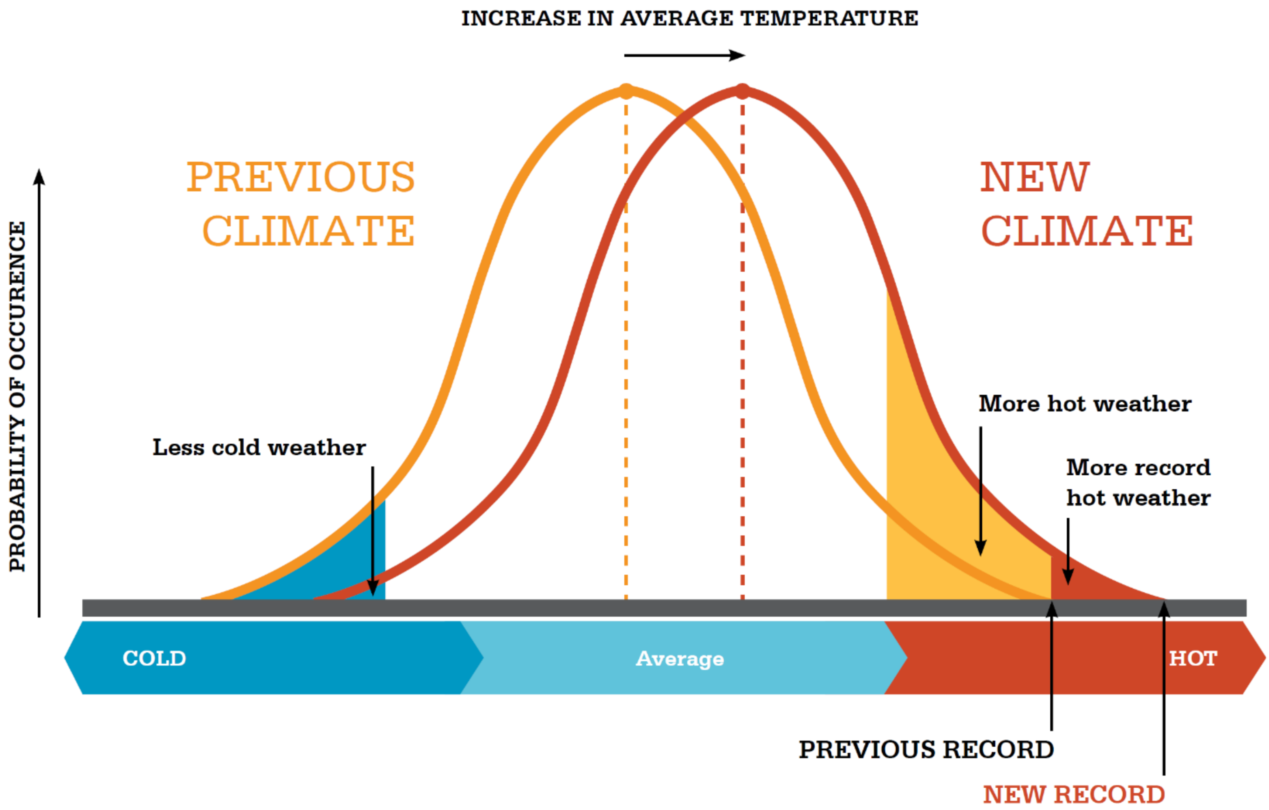


Figure 2: Relationship between temperature averages and extremes, showing the potential role for urban cooling strategies (Climate Council 2013)

2.2 WESTERN SYDNEY IS PARTICULARLY EXPOSED TO HEAT

Analysis of temperature records by the Climate Commission (2012) has shown that as the climate changes, Western Sydney is experiencing a greater increase in temperatures and number of hot days, compared to the city's east. There are several factors involved.

Geography and weather patterns intensify the UHI effect in the west

The urban heat island (UHI) effect means that the average ambient temperature in cities tends to be hotter than surrounding non-urban areas. Urban heat islands occur because buildings and paved surfaces absorb, store and re-radiate heat from the sun back to the environment. In an urban environment, less vegetation cover and less water retained in the landscape also reduces evapotranspiration, which is a key process for removing heat from the environment. Evapotranspiration includes evaporation of water from surfaces, as well as transpiration of water by plants. Waste heat from transport and (paradoxically) air conditioning also contributes to additional heat in urban areas.

Santamouris *et al* (2020, 2017a) investigated the magnitude and characteristics of the UHI effect in Sydney, finding that the temperature differences between urbanised Western Sydney and surrounding rural zones can range between 6-10°C. Importantly, the researchers also found that the UHI effect is non-uniform across the city, and its intensity is strongly influenced by weather conditions; in particular hot westerly winds and cooling sea breezes. Being more frequently exposed to hot westerly winds and less frequently cooled by sea breezes, a high magnitude, positive UHI effect was more common in Western Sydney than in the city's east.

Urbanisation is having a more significant effect in Sydney's West

Urban development is a second factor contributing to increased urban heat over the coming decades, however development type has an important influence on heat impacts. While Sydney's east will see significant densification of existing urban areas, much of Western Sydney's development is characterised by the conversion of forest and grassland to urban development. The latter has a far greater effect on local temperatures. Adams *et al* (2015, p.24) found that "[the] converting of areas in the north-west and south-west of Sydney from forest and grasslands to new urban development more than doubles the temperature changes already projected to occur as a result of climate change."

Figure 3 shows the expected change in the annual number of hot days (with temperatures above 35°C) in the period 2020-2039. The Western Sydney region is projected to experience an additional 5-10 hot days per year in the 2020-2039 period. This increases to 10-20 more hot days per year by 2070 (NSW OEH 2014).

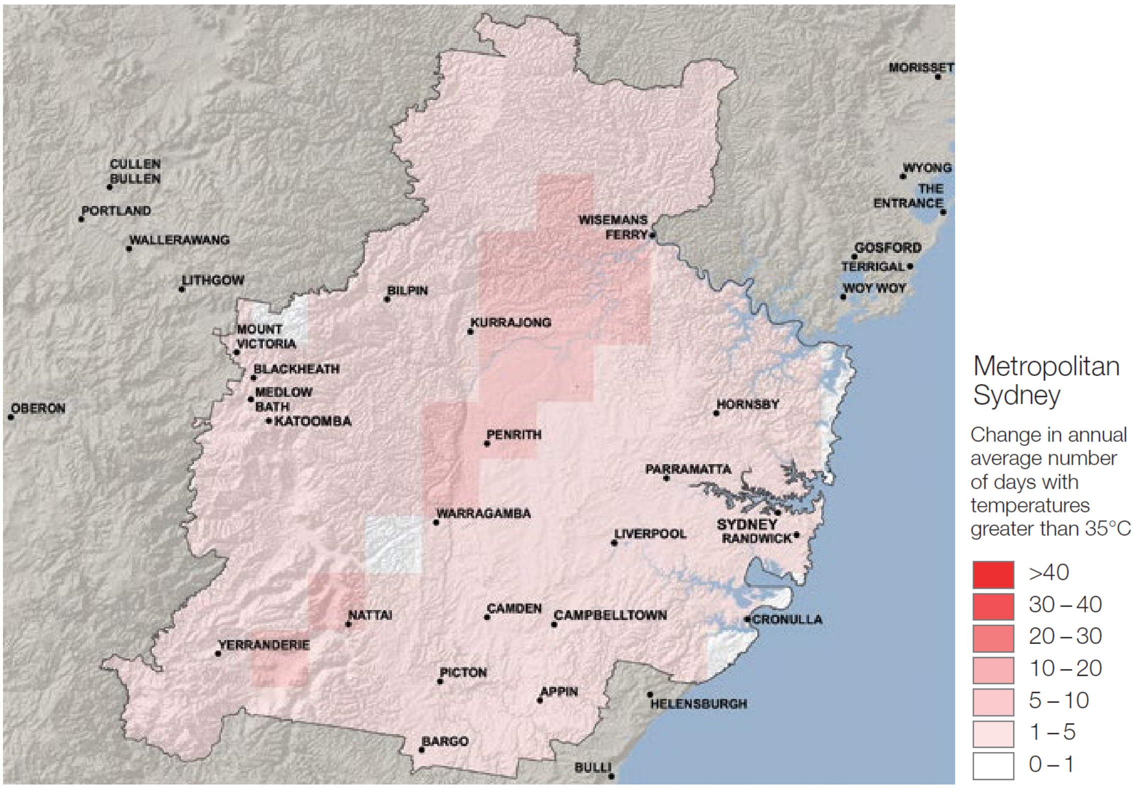


Figure 3: 2020–2039 projected changes in the number of days per year with maximum temperatures above 35°C (NSW OEH, 2014)

There is local variability within Western Sydney

"Benchmarking Heat" studies undertaken in 2019-20 for the City of Parramatta, Cumberland, Campbelltown and Penrith City Councils (Pfautsch and Rouillard 2019a, b, c; Pfautsch, Wujeska-Krause and Rouillard 2020) showed great variability in heat across these LGAs. The benchmarking studies revealed significant temporal and spatial temperature variations between different parts of each LGA. Importantly, they found that at some locations, the number of days where air temperature reached above 35°C was much greater than others:

- In Parramatta LGA, some locations experienced temperatures greater than 35°C on 47 days during the study period, compared to 10-25 days at local BoM weather stations.
- In Cumberland LGA, suburbs in the west of the LGA experienced four times the number of days where temperatures exceeded 35°C (41 days during the study period) compared to the area around Sydney Olympic Park (10 days).
- In Campbelltown LGA, the official BoM weather station on the western edge of the LGA (Mt Annan) recorded temperatures above 35°C on 23 days, while 3 km to the east near Campbelltown Station, such temperatures were measured on 39 days during the study period.
- In Penrith LGA, the number of days with air temperatures at or above 35°C was far greater across the LGA (39 days) compared to the measurements from the official weather station (24 days). Maximum air temperatures of more than 50°C were recorded at six locations.

These findings highlight the importance of considering heat at the local scale, as local factors can amplify hot conditions.

The Benchmarking Heat studies also show evidence of significant heat variability at a smaller scale. In the Parramatta LGA, the study investigated temperature differences between different streets, including two streets in North Parramatta only 1 km apart but with different physical characteristics:

- Daking Street, with an estimated 10.6% canopy cover
- Galloway Street, with an estimated 30.5% canopy cover.

The study found that the absolute difference in air temperature between the two streets at the same time of day can be up to 8°C, and the biggest differences occur on the hottest days, when temperatures are at their peak. Figure 4 shows air temperatures at the two streets over a five-day period during a hot spell. This shows that during this hot spell, Daking Street not only experienced higher peak temperatures, but also experienced more hot days, and high temperatures for a longer period each day.

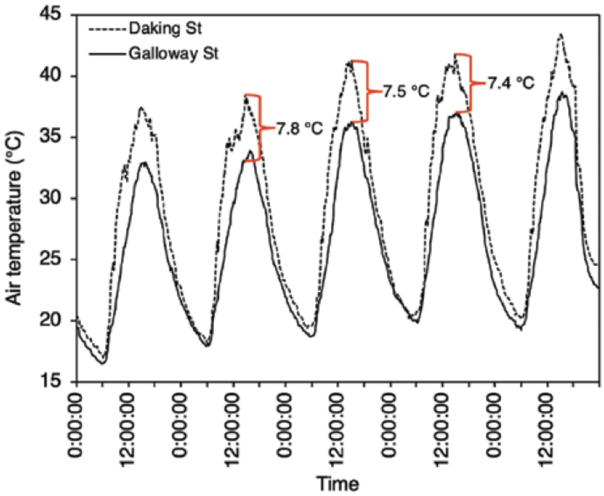


Figure 4: Air temperatures at Daking St and Galloway St during a hot spell, 25-29 December 2018 (Pfausch and Rouillard 2019a)

The Daking and Galloway Street findings highlight how differences in urban design can create significantly different temperature effects in two places that are subject to the same climatic conditions.

2.3 URBAN HEAT HAS MULTIPLE INTERCONNECTED IMPACTS

Urban heat causes major liveability and resilience problems in cities, with critical impacts for human health, infrastructure, emergency services, the natural environment and the economy. While there is a general trend of overall warming, it is the related but more episodic issue of longer, more frequent and more intense heatwaves that has the most significant impacts:

- Heat-related deaths: Heatwaves kill more Australians than any other natural disaster (Zander *et al* 2015). Living in warm neighbourhoods increases the heat-related mortality risks of residents by nearly 6% compared to those living in cooler suburbs, and older people are particularly vulnerable (Santamouris 2020, Schinasi *et al*. 2018). A 2011 heatwave in Western Sydney caused a 13% increase in mortality (Schaffer *et al* 2011).
- Chronic human health impacts: Urban heat causes a dramatic reduction in the amenity of the urban environment. Outdoor spaces become unusable, with impacts on health and wellbeing. These impacts are harder to quantify.
- Impacts on urban infrastructure: During heatwaves, demands for energy, water and health infrastructure are high, sometimes pushing these systems to their limits. Peak electricity demand increases by almost 100% when temperatures rise from 20 to 40°C (Santamouris *et al*, 2017b). During heatwaves, extreme heat also puts physical stress on electricity infrastructure. Power outages therefore become more likely. This in turn affects other urban systems connected to the electricity grid, for example trains and traffic lights. QUT (2010) also found other significant impacts on transport infrastructure, including buckling of rail tracks and air conditioning failure in buses and trains. These issues not only have cost implications for maintenance and repair, but can cause significant and cascading impacts to health and productivity.
- Environmental impacts: Heatwaves put flora and fauna under stress. Heatwaves can lead to mass deaths of sensitive species such as flying foxes and birds (Steffen *et al* 2014). Between 1994-2008, more than 30,000 flying foxes have died in heatwaves at sites along the east coast of Australia, with sometimes thousands dying in single events (Welbergen *et al* 2008). In the Sydney region, grey-headed flying foxes rely on urban habitat and are vulnerable to urban heat.
- Productivity impacts: Zander *et al* (2015) estimated Australia's annual lost productivity due to heat stress at work at $6.9 billion.

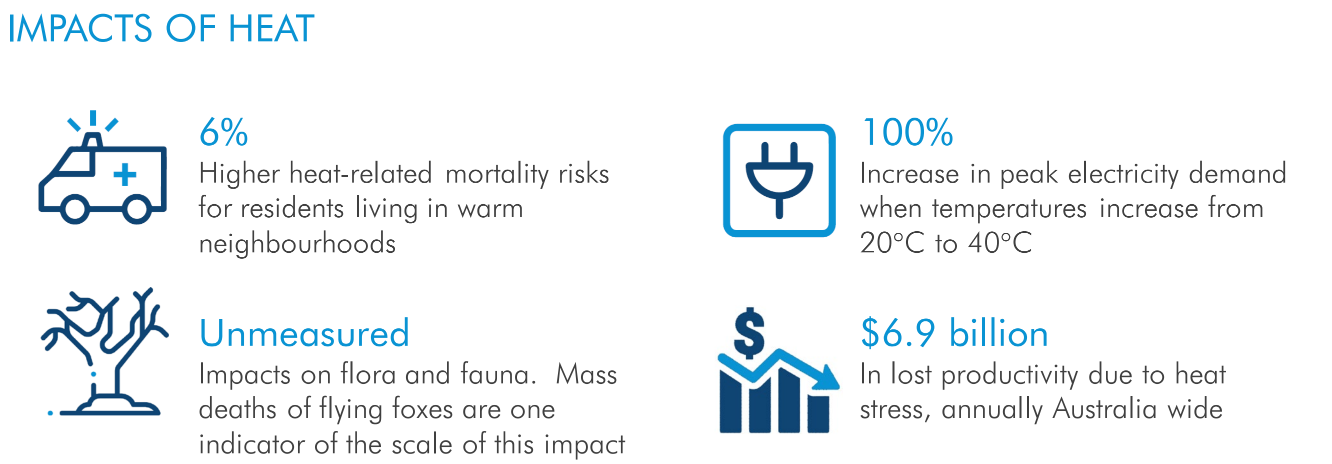


Figure 5: Heatwave impacts (modified based on WSROC 2018, p.15)

3 WHY FOCUS ON LOCAL PLANNING AND DEVELOPMENT CONTROLS?

Local councils in Western Sydney understand the significance of urban heat to the region and are taking steps to address its impacts. For example:

- Several councils have recently undertaken studies to better understand the distribution of heat and vulnerable residents across the LGA (e.g. Pfautsch and Rouillard 2019a, b, c; Pfautsch, Wujeska-Krause and Rouillard 2020).
- Councils are looking at ways to reduce heat in the public domain, and implementing pilot projects, such as planting more trees and changing road surfaces.
- Councils are helping the community prepare and respond to heatwaves (e.g. the Cool Parramatta website is a good example).

This toolkit focuses on local land use planning and development controls because this has also been identified as an important area where councils should take action to improve urban heat resilience.

Figure 6: Temperature monitoring

Figure 7: Cool Roads Trial in Parramatta LGA

3.1 HIGHER-LEVEL STRATEGIC PLANS IDENTIFY THE NEED

Strategic plans for Greater Sydney, the Central and Western City Districts and local government areas in Western Sydney all identify urban heat as a priority issue that needs to be supported by local land use planning provisions and design controls.

Greater Sydney Region Plan

The Greater Sydney Region Plan (Greater Sydney Commission 2018a) sets the direction for Sydney's growth to 2056, showing how the city will accommodate growth within a liveability, productivity and sustainability framework. It establishes the objective that **"heatwaves and extreme heat are managed"**, and includes Strategy 38.1: **"Mitigate the urban heat island effect and reduce vulnerability to extreme heat"**. It notes:

- Particular exposure of the Western Parkland City to heat
- That climate change will increase urban heat
- Health aspects of urban heat
- The role of heat in placing pressure on infrastructure – particularly the electricity network
- Impacts of heat on liveability.

District Plans

Below the Greater Sydney Region Plan, the city is divided into five districts. District Plans have been prepared for each of these districts. The District Plans (Greater Sydney Commission, 2018b,c,d,e,f) each include three Directions relevant to urban heat, which are listed in Table 2, along with the priorities and objectives relevant to urban heat. These provide a basis in the planning system to implement local planning provisions and development controls related to urban heat.

Local Strategic Planning Statements

Local Strategic Planning Statements (LSPSs), newly adopted by each NSW council in 2020, give effect to Regional and District Plans, and inform local planning. An LSPS sets out the 20-year vision for a local government area, demonstrates how change will be managed, and identifies local priorities for updating council Local Environmental Plans (LEPs). The LSPSs of councils in the Central and Western City Districts therefore pick up on the directions, priorities and objectives shown in Table 2, giving them local expression.

The LSPSs of WSROC's member councils were reviewed to understand how urban heat has been included in these documents. WSROC's members are diverse and heat is more of an issue to some than to others – in general, it is more relevant to those with greater urbanised areas and more intense urban development.

The LSPSs of all metropolitan councils identify the issue of urban heat, its relevance to the local area, and include relevant planning priorities:

- All include a planning priority related to improving resilience and/or adaptation to natural hazards.
- Most include a priority related to resource efficiency, typically putting this in the context of climate change/sustainability.
- Most include a priority related to green infrastructure, and some include the concept of canopy cover. Only one of WSROC's member councils has set a tree canopy cover target in its LSPS, although several have discussed the challenge of increasing tree canopy cover from a relatively low baseline, and have included actions to begin increasing canopy cover.
- Four councils include a specific action to update planning controls to better address urban heat.

Table 2: Directions, priorities and actions in the District Plans, relevant to urban heat (Greater Sydney Commission, 2018b,c,d,e,f)

Directions	Relevant priorities	Relevant objectives	Relevant actions
A resilient city	Adapting to the impacts of urban and natural hazards and climate change	People and places adapt to climate change and future shocks and stresses Exposure to natural and urban hazards is reduced Heatwaves and extreme heat are managed	Support initiatives that respond to the impacts of climate change Avoid locating new urban development in areas exposed to natural and urban hazards and consider options to limit the intensification of development in existing urban areas most exposed to hazards Mitigate the urban heat island effect and reduce vulnerability to extreme heat
An efficient city	Reducing carbon emissions and managing energy, water and waste efficiently	A low-carbon city contributes to net-zero emissions by 2050 and mitigates climate change Energy and water flows are captured, used and re-used	Support initiatives that contribute to the aspirational objective of achieving net-zero emissions by 2050, especially through the establishment of low-carbon precincts in Growth Areas, Planned Precincts, Collaboration Areas, State Significant Precincts and Urban Transformation projects
A city in its landscape	Increasing urban tree canopy cover and delivering Green Grid connections	Urban tree canopy cover is increased	Expand urban tree canopy in the public realm

3.2 WSROC'S TURN DOWN THE HEAT STRATEGY CALLS FOR ACTION IN THIS AREA

The Western Sydney Regional Organisation of Councils (WSROC) are leading an initiative called **"Turn Down the Heat"** that takes a collaborative, multi-sector approach to tackling urban heat in Western Sydney, and focuses on achievable actions to reduce the impacts of heat.

The **Turn Down the Heat Strategy** was launched in December 2018. Developed with the input of 55 different organisations, the Strategy lays out a five-year plan for a cooler, more liveable and resilient future. The Strategy aims to:

1. Identify and leverage existing best practice to develop a program of effective actions at the household, precinct and regional levels.
2. Acknowledge the limitations of the current policy framework with regard to urban heat to galvanise action across diverse stakeholders.
3. Propose a series of priority actions for development with a broader stakeholder group.

The Strategy includes four targets and five strategic drivers, shown in Figure 8 and Figure 9.

The Turn Down the Heat Strategy (WSROC 2018, p.48) identifies that "managing the way that the built environment… contributes to urban heat will be imperative to making any substantial progress in lowering temperatures in Western Sydney". One of five strategic drivers is to "design and plan to cool the built environment", and one of the actions under this driver is "Land use and design controls that prioritise resilience". This action includes three steps:

1. Develop a heat related State Environmental Planning Policy (SEPP), or modify the BASIX SEPP to address urban heat.
2. Add consistent clauses outlining urban heat standards to LEPs and DCPs.
3. A systematic change to building codes and specifications to promote development that addresses and minimises urban heat island effects.

TURN DOWN THE HEAT TARGETS

1. Increase multi-sectoral collaboration and investment to deliver more projects to address the impacts of urban heat in Western Sydney by 2023.

2. Reduce the average peak ambient temperatures in Western Sydney by 1.5°C through water, greening and cool materials strategies by 2023.

3. Zero net increase in economic impacts of heatwaves by 2023.

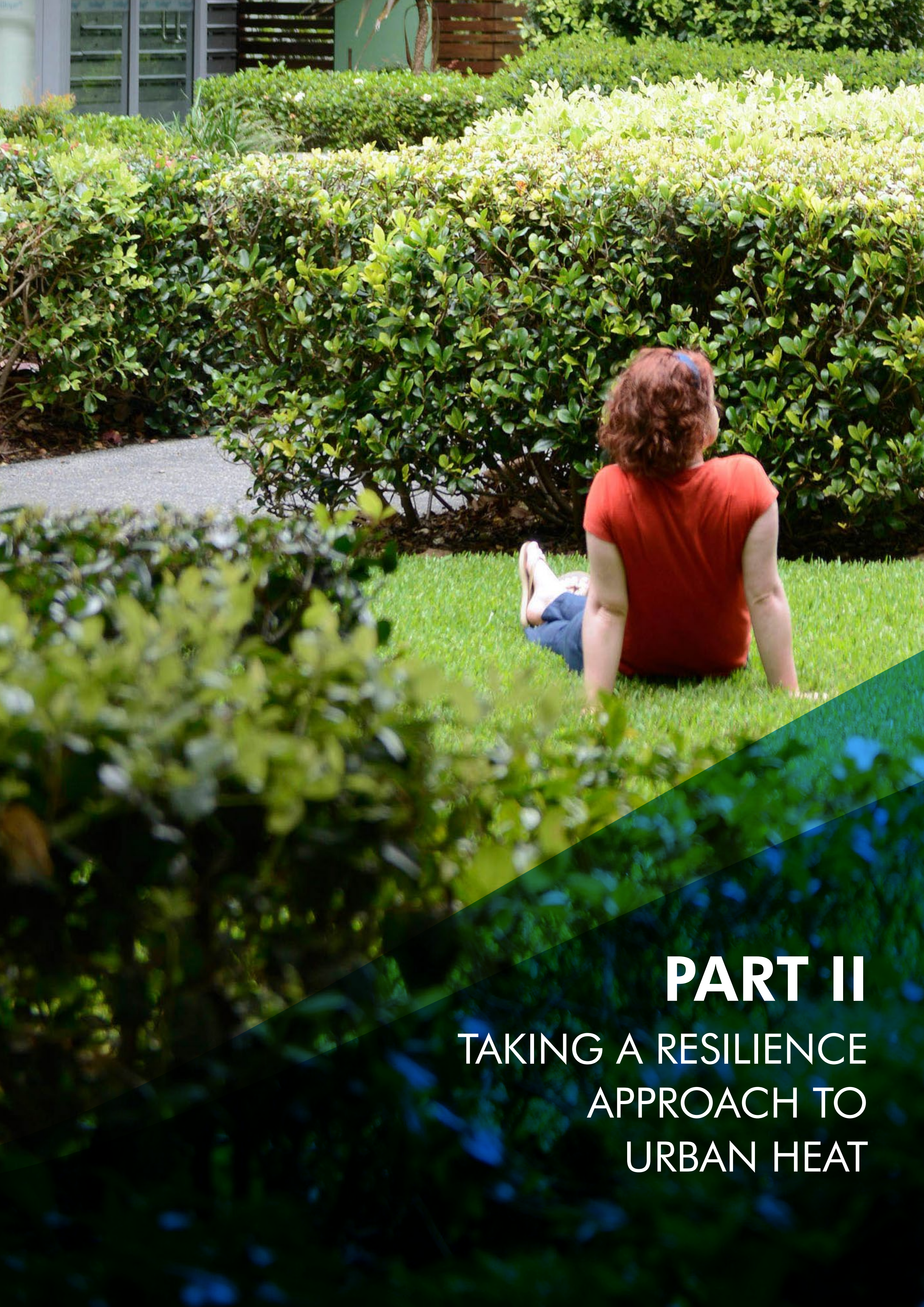
4. Zero net increase in morbidity and mortality impacts of heatwaves in Western Sydney by 2023.

Figure 8: Turn Down the Heat targets (WSROC 2018)

TURN DOWN THE HEAT STRATEGIC DRIVERS

- **Take action together**
- **Design and plan to cool the built environment**
- **Innovative and responsive infrastructure**
- **Cool with green space and water**
- **Build a community that is healthy and prepared**

Figure 9: Turn Down the Heat strategic drivers (WSROC 2018)



PART II

TAKING A RESILIENCE APPROACH TO URBAN HEAT

Urban heat is a significant and growing issue for Western Sydney. The region will experience substantial new development and redevelopment over coming years, with the potential to exacerbate the urban heat island effect and worsen the local impacts of heat.

Urban heat has been identified as a priority issue by the Greater Sydney Commission. WSROC, local councils and other organisations are tackling urban heat on multiple fronts. Local land use planning and design has been identified as one important area for improvement, and this is the focus of this toolkit.

4 RESILIENCE PRINCIPLES

Heat places both acute shocks and chronic stresses on people, urban infrastructure and the environment. Heatwaves and extreme heat take the form of an acute shock, while an increasing number of hot days is more of a chronic stress. While we can take action to reduce heat, and reduce the frequency of hot days, these shocks and stresses will still occur. A **resilient** Western Sydney would not only act to reduce localised heating, but be better equipped to cope with the impacts of heat when they occur.

Resilience is a theme that comes through in the Turn Down the Heat Strategy (WSROC 2018), where Action 4 is "Land use and design controls that prioritise resilience". The Greater Sydney Region Plan (Greater Sydney Commission 2018) also includes a strong resilience theme, with one of the directions for sustainability being "A resilient city".

4.1 RESILIENT SYDNEY STRATEGY

The Global Resilient Cities Network provides international leadership on city resilience, and as a member of this network, Resilient Sydney has developed a city-wide resilience strategy for Sydney. Resilient Sydney brought together 33 Sydney councils, several state agencies and other groups to develop the strategy (Resilient Sydney 2018), which defines city resilience as follows:

> **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"

In terms of urban heat, in a resilient city:

- Individuals would have greater capacity to **survive** heatwaves, and heat-related mortality would be reduced.
- The community, businesses and systems would have the capacity to **adapt** in heatwave conditions, so that social and economic disruption from urban heat would be minimised.
- Liveability would be maintained, allowing people to **thrive** in a warmer climate. Heat-related morbidity would be reduced.

This provides the starting point for the resilience framework that has been used in this toolkit to consider built environment strategies to respond to urban heat. It suggests different approaches to tackle different impacts of urban heat:

- <u>To help people survive heatwaves:</u> It is important to consider those most vulnerable to heat stress – those who are old, very young or have underlying health conditions. A crucial objective should be to improve the performance of homes in heatwaves, including making air conditioning available and affordable to use, reducing the risk of disruption to the electricity supply, and improving the "passive thermal performance" of homes, so that conditions remain survivable for longer, even when air conditioning fails.
- <u>To help people adapt and thrive:</u> The response also needs to consider how to enable people to continue moving around the city and undertaking activities such as working, shopping, social interaction and outdoor recreation. The objectives should broaden to improving thermal comfort in workplaces, public places and the outdoor environment.

Resilient Sydney (2018) also identifies seven guiding principles for resilience, which are listed below. These principles were considered in weighing up the options to modify planning provisions and development controls.

Resilience principles (Resilient Sydney 2018, p. 31)

> **The resilience lens – 7 guiding principles**
>
> The resilience lens provides guiding principles at each phase to direct effective research, consultation, planning and action.
>
> The lens helped us to:
>
> - Approach the challenge in an integrated and holistic way that crosses silos, using the City Resilience Framework
> - Consider impacts of multiple shocks and stresses identified through a broad risk and hazard assessment
> - Aim for short, medium and long-term benefits
> - Consider resilience behaviours and qualities when proposing solutions
> - Strive for equitable outcomes
> - Leverage actions across a broad group of stakeholders
> - Consider cross-jurisdictional implications at intercity, regional, national, global levels.

4.2 URBAN HEAT RESILIENCE FRAMEWORK

WSROC has developed a resilience framework for urban heat, which includes four steps, as shown in Figure 10:

1. Awareness: This involves assessing the physical conditions in the area, and the vulnerability of residents and urban infrastructure to heat.
2. Reduce: This involves reducing the effects of both climate change and the UHI, to reduce average ambient temperatures as much as possible in the design and making of the physical environment.
3. Adapt: At most, we can reduce ambient temperatures at the city scale by only approximately 2°C, which means that high temperatures and heatwaves could still have significant impacts on Western Sydney, particularly as the climate warms. Therefore it is also important to design and build urban infrastructure that will enable Western Sydney residents to survive heatwaves and thrive in hotter conditions.
4. Respond: Even with best practice design, there will still be residual heat-related risk in extreme events. Therefore we also need emergency preparedness and response measures to help the most vulnerable people in the community.

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

Figure 10: Urban heat resilience framework

4.2.1 Reducing urban heat

Part of the reason why heat is becoming more problematic in Western Sydney is that the climate is getting hotter (see Section 2.1). Actions that reduce carbon emissions and mitigate the effects of climate change are therefore relevant to reducing the impacts of urban heat. Climate change mitigation is an important starting point for resilience planning, because if climate change can be brought within manageable bounds, then resilience planning becomes a realistic approach to deal with its consequences. If climate change continues unchecked, a resilient city becomes a more and more challenging goal.

A second reason why heat is problematic in Western Sydney is the urban heat island effect (UHI). UHI is caused by urban development, but varies in intensity depending on the location and nature of development (see Section 2.1). There is scope to manage the intensity of the UHI as Western Sydney develops, so that its effects are also kept in check.

Planning and design can play a role both in reducing the carbon footprint of the city, and in reducing the intensity of the urban heat island effect. However, while these are both important strategies, climate change can't be halted quickly, and urban cooling measures can only have a limited effect on ambient temperatures at the city scale. The CRC for Low Carbon Living (Osmond and Sharifi 2017) looked at a range of strategies for cooling the urban environment, including cool materials, green infrastructure and evaporative cooling options. The report recommends that these strategies can reduce "precinct scale" air temperatures by up to 2.0°C. However, even if all these strategies are used in combination, their maximum effect, when measured at this scale, is not expected to be more than a 2.0°C reduction in ambient temperature.

Given the expected temperature increases associated with climate change, and the magnitude of the UHI effect in Western Sydney, urban cooling strategies can only be expected to partially offset increasing temperatures in the long term. More frequent hot weather and extreme heat will remain a feature in Western Sydney, and therefore adaptation strategies will also be important to help mitigate its impacts.

4.2.2 Adapting to a hotter climate

To address the remaining impacts of urban heat, adaptation is a crucial area where urban planning and design can have a positive impact. Given the importance of adaptation, and the multiple potential roles of urban planning and design in this area, in this toolkit the "adapt" step has been broken down into two parts:

1. Enabling people to thrive in a hotter climate: We need to plan and design urban infrastructure, including buildings, streets, open space and urban systems, to function well in hotter conditions. If people can continue to engage in normal economic, social and physical activities in a hotter climate, it will help reduce the economic and health impacts of heat.
2. Enabling people to survive heatwaves: We need to plan and design residential development so that people's homes are safe places in heatwave conditions. This includes improving reliability and affordability of power, as well as ensuring that safe conditions can be maintained even when power supplies fail. If vulnerable people can retreat during a heatwave to a safe environment at home, this will reduce mortality in these extreme events.

These two approaches align with two of the other high-level targets in the Turn Down the Heat Strategy (WSROC 2018): zero net increase in morbidity and mortality of heatwaves, and zero net increase in economic impacts of heatwaves.

Figure 11 identifies seven ways that urban planning and design can address urban heat, aligned with the approaches of reducing urban heat and helping people adapt to heat, by enabling people to survive heatwaves and thrive in a warmer climate. Section 5 expands on each of these, considering a range of different measures that could be implemented in the planning and design of new development, identifying how they contribute to addressing heat and its impacts and where possible, quantifying their potential effect.

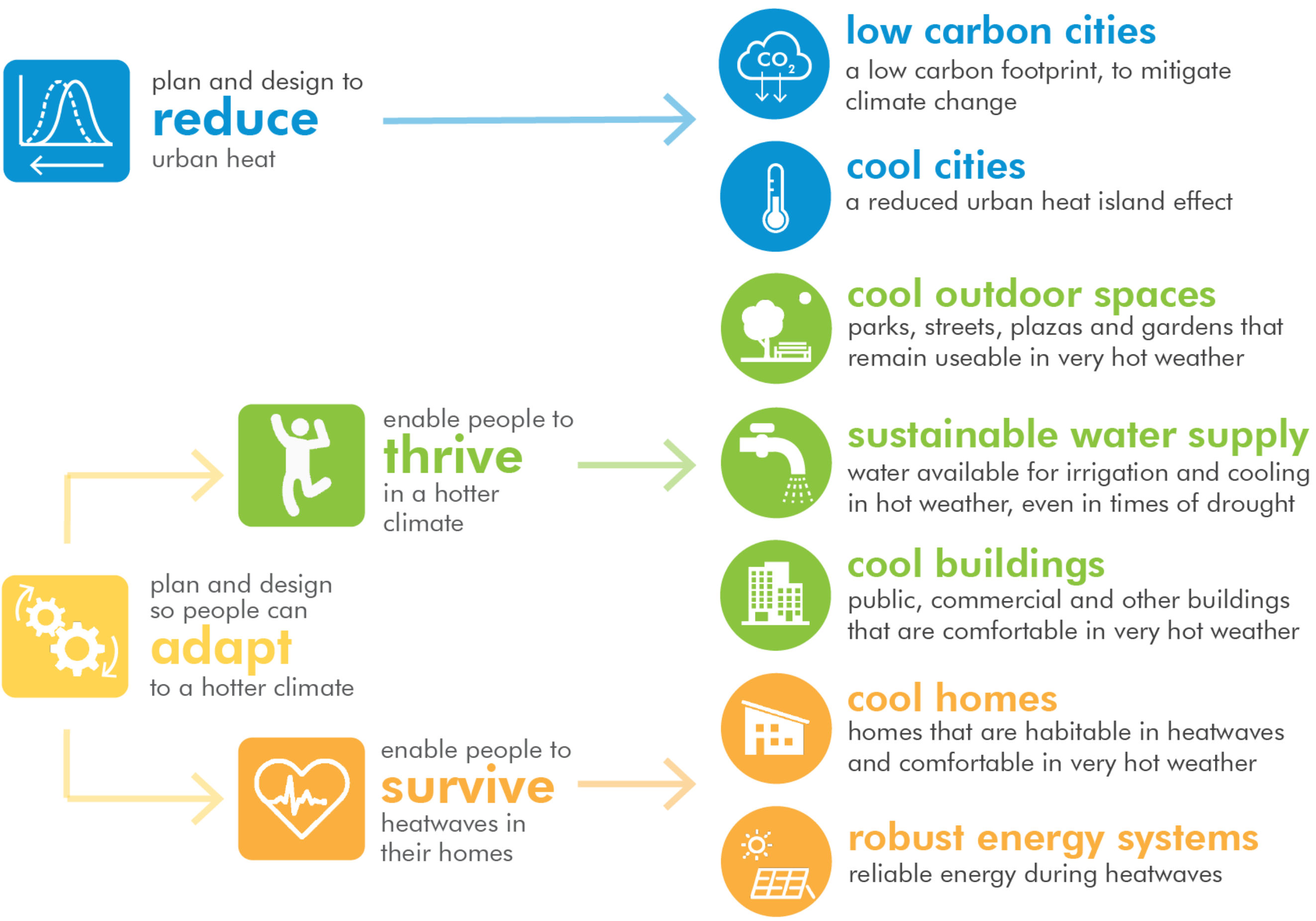


Figure 11: Urban planning and design approaches to reduce urban heat and help people adapt to urban heat

5 DESIGN STRATEGIES FOR URBAN HEAT RESILIENCE

Potential planning and design measures to mitigate urban heat in new development are shown in Figure 12. Note that in Figure 12 and in the following sections, the concepts of "cool homes" and "cool buildings" refer to the indoor environment. "Cool cities" and "cool outdoor spaces" both refer to the outdoor environment, but at different scales – the city (or large precinct) scale and the microclimate or "human" scale of outdoor spaces that people inhabit.

It is useful to make these distinctions, to distinguish between different outcomes of urban heat mitigation measures. However, there is significant overlap between the physical measures that could be employed to meet each different outcome. For example:

- Cool roofs would contribute to cooling at the city scale, as well as contributing to cooler homes and other buildings.
- Improved energy efficiency and installation of rooftop solar power would help both to reduce the carbon footprint of the city, and to create a more robust energy system with greater capacity to meet peak demands and avoid power outages.
- Greater green cover is listed as a "cool city" strategy, but many types of green cover – particularly canopy cover and irrigated vegetation – can also help create cool outdoor spaces (including private gardens, parks and streetscapes). When trees cast shade onto buildings, they also help cool the building.
- Rainwater harvesting, stormwater harvesting or recycled water systems would enable greater irrigation, including during times of drought. This would help create cooler outdoor spaces as well as contributing to cooling at the city scale. Water features and permeable paving also support evaporative cooling at both 'cool outdoor spaces' and 'cool cities' scale.

The following sections outline design strategies addressing each part of the framework, discussing the key considerations when applying each of them.

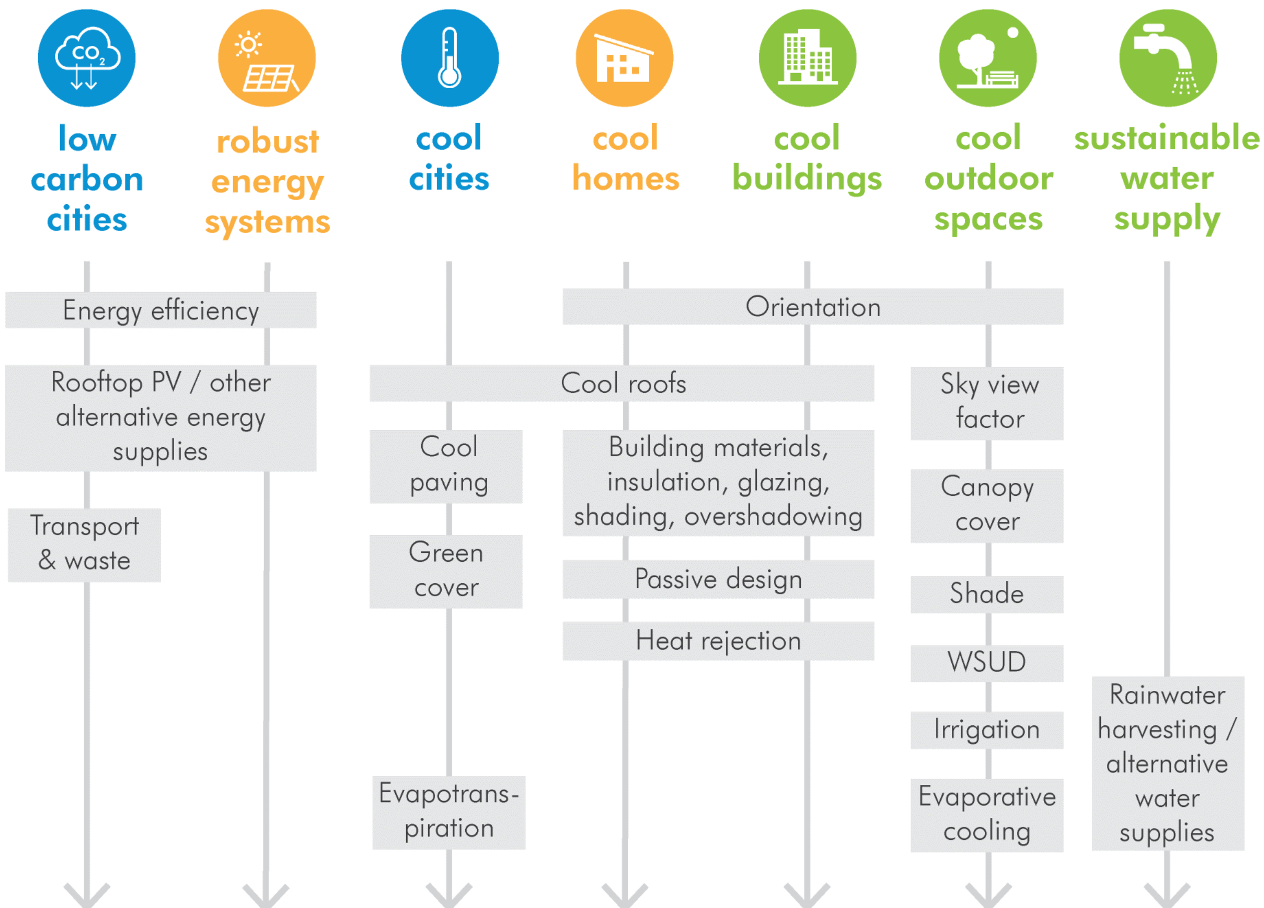


Figure 12: Potential design measures for reducing the impacts of urban heat

5.1 LOW CARBON CITIES

Given the role of climate change in increasing urban heat (refer to Section 1.1), measures that reduce carbon emissions are relevant to reducing urban heat.

At the national scale, Australia's carbon emissions are dominated by electricity generation, agriculture and transport, with smaller contributions from industrial fugitive emissions, industrial processes, land clearing and waste.

Figure 13 shows the sources of greenhouse gas emissions across Greater Sydney, showing how emissions are expected to change between 2015 and 2036. Emissions in Sydney are dominated by buildings, accounting for two-thirds of current emissions, and expected to increase their share in the future. Transport is the next biggest category, accounting for approximately 20% of the total. Waste accounts for just over 10% of the total.

Given this picture, some of the key actions which could reduce Sydney's greenhouse gas emissions are:

- Reducing energy use in buildings: Because a large proportion of buildings' energy use is linked to heating and cooling, improved building design for thermal performance (e.g. insulation, natural ventilation) could play an important role here.
- Increasing renewable electricity generation: Rooftop solar power can play an important role in urban areas. Rooftop solar PV can also reduce the need for air conditioning by shading the roof, and can reduce the UHI by absorbing solar energy (Masson *et al* 2014).
- Reducing transport emissions: Reducing private vehicle use and increasing the role of electric vehicles can both play a role here. Local government can encourage these changes by providing infrastructure for active transport and electric vehicles.
- Reducing waste to landfill: There is potential to divert more recyclable and compostable waste from landfill.

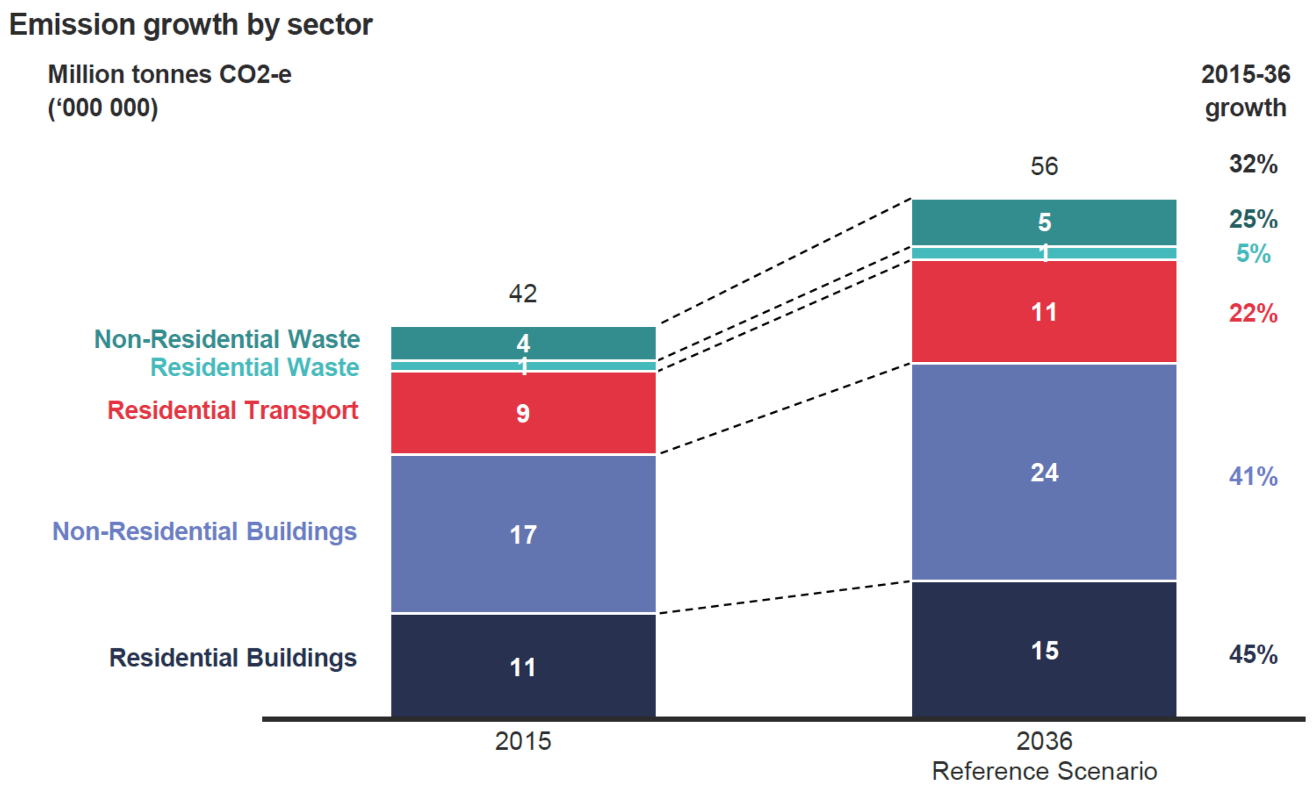


Figure 13: Greater Sydney greenhouse gas emissions by sector, 2015-2036 (Kinesis 2017)

5.2 COOL CITIES

The Turn Down the Heat Strategy (WSROC 2018) sets a target to "reduce the average peak ambient temperatures in Western Sydney by 1.5°C through water, greening and cool materials by 2023". Temperatures can be reduced at a city-scale with strategies that reduce the UHI effect, including:

- Using cool materials: Roofing, wall and paving materials with greater reflectance, less capacity to store heat, and (in the case of paving materials) more permeability.
- Increasing green cover and minimising impervious surfaces: Vegetation reduces heat by increasing evapotranspiration and shading adjacent surfaces.
- Using water in the landscape: Water can be used to increase evapotranspiration. This could include water features and irrigated vegetation. Vegetation with access to water can evapotranspire and reduce heat more effectively.
- Reducing waste heat production: Reducing heat emissions (for example heat associated with vehicles and air conditioning systems) would also help reduce the UHI effect.

The sections below outline design strategies for building roofs, external walls and outdoor spaces, specifically focused on **reducing their impact on the UHI effect**. Note that many of these strategies, as well as working to reduce the UHI effect and reduce heat at the city-scale, can also help contribute to **cool homes and buildings** (i.e. indoor thermal performance) and **cool outdoor spaces** (i.e. outdoor microclimate). These latter aspects of design are the focus of Sections 5.3, 5.5 and 5.6.

Reducing the UHI effect of roofs

Buildings make up a large proportion of hard surfaces in the urban environment, and therefore they make a significant contribution to the UHI effect. Most buildings are exposed to full sunlight across their roofs and some of their walls. Traditional building materials like brick, concrete, and clay tile are thermally massive; they absorb large amounts of heat when in the sun or surrounded by hot air. This heat is released when the environment around the material is cooler, typically at night. This slow release of heat is a key contributor to the UHI effect.

A few fundamental design decisions can substantially reduce a building's urban heating effects. Any measures to limit urban heat caused by buildings should start with roofs, which are directly exposed to the sun and which are also the easiest to keep cool. Design strategies for roofs to combat urban heat, listed in approximate order of priority, include:

1. Use cool roofs: Cool roof surfaces reflect sunlight and/or rapidly radiate absorbed heat (depending on the material). Cool roofs are particularly useful as a precinct-scale cooling strategy and to improve indoor thermal performance. They have a limited effect on local temperatures at ground level, however the effect of cool roofs is more noticeable at ground level when roofs are closer to the ground. The performance metric for cool roof surfaces is the Solar Reflectance Index (SRI), a scale from 0 to 1, where a white membrane roof would score 1. Note that in general, the whiter a roof, the cooler it remains (Figure 14). Cool roofs are a straightforward measure, as it has become relatively common practice to provide SRI values for roofing materials, and a wide range of suitable products are readily available. Cool roofs are also low-cost, with no need to spend more on materials. However, one caveat is that roofs in view 'downslope' from the public realm in hilly areas, or in view from taller adjacent buildings should avoid white or very light-coloured finishes that would cause glare concerns. In these locations, mid-toned cool roof finishes or vegetated roofs (below) are appropriate. Note also that a range of darker-toned, high SRI roofing and paving materials (with specially formulated coatings that are low reflectance in the visible range, and high reflectance in the infrared/near-infrared range) are being developed (Santamouris and Yun, 2020) and starting to come onto the market.

Figure 14: In general, lighter coloured roofs are cooler, with higher SRI

2. Consider alternatives to thermally massive roof materials: Consider alternatives to concrete or tile, that absorb energy and release it slowly (noting that where a thermally massive material has a high SRI surface, it can still deliver a significant improvement over low SRI materials).
3. Use rooftop solar panels: In solar panels, photovoltaic cells convert a portion of the sun's energy into electricity or hot water. Solar panels do get hot, as much of the residual solar energy is converted to heat. However, the benefits of solar panels (refer to Sections 5.1 and 5.3) makes them a worthy roof topper, despite being less effective

than cool roofs or green roofs at combatting local UHI effects. Interestingly, rooftop solar panels mounted over green roofs can demonstrate improved solar conversion efficiency by evapotranspirative cooling (Shafique et al, 2020).

4. Where feasible and appropriate, use green roofs: A green roof (Figure 15), where the uppermost roof surface is a layer of plants, is also effective at mitigating heat. Green roofs have a higher albedo than typical roofing materials, and they also create multiple cooling effects including insulation, evapotranspiration, and conversion of solar energy into plant growth. Some green roofs even include trees, which can shade adjacent surfaces. Green roofs that are irrigated will stay cooler than those relying on rainfall. The latter will get hotter during dry spells. Plant selection should reflect desired function, for example herbaceous perennials and small shrubs are more appropriate for cooling than very drought-tolerant species with low evapotranspiration.

Figure 15: Green roof at Pagewood Green, NSW (image: Meriton)

Reducing the UHI effect of building walls

The thermal mass of building walls also contributes to urban heat. Measures can be taken to limit this detrimental effect, however walls have more complex design requirements than roofs due to their direct interface with important indoor and outdoor spaces. Walls should stay cool, but they also need to admit daylight to spaces within, allow views out, and they need to avoid creating glare risks for drivers, pedestrians, and people in adjacent buildings. Walls that emit or reflect heat can also raise temperatures in adjacent outdoor areas, making them more uncomfortable in hot weather. These include glazed façades which are spectrally selective to meet the requirements of BCA Section J for reducing internal solar gain.

The primary steps to maintaining cool building walls are:

1. Wherever possible, shade building walls: This is particularly important for western walls that receive afternoon sun and can absorb significant heat, as well as for glazed façades, which can reflect significant solar radiation downwards. Flux (2020) demonstrated that this effect could be significantly reduced with adequate shading. At low levels, shade is preferably achieved using surrounding trees or other vegetation that converts the sun's energy into growth. Where vegetation is not feasible, architectural features such as eaves, fins, returns etc. can also provide shade.

2. Use light coloured finishes: Ideally, light-coloured walls should reflect sunlight into the landscape, where the energy can be absorbed by trees and other vegetation, or conversely, where the radiation can be reflected to the sky. However, if a building has no surrounding vegetation (e.g. in urban settings without street trees), this measure has more complex effects. It would mean less daytime heat absorption (and re-radiation overnight), but it would also mean solar energy is reflected from building walls to the surrounding streets and public realm. Less absorbent materials are the most desirable in most contexts, but design should consider the local place and its specific needs.

3. Take particular care if employing thermally massive surface materials: Take care with materials like concrete, which absorb energy and stay warm. Correctly used, thermal mass can improve a building's energy performance, but it should be noted that these features work best in climates with large diurnal temperature ranges (i.e. a large difference between daily maximum and minimum temperatures).

4. Where appropriate, also consider green walls or green façades: Both use small-scale vegetation to cover the vertical surfaces of a building. Green walls use a framework attached to a wall to support light weight growing media and plants; green facades use climbing plants typically rooted in soil. Green walls have high and complex maintenance needs, and typically require extensive irrigation to survive, let alone thrive, so this approach is best applied where localised cooling benefits are maximised or where there is an ample supply of rainwater or recycled water. Green façades can be easier to maintain and less reliant on irrigation, but are not maintenance-free. Their benefits include cooling the building by direct shading, evapotranspiration and insulation provided by the still air trapped between the foliage and building façade. Extended green walls can also contribute to street level cooling.

Figure 16: Green façade at Our Lady of Mercy College, Parramatta (image: Tzannes Associates)

Applying a general requirement for building external walls to meet a cool surface standard like SRI would be difficult to implement for a number of reasons. The main problem is that, as noted in Step 3 above, surfaces that reflect solar heat to the ground will exacerbate urban heat at street level wherever there is no vegetation to absorb the energy or re-reflect it to the sky. This means more people will experience urban heat as direct thermal discomfort. Also, unlike roofing, few building wall materials have SRI data available currently, although this problem could be solved over time with manufacturer co-operation.

The key principle in developing guidance around façades/wall surfaces is to minimise the prospect of street level impact, which means consideration of urban geometry as well as material properties, and prioritising façades and walls that receive high solar radiation during summer and particularly during the afternoon. Where these impacts can be avoided, cool wall surfaces can play a role in urban cooling.

Reducing the UHI effect of outdoor spaces

Outdoor spaces, both public and private, include significant paved areas, including roads, footpaths, plazas, courtyards and forecourts. These spaces therefore make a significant contribution to the UHI effect.

Many outdoor spaces also need to function as usable places in hot and very hot weather, i.e. they need to function as cool spaces at the human scale. This aspect of design is discussed in Section 5.3. The following design strategies are focused on reducing the heating effect of outdoor spaces at the city scale. There is overlap between these strategies, but it is useful to understand how each of them works at different scales. The following strategies are applicable across all outdoor spaces in the city.

Design measures to reduce the city-scale heating effect of urban outdoor spaces are:

1. Increasing green cover and reducing impervious areas as much as possible: At the city scale, any green cover is preferable to paved surfaces. Tree canopy cover will also maximise opportunities for cooling and shading of the public realm, for microclimate cooling effects. Vegetation in urban areas can also help meet other objectives, such as biodiversity, and the type of green cover may be selected to meet other objectives.
2. Where paved surfaces need to be provided, consider the following strategies, in approximate order of priority:
    a. Shading paved areas wherever possible: Shade paved surfaces, preferably with surrounding trees, by maximising canopy cover. Prioritise places with high solar exposure, where trees can provide maximum shading. When it comes to streetscapes, Norton et al (2015) and the CRC for Water Sensitive Cities (2014) recommend prioritising wide, east-west oriented streets for increased street tree planting, as these tend to be the streets with highest solar exposure. Norton et al (2015) caution against creating a continuous tree canopy, as this can trap heat at night, however this is only likely to be a concern in high density environments, with narrow streets and multi-storey buildings, where the tree canopy could potentially extend wall-to-wall across the canyon.
    b. Using cool paving: Cool paving has high albedo (high solar reflectance) and/or high thermal emittance (which releases heat quickly) and is particularly useful where there is limited opportunity to establish canopy cover. Cool paving is best applied where there are few obstacles blocking view of the sky, so the reflected heat and light can escape to the sky rather than being reflected onto other urban surfaces. However, also consider potential negative impacts on pedestrians and vehicles in specific circumstances – Middel *et al* (2020) found that cool paving, while reducing surface temperatures, tended to increase mean radiant temperatures in the afternoon, which would have a negative effect on thermal comfort for pedestrians. Cool paving also has the potential to cause glare. Therefore cool paving may not be the best option where there high pedestrian activity or where glare could be problematic for vehicles.
    c. Using permeable paving: Permeable paving may be designed to promote deep soil infiltration or may be provided with near surface water storage instead – the latter possibly being more relevant on many Western Sydney clay soils. The latter type of design could also potentially facilitate pavement watering as an effective cooling strategy (where an appropriate water supply is available). However, permeable paving may not be appropriate for high traffic loads.

Figure 17: Trees shading the street at The Ponds

3. Where green cover is provided, ensure wherever possible that vegetation has access to water, by:
   a. Providing an irrigation system: Preferably supplied by rainwater or suitably treated stormwater/recycled water.
   b. Enabling passive irrigation: Direct runoff from paved surfaces into vegetated areas, so that water can be absorbed into the growing medium.
   c. Including wetlands and rain gardens: Where appropriate (e.g. where stormwater treatment is required) include wetlands and rain gardens in the landscape, which retain water (Figure 18).

Figure 18: Wetland at Blacktown Showground

Summary of design strategies to reduce city-scale heating effects of buildings and outdoor spaces

Design strategies, in approximate order of priority		*Potential negatives*
1. Green cover	Across the urban area as a whole, **minimise impervious areas** as much as possible.	
2. Shade	**Shade** paved areas and building walls wherever possible, preferably with the canopy of surrounding trees or alternatively with shade structures.	*Continuous canopy (only in certain high-density environments)*
3. Cool materials	Install **cool roofs**, with a high SRI value. Use **cool paving**, with high albedo (high solar reflectance) and/or high thermal emittance (which releases heat quickly). Use **permeable paving**, either to promote deep soil infiltration or with near-surface water storage. Also consider **light coloured materials for walls/vertical surfaces**, but preferably only where heat can be absorbed by surrounding vegetation.	*Glare reflected from light-coloured surfaces* *Solar radiation reflected or absorbed and re-radiated onto other hard surfaces*
4. Water in the landscape	Where green cover is provided, ensure wherever possible that vegetation has access to water, by: a. Providing an **irrigation** system, preferably supplied by rainwater or suitably treated stormwater/recycled water. b. Enabling **passive irrigation** (i.e. direct runoff from surrounding surfaces into vegetated areas, so that water can be absorbed into the growing medium). c. Designing vegetated areas and stormwater treatment systems as **wetlands** and **rain gardens**, which retain water.	
5. Green roofs, façades and walls	Green roofs, façades and walls are effective urban cooling strategies, however they are high cost to install and maintain, and therefore not appropriate everywhere.	*High costs*

5.3 COOL OUTDOOR SPACES

In order to thrive, people need access to cool spaces in their local environment. This is particularly relevant in high pedestrian activity areas such as town centres, public transport nodes, active transport routes, parks and other places where people gather outdoors. Also consider where vulnerable people may be particularly exposed to heat, for example in car parks and at bus stops. A cool bus shelter, installed as a pilot by Penrith City Council, is shown in Figure 19.

Cool private spaces are also important for people's wellbeing, for example outdoor work areas in commercial development, and residential gardens, which for some people, may be the only place they spend time outdoors during hot weather. In these spaces, human comfort outdoors is a relevant objective.

When outdoor spaces are considered at a human scale (as they are experienced by people using them), 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. Sometimes we refer to the "microclimate" of a place - 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 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. As noted above, this can enable physical, social and economic activity to continue even when ambient temperatures are very high, reducing the impacts of urban heat.

Figure 19: Cool bus shelter at Derby Street, Kingswood, Penrith LGA (image: Penrith City Council)

Measuring outdoor thermal comfort

In outdoor spaces, surface and air temperatures are often measured as indicators of potential human thermal comfort, but they display different effects:

- The greatest variability is in surface temperatures: A thermal image (Figure 20) illustrates surface temperatures across the Parramatta CBD on a hot day, which range from approximately 20 to 60°C.
- There are smaller air temperature differences between nearby sites: Air temperature differences are not so pronounced as surface temperature differences, however the differences can still be significant – Section 2.2 referred to differences of up to 8°C between nearby streets.

How humans experience heat is influenced by air and surface temperatures, but is also influenced by other physical factors such as humidity and local air movement (e.g. whether or not there is a breeze) as well as personal factors including metabolic rate (essentially, our level of activity), clothing, and our psychological response to heat.

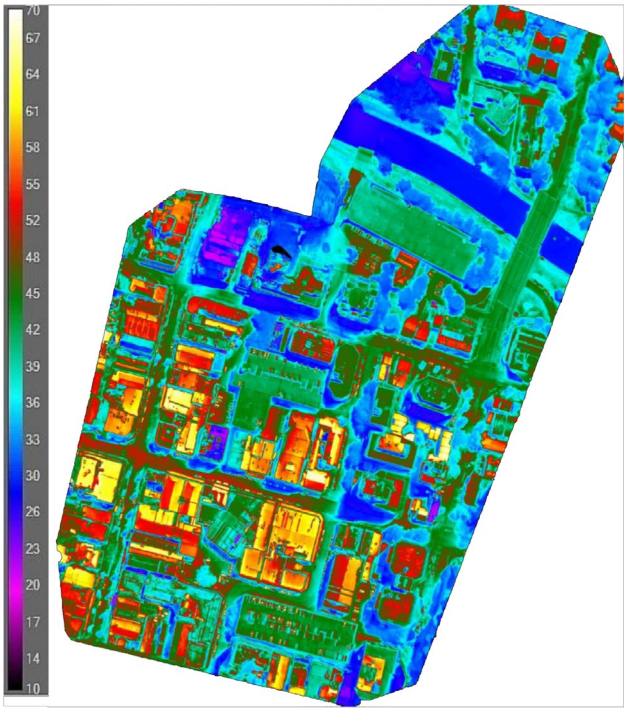


Figure 20: Thermal map of Parramatta CBD, 28/02/2018 (Santamouris et al 2020)

Often, alongside an actual air temperature, a relative temperature, more relevant to human thermal comfort, is expressed as a **"feels like"** temperature. One method to estimate a "feels like" temperature is the Universal Thermal Climate Index (UTCI). It combines personal factors (human activity and clothing) and thermal-physiological factors (air temperature, mean radiant temperature, relative humidity, and wind speed) to assess the effect of design measures on outdoor thermal comfort at pedestrian level. The UTCI temperature scale is shown in Figure 21.

A "feels like" measure of outdoor thermal comfort can be used to assess how a design intervention will influence the physical comfort, health and well-being of pedestrians or users of the public realm (for example providing shade along a pedestrian walkway), or for assessing design interventions to support outdoor activities on hot days.

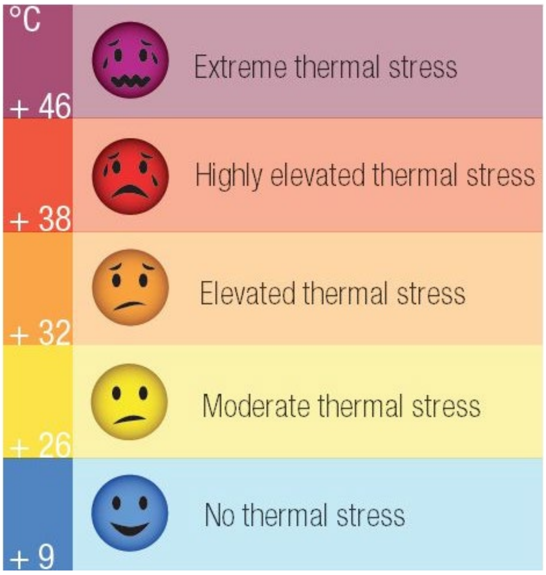


Figure 21: UTCI thermal stress categories – high temperatures (source: en.institutparisregion.fr)

Figure 22: Richmond Park in Hawkesbury LGA is well shaded by mature trees

Design measures for cool outdoor spaces

Table 3 lists potential effects on surface temperatures, air temperatures and thermal comfort (expressed as a "feels like" temperature) for a range of cooling strategies. Each of these temperature effects helps to indicate where each design measure is most effective:

- Shade, including mature trees and shade structures: The most effective strategies for improving feels like temperatures are those that create shade. Figure 22 and Figure 23 show examples of well-shaded playgrounds.
- Cool materials: Cool pavements, roofs and walls are all effective for reducing surface temperatures. However, they have a limited effect on air temperatures or feels like temperatures. The playground in Figure 23 is designed with cool materials.
- Evaporative cooling measures: Evaporative cooling, particularly misting fans, can create significant reductions in air temperatures, but they are expensive to install and maintain, they rely on a water supply and only work within a relatively small zone of influence. These measures could be appropriate for creating particular outdoor "cool zones" at strategic locations. It is worth noting that the presence of water features in the landscape such as fountains and ponds, as well as providing some 'real' cooling also provide users of the public realm with a *perception* of cooling.
- Air movement: Although not included in Table 3, air movement is also effective at reducing "feels like" temperatures, and orientation is included at the top of the list of recommended design measures on page 24.

Note that the role of several of these measures in city-scale cooling was discussed in Section 5.2. Table 3 is concerned with their effects at a human scale.

Figure 23: Cool and UV smart playground in Cumberland LGA

Table 3: Cooling capacity of different strategies (updated based on Osmond and Sharifi 2017)

Heat mitigation strategy	Maximum air temperature reduction within the zone of influence[a]	Thermal comfort improvement (Feels-like temperature)[b]	Maximum surface temperature reduction[c]	Key constraints
Mature street trees	4.0 °C	8.0 °C	15 °C	Space/conflict with grey infrastructure
Solar control systems (shading)	0.8 °C	8.0 °C	15 °C	Installation cost
Cool pavements	2.5 °C	0.5 °C	33 °C	Reflectance changes over time Undesirable glare
Permeable pavements	2.0 °C	2 °C (after sprinkling with water)	20 °C	Less suitable for heavy traffic Evaporation is less effective in humid weather and only effective when there is moisture present Maintenance
Cool roofs / walls and facades	2.5 °C (indoors)	0.5 °C	33 °C	Undesirable glare Complex reflectance in street canyon
Green roofs and walls	4.0 °C	0.1 °C	20 °C	High cost to install and maintain Water supply for walls Heat- and water- stress
Green open spaces	4.0 °C	4.0 °C	15 °C	Need to accommodate multiple needs
Evaporative cooling[d]	8.0 °C	1.0 °C	N/A	High cost to install and maintain Water supply required Less effective in humid weather Small zone of influence
Misting fans[e]	15 °C	1.0 °C	N/A	

Effectiveness[f]	Very high	High	Medium	Low	Negligible

Notes:

a. This indicator is best used when evaluating the overall temperature outcome along a street canyon, across an urban precinct, neighbourhood or development site. The zone of influence may vary depending on the type and size of intervention from few meters to several dozens of meters; as well as height of the intervention (i.e. cool/green roofs may have a stronger influence several meters above the ground).

b. Outdoor thermal comfort is best used to assess the capacity of an intervention to improve people's thermal perception (feeling), or levels of heat stress in open spaces. This is typically assessed by thermal comfort indices such as the Universal Thermal Climate Index (UTCI) or Physiological Equivalent Temperature (PET) using a scale that ranges from very hot (extreme heat stress) to very cold (extreme cold stress) thermal perception.

c. Surface temperature drops are best used to determine the potential impact of interventions on ameliorating urban overheating across large areas. It is also a relevant indicator on the potential outdoor thermal improvement that may be achieved as surface temperatures influence on the amount of heat directly emitted by surfaces towards pedestrians.

d. Generally, it refers to water bodies like ponds that are passive technologies.

e. Generally, it refers to active technologies such as sprinklers or misting fan systems.

f. Effectiveness may vary depending on context (i.e. industrial versus residential site), macroclimatic conditions (i.e. during heatwave compared to a typical summer day), location and extent of the mitigation technology.

Summary of design strategies to improve outdoor human thermal comfort

Design strategies, in approximate order of priority			*Potential negatives*
1.	Orientation	Consider orientation of site features: a. Consider prevailing breezes, skyview factor and solar aspect. b. Place loading docks and outdoor work areas on the southern/eastern side of buildings to reduce northern and western sun exposure. c. Prioritise canopy trees and shade structures on the northern and western sides of buildings.	
2.	Shade	Provide shade, particularly where people are likely to undertake outdoor activities in hot weather (including parks, streets and private gardens): a. Wherever possible, provide trees with dense, contiguous canopy coverage, as green cover will also have a larger-scale cooling effect. Parks, streetscapes (especially priority pedestrian and cycle routes), plazas and private gardens should all include canopy. b. Provide shade structures where trees are impractical, e.g. over playgrounds and picnic areas. These can include temporary 'pop-up' shading devices in the hottest times of the year. Awnings are already common in street-front retail.	*Continuous canopy (only in certain high-density environments)*
3.	Evaporative cooling	Provide evaporative cooling: a. In key "cool zones", consider installing active evaporative cooling features such as misting fans and water fountains. b. Wherever possible, provide sustainably sourced water supplies (see Section 5.4) and irrigation to maximise cooling. Cooling can be achieved by supplying vegetation with sufficient water in hot weather, so that evapotranspiration can work to reduce heat. Water can also potentially be applied to other urban surfaces to assist with cooling (e.g. night time watering of pavements is a strategy used in Japan for centuries). c. In parks and gardens, include ponds, wetlands and rain gardens, which retain water and help cool the immediate area via evaporation/evapotranspiration.	
4.	Cool surfaces	Use permeable paving for pedestrian areas, or lighter coloured pavements (high reflectance and infrared emittance values) where appropriate, noting the caveats from Section 5.2.	*Glare reflected from light-coloured surfaces* *Pavements/walls which reflect solar radiation or absorb and re-emit heat into areas frequented by pedestrians*

5.4 SUSTAINABLE WATER SUPPLIES

Water can play an important role in reducing urban heat. Sydney Water (2017) looked at the role of water in reducing heat at the city scale, finding that "combining cool materials and water-based technologies was the most effective strategy to mitigate the negative impacts of urban overheating on ambient temperatures, energy, peak electricity demand, heat-related mortality and thermal comfort" (Sydney Water 2017 p.14).

Water could play an even more important role at the human scale, in cooling outdoor spaces. Table 3 showed the significant potential effect of evaporative cooling and misting fans on nearby air temperatures. Irrigated landscapes have also been shown to be significantly cooler than dry landscapes. South Australia Water undertook an irrigation trial of turf areas at Adelaide Airport, finding an average 2.2-2.4°C air temperature reduction within the irrigation area, compared to adjacent non-irrigated area (Ingleton *et al* 2018). The CRC for Water Sensitive Cities (2020, p.12) found that "dry grass can be as hot as road surfaces on extreme heat days while irrigated grass can be as cool as trees" – see Figure 24.

Unfortunately, hot days and heatwaves may coincide with periods of drought and water restrictions, limiting the capacity for irrigation of urban landscapes in both the public and private domain, and may also limit the use of more active cooling measures such as water features and water play.

To improve resilience to droughts, existing planning policies aim to reduce water demands in urban development, encouraging xeriscaping (landscape design that reduces or eliminates the need for irrigation) and the use of more efficient irrigation systems. When it comes to specifying new vegetation, particularly long-lived plants such as trees, it is important to consider species that are heat and drought-resistant, considering future temperature rise projections. The "Which Plant Where" project (a collaboration between Hort Innovation, Macquarie University, Western Sydney University and the NSW Department of Planning, Industry and Environment) aims to deliver a decision support tool for urban tree selection, which considers future climate change. When this becomes available, planning provisions could potentially refer to it for species selection. To improve resilience to urban heat, planning policies should also encourage the use of irrigation to help mitigate urban heat.

These two competing objectives can be reconciled if there is a strong emphasis on sustainable water supplies (e.g. rainwater, stormwater harvesting, recycled water) for irrigation purposes.

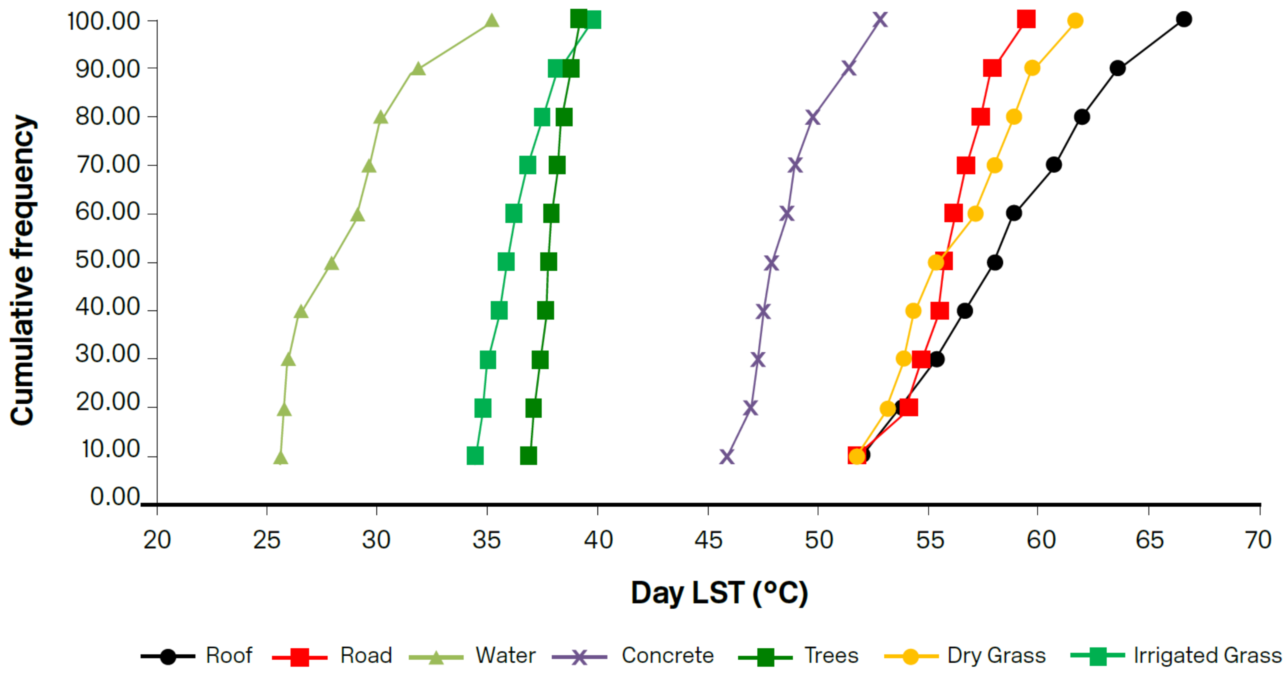


Figure 24: Temperatures of different urban surfaces (CRC for Water Sensitive Cities, 2020)

5.5 COOL BUILDINGS

Strategies to reduce the contribution of buildings to heating the urban environment were discussed in Section 5.2. This section is concerned with keeping buildings cool on the inside, to ensure thermal comfort and safety of building occupants. While non-residential buildings don't have the same role as homes, which are essential places of shelter in extreme conditions, they still play important roles in our economy and society, and if they function reliably through hot weather and heatwaves, then social and economic disruption will be minimised.

The specific set of conditions defined as "comfortable" depends on the nature of the use of a building and can be calculated using the thermal comfort metric most appropriate to the building use. In the case of office or workplace environments, an appropriate thermal comfort metric is Predicted Mean Vote (PMV), which reports comfort on a scale from Cold to Neutral to Hot, and which varies the target comfortable range of temperatures based on personal activity and clothing levels, among other things. A variant of this metric is the Adaptive Comfort metric (described in ASHRAE Standard 55: Thermal Environmental Conditions for Human Occupancy), which reflects that indoor temperatures perceived as comfortable increase as it gets hotter outside.

For non-residential structures (e.g. offices, cultural and industrial buildings), the recent 2019 NCC update included changes that indirectly improve urban heat outcomes for buildings. Notably, the update substantially increased the passive conditioning requirements for building envelopes (roof, walls, windows) that will help keep building interiors at safer temperatures during heatwaves. These passive design requirements for non-residential buildings are now relatively stringent compared to other international building codes and standards (such as ASHRAE 90.1 Standard for Energy Use in Buildings in the US, or Part L building regulations in the UK). Therefore, new non-residential buildings in Western Sydney should meet relatively high standards.

Heatwaves remain the crucial condition in which the performance of these buildings may be limited. Because almost all new office, civic, industrial, and other non-residential buildings are built with air-conditioning and heating systems, the primary thermal comfort challenge these buildings face is achieving comfort during heatwaves, which pose higher cooling loads than current code design conditions recognise. The consequence of this is typically that indoor areas of buildings near windows get too warm, especially those directly in the sun. A secondary consequence is that buildings use more energy to keep spaces cool, which in turn strains the capacity of the electrical utility grid as noted previously.

In circumstances where buildings lose power, or the air-conditioning equipment fails, there are rarely thermal safety concerns; most buildings can be closed temporarily, with occupants sent home or to other facilities to avoid any safety risks. Hospitals, police stations, and mission critical facilities that must remain occupied manage this risk through a combination of on-site emergency power generation and equipment redundancy.

5.6 COOL HOMES

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

Thermal safety, or better still, thermal comfort, has traditionally been provided to people by buildings: a roof and walls to keep us dry, shaded, and not too hot or cool. The look and feel of Sydney's vernacular architecture – across many styles – was shaped by the need for walls and windows to create thermally comfortable indoor environments without supplemental heating or cooling.

Following the advent of reliable and affordable air conditioning in the latter 20th century, buildings no longer had to provide comfort passively. Accordingly, design conventions changed to prioritise views, lower-cost construction, and other outcomes. Passive design for thermal comfort became a lower priority.

The importance of thermal safety in homes

Unlike most other building types, our homes have a fundamental requirement to provide us with safety at all hours of the day and night, under all circumstances.

The life-threatening events that affect Western Sydney most frequently are heatwaves. As noted in Section 1.3, heatwaves kill more Australians than any other natural disaster, and elderly people are particularly vulnerable. Ensuring that building interiors have the capacity to remain within a safe temperature range during a heatwave is a fundamental public health concern.

By day, some people have the option of seeking shelter from the heat in cooler public places: shady parks, swimming pools or natural water bodies, or inside air-conditioned buildings like libraries and shopping malls. But many people, especially the elderly or those with mobility limitations, have no choice but to shelter during the day at home. Even when it is possible for people to seek refuge in cool locations during the day, most must return home at night where temperatures may still be very high. Extreme heat events with little overnight respite are widely considered to present the biggest health risks to vulnerable people, by prolonging heat exposure (e.g. Loughnan et al 2014; Bi *et al* 2011). Accordingly, homes are the building type most in need of regulation for achievement of a safe thermal environment.

Within homes, the space where we most need safe temperatures is the bedroom. For some people, this is the only room in their residence; for everyone, this is room with the most reliable occupancy. Accordingly, this is the space in a home that should be subject to the most stringent thermal safety requirements.

'Thermal autonomy' design standards

A directly applicable metric for how our residential buildings should cope with heat waves is **thermal autonomy**: a measure of the percentage of time a building can maintain a specific set of comfort conditions passively (without air conditioning or heating), despite outdoor temperature fluctuations (Levitt, et.al., 2013) (Figure 25). Thermal autonomy is the aspect of passive survivability that gauges whether people will remain safe in their homes without air conditioning, during heat waves. Thermal autonomy is a better gauge of a building's resilience to heatwaves because its exclusion of supplemental air conditioning from the assessment of comfort reflects conditions where power is lost, and it reflects the performance of buildings that either have no air conditioning or cannot afford to use it.

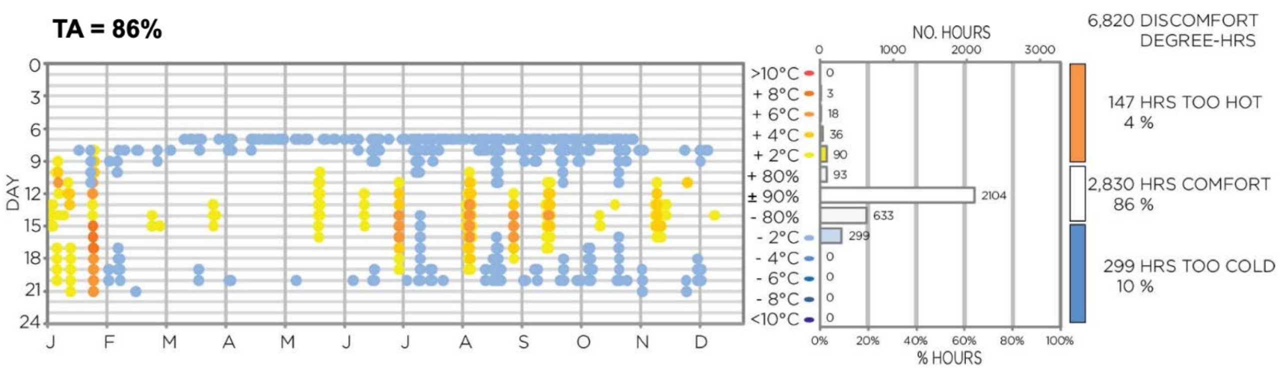


Figure 25: Thermal autonomy reporting example (Levitt et.al, 2013). In the dot plot portion of the diagram (left), blue dots represent hours Too Cold, while yellow and orange dots represent hours too hot. The Discomfort degree-hour total combines hours of discomfort with intensity of discomfort into a secondary but less precise metric of discomfort.

The concept of thermal autonomy allows the nomination of specific thermal comfort, or thermal safety, conditions as required. The percentage of time a space is compliant can either be met by a thermal simulation over a span of time with particular weather conditions (typically a reference year) or could be met by complying with nominated Deemed to Satisfy passive design features of a building's envelope.

For residences, thermal autonomy and the idea of adaptive comfort (perceived comfort that adjusts with varying outside conditions) come together in a new design guide from the UK focused on overheating risk assessment in homes (CIBSE TM 59). This guideline defines an upper comfort limit, which increases with average outdoor temperature, and requires that indoor temperatures stay below that limit, without assistance from air-conditioning, for all but 3% of occupied hours. For bedrooms, an absolute upper limit on temperature of 26°C can only be exceeded for 1% of hours between 8 pm and 7 am, which acknowledges that at night people cannot flee to other publicly accessible air-conditioned places.

CIBSE TM59 is widely used in the UK to assess residential and non-residential buildings for risk of overheating. Indoor overheating risk assessments, including design team thermal simulation evidence, are required by the Greater London Authority during the initial and final stages of planning approvals for all residential and commercial "Major Developments".

Future climate should inform today's design

The future climate is expected to be warmer than the present day, bringing heatwaves of increasing frequency and severity. As housing built today is expected to last many decades, it is important to design for anticipated future conditions, or today's housing will perform poorly over its lifetime.

Three case studies are included on pages 29 to 31. The first two case studies compare the thermal comfort outcomes of higher- and lower-performing homes. These both demonstrate the benefit of designing for high passive thermal performance. The second study (Brannon 2018) affirms that more stringent building envelope requirements including a thermal autonomy design standard (not currently required by BASIX) would deliver homes in Western Sydney that are substantially more thermally comfortable and, during heat waves, much safer thermally. The CIBSE TM 59 design standard was used by Brannon (2018) in the second case study, to define thermal autonomy.

The third case study (WSP 2021) investigated the climate resilience of homes in Eastern Sydney, modelling how these dwellings would perform if built to current standards, and then subjected to future climate conditions. It showed that cooling loads would increase substantially, presenting a risk that homes built today will be very difficult to keep comfortable in future climate conditions.

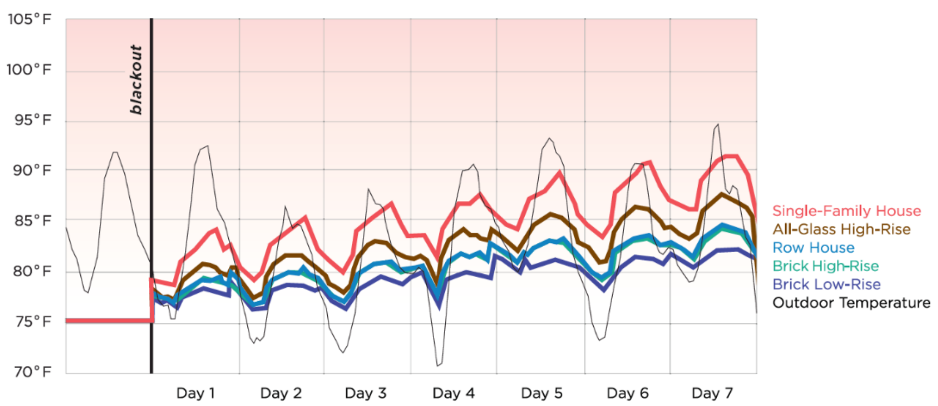
CASE STUDY 1: THERMAL PERFORMANCE OF NON-AIR-CONDITIIONED HOMES DURING A HEATWAVE

Thermal autonomy benefits resulting from good passive design were illustrated in a 2014 study of indoor temperatures across a range of residential buildings in New York City, with no air-conditioning available during a summer heatwave (Urban Green, 2014). The summer ambient temperatures during the week of this study are comparable to those of Western Sydney (daytime highs at 95°F / 35°C, night lows around 72°F / 21°C), so the trends illustrated in this study are relevant in both locations (Figure 26, Figure 27).

Compared to conventional buildings (Figure 27), high performance residences with good passive design strategies – analogous to meeting a stringent energy code like Passive House or the UK Part L building regulations – would see much cooler indoor temperatures through the heat wave (Figure 26). For some building types, indoor temperatures would increase by only a few degrees – even after five consecutive days without air conditioning.

This study also makes explicit that detached houses are particularly susceptible to overheating during heat waves, a consequence of the high surface to volume ratio and windows on all orientations (Figure 26 and Figure 27, "Single Family House" cases). The study also makes it very clear that highly glazed apartment buildings respond to heat waves like solar ovens, quickly heating during the day but not cooling as much at night (Figure 27, "All Glass High Rise" case).

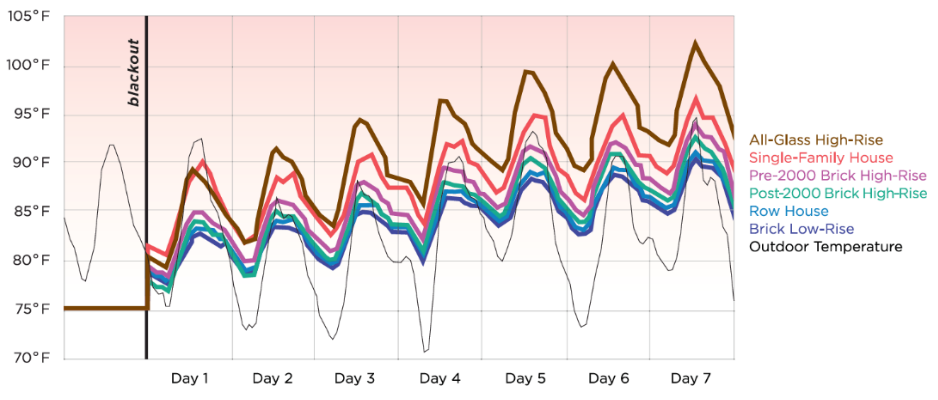
High-Performing Building



High-performing brick buildings, including the row house and brick low- and high-rise apartments, would stay below 80°F for the first half of the week, and never go above 85°F. The high-performing glass building reaches 88°F and the single-family house still rises above 90°F.

Figure 26: Modelled temperatures inside high-performance homes during a summer blackout in New York City (Urban Green 2014)

Typical Building



The typical all-glass high-rise apartment and single-family house heat to almost 90°F on the first day. The all-glass apartment climbs above 95°F on the fourth day and peaks over 100°F. The brick buildings, including the row house, low-rise and high-rise apartments, stay cooler throughout the week but still end above 85°F.

Figure 27: Modelled temperatures inside low performance homes during a summer blackout in New York City (Urban Green 2014)

CASE STUDY 2: THERMAL AUTONOMY IN RESIDENTIAL BUILDINGS IN WESTERN SYDNEY

A more recent study of thermal resilience in residential buildings in Western Sydney (Richmond weather data was used) illustrates the positive benefit of building homes to a higher passive design standard (Brannon 2018). In one case, a unit modelled with a minimally code compliant building envelope exposed to recent weather achieved thermal autonomy only 46% of the time, with 23% of hours too warm (Figure 28). That same unit, using synthetic weather data based on climate change forecasts for 2090, shows 33% of hours uncomfortably warm.

By comparison, that same unit exposed to recent weather but modelled with a high-performance envelope (analogous to compliance with current UK Part L residential regulations), achieved thermal autonomy 89% of the time, with only 3% of the hours too warm (Figure 29). Exposed to 2090 weather, the percentage of time too warm increases to 12%, but the percentage of time too cold almost disappears. Thermal autonomy remains almost unchanged at 87%.

Brannon (2018) also points out the consequences of continued climate change on thermal comfort and safety in Western Sydney. Even with best practice building envelopes, residences exposed to recent weather will exceed the threshold of overheating risk at night by 4% of overnight hours annually. By 2090, though, these homes could be overheated by as much as 16% of overnight hours annually, a four-fold increase (Figure 30).

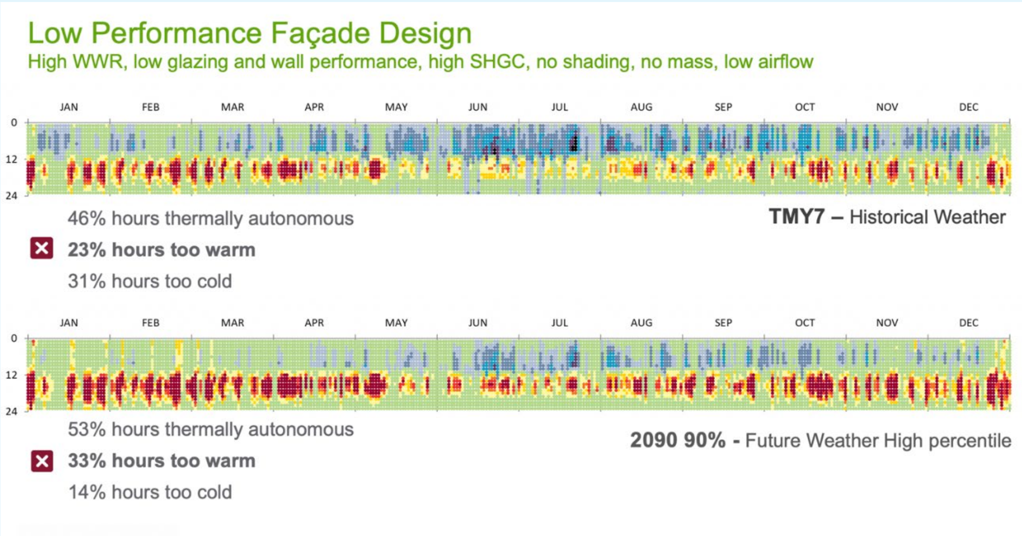


Figure 28: Modelled thermal autonomy for a minimally code-compliant apartment in Western Sydney, using both recent weather (TMY7 case) and predicted weather (2090 90% case) (Brannon 2018).

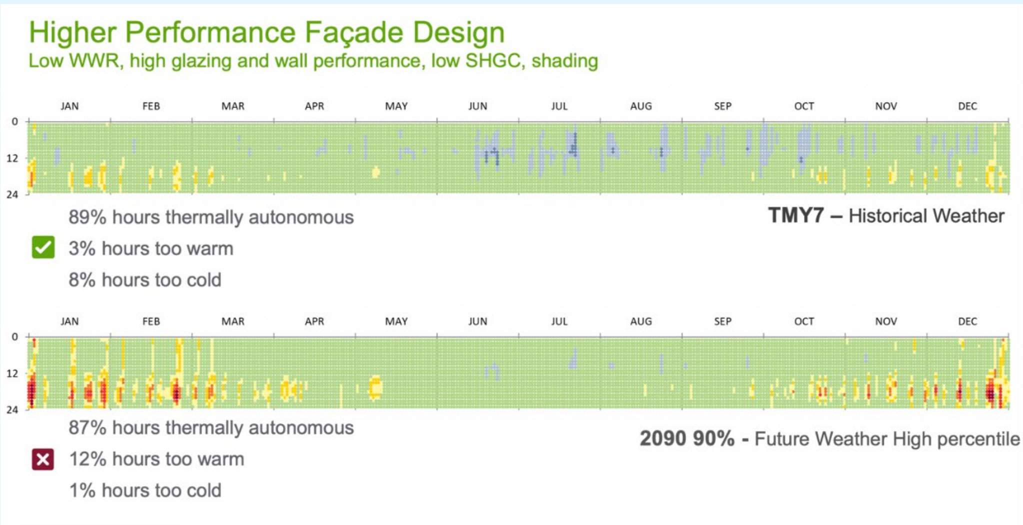


Figure 29: Modelled thermal autonomy for a high performance envelope apartment in Western Sydney, using both recent weather (TMY7 case) and predicted weather (2090 90% case) (Brannon 2018).

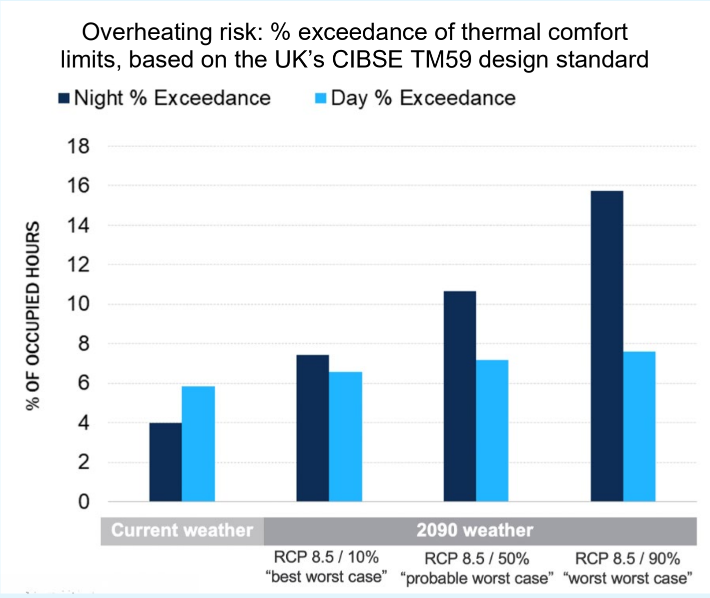


Figure 30: Current and future annual overheating risk to a bedroom with a high performance building envelope, without using air conditioning. The three 2090 cases reflect arrange of future weather models and show that thermal comfort and safety will be particularly vulnerable to night time temperature increase. Intermediate time forecasts were not modelled. (Brannon, 2018)

CASE STUDY 3: CLIMATE RESILIENCE OF EASTERN SYDNEY HOMES

A recent study of typical housing in Sydney's Eastern Suburbs (WSP 2021) modelled how these dwellings would perform if built to current standards (as per BASIX) and then subjected to future climate conditions, including 2030 and 2070 scenarios. A summary of thermal performance results from this study are shown in Figure 31. This shows that for all dwelling types, cooling loads would increase substantially in 2030 and 2070. The study found that:

- In 2030, cooling loads increased by 55%-79% above the Baseline Year
- In 2070, cooling loads significantly increased by 254%-340% above the Baseline Year.

The study used baseline year climate data to make the best possible match with the climate data currently used in BASIX. Climate change scenarios were based on the RCP8.5 scenario, which represents high emissions throughout the 21st century. The study illustrates the risk that homes built today will be very difficult to keep comfortable in future climate conditions. The study also found that both energy and water consumption could be expected to increase significantly in the future, with implications for equity, affordability, reliability of rainwater tanks and stability of the electricity grid.

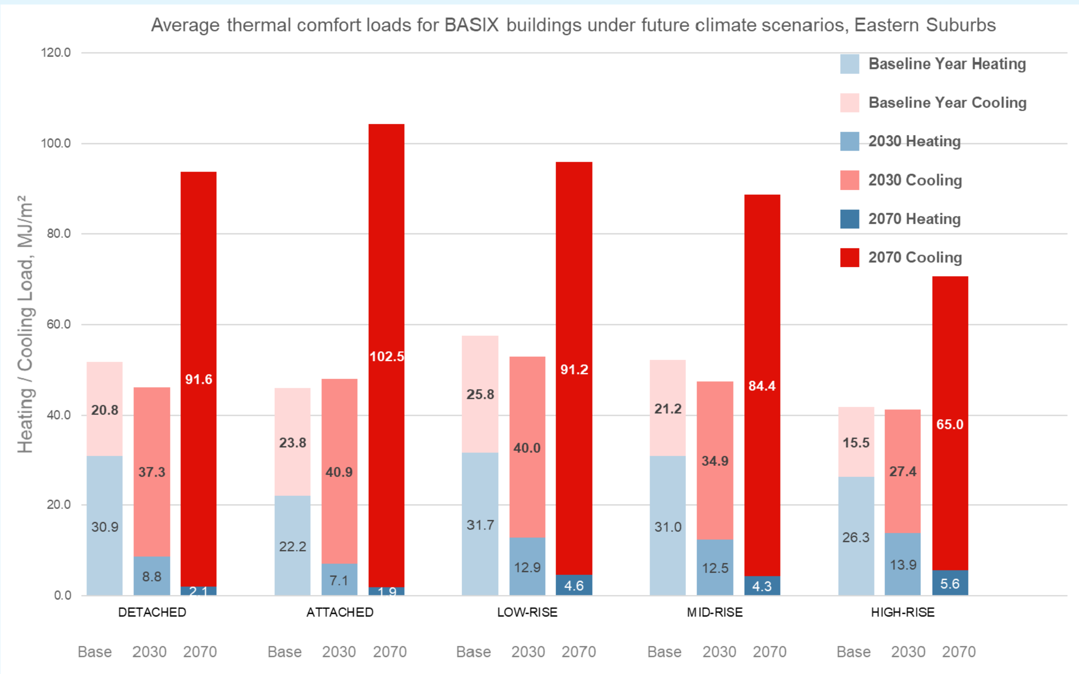


Figure 31: Heating and cooling loads on Eastern Suburbs homes under future climate scenarios (WSP 2021)

5.7 ROBUST ENERGY SYSTEMS

Most buildings have air conditioning, and in a changing climate, its use is likely to become more frequent, and more critical to safeguarding the health of people living and working in Western Sydney.

Air conditioning only works when there is power to run it, and as has been noted in Section 1.3, extreme heat places multiple stresses on the electricity network, increasing the likelihood of power outages:

- During hot weather, peak electricity demands are driven by air conditioning. As temperatures increase, air conditioning demands increase and electricity use increases accordingly. Peak demand typically occurs in the late afternoon.
- Extreme heat places physical stress on the grid, reducing the efficiency of generation infrastructure and reducing the capacity of the transmission and distribution system. Gas and coal fired power plants are also more likely to break down in very hot conditions (The Australia Institute 2018).

If the electricity grid fails and people are unable to run air conditioning during hot conditions, their homes can quickly overheat, with severe impacts on health. Therefore, an important strategy for reducing heat-related mortality is to improve the reliability of the electricity network.

The capacity of the electricity network has been expanded in the past by increasing the capacity of both the fossil fuel-based generators and the transmission and distribution system. However, continual expansion increases the cost of electricity, with impacts on vulnerable people in the community. Furthermore, with extreme heat placing increased stress on this infrastructure, we are chasing an ever higher peak capacity.

If we shift our approach to focus on reducing peak demands, we can improve the resilience of the electricity network. Two broad options to achieve this are:

1. To reduce reliance on air conditioning.
2. To reduce reliance on centralised electricity generation.

The former option is discussed in Sections 5.6 and 5.5, which focus on improving the passive thermal performance of homes and other buildings. The latter option involves provision of decentralised power generation and/or storage (which could be either on-site or at a local community scale).

In urban areas, solar power has become popular with residential and commercial building owners, as it can offer a sound financial return on investment. Rooftop solar is reliable on hot days due to ample sunshine. Although PV output drops as temperatures rise, it can still play an important role reducing peak demands on hot days. Across Australia's National Electricity Market, rooftop solar is already assisting to reduce peak demands in heatwaves.

Local development controls could encourage or require the installation of solar power, at least for non-residential development, and some already include provisions to prevent overshadowing of existing systems (e.g. to prevent trees from overshadowing).

When rooftop solar systems are combined with on-site battery storage, there is potential to further reduce the magnitude of peak demands, by storing energy for use in the late afternoon and evening, as solar generation declines and demand remains high (The Australia Institute 2018). Battery systems are also becoming more affordable and residential installations are increasing.

A further measure to consider, particularly for buildings that house vulnerable residents, is to enable them to disconnect (to be "islanded") from the grid when there is a power outage. This is not something most buildings are set up to do, however, in order for PV and battery storage systems to power a building during a utility blackout, the building's power system needs to be configured to enable this.

Air-conditioning system efficiency is affected by heat waves, with most cooling units losing some cooling capacity above 40°C as the equipment reaches its design limits. Some equipment stops working entirely when ambient temperatures reach a given temperature, sometimes 40°C and often 45 °C, to protect the unit from overheating damage.

In order to ensure that air conditioning works reliably when it is most needed, design guidelines and building codes should all establish a basic requirement that air conditioning equipment must work through peak ambient temperatures of 45°C, which are experienced in Western Sydney with increasing frequency.

CASE STUDY 4: ROOFTOP SOLAR

The Australia Institute (2018, p.3) found that "rooftop solar consistently reduces the size of the crucial summer day demand peaks and delays the timing of the peak to later in the day".

18 January 2018 was very hot and was the second-highest demand day of that month. On that day, Victoria's Low Yang B coal-fired power station broke down, reducing power supplied to the grid by over 500 MW. However, that day in the states connected to the national grid, rooftop solar reduced the peak demand by around 1,600 MW, greatly reducing the consequences of the breakdown (The Australia Institute 2018).

Figure 32 shows total electricity demand in NSW on 19 January 2018, which was the highest demand day of the month. Figure 32 highlights the quantity of total demand supplied by rooftop solar power. The contribution of solar power reduced the magnitude of the peak demand by 10%, and delayed the timing of peak demand on the grid. Across all of the states connected to the national grid, on 19 January 2018, solar power reduced peak demand by more than 2,000 MW (The Australia Institute 2018).

Similar effects are seen in other Australian cities and on other hot days as well.

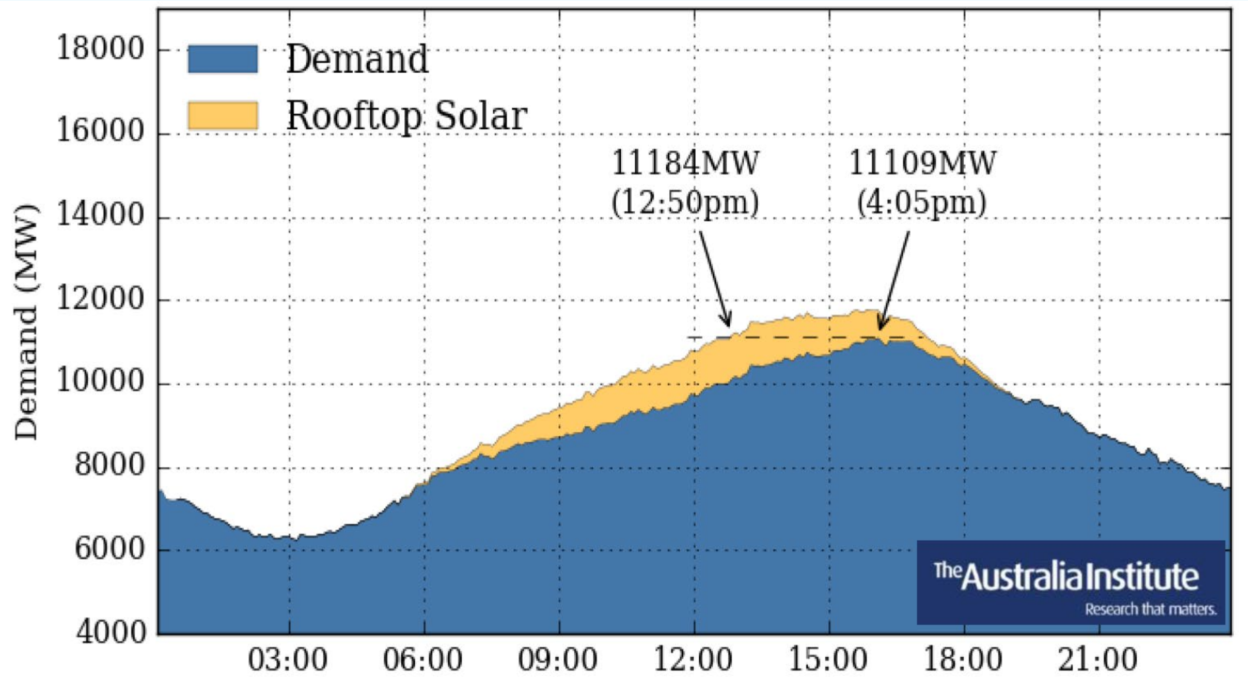


Figure 32: Solar demand reduction and total demand in NSW (19 January 2018) based on data from OpenNEM (The Australia Institute 2018)

PART III

APPLYING THE APPROACH TO LOCAL PLANNING PROVISIONS

Planning and design of new development is governed by many different regulatory instruments, policies, plans and codes, from national to local level, and urban heat is an issue that cuts across many different aspects of urban planning and design.

It is important to consider what can be codified effectively in local planning provisions, while balancing competing objectives.

6 CHALLENGES AND LIMITATIONS

6.1 LOCAL PLANNING PROVISIONS HAVE A LIMITED ROLE

Councils can play an important role in improving the urban heat outcomes in new development, via local planning provisions and development controls. There are three key plans that each council prepares:

1. The Local Strategic Planning Statement (LSPS): The As discussed in Section 3.1, LSPSs establish the policy basis for provisions in the LEP and DCP.
2. The Local Environment Plan (LEP): This is intended to implement the strategies and planning priorities described in the Local Strategic Planning Statements. LEPs establish land use zoning across local government areas, as well as including local provisions to provide a framework of controls and guidelines for development.
3. The Development Control Plan (DCP): This provides detailed planning and design guidance to support planning controls in LEPs. DCPs include a mix of specific controls and general guidance.

As noted in Section 3.1, several Western Sydney councils have included a specific action in their LSPS to update planning controls to better address urban heat.

Improved local provisions can help ensure that urban heat is considered in the design of new development and that each development meets the most appropriate design standards, however it is also important to note the limitations of local provisions. Many developments bypass these provisions with other approval pathways (e.g. exempt, complying and state-significant development). There are also other planning instruments (e.g. BASIX) that prevail over certain local provisions. These limitations are discussed below.

Exempt and complying development

The State Environmental Planning Policy (Exempt and Complying Development Codes) 2008 (The Codes SEPP) enables some development to be undertaken without development consent, as exempt or complying development. The NSW Housing Code, within the Codes SEPP, enables new residential dwellings, including several types of attached dwellings, to proceed as complying development, providing that they meet various basic minimum design standards.

One of the key features of the Housing Code is that it defines minimum landscaped areas for new residential development, allowing as little as 20% of a 600 sqm lot and 10% of a 300 sqm lot to be landscaped area. This is less than most council DCPs require, and puts a limit on the potential for green infrastructure to play a role in the private domain.

An increasing proportion of development in NSW is complying development, as shown in Figure 33. In Western Sydney, the proportion is even higher – in Camden, Campbelltown, Liverpool and Penrith LGAs in the 2018 financial year, the proportion was more than 50% (based on data from the Local Development Performance Monitoring Report, DPIE 2020).

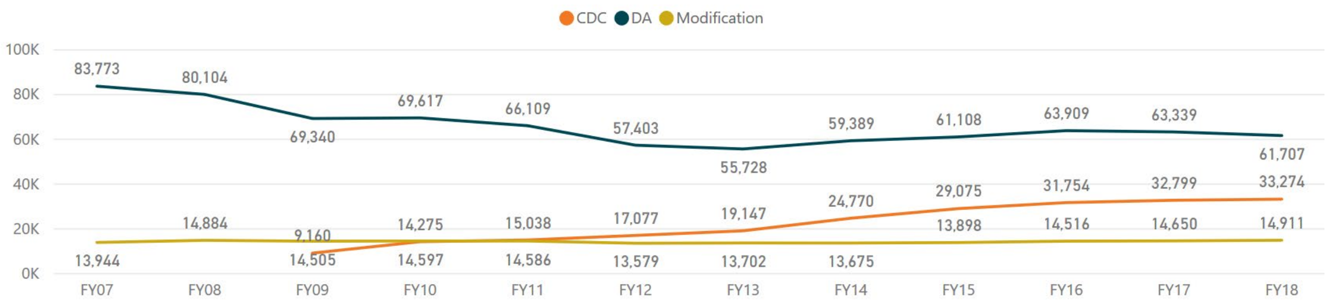


Figure 33: Number of development applications approved by financial year, showing increasing proportion of Complying Development Certificates (CDCs) and reducing proportion of Development Applications (DAs) (NSW DPIE 2020)

Site-specific SEPPs for major growth centres

There are site-specific SEPPs in effect for large areas in Western Sydney, including the *SEPP (Sydney Region Growth Centres) 2006* and the *SEPP (Western Sydney Employment Area) 2009*. Another SEPP has been proposed for the Western Sydney Aerotropolis. These are accompanied by site-specific DCPs. While local councils are the consent authority within the Growth Centres and the Employment Area, the relevant SEPPs establish the planning framework in these areas, and the relevant DCPs are developed by the NSW Government.

Site-specific LEPs and DCPs

Major growth precincts (for example, Wentworth Point Priority Precinct in the Parramatta LGA) also have their own DCPs, which are typically developed via collaboration between the relevant council, the NSW Government, and the developer of the precinct.

Individual properties outside growth precincts may also have a site-specific LEP and DCP if the developer negotiates for rezoning.

The Western Sydney Aerotropolis Phase 1 DCP (Western Sydney Planning Partnership 2020) includes provisions related to urban heat. These are in the form of simple performance outcome statements, rather than detailed provisions.

State-significant development

The State and Regional Development SEPP (2011) also provides a pathway for certain development, deemed to have state significance, to bypass local planning provisions. The Minister for Planning or the Independent Planning Commission becomes the consent authority and applies conditions to these developments.

BASIX

In NSW, the State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004, also known as the BASIX SEPP, sets water efficiency, energy efficiency and indoor thermal performance requirements for residential buildings. The BASIX SEPP also explicitly prevails over any other environmental planning instruments (including LEPs and DCPs) in the case of any inconsistency. This prevents councils from mandating any provisions that relate to indoor thermal comfort, energy efficiency, or water efficiency of residential buildings.

Apartment Design Guide

SEPP 65 - Design Quality of Residential Apartment Development, and its supporting Apartment Design Guide (NSW Department of Planning and Environment 2015), is also relevant for residential apartment development of three or more storeys and four or more dwellings.

It refers to BASIX requirements for energy efficiency, thermal comfort and water efficiency, but also has an additional requirement for natural cross ventilation (requiring natural cross-ventilation for 60% of apartments in the first nine storeys of a building).

It also includes some design guidance on principles and potential design solutions for passive solar design, natural ventilation and water sensitive urban design, which may encourage better design.

The Apartment Design Guide also includes guidance on some other design parameters relevant to urban heat, such as building separation, setbacks and orientation. It also includes a minimum design standard for deep soil zones (7% of the site area, with some additional requirements for minimum dimensions).

Unlike BASIX, SEPP 65 also leaves some scope for local DCP provisions to set different criteria on certain topics. Clause 6A(1) lists nine topics where local DCPs cannot be inconsistent with the guide, but leaves other topics open.

Proposed Design and Place SEPP

The NSW Government is currently developing a new SEPP, "Design and Place", building on the Greener Places Framework (NSW Government Architect 2020a) and Draft Design Guide (*ibid*, 2020b). At this stage the proposed coverage and content of the Design and Place SEPP is largely unknown, but there is potential for significant overlap with topics related to urban heat, such as green cover and tree canopy. A Statement of Intended Effects is due for release in early 2021.

A draft version of this urban heat toolkit has been provided to staff from various sections of the Department of Planning, Industry and Environment (DPIE), including the team developing the Design and Place SEPP. This has been done both to inform their work and to seek their feedback on the toolkit.

6.2 URBAN HEAT IS INSEPARABLE FROM OTHER PLANNING ISSUES

Urban heat is inextricably interwoven with multiple other issues in urban development. Every building, paved surface and landscaped area plays a role in regulating heat in the urban environment. Buildings both contribute to the UHI effect and function to shelter people during heatwaves. Urban landscapes can make positive or negative contributions to urban heat and its impacts.

These elements of the built environment also play multiple other important roles, and therefore need to be designed to meet multiple objectives. Rather than urban heat being a separate consideration in urban development, that can be addressed with its own set of solutions, it needs to be seen as one of multiple interconnected considerations, that must be addressed with an integrated design approach.

Local planning documents (LEPs and DCPs) already include multiple provisions relevant to urban heat:

- Landscape provisions: These include minimum landscaped areas for different types of development, requirements for landscaped setbacks, and minimum deep soil areas for certain development types.
- Tree provisions: These include tree preservation requirements as well as provisions to replace or plant new trees in certain circumstances.
- Provisions for water sensitive urban design (WSUD): These typically include stormwater quality improvement targets, and encourage the use of green infrastructure to meet those targets.
- Provisions for energy and water: These typically cover energy and water efficiency and alternative energy and water supplies in non-residential buildings.

These provisions have generally been written without considering urban heat mitigation as a specific objective, but each of them has the potential for strong alignment with urban heat mitigation objectives, and could be modified to strengthen the outcomes from an urban heat perspective. For example, tree provisions could be modified to focus more on canopy cover as a key outcome.

A greater challenge is that each of these planning provisions has also been written to strike a balance with other competing objectives, for example housing affordability and life cycle costs. Green infrastructure is a good example. Integrating more green infrastructure into the urban environment would have multiple benefits, including urban heat mitigation, but it is in tension with other objectives.

Whether green infrastructure is located in the public or the private domain, it competes for space with other land uses. This issue is explored further in Section 6.3, particularly as it relates to tree canopy.

Long-term maintenance is also a challenge. Green roofs and walls may overcome the issue of competition for space (although they don't provide the same outcomes as trees), but they have significant maintenance requirements, which few land managers are prepared to take on. Even when it comes to simpler forms of green infrastructure, many land managers (public and private) lack capacity for effective maintenance.

Figure 34 shows an example of recent development in Schofields, with very limited green space.

Figure 34: Recent development at Ludhiana Glade, Schofields (image: NearMap 2020)

6.3 GREEN INFRASTRUCTURE COMPETES FOR SPACE

Canopy cover is a useful indicator of green infrastructure, as trees are widespread, canopy cover is relatively easy to measure, and canopy cover is strongly linked with urban heat outcomes.

Across Greater Sydney the state government has established a canopy over target of 40% (Greater Sydney Commission 2018a). However, the current canopy cover across the Western Sydney District is only 19% (Greater Sydney Commission 2018b) and it is much lower in many suburbs – see Figure 35 below.

Councils face many challenges increasing tree canopy cover in Western Sydney. Silk (2020) looked at trees in streetscapes, in Camden LGA, and found that trees lack the status of "essential" infrastructure, and must compete for space with:

- Hard surfaces including the roadway, parking areas, driveways and footpaths.
- Underground services such as water, wastewater, electricity, gas and telecommunications infrastructure, which are all allocated space in the verge.
- Electricity infrastructure is sometimes also above-ground where it competes for space with tree canopies.
- Space allocated to parking and waste collection.

Within the private domain, green infrastructure also competes for space. Lot sizes have decreased significantly during the last decade (UDIA 2020), and while house sizes have also decreased over this time (CommSec 2020), the overall effect has been smaller areas of private open space. An increasing emphasis on infill development also means decreasing areas of private open space, particularly when it comes to areas of deep soil.

There are opportunities for local planning provisions and precinct design guidelines to ensure that more space is provided for green infrastructure, however the necessary trade-offs are fraught. In streetscapes, Silk (2020) recommended mandating greater lot widths, wider road reserves and specific driveway locations and widths. Silk (2020) also suggested consideration of different waste collection mechanisms, so the space allocated to waste collection could be reduced. In the private domain, planning provisions could mandate greater landscaped areas and deep soil zones, and specific requirements to plant trees, but substantial changes could face significant industry resistance. To challenge well-established and widespread practices, which are supported by current policies, will require a co-ordinated approach beyond individual councils.

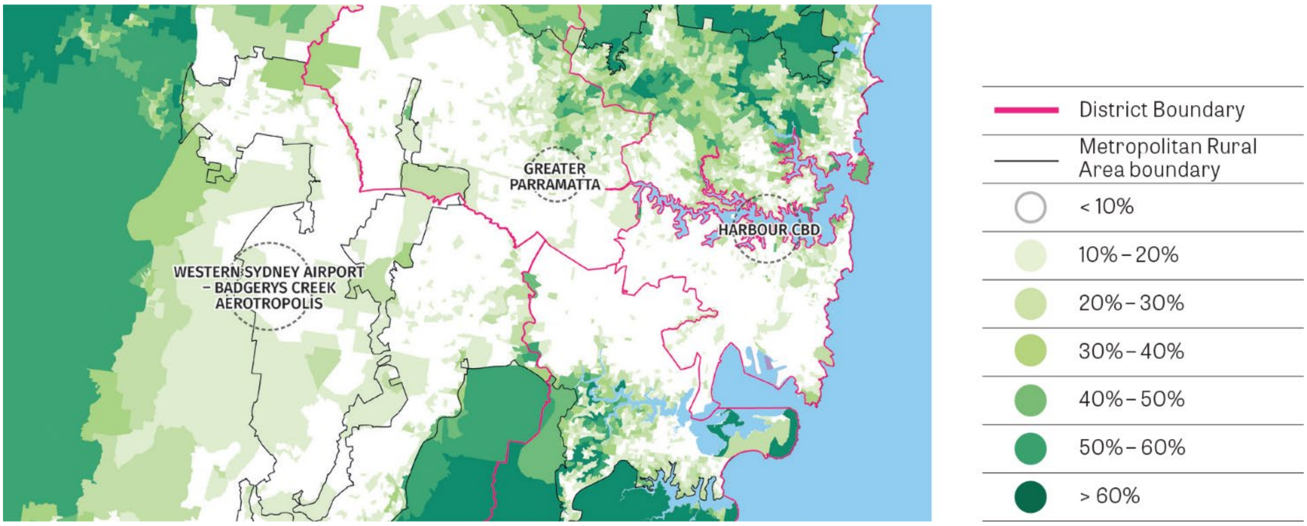


Figure 35: Tree canopy cover (per cent) across Greater Sydney in 2011 (Greater Sydney Commission 2018b)

7 LOCAL PLANNING CONTROLS

7.1 INTRODUCTION TO THIS SECTION

Different LEPs and DCPs deal with the same topics in different ways, and in a new field like urban heat resilience, there are few precedents for planning provisions related to urban heat. One example published recently is the Western Sydney Aerotropolis Phase 1 DCP (Western Sydney Planning Partnership 2020), where urban heat provisions are both grouped together in one section of the DCP (5.1.7) and also scattered throughout other sections (5.1.1 to 5.1.3) which have a relationship with urban heat outcomes. This toolkit takes a similar approach, recommending both standalone urban heat provisions for the LEP and DCP, as well as suggesting where other related provisions can be strengthened to better support urban heat resilience outcomes.

There is also similarity between the planning principles underpinning the Aerotropolis Phase 1 DCP provisions and those covered in this toolkit. Table 4 lists the "performance outcomes" from the Aerotropolis Phase 1 DCP, and notes the relationship with the framework from Section 5 of this toolkit. The aerotropolis DCP includes objectives that relate to:

- Energy efficiency and renewable energy (low carbon cities/robust energy systems)
- Reducing/minimising urban heat island effects (cool cities)
- External thermal comfort (cool outdoor spaces)
- Internal thermal comfort (cool buildings/homes)
- Recycled water (sustainable water supplies).

The Aerotropolis Phase 1 DCP provisions also make reference to some of the most important design measures that are recommended in this toolkit, including: cool materials for roofs and pavements, canopy cover and landscaping, retaining water within the landscape, and passive design (minimising the need for mechanical heating or cooling).

While there is strong strategic alignment between this toolkit and the Aerotropolis DCP, the provisions outlined in the Aerotropolis DCP are limited to high-level statements., which it terms "performance outcomes". This is different to the approach taken in this toolkit. The following sections provide a hierarchy of suggested local planning provisions, ranging from high level planning principles to quantitative targets. This is illustrated in Figure 36. Figure 36 also shows how suggested provisions for the LEP and DCP have been organised to include high-level planning principles and performance objectives in the LEP, while the DCP begins with objectives, then goes into design principles, and where possible, quantitative targets. Planning provisions could be organised differently and each council will need to consider what's right for their local context.

The following sections include suggested wording for LEP and DCP provisions. Appendix A also includes examples from existing documents. The suggested wording and examples are not intended to be presented as "model clauses" to be adopted as is, but as a starting point for each council to work from, considering their own local policy and planning context.

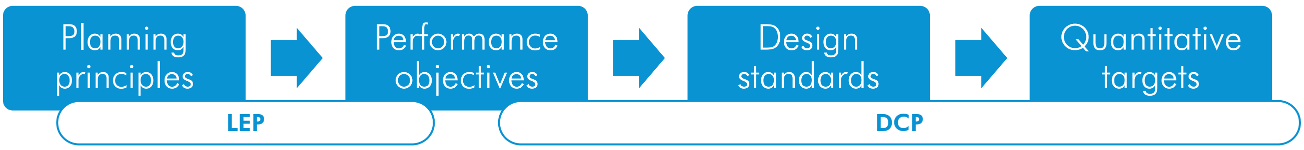


Figure 36: General approach taken in this toolkit to organise a hierarchy of planning provisions into suggestions for LEPs and DCPs

Table 4: Urban heat provisions in the Aerotropolis Phase 1 DCP (Western Sydney Planning Partnership 2020)

Section	Performance outcomes	Links with this toolkit
5.1.1 Urban Design	Urban Development PO16: Provide a range of urban typologies which minimises urban heat island effects and appropriately respond to the urban context and topography of the area including stormwater and rainwater retention and re-use, recycling and efficient use.	Cool cities; Sustainable water supplies
5.1.2 Street Design and Network Layout	Street Design PO8: Alternatives to high heat absorbing and reradiating materials (such as asphalt) should be used where possible.	Cool cities; Cool outdoor spaces
5.1.3 Building Design	Built Form Principles PO9: Provide innovative and environmentally responsible design that achieves energy efficiency, renewable energy outcomes, retains water within the landscape and reduces the urban heat island effect. Landscaping PO28: Preserve and increase the tree canopy cover (with appropriate species) and landscaping to reduce ambient temperatures and urban heat island.	Cool cities; Cool buildings; Cool homes; Cool outdoor spaces; Robust energy systems
5.1.7 Urban Ecology and Sustainability	Design for Climate, Urban Heat and Thermal Comfort: PO4: Use cool materials, low-reflectivity roofing and other building materials, streets pavements that are low reflectivity and pervious. PO5: Building materials used should contribute to internal and external thermal comfort, minimise the necessity for mechanical heating and air conditioning. PO6: Integrate waterways and recycled water reuse into site design, maximise permeable surfaces, implement innovative solutions to retain water within the landscape.	Cool cities Cool buildings; Cool homes; Cool outdoor spaces; Sustainable water supplies

7.2 LOCAL ENVIRONMENT PLANS

Each council prepares an LEP, which provides controls and guidelines for development. It defines what types of development can occur on land zoned for different purposes, and maps where each of these land use zones apply across the local government area.

LEPs are legal instruments, which means they have more weight than DCPs in planning decisions, however they need to be prepared in line with a standard template. The Standard Instrument LEP template defines:

- The land use zones: Including the objectives for each zone and what types of development are permitted with/without consent or prohibited within each zone. Limited modification of these zoning clauses is permitted.
- Provisions on specific topics: These include compulsory provisions (e.g. bush fire hazard reduction) and other optional provisions. Few of the compulsory provisions have a relationship with urban heat, energy efficiency or green infrastructure.

There is the option to include additional local provisions on any topic of local importance, including a topic such as urban heat. There is now an opportunity, and even an imperative, for councils to escalate and incorporate urban heat objectives into their LEPs to strengthen the consideration of urban heat and associated planning and design requirements early in the development assessment process.

Note that LEPs need to go through the Planning Proposal process and be approved by DPIE. DPIE will consider whether proposed local clauses are appropriate in the context of strategies and planning priorities established in District Plans and Local Strategic Planning Statements.

The District Plans clearly identify urban heat as an important issue to address in Sydney's growth – see Section 3.1, which included a summary of the directions, objectives and actions relevant to urban heat in the Central and Western City District Plans. Previous advice from Boston Planning (2019) stated that "LEPs must give effect to the District Plans… The District Plan specifically mentions urban heat objectives/actions. Therefore, by virtue of clause 3.8 (3) of the Environmental Planning and Assessment Act, 1979, each council to which the district plan applies must review their local environmental plan(s) for the area and prepare a planning proposal to give effect to the District Plan".

Also discussed in Section 3.1, most Western Sydney councils have included heat-related planning priorities (e.g. to improve resilience, resource efficiency, and green infrastructure) in their Local Strategic Planning Statements. Some have included a specific action to update planning controls to better address urban heat.

As discussed above, there are many different aspects to addressing urban heat, and different ways that urban heat provisions could be incorporated into an LEP. Three important high-level recommendations are:

- That urban heat should be addressed with a standalone local provision: This would mean that it is clearly identified as a priority with its own section.
- That urban heat provisions should apply across the whole LGA: This could include specific considerations or requirements for different land use zones, but there is no need for additional mapping to define where urban heat provisions apply.
- That other sections of the LEP should also be reviewed to see where there are opportunities to improve provisions that have some relationship with urban heat: For example, some LEPs include a "design excellence" section, which could be amended to include urban heat as a matter to address. Some include landscaped area and/or water sensitive urban design clauses, which could also be strengthened with respect to urban heat.

Suggested wording for a standalone urban heat provision is included in the box on the following pages. Annotation alongside the suggested wording highlights the main issues for councils to consider.

Suggested Local Provision: Urban Heat

1) The objective of this clause is to ensure new development incorporates effective planning and design to reduce the impacts of urban heat, to help the community survive heatwaves and thrive in a warmer climate.

2) This clause applies to all developments in residential, business, industrial, recreation, special purpose and environmental living zones.

3) Before granting development consent, the consent authority must be satisfied that:

   a) The development makes adequate allowance for ***green infrastructure***, including an appropriate contribution to tree canopy cover targets adopted by Council. This means allowing for sufficient deep soil and plantable area to encourage root development and minimise conflicts with utilities;

   b) Building roofs (other than green roofs) are designed as ***cool roofs***, wherever they are not designed as green roofs or covered with solar panels;

   c) Building exteriors are designed to minimise heat impacts in their immediate surroundings, particularly where these spaces are frequented by people. This includes solar radiation reflected from façades, heat absorbed and re-radiated from walls and heat ejected from heating, ventilation and cooling systems;

   d) Buildings are designed to achieve high ***passive thermal performance*** and reduce reliance on air conditioning to maintain comfortable and safe indoor conditions, even during heatwaves;

   e) Public and private outdoor spaces that are accessible to residents, workers or the general public, including gardens, courtyards, parks, plazas and streetscapes, are designed as ***cool spaces***;

   f) The development makes a contribution, proportionate to its scale, to renewable energy supply and/or storage, which will reduce the peak demands on the grid during heatwaves; and

   g) The development has access to an appropriate sustainable supply of non-potable water (e.g. rainwater, harvested stormwater or recycled water) to enable irrigation for cooling, even at times when drinking water use is restricted.

> The LEP should be clear in its objective/s

> Each council should consider which zones the provision should apply to in their LGA. This list includes most zones other than rural and environmental zones (other than environmental living).

> Clause (3) includes a set of performance objectives. There are suggested performance objectives to cover each element in the framework introduced in Figure 11 (Section 4).

> The wording of each performance objective is relatively general, similar to the clauses in the Aerotropolis Phase 1 DCP. This toolkit covers specific design standards and targets in the DCP section (7.3). Councils may wish to include more specific design standards and targets in the LEP; it is for each council to consider how detailed and specific their requirements should be in each of these documents.

> Thermal performance standards are beyond the remit of local councils (they are defined within the National Construction Code and BASIX SEPP). It is not recommended that councils establish new standards for thermal performance; however this performance objective is included to signal that high passive thermal performance is a desirable outcome for all buildings.

> This suggested wording includes performance standards for a broad range of topics related to urban heat, however some councils may wish to incorporate some of these elsewhere in their LEP (for example they may have separate clauses covering sustainable energy and water).

> Performance standards for residential water efficiency are also defined in BASIX, which will prevail over any local provisions, so this is worded in general terms. The LEP/DCP could be more specific about non-residential water supply, see Section 7.3.3.

4) In this clause:

a) *Green infrastructure* includes all types of vegetation found in urban areas, including natives and exotic species, remnant and planted vegetation, trees, shrubs, grasses and groundcovers, vegetation in parks, streetscapes, public and private domain. It includes elements such as green walls and roofs, rain gardens, wetlands and swales, productive, ornamental and native gardens, trees, turfed areas, bushland and riparian vegetation.

b) *Cool roofs* use materials of high reflectivity (particularly in the infrared and near infrared spectrum) and/or high thermal emittance (they easily re-radiate any absorbed solar energy).

c) *Passive thermal performance* is achieved by designing with passive heating/cooling measures (such as orientation, natural ventilation, cool materials, external shading, glazing and appropriate use of thermal mass), to reduce the reliance on mechanical heating or cooling to maintain thermal comfort.

d) *Cool spaces* in the outdoor environment (in both the public and private domain, including parks, streetscapes, plazas/public squares, private gardens, courtyards, balconies, outdoor work areas) are designed to implement principles that maximise human thermal comfort in outdoor environments, including:

i) Maximising summer shading (e.g. via shade structures or tree canopy);

ii) Minimising heat reflected from building walls and façades into pedestrian gathering or circulation areas;

iii) Minimising heat input to pedestrian circulation areas from sources such as vehicles and building HVAC systems;

iv) Maximising the amount of water retained in the landscape, including both rainfall intercepted and retained in soils, and the use of irrigation (using sustainable water supplies such as rainwater, harvested stormwater or recycled water) to maintain healthy vegetation and maximise evapotranspiration;

v) Incorporating evaporative cooling systems such as water features or misting fans to create particular cool zones; and

vi) Using permeable paving where possible and prioritising the use of cool paving materials wherever glare is not a constraint and there are potential cooling benefits.

Clause (4) includes a series of definitions for important terms used in Clause (3). These also define the key design measures that should contribute to meeting each performance outcome.

Green infrastructure performance standards and targets (e.g. landscaped area, deep soil and tree requirements), are typically already included in DCPs. Section 7.3.3 discusses how these provisions could be strengthened.

Proposed cool roof performance standards, including quantitative targets, are included in the suggested DCP wording (Section 7.3.2).

See comments above re thermal performance design standards. These are set in the National Construction Code Section J (for non-residential development) in BASIX (for residential development).

Performance objectives for cool outdoor spaces should ideally be supported by design guidelines – this is discussed in Section 8.3.

Appendix A includes example DCP clauses drafted by the City of Parramatta for cool façades and heat emitted from HVAC systems.

A stormwater flow volume reduction target (mean annual % reduction in runoff) could support this outcome – this is discussed in Section 7.3.3.

7.3 DEVELOPMENT CONTROL PLANS

A principal aim of this toolkit is to provide advice to local government on urban heat provisions they can include in DCPs, however, as noted in Section 3, there are some challenges to incorporating urban heat provisions into DCPs:

- The BASIX SEPP prevails over certain local planning provisions: This is the case for thermal comfort, energy and water efficiency of residential dwellings.
- Urban heat is a complex issue, inseparable from other planning issues: Most DCPs include an extensive set of existing provisions covering topics such as trees, landscaped areas, water sensitive urban design, energy efficiency (non-residential), and other topics relevant to urban heat. Addressing urban heat with separate provisions, overlapping with the same topics, doesn't make sense.
- Existing provisions on these topics have been negotiated to strike a balance with competing objectives: Competing objectives include housing affordability and public/private life cycle costs. Modifying these provisions may not be straightforward – each council will need to weigh up the issues in their local context and consider what is appropriate.

Given these challenges, the following opportunities emerge for improving DCPs to better address urban heat:

1. Add new provisions: Where there is a clear gap in existing DCPs, and where new provisions can be added without raising major concerns about affordability, life cycle costs, or legal contestation, add new urban heat provisions to DCPs. A model urban heat provision has been provided in this toolkit, which aims to cover this territory.
2. Modify existing provisions: Where there is potential to improve urban heat-related outcomes, strengthen existing provisions, particularly those relating to trees, landscaped areas, water sensitive urban design and energy efficiency (non-residential). Each council will need to navigate their own way through this process; this toolkit provides principles, evidence that could be used to support a business case, and best practice examples from existing planning documents.
3. Keep working on topics where there are concerns: Where complexities and competing objectives make new or modified provisions untenable, continue gathering evidence to build the case for local planning reform. Recognise that urban heat is a relatively new area for local planning controls, and it is likely to take several iterations to refine the first generation of DCP provisions. This is discussed further in Section 7.5.

Table 5 brings together all the objectives and a summary of the planning and design strategies recommended in Section 5, identifying where they could be included in DCPs, and whether the DCP should play a central or supporting role in each objective.

Table 5 then identifies what provisions should be included in DCPs, and whether each should be included as new/standalone provisions, or by modifying existing provisions. These two categories should be the highest priorities for councils updating their DCPs. Table 5 also lists potential additional provisions that could be considered, but where their applicability is likely limited to more specific situations. These should be a lower priority.

The following sections expand on the recommendations in Table 5:

- Section 7.3.1 introduces a suggested urban heat clause for a DCP: It focuses on the objectives and design principles. As has been identified above, although DCPs include many existing provisions related to urban heat, they don't address urban heat directly. A set of provisions directly addressing urban heat would give the issue more prominence in the DCP, clearly identifying it a priority.
- Section 7.3.2 suggests specific controls: These include cool roofs, cool façades and heat emissions from HVAC systems. Quantitative targets are included wherever possible. These measures are directly relevant to urban heat and worth introducing new development controls.
- Section 7.3.3 discusses other DCP provisions which focus on other topics: These include provisions covering trees, landscaping and WSUD. Not all aspects of urban heat can be addressed with separate standalone urban heat provisions, but other provisions on related topics could be strengthened to better support urban heat resilience. These provisions will need to balance multiple objectives, but the toolkit focuses chiefly on how to support urban heat resilience, with suggestions to modify existing provisions to improve urban heat outcomes, while also retaining their original intent.
- Section 7.4 suggests some additional ideas: These are secondary considerations, which could also be incorporated into DCPs to encourage higher standards of built infrastructure for urban heat resilience.

All of the sections above refer to example clauses, drawn from existing local planning documents. Key examples are included in Appendix A.

Table 5: How to address urban heat in DCPs

Aspects of heat resilient planning and design	Objectives	Planning and design strategies	Roles for local planning provisions: Central	Roles for local planning provisions: Supporting	Roles for local planning provisions: No role
Low carbon cities	Reduce carbon emissions	Energy efficiency Renewable energy Transport and waste management	Energy efficiency: non-residential	Renewable energy, autonomous energy, transport, waste	Energy efficiency: residential (BASIX prevails)
Cool cities	Reduce temperatures at the city/precinct scale	Cool materials Green cover Water in the landscape	Key roles in all these areas		
Cool outdoor spaces	Create cool outdoor spaces in public and private domain Prioritise areas with high activity, consider vulnerable groups	Cool materials Tree canopy Shade structures – permanent or removable Evaporative cooling	Key roles in all these areas		
Sustainable water supply	Use sustainable water supplies for evaporative cooling	Rainwater harvesting Stormwater harvesting Recycled water	Rainwater harvesting: non-residential	Recycled water	Rainwater harvesting: residential (BASIX prevails)
Cool buildings	Thermal comfort in non-residential buildings	Cool materials Climate responsive architecture Efficient cooling systems		No need to set higher standards than the NCC, but DCPs can encourage good design	
Cool homes	Thermal comfort in hot conditions Thermal autonomy (passive survivability in extreme heat conditions)	Cool materials Climate responsive architecture			BASIX clearly prevails on thermal comfort; thermal autonomy standards are likely also be viewed as conflicting with BASIX

Table 5 – continued

New/standalone provisions to include (Section 7.3.2)	Existing provisions to strengthen (Section 7.3.3)	Additional considerations (Section 7.4)	*Examples in Appendix A*
	Energy efficiency for non-residential development	Consider incentives for developers to meet higher energy efficiency performance standards Solar power could be encouraged with appropriate provisions (if not mandated) Electric vehicles can be encouraged	*Energy efficiency for non-residential development* *Electric vehicles (provision for parking)*
Cool roofs	Tree provisions Landscape provisions Deep soils Water Sensitive Urban Design	Irrigation should be encouraged and even mandated for certain types of landscaped areas (preferably in connection with sustainable water supply) Green roofs can be encouraged	*Green roofs* *Trees*
Cool façades Heat emitted from HVAC systems	Tree provisions Landscape provisions Deep soils Water Sensitive Urban Design	Shade could be a requirement for high pedestrian activity areas Irrigation should be encouraged and even mandated for certain types of landscaped areas (preferably in connection with sustainable water supply) Green walls can be encouraged	*Cool façades* *Heat emitted from HVAC systems* *Green walls* *Trees*
	Alternative water supplies including rainwater/stormwater harvesting for non-residential development (public and private realm)	Recycled water can be encouraged Rainwater tanks can be encouraged and even incentivised, even though local government can't mandate residential rainwater harvesting	

7.3.1 DCP objectives and design principles

Suggested wording for a standalone urban heat provision is included in the box below. Annotation alongside the suggested wording highlights the main issues for councils to consider.

Urban Heat

In the LGA, all development will be required to implement design principles that minimise the impacts of urban heat. This means that each development should minimise its carbon emissions, reduce its peak demand on the electricity grid and minimise its contribution to the urban heat island effect; as well as being designed to ensure that both indoor and outdoor spaces are designed to stay as cool as possible in hot weather.

The requirements for urban heat mitigation and the information required to support a Development Application varies for different types and scales of development.

Objectives:

- To reduce carbon emissions from the development, considering both construction and operational emissions.
- To reduce peak demand on the electricity grid and support a robust electricity network, by improving energy efficiency and installing solar panels.
- To reduce the development's contribution to the urban heat island effect, by minimising hard surfaces, using cool materials, maximising landscaped area, and retaining water in the landscape where it is available for evapotranspiration.
- To design homes for high passive thermal performance, so that they stay as cool as possible through heatwaves, and maintain habitable conditions even in the event of an extended power outage.
- To design non-residential buildings for high passive thermal performance, so that they remain comfortable for workers and visitors in hot weather, while also minimising energy demands. Prioritise buildings (or parts of buildings) which are open to the public and those where people work.
- To design outdoor areas that are accessible to residents, workers or the general public to stay as cool as possible during hot weather, so that people can still work, socialise and recreate outdoors and also use active transport modes.

Design principles: buildings

- Design buildings for high passive thermal performance, to reduce reliance on energy for cooling (and heating).
- Install energy-efficient fittings and appliances.
- Install or connect to renewable energy systems, to offset energy demands and reduce peak electricity demands.

The DCP should be clear in its objectives. This suggested set of objectives is broad, reflecting the broad range of issues that impact on resilience to urban heat. The six suggested objectives align with the six themes into which the planning and design measures were grouped in Section 5 of this document.

The suggested design principles are broad, encouraging best practice design, even in areas where the DCP cannot include specific controls, and including principles that are directly and indirectly relevant to urban heat.

- Use cool roofing materials, with a high Solar Reflectance Index (SRI). Green roofs are also encouraged, particularly where there is a need to minimise glare from roofs.
- Limit the solar reflectivity of glazed façades, and shade reflective façades with vegetation and/or architectural features.
- For external walls, minimise the use of thermally massive materials like concrete that absorb energy and stay warm, re-emitting heat into outdoor areas.

Design principles: outdoor areas

- Design outdoor spaces to stay cool in hot weather, considering orientation, including as much shade as possible, and providing irrigation to landscaped areas.
- Prioritise these design measures in areas frequented by people, including town centres, transport nodes, active transport routes.
- Shade paved surfaces and walls where possible, also considering solar access in the cooler months.
- Consider cool paving (high albedo and/or high thermal emittance) or permeable paving. Although these materials are not suitable in all situations, they should be used wherever possible. Use cool paving wherever glare is not a constraint and there are potential cooling benefits. Use permeable paving where traffic loads are light and where there is an opportunity for rainfall to soak into soil below the pavement.
- Maximise landscaped area within the development. Within landscaped areas, maximise soil volumes, and plant trees that will grow to have large, dense canopies. Also include understorey plantings.
- Provide irrigation to landscaped areas, to support healthy vegetation and enable evapotranspiration, which has a cooling effect.
- Where an irrigation system is not feasible, provide passive irrigation – enable runoff from adjacent hard surfaces to soak into landscaped areas.
- Include features that store water in the landscape – for example rain gardens, wetlands and ponds. Also consider the use of fountains, misting fans or water play features to create particular cool zones in the landscape.
- Connect irrigation systems and water features to a sustainable supply of non-potable water (e.g. rainwater tank, stormwater harvesting scheme, recycled water) so that a water supply is more likely to be available for cooling, even in times of drought and restricted mains water use.

Development controls:

- All development must consider the design principles above.

Important terms will need to be defined, for example "cool roofing materials" and "cool paving".

The design principles acknowledge some of the complexity associated with various design strategies, but it would also help to refer to appropriate design guidance, which can include more detail than the DCP.

Where this clause introduces design principles related to other topics, it could cross-reference other sections of the DCP.

- All development needs to meet the cool roof performance standards [REFER TO SECTION 7.3.2].
- Development within the CBD / B3 and B4 zones / [other defined areas] needs to meet the cool façade performance standards [REFER TO SECTION 7.3.2 and APPENDIX A].
- All development needs to adhere to the controls for heat emitted from HVAC systems [REFER TO SECTION 7.3.2 AND APPENDIX A].
- There are other requirements listed elsewhere in this DCP that are also relevant to meeting the urban heat objectives above:
    - Energy efficiency in non-residential buildings
    - Rooftop solar power
    - Landscaped areas (including minimum total areas, minimum deep soil areas, minimum irrigated areas)
    - Trees (including tree protection, tree replacement and requirements for new trees)
    - Alternative water supplies for non-residential development
    - Water sensitive urban design
    - Electric vehicles.
- For residential buildings, thermal performance and energy efficiency standards are set within BASIX.
- For non-residential buildings, thermal performance standards are defined in the National Construction Code, for the relevant building type.

Further information

- WSROC 2021 *Urban heat planning toolkit*
- WSROC (TBC) *Cool Suburbs Tool*

Cool roofs, cool façades and heat emitted from HVAC systems are all fundamental to urban heat resilience, and therefore it is recommended that specific development controls should be included here.

It is suggested that the urban heat provisions should also refer to requirements elsewhere in the DCP, which also support urban heat resilience. This helps create a more complete picture of how developers can meet the full set of urban heat objectives listed above.

The DCP should recognise that other instruments cover thermal comfort, energy/greenhouse reduction and water reduction and clearly communicate that.

7.3.2 Specific development controls for urban heat

These three suggested development controls, for cool roofs, cool façades and heat emitted from HVAC systems, are all fundamentally linked with urban heat, and should fit well within local planning provisions. Suggested/example wording is provided for each of these controls, however each council will need to consider suitability to their local context.

Cool roofs

Recommended wording for a cool roof clause is included on the right. Note that these performance standards match those in the current Green Star rating system and the planned Green Star for Homes scheme currently in development (due to be finalised early 2021). These standards also align closely with the LEED building rating system used internationally. The proposed clause requires 75% of the roof to meet the performance standards. This is a simplified version of the Green Star credit for urban heat island mitigation, which looks at overall site coverage. One of the specific exemptions (solar hot water) uses this as the minimum area to be finished with cool materials after excluding the area of solar hot water. 75% is also the minimum coverage nominated in the LEED rating system to qualify as a cool roof. It represents sufficient coverage to be meaningful, while acknowledging that roof areas also need to meet other needs.

Cool roof standards should be applicable to most roofs. Councils may need to consider exemptions for heritage buildings and particular locations where glare is likely to be an issue from areas above building roofs.

Cool façades

Solar radiation reflected from façades is a particular concern in high density commercial zones (e.g. CBDs) where reflective materials are often used on building façades. It may be relevant in smaller town centres, depending on the scale and nature of development.

The City of Parramatta has been developing draft DCP provisions for urban heat in the Parramatta CBD, and they have developed a proposed DCP provision to minimise the reflection of solar radiation from façades. This may be relevant to other councils who wish to control this type of development. Other councils will need to review the City of Parramatta's proposed provisions and determine its suitability to their own circumstances.

The City of Parramatta's draft provision is included in Appendix A (page 71). This was developed following a technical study (Flux 2020) to investigate available evidence and define suitable parameters. The study quantified the effects of different glazing types and of shading façades, demonstrating how shading could be applied most effectively. A simple illustration is included in Figure 37. The study also looked at the costs involved. The draft clause includes requirements for both minimising the solar reflectivity of façade materials, as well as for minimum shading of façade surfaces.

Cool roof performance standards:

- This clause applies to all buildings, with the following specific exceptions:
  - Heritage requirements preclude the use of cool roofing materials; or
  - It can be demonstrated that glare would be a problem for particular locations above the building's roof.
- The standards below apply to all parts of the roof across the site, with the following specific exceptions:
  - Parts of the roof designed as a green roof and covered with vegetation.
  - Parts of the roof where PV is mounted flat on roof (all other roof areas with PV count toward the Cool Roof calculation).
- Roofing materials need to meet the following Cool Roof performance standards:
  - At least 75% of the roof area is to meet nominated Solar Reflectance Index (SRI) values
  - Nominated SRI minimums:
    - for roof pitch $< 15°$, 3-year SRI minimum of 64
    - for roof pitch $> 15°$, 3-year SRI minimum of 34
    - for terrace areas, 3-year SRI minimum of 28.
- Provide a plan illustrating all roof surface areas and associated SRI values or notation as green roof.
- Provide roof product cut sheets to verify SRI performance.

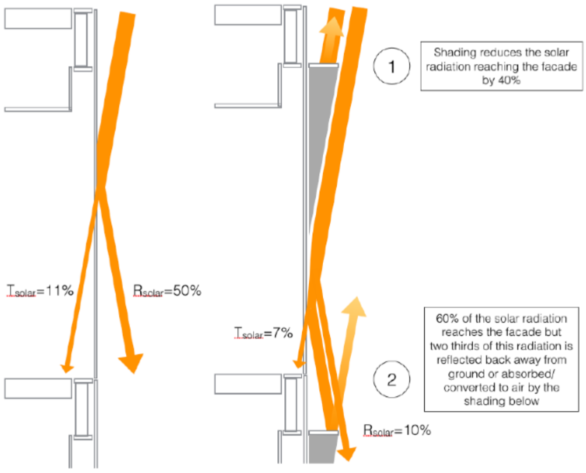


Figure 37: Illustration of how shading reduces solar reflectance, particularly at high angles of incidence (Flux 2020)

Heat emitted from HVAC systems

The City of Parramatta's draft CBD DCP also includes a proposed clause relating to heat rejection from cooling systems. Again, this is applicable to high density development. The proposed clause, included in Appendix A (page 72), encourages centralised heat rejection from the upper most roof.

In lower density development, centralised heat rejection from the roof is less likely to be feasible. Small residential air conditioning condenser units (the outdoor unit, see Figure 38) are usually placed at ground level or mounted on the wall.

Some DCPs include requirements for locating residential air conditioning units with respect to neighbouring properties. Existing provisions are typically focused on noise and sometimes visual amenity. To meet these objectives, DCPs may include a requirement that air conditioning units are located away from property boundaries and/or away from the habitable rooms of adjoining properties, however some also allow noise and visual objectives to be met with a screening structure.

Consider stricter requirements for air conditioning units to be located away from the habitable rooms of adjacent properties, to minimise heat transfer.

Figure 38: Air conditioner condensers in Parramatta

7.3.3 Other DCP provisions to strengthen in relation to urban heat

The following topics are multi-objective, and often covered already in existing DCPs. Recommendations are provided on how these existing provisions could be strengthened to better address urban heat. Relevant examples are provided in Appendix A.

Tree preservation

Most DCPs define prescribed trees on the basis of tree height, sometimes also trunk diameter. A simple yet important amendment to improve urban heat outcomes would be to add a canopy spread and/or crown width criteria to the definition of a prescribed tree. Some DCPs include canopy spread as an additional consideration, but ideally it should be included as one of the basic criteria.

North Sydney's DCP 2013 Section 16 (Tree and Vegetation Management) is a good example that focuses on canopy throughout. It includes a crown width of 10m as one of the criteria defining a prescribed tree. This section of North Sydney's DCP is included for reference in Appendix A (page 76).

Tree replacement and new plantings

Some DCPs include provisions for new trees as part of new development, as well as requirements for replacing any trees that are removed from the private domain. For example, Cumberland City Council's draft DCP 2020 includes a simple requirement that when trees between 4-9 m high are removed, they need to be replaced at a ratio of 1:1, while trees greater than 10 m high need to be replaced at a ratio of 2:1. Their draft clause also includes several specific provisions about the required size and location of replacement trees. Cumberland's draft clause also indicates that Council will consider offsite replacement trees on merit. The draft clause is included in Appendix A (page 78).

Note that Cumberland City Council's draft clause (Appendix A, page 78) requires replacement trees to be at least 2 m from all boundary fence lines, however they are asking for trees that will reach at least 10 m high. Where lot sizes are smaller, it would be more appropriate to specify smaller trees but allow them to be planted closer to boundaries. For example, the Greenfield Housing Code (State Environmental Planning Policy (Exempt and Complying Development Codes) 2008, Part 3C), in Division 6, clause 3C.37(4) requires an 8 m tree in the front yard and a 5 m tree in the back yard of new dwellings. This code allows lot sizes as small as 200 m^2.

The City of Stirling, WA (City of Stirling 2019) requires an increasing number of trees to be planted as the lot size increases – refer to Table 6. They also require a 9 m^2 soil space surrounding each tree.

The City of Stirling provides a set of guidelines to support their tree provisions. The guidelines include:

- Definition of an "advanced tree" in terms of root ball size
- Recommended minimum dimensions of the 9 m^2 soil area, and recommended location of a tree in relation to boundaries and structures

- Acceptable ground treatments within the 9 m^2 soil area
- How to pick the best location for a tree, including shade considerations
- A suggested species list, which includes information on each tree's mature height and canopy spread, and includes a wide range of trees, including smaller trees appropriate to small lots (the smallest are 4 m high and 2 m canopy spread) as well as large trees appropriate for large lots.

Table 6: City of Stirling tree planting requirements for new development over $100,000 value (City of Stirling 2019, p. 6.11-2)

Site area (m^2)	Number of advanced trees to be planted
1-500	1
501-1,000	2
1,001-1,500	3
1,500-2,000	4
Over 2,000	1 for every 500 m^2 (or part thereof)

Consider strengthening provisions for tree replacement and new plantings as follows:

- Include minimum requirements for new trees on development sites, even where there are no prescribed trees removed. Specify minimum requirements in relation to either the lot size or the size of the required landscaped area, with more and larger trees required on larger lots or those with larger landscaped area requirements.
- Where prescribed trees are removed, consider requiring their replacement with multiple trees, depending on the size of the tree removed.
- Provide clear requirements for any new trees, e.g. minimum pot size, expected height, canopy spread
- Specify where new trees are required to be planted (e.g. within the front yard/back yard, setbacks, deep soil zones), and required planting density.
- Provide guidance on the best location/s to place trees on the block, so that they shade walls, windows and the roof to provide maximum cooling benefit during summer (see below or refer to Simpson and McPherson 1996).
- Provide a list of suitable species, including species appropriate to different situations, and considering species likely to be resilient to climate change. Where councils have not developed their own species lists, the 'Which Plant Where' project may provide a useful resource when its proposed plant selection tool becomes available.
- Provide guidance on establishment and long-term maintenance of trees, including active or passive irrigation.

Coutts and Tapper (2017) argue that trees should be placed strategically throughout the landscape so as to deliver the largest cooling and thermal comfort benefits possible. The priorities are:

- Hotspots, e.g. where there is a large amount of impervious surface
- Areas of concentration of vulnerable populations (elderly and very young)
- Areas where people move and gather outdoors (behavioural exposure).

Coutts and Tapper (2017) recommend prioritising trees on the southern side of east-west oriented streets (to shade north-facing walls of adjacent buildings) and the eastern side of north-south oriented streets (to shade west-facing walls of adjacent buildings). Use of deciduous species is recommended where solar gain is desired for either buildings or outdoor open spaces in winter.

While contiguous shade can be important (e.g. for active transport corridors), some studies also point out that it is also important to allow sufficient gaps between groups of trees to prevent trapping of heat at night – heat should be able to dissipate to the night sky (Norton *et al* 2015). Realistically, this is only likely to be a relevant concern in certain high density urban environments. In most areas, there are likely to be ample gaps in the canopy and between buildings for heat to escape at night, and development controls should emphasise the requirements for greater tree canopy, rather than introducing new reasons to plant fewer trees.

Landscaped areas

Most existing DCPs include landscaped area targets (as a proportion of the site area) for different development types. Targets often vary according to lot size.

Consider strengthening these provisions by:

- Specifying minimum landscaped areas for all development types
- Increasing targets where possible
- Defining landscaped areas as a percentage of the site area, so that overall outcomes are clear
- Clearly defining the landscaped area as a vegetated, pervious area
- Including requirements for minimum dimensions of landscaped areas, as landscaped areas with more generous dimensions should be better able to support large canopy trees. For example, the Warringah DCP 2011, Section D1 states that "any open space areas with a dimension of less than 2 metres are excluded from the calculation [of landscaped open space]"

- For subdivisions, including requirements that a specified proportion of the landscaped area is provided in a consolidated area (e.g. as communal open space) which can support multiple large trees.

Currently most landscaped area provisions in DCPs are focused on minimum targets, but new approaches are emerging that encourage higher performance (e.g. landscaped areas that work harder to reduce urban heat) beyond minimum requirements. An approach currently being used internationally and trialled on a voluntary basis in the City of Melbourne is a 'green factor' scorecard, which can be designed to account for a wide variety of landscape/green infrastructure features in a development, and give each element a weighted score. Developers may be asked to meet a minimum score, but are given flexibility as to how that score is achieved. Developers could also potentially be offered incentives to meet higher scores.

Deep soils

Some DCPs include provisions for deep soil zones in medium and high density residential development, typically as a proportion of the site area.

Consider strengthening these provisions by:

- Clearly defining what is meant by a deep soil zone (i.e. no structures below such as underground car parks).
- Defining minimum targets for all types of development.
- Defining minimum dimensions for deep soil zones (e.g. a minimum width or square area or similar dimension) so that the space can support a tree/s of a specific sizes (small, medium, large) depending on the site and immediate context).
- Defining physical features to be avoided, wherever possible, in deep soil zones (e.g. shallow bedrock, steeply sloping land), to maximise potential for deep soil zones to support canopy cover and retention of water for evapotranspiration.
- Defining suitable alternatives (e.g. structural soils) where deep soil is not achievable.
- Defining not only the required area of deep soils, but also requirements for tree planting and other vegetation within deep soil zones.

The Victorian Planning Provisions, Clause 58.03-5 tabulates deep soil and canopy tree requirements for developments of different scales. These are reproduced in Table 7.

Table 7: Deep soil areas and canopy trees required in the Victorian Planning Provisions, Clause 58.03-5 (Table D2)

Site area	Deep soil areas	Minimum tree provision
750 - 1000 square metres	5% of site area (minimum dimension of 3 metres)	1 small tree (6-8 metres) per 30 square metres of deep soil
1001 - 1500 square metres	7.5% of site area (minimum dimension of 3 metres)	1 medium tree (8-12 metres) per 50 square metres of deep soil or 1 large tree per 90 square metres of deep soil
1501 - 2500 square metres	10% of site area (minimum dimension of 6 metres)	1 large tree (at least 12 metres) per 90 square metres of deep soil or 2 medium trees per 90 square metres of deep soil
>2500 square metres	15% of site area (minimum dimension of 6 metres)	1 large tree (at least 12 metres) per 90 square metres of deep soil or 2 medium trees per 90 square metres of deep soil

Note: *Where an existing canopy tree over 8 metres can be retained on a lot greater than 1000 square metres without damage during the construction period, the minimum deep soil requirement is 7% of the site area.*

Water sensitive urban design

Water sensitive urban design (WSUD) is often identified as a key strategy to reduce urban heat, however its main objective is typically focused on improving the health of urban waterways.

In principle, WSUD involves reducing impervious cover and retaining more water in the landscape, encouraging more infiltration and evapotranspiration, reducing runoff, and treating any stormwater runoff before it is discharged offsite. Vegetated stormwater treatment systems including wetlands, rain gardens and swales are classic features of a WSUD approach.

However, when WSUD provisions have been written into DCPs (and most metropolitan councils now include such provisions) the focus has been on stormwater quality outcomes. While the objectives listed in the DCP may be broader, typically the only quantitative targets set are to reduce stormwater pollutant loads. These have become the focus of development approvals, as they form a clear performance standard against which development can be assessed.

The response of the development industry has been to optimise stormwater treatment systems to meet stormwater quality targets in the smallest possible footprint, at the lowest possible cost. Rather than vegetated systems, many developers (particularly on smaller, infill sites) are installing cartridge filters, which can be accommodated in the basement of a building. This approach involves no increase in green infrastructure, no additional water retained in the landscape, and no tangible reduction in urban heat.

There are several organisations currently working towards better implementation of WSUD in Western Sydney, including:

- Sydney Water has been testing development scenarios for Western Sydney growth areas, and investigating how to improve water management outcomes (Sydney Water 2020).
- The Parramatta River Catchment Group (PRCG) are currently investigating options to improve planning provisions both at local and state level, to help realise the goals of the Parramatta River Masterplan (McAuley and Davies, 2021).

In both cases, their work has recommended more focus on reducing runoff and retaining water in the landscape, via:

- Increasing the landscaped area and tree canopy area in new development.
- Use of vegetated stormwater treatment systems, which filter water, retain water in the landscape, and create evapotranspiration.
- Where subsurface conditions are appropriate, vegetated stormwater treatment systems should also be designed to encourage infiltration into underlying soils.
- A much stronger emphasis on rainwater or stormwater harvesting and reuse.

These measures would support better outcomes for urban waterways as well as better green infrastructure outcomes in the catchment.

Among the recommended improvements to planning provisions in McAuley and Davies (2021) there is significant overlap with the suggestions above, particularly to improve provisions for landscaped areas, deep soils, trees, and alternative water supplies. There are also recommendations to:

- Include stormwater flow volume reduction targets in DCPs. This would be defined as a percentage reduction from baseline mean annual flow volume (where the baseline is usually defined as post-development, before stormwater management measures are applied).
- Encourage vegetated stormwater treatment systems, particularly bioretention systems with saturated zones.

Both of these recommendations would also improve urban heat outcomes by encouraging the retention of more water in the landscape, and therefore both should be supported from an urban heat perspective.

Energy efficiency (non-residential)

Many DCPs already include energy efficiency targets for non-residential buildings (i.e. those buildings not covered by BASIX). A simple approach is to set a target with reference to the National Australian Built Environment Rating System (NABERS). There are several councils that now require minimum NABERS ratings (based on actual building energy use) above and beyond minimal code design. An example from the City of Sydney's DCP (2012) is included in Appendix A (page 74). It sets a NABERS 5.5 star target for new developments above a certain size.

Another option is to set energy requirements with reference to Green Star. Waverley Council's DCP (2012, Amendment No. 8, Section B2-2.5) requires all mixed use and commercial development with a cost of works of $3 million or greater to submit an "Energy Assessment Report… [demonstrating] that the proposed development's predicted greenhouse gas emissions are 30 percent less than those of a reference building" (Waverley Council 2012, p.22). Their clause references the Green Star Greenhouse Gas Emissions Calculator as the method to be used. Section B2-2.5 also encourages the same developments (over $3 million value) "to register and maintain a minimum of a 4 star Green Star Certified Rating", (Waverley Council 2012, p.21) in which case the Energy Assessment Report is not required.

Note that the City of Parramatta has taken a different approach with their proposed "high performing buildings" clause in the draft LEP provisions for the CBD. This clause is proposed to apply to a range of development types including residential and commercial buildings above certain size thresholds. The clause applies differently to commercial and residential development (or the commercial/residential components of a mixed-use development).

For commercial buildings, the proposed approach uses a 'best-in-market' target. A new development must meet a performance standard which is "within the top 15% of the performance of similar existing buildings of a similar usage type in the Sydney metropolitan region, benchmarked on an emissions (CO_2e/sqm) basis at the time of application" (City of Parramatta 2020). This example is also included in Appendix A (page 74), however it is important to note that this is only a draft provision, and a Planning Proposal is currently with DPIE for review.

Alternative water supplies (non-residential)

Some DCPs include provisions for alternative water supplies in non-residential development. Typically, these are included along with other water-related provisions in DCPs, under a water conservation objective. Examples include:

- Blacktown DCP 2015 Part J (p.17) includes a provision "Industrial and business developments must supply 80% of their non-potable demand using non-potable sources. Rainwater shall be the primary source and only supplemented by recycled water when rainwater cannot meet 80% of the demand. When the 80% demand threshold cannot be met, the use of non-potable sources shall be maximised and be considered on a merits basis by Council."
- Parramatta DCP 2011 Part 3, Section 3.3.6.2 (pp.68-69) includes the following requirements for non-residential developments above certain size thresholds:
    - "Rainwater tanks or other alternative water sources are to be installed to meet 80% of toilet and laundry demands."
    - "Irrigation, water features and other open space features are to be supplied from alternative sources (e.g. rainwater, greywater, or wastewater) to meet 80% of demand."

7.4 POTENTIAL ADDITIONAL PROVISIONS (LEP OR DCP)

The following ideas could also be incorporated into local planning provisions to support urban heat resilience outcomes. These ideas are lower priority than the suggestions in the sections above, however they could play a supporting role. As above, each council will need to consider the applicability of examples to their local context.

Shade

Shade is a significant factor in outdoor thermal comfort, which could be made a requirement in key locations of high pedestrian activity, however there are few existing examples in planning provisions. Some DCPs require awnings in certain situations. Consider additional requirements for shade cover, particularly where development will extend into the public domain and where there is high use or pedestrian traffic. Consider temporary structures, or structures that can be removed and replaced with the seasons, as well as permanent structures. Streetscape and public domain design guidelines could provide more detailed design guidelines for shade.

Irrigation

Most DCPs encourage xeriscaping rather than irrigation, however this would have negative consequences for urban heat. Irrigated landscapes help lower ambient temperatures as well as having cooling effects at the microclimate scale.

Consider setting targets for minimum irrigated areas and irrigation system design standards in different development types. Ideally, irrigation should be paired with alternative water supplies – this could be explicitly required for non-residential development. One example is the Sutherland DCP 2015 Chapter 4 (Multi Dwellings), which requires irrigation systems to be installed in common open space areas and for podium planting, with rainwater tank connection. Installation of irrigation systems could also be made a requirement for certain types of landscaped areas in the public domain, for example playing fields. Councils often seek to limit irrigation in the public domain, to minimise operation and maintenance costs. However, turf playing fields are typically irrigated.

WSROC is currently implementing a project (in collaboration with Western Sydney University, University of Melbourne, Blacktown City Council, Penrith City Council, Stormwater NSW and Sydney Water) called "Climate Resilient Street trees" which is experimenting with the use of passive irrigation reservoirs under street tree plantings. If preferred designs can be established for such systems, then these could be included in planning provisions.

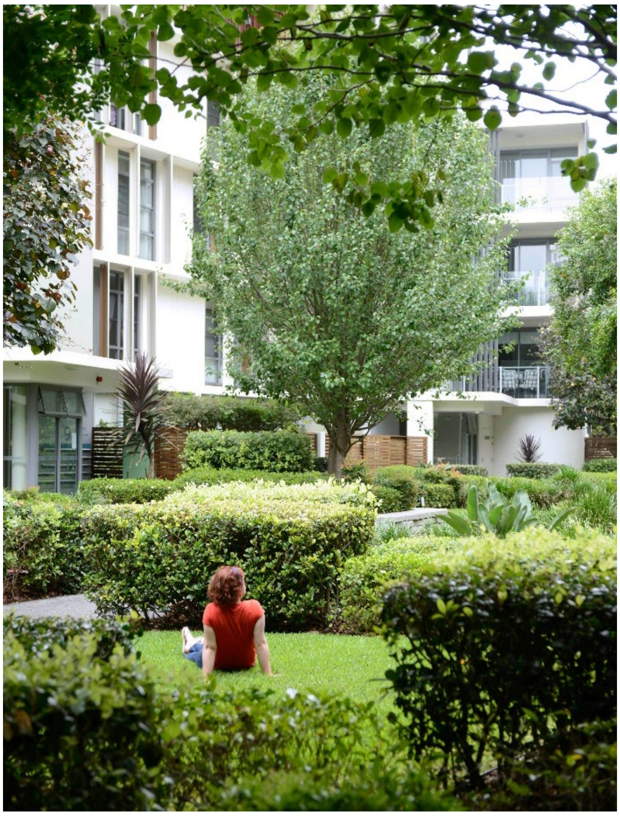


Figure 39: Irrigated landscapes have a cooling effect

Incentives for higher energy performance

As mentioned above, the City of Parramatta's draft high performing buildings clause for their CBD LEP is also proposed to apply to residential buildings. As residential buildings are subject to the BASIX SEPP, higher performance targets would not be mandatory for residential buildings (or residential components of mixed use development), but developers would be encouraged to meet higher standards, with an incentive of a floor space bonus (5% additional FSR). The City of Parramatta has arrived at this policy after researching the costs and benefits for typical CBD developments, to ensure that the higher performance targets are achievable and that the additional floor space is a reasonable incentive.

In the City of Parramatta's proposed LEP, the high performance standards for residential buildings would be set with reference to BASIX, calling for BASIX energy and water scores 10-25 points above the minimum (depending on the height and FSR of the building).

The City of Parramatta example is also included in Appendix A (page 74). A similar approach may be applicable in other high-density (e.g. CBD) locations. Beyond these areas, bonus floor space may not be an appropriate incentive, but other incentives could potentially be devised. When it is released, Green Star Homes could also be used as the benchmark for high performance residential development.

Decentralised energy

Decentralised energy schemes could include on-site solar PV and/or community energy storage. Mandating such schemes is unlikely to be appropriate in local planning provisions. For residential development, BASIX would prevail. Mandatory solar power may be appropriate for certain types of large development (e.g. industrial developments with large roof areas and high energy demands), where the up-front expense is easier to justify. However no examples of existing DCP provisions have been identified.

What most DCPs currently include is solar access provisions, which minimise the extent to which development can block solar access to neighbouring properties, particularly to their principal living areas and principal open space. Sometimes these provisions also mention overshadowing of solar panels as a relevant consideration, however this is not usually accompanied by any strict controls. One example where the DCP encourages new buildings to avoid overshadowing is the Tweed DCP 2016, Section A1, 4.3 (p. 54): "New dwelling design should minimise overshadowing on existing adjacent solar panels where other reasonable design alternatives are possible."

In Victoria, Moreland Council has a stronger provision in their planning scheme (within Clause 55.03-5, Standard B10):

"Buildings should be:

- "Sited and designed to ensure that the energy efficiency of existing dwellings on adjoining lots is not unreasonably reduced.
- "Sited and designed to ensure that the performance of existing rooftop solar energy systems on dwellings on adjoining lots in a General Residential Zone, Neighbourhood Residential Zone or Township Zone are not unreasonably reduced. The existing rooftop solar energy system must exist at the date the application is lodged."

Moreland Council has also published an 'Advisory Note' on assessing overshadowing impacts on solar panels, which establishes a process where Council can request a detailed technical report assessing the 'reasonableness' of the impact, and suggesting a pathway where the applicant is encouraged to enter into discussions with an objector to explore mutually agreeable alternatives such as re-designing the development to reduce the overshadowing impact on the solar panels, contributing to the supply of new panels or relocating existing panels.

More commonly, current NSW DCPs encourage developers to consider potential future development and anticipate potential future overshadowing in the placement of solar panels (e.g. Marrickville DCP 2011, Part 2.7).

Active transport and electric vehicles

Transport is a significant factor in city-scale carbon emissions. Traditional (combustion engine) vehicles also create heat in the urban environment. To a large extent, transport planning is beyond the remit of local council planning provisions and development controls, however there are a few important levers available to councils in local planning instruments, such as provisions for parking (both car and bicycle parking) and electric vehicles.

DCPs can encourage less car use, a transition to electric vehicles and active transport, by:

- Requiring fewer car parking spaces and more bicycle parking in new developments
- Requiring end-of-trip facilities for active transport in commercial and industrial buildings (e.g. showers and change rooms)
- Providing for electric vehicles, for example by requiring dedicated parking and charging stations in new development.

An example electric vehicle clause is included in Appendix A (page 78), from Waverley's DCP (2012).

Green roofs and walls

While high life cycle costs make it inappropriate to mandate green roofs and walls, a DCP can encourage these by including appropriate design guidance.

An example DCP clause, developed by the City of Parramatta for their draft CBD DCP, is included in Appendix A (page 73). This establishes minimum design standards for situations where these features are included in a development. This example could be strengthened by including reference to design and technical factors which support cooling, for example insulation values.

Dual water systems for recycled water

It would be difficult for councils to mandate recycled water in new development. In residential development, BASIX would prevail. However, even in non-residential development, the availability of recycled water depends on either Sydney Water or a motivated private sector operator to develop a recycling scheme, and there are many barriers to developing such schemes.

Local government can help reduce one of the barriers via planning provisions that require new buildings to be built ready to connect to a future recycled water system. In a precinct with significant redevelopment, this would create a number of future customers within the area, reducing uncertainty for potential operators.

The City of Parramatta's Planning Proposal for the CBD LEP (2020) is planning for the hopeful future availability of recycled water in the Parramatta CBD, by calling for all new buildings (and significant alterations to existing buildings) to install dual water systems for both potable water and recycled water. In a building with a dual water system, fittings that don't require drinking quality water (e.g. outdoor taps, toilets and laundry taps) should be plumbed to a separate water supply connection. This requirement is relatively straightforward and low-cost for developers (particularly at the scale of development in the Parramatta CBD), and while few are likely to have the capacity to install their own recycled water supply, this requirement will ensure that new buildings are ready to switch to recycled water when this becomes available in the area (more likely from a regional scale scheme).

Encouraging residential rainwater harvesting

While local government can't set requirements for residential rainwater harvesting, there are ways to encourage the practice via local planning provisions. Some DCPs create an indirect incentive for rainwater harvesting by allowing a reduction in on-site detention (OSD) volume, where on-site retention (i.e. rainwater/stormwater storage) is provided instead. The implications for downstream flooding should be considered before adopting this approach – a reduced OSD volume will be less effective for reducing peak flows.

7.5 IMPROVING LEP AND DCP PROVISIONS OVER TIME

As noted above, the first generation of local planning provisions for urban heat will need to be reviewed and improved over time. This should include:

- Monitoring and review to understand effectiveness of the provisions in practice, identify unintended outcomes and opportunities for improvement
- Including updated research findings as the field progresses
- Incorporating new tools and methods as these are developed
- As technology evolves, planning provisions will also need to evolve to accommodate both increasing availability of current technologies (e.g. electric vehicles, solar battery storage) as well as new technologies not yet considered.

Councils are encouraged to review urban heat provisions in their DCP at least every five years. It is also recommended that WSROC should update this toolkit after a similar timeframe.

8 BEYOND LOCAL PLANNING CONTROLS

8.1 IMPROVING BASIX

Existing thermal performance standards

Building safety, health, amenity, and energy efficiency standards are set across Australia by the National Construction Code (NCC). Maintained by the Australian Building Code Board (ABCB), the requirements of the NCC apply to all new buildings, additions, and major renovations. The code recognises and sets specific requirements for four separate residential building types and six non-residential building types (NCC Building Classifications 1-10).

Within the NCC, Section J: Energy Efficiency, establishes the requirements for energy efficiency and ventilation. For non-residential buildings and hotels, Section J directly governs efficiency, ventilation, and comfort requirements. For residential buildings and homes, energy and thermal performance is governed through two sub-codes, BASIX for NSW and the National House Energy Rating Scheme (NatHERS) for all other states and territories. This is illustrated in Figure 40.

Limitations of existing standards

For residential buildings within NSW, BASIX sets requirements for energy efficiency, water efficiency and thermal comfort. However, the thermal comfort standards in BASIX are not the same as a thermal safety or thermal autonomy design standard. In BASIX, and in the other sub-codes of the NCC, there is no recognition of thermal safety or thermal autonomy as a fundamental objective of compliance. Thermal safety within buildings, let alone during heatwaves, is not identified in any of the Building Codes as a guiding principle or critical outcome.

Where the building codes do recognise thermal comfort, they do so in terms of energy use limits placed on heating/cooling systems to maintain that comfort. In BASIX, heating and cooling caps define the maximum load placed on heating/cooling systems to maintain comfortable indoor conditions. This is an indirect measure of a building's thermal performance. While it is possible to choose no active heating or cooling, and meet the BASIX target based on passive measures, most homes include air conditioning and in these cases, the inherent assumption is that this will function during heatwaves. However, not all homes have functional air conditioning, not all residents can afford to run it, and air conditioning is dependent on reliable power.

Furthermore, the thermal comfort requirements in BASIX are also limited by the fact that the tool's peak design conditions (outdoor temperatures) and weather data are out of date and do not reflect the severity nor the frequency of heatwaves experienced now, especially in environments like Western Sydney, which are particularly exposed to heat.

This means that houses or apartment units in NSW, including in Western Sydney, will typically get hotter, faster, than they would if built to more stringent international residential building standards, and if they were built to meet these standards in the context of expected future climatic conditions.

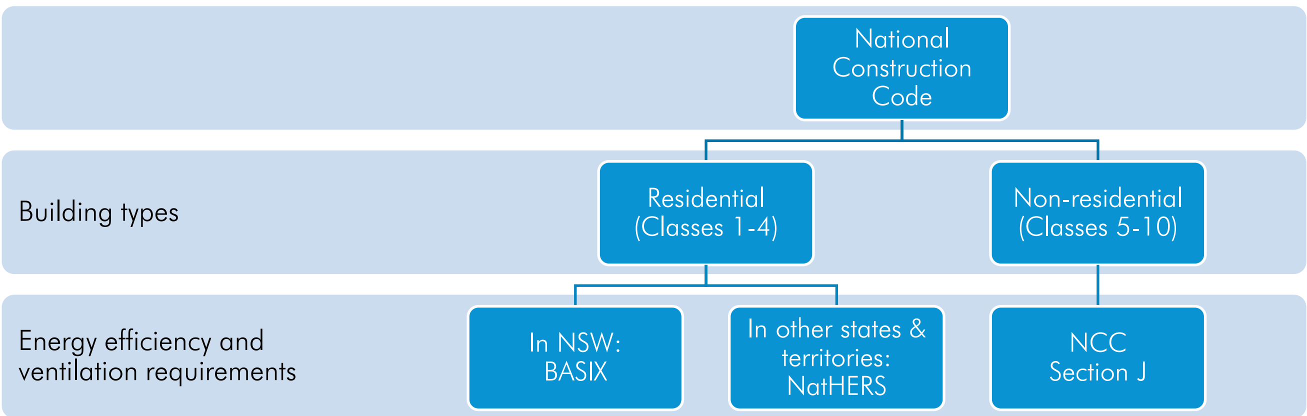


Figure 40: Energy efficiency and ventilation requirements for Australian buildings are defined by different codes depending on the building type and the state/territory

Post-occupancy performance issues

There is also evidence to indicate that in terms of actual post-occupancy performance, many BASIX-compliant homes are falling short of the standards reported in their BASIX certificates. Post-construction monitoring has shown that BASIX-compliant homes are not reliably thermally comfortable, despite the code's intention to deliver comfortable indoor conditions. This partly results from the BASIX assessment method (discussed above), which doesn't directly calculate comfort, instead it calculates peak heating and cooling energy demands as a proxy for comfort.

Furthermore, there is evidence that BASIX substantially underestimates average energy requirements for cooling, particularly in Western Sydney (Ding *et al* 2019). The same study found that in the homes with high cooling energy use, poor design and build quality were key issues. These poorly performing homes may be failing to achieve thermal comfort or thermal safety. This indicates a potential gap at the compliance stage. This compliance gap is something that councils can potentially improve, noting that there are also limitations to councils' role at the compliance stage, including the widespread use of private certifiers.

Ensuring thermally safe homes

Cool homes are a vital element in addressing the impacts of urban heat, as houses are a key refuge in heatwaves, and need to maintain safe temperatures during extreme events. Current codes and regulations need to acknowledge this.

The concept of thermal autonomy aligns well with existing building codes but can be defined as a distinctly separate thermal safety standard, focused on public health outcomes. This distinguishes it from the energy efficiency and thermal comfort outcomes at the centre of BASIX.

When it comes to cool homes in particular, technical complexity, combined with a complicated planning and regulatory system, makes it challenging to set new standards. However, there is good design guidance on passive design to achieve thermal safety/passive survivability objectives, and new design tools are available to inform better design decision making. There are international precedents for stronger thermal performance standards, and the key question now is how to include similar standards in our planning system. This will only become more important with time, as average temperatures and days of extreme heat both increase.

In the Section 6.1, the point was made that local planning provisions have a limited role, and several important aspects of urban heat are covered by the NCC and BASIX. Because the BASIX SEPP prevails over any competing environmental planning instruments, local councils have little recourse to address urban heat challenges related to thermal comfort within residential buildings (nor energy or water used by people to stay cool in their homes).

The NSW Government has suggested a potential review of BASIX targets as part of the Design and Place SEPP. It is unclear how extensive this review may be, but councils should advocate for substantial improvements to address urban heat and address the shortfalls outlined above.

A substantial revision to the BASIX SEPP and BASIX tool should include:

- Updated climate data
- Review of all parameters likely to be affected by a changing climate
- Review available technologies to include new options available today
- Stronger energy efficiency and thermal comfort targets
- An additional performance target for thermal safety/thermal autonomy, similar to CIBSE TM 59
- The ability for local councils to impose higher or more detailed standards where local circumstances like urban heat stress warrant this consideration.

WSROC and its member councils should engage with DPIE to press the case for improving BASIX.

8.2 IMPROVING PLANNING FOR MAJOR PRECINCTS

In precinct-scale development, particularly in greenfield areas, there are important decisions made in the early planning stages (e.g. at structure planning stage) that have a bearing on urban heat outcomes. For example:

- Orientation of streets, and the buildings that address them, in relation to solar exposure and prevailing breezes.
- Geometry of streets – the ratio between street width and the height of the built form on either side.
- Street design – in the early planning stages when space is allocated to road reserves, canopy cover and water sensitive urban design need up-front consideration.
- Planning for parks, open space and green grid connections should consider how the precinct will provide appropriate opportunities for outdoor recreation and active transport connections to community facilities and transport nodes, which are appropriate for use during hot conditions.

General design considerations around outdoor thermal comfort, with a view to optimising urban design for solar access, shading, materials and appropriate vegetation, are:

- Open spaces between low buildings experience higher temperatures during the day due to high solar exposure – in comparison, narrow spaces between tall buildings that are shaded during the day may trap heat at night. Large street trees would provide a higher cooling benefit in the former situation.
- Building spacing and (where possible) street orientation should facilitate cross-ventilation and wind circulation. Santamouris *et al* (2020) identifies the directions of the main cooling breezes in Western Sydney.
- Topography is a significant factor: placing tree canopy on the northern side of a development which slopes to the south is a much more effective design measure than applying shading devices to the southern side of the building; and green open space at the top of a hill may distribute cool air to its surroundings more effectively than green open space at a low point in the landscape.

These considerations are mainly relevant in larger development precincts, where there are opportunities to define such major features of the urban form. Therefore, rather than including these considerations in councils' main DCP document, it would be worth considering other avenues, such as precinct master planning, to encourage their consideration in precinct planning.

Other potential opportunities in larger precincts could include:

- Strategic location of cool zones, cool streets and cool refuges (including links with the Green Grid)
- Higher site-specific standards (e.g. NABERS or BASIX targets, landscaped area targets, etc.)
- Precinct-wide strategies for energy, water, transport and other services, that enable innovation.

8.3 PROVIDING LOCAL DESIGN GUIDELINES

Councils often publish design guidelines, fact sheets, standard drawings or other supporting information on specific topics where more detailed design guidance is required beyond the DCP. Additional guidance is particularly valuable in situations where:

- Councils prefer the use of consistent materials, furniture and repeated design elements – this is particularly important in the public domain. Many councils have published public domain design guidelines, streetscape design guidelines and landscape design guidelines, which provide more detail beyond the DCP.
- Planning provisions address a relatively new topic, particularly if it involves complex concepts and design elements, and/or a shift in industry practice. For example, as they adopted new WSUD planning provisions, many councils also provided water sensitive urban design guidelines and fact sheets to support these provisions.

There is likely to be a similar need for urban heat design guidance to support new planning provisions, although it is an open question as to which organisations are best placed to provide such guidance. To date, universities, governments and WSROC have all published or are developing relevant guidance documents and tools, including:

- The CRC for Low Carbon Living published the "Guide to Urban Cooling Strategies" (Osmond and Sharifi 2017), which includes guidance tailored to different climatic zones including Western Sydney.
- The CRC for Water Sensitive Cities has released several guidance documents related to urban heat mitigation – notably the "Guidelines for passively irrigated landscapes" (CRC WSC 2020) and "Guidelines for optimised tree placement" (Coutts and Tapper 2017), which provide guidance on planting design for cooling in relation to street geometry.
- The Victorian Government has published "Trees for Cooler and Greener Streetscapes: Guidelines for Streetscape Planning and Design" (E2 Design Lab 2019), which provide guidance on integrating WSUD with trees to support cooler streets.
- Which Plant Where, a project being undertaken in partnership between Macquarie University and Western Sydney University, is developing guidance on selection of appropriate plant species for locations around Australia, considering which species will be suitable as the climate changes.
- WSROC, in collaboration with Resilient Sydney and the Greater Sydney Commission, is developing a 'Cool Suburbs' decision support and design guidance tool, which will provide a 'cool score' for new and existing suburbs.
- WSROC has developed this toolkit.

Most of the examples above are focused on design of the outdoor environment. Building design for thermal performance is a more complex technical topic, where specialists draw on a range of industry guidelines and design tools. However, there is the "Your Home" website and technical manual published by the Australian Government, which is pitched at a broader audience.

A suggested pathway for councils who want to provide local guidance related to urban heat is to:

- Identify the relevant parts of existing guidelines and tools published by others.
- Provide local guidance that simply refers to other guidelines and tools and identifies which elements are relevant locally, or explains how to apply them locally.
- Update existing council guidelines (e.g. public domain, streetscape, landscape and WSUD design guidelines) to incorporate urban heat resilience thinking.

Regional guidelines are also a possible way forward. A recent Western Sydney project has developed (to final draft stage) the Western Sydney Street Design Guidelines (Aspect 2019). These are a good model that accounts for all the spatial conflicts in streetscapes and aims for better landscape outcomes. These guidelines should also incorporate best practice thinking for urban heat mitigation in streetscapes.

8.4 PROVIDING HEATWAVE RISK MANAGEMENT GUIDANCE

A gap analysis conducted as part of WSROC's heatwave resilience initiative, Heat Smart Western Sydney, identified that heatwave risk management guidance is currently lacking in NSW. Existing state legislation and guidelines govern and guide the management of other natural hazards such as flooding, coastal erosion and bushfire. In these cases, there are strong links between relevant legislation, guidelines and the planning system:

- Local floodplain management planning is supported by the *Local Government Act 1993* Section 733 and the NSW Floodplain Development Manual.
- Local planning for coastal erosion is supported by the *Coastal Management Act 2016*, the Coastal Management SEPP, and Coastal Management Manual.
- Local bushfire planning is supported by the *Rural Fires Act 1997* and the Bush Fire Co-ordinating Committee's Bush Fire Risk Management Guidelines.

This means that local planning provisions for floodplain management, coastal erosion and bushfire are backed by legislation and can refer to the relevant guidelines for more detail on the design standards that new development is expected to meet.

Urban heat planning would benefit from a similar approach, however this will likely take some time to develop. Changes to the NSW Heatwave Sub-Plan to include prevention/mitigation responsibilities for heatwaves could pave the way for development of a legislative and policy framework for heat-mitigating urban planning.

PART IV

SUPPORTING INFORMATION

GLOSSARY

Adaptive comfort	Perceived thermal comfort that adjusts with varying outside conditions.
Albedo	A measure of the diffuse reflection of solar radiation from a surface, measured on a scale from 0 to 1, where a value of 0 would mean that all incident radiation is absorbed, and a value of 1 would mean that all incident radiation is reflected. In simple terms, high albedo surfaces reflect more solar radiation than they absorb.
Ambient temperature	Average air temperature in the environment. In this toolkit, the term "ambient temperature" is used to refer to the average air temperature at the city-scale or precinct-scale (as distinct from a microclimate scale).
Evapotranspiration	The process by which water is transferred from the land to the atmosphere, both via evaporation from the soil and other surfaces, and via transpiration by plants.
Extremely hot days/ Extreme heat	Defined by the Climate Council as temperatures 40°C and over.
Feels like (temperature)	An expression of the equivalent temperature defined by human experience. "Feels like" temperature generally takes into account wind speeds and humidity, and may include other factors, to assess how the human body actually feels temperature.
Green infrastructure	Any vegetation in the urban environment.
Heatwaves	Defined by the Australian Bureau of Meteorology as a period of three or more consecutive days of high maximum and minimum temperatures which are unusual for that location.
Hot days	Defined by the Climate Council as days between 30°C and 35°C.
Microclimate	The climatic conditions of a very small or restricted area, especially when this differs from the climate of the surrounding area. In the case of urban heat, microclimate typically refers to conditions experienced at a human scale in different places within the urban environment – 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.
Passive survivability	A building's ability to maintain critical life-support conditions in the event of extended loss of power, heating fuel, or water.
Passive thermal performance	A building's ability to maintain a comfortable and relatively stable internal temperature, without powered heating or cooling, in fluctuating external conditions.
Radiant temperature	A measure of thermal radiation emitted from adjacent surfaces.
Solar Reflectance Index (SRI)	A measure of a constructed surface's ability to reflect solar heat, as shown by a small temperature rise. It is defined so that a standard black surface (reflectance 0.05, emittance 0.90) is 0 and a standard white surface (reflectance 0.80, emittance 0.90) is 100.
Surface temperature	Temperature measured at a surface.
Thermal autonomy	A measure of the percentage of time a building can maintain a specific set of comfort conditions passively (without air conditioning or heating), despite outdoor temperature fluctuations.

Thermal comfort	The condition of mind that expresses satisfaction with the thermal environment; i.e. the conditions in which a person feels neither too cold nor too warm.
Thermal emittance	The rate at which heat is radiated from a surface
Thermal safety	The condition of body that maintains balanced heat gains and losses with the environment to avoid inducing a dangerously low or high body temperature. A thermally safe environment remains within a range of temperatures that protect people from injury or death resulting from over-heating or over-cooling.
Universal Thermal Climate Index (UTCI)	A standard measure of "feels like" temperature.
Urban heat	A general term that refers to high temperatures in urban areas that pose a risk to our communities and infrastructure.
Urban heat island (UHI) effect	The tendency of cities to be much warmer than their rural counterparts. Urban surfaces such as roads and roofs absorb, hold, and re-radiate heat; raising the temperature in our urban areas. Human activities such as traffic, industry, and electricity usage also generate heat that adds to the urban heat island effect.
Very hot days	Defined by the Climate Council as days between 35°C and 40°C.
Water sensitive urban design (WSUD)	An approach to urban water management that aims to minimise impacts on the natural water cycle.
Xeriscaping	The practice of designing landscapes to reduce or eliminate the need for irrigation.

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APPENDIX A EXAMPLE CLAUSES

COOL FACADES

City of Parramatta draft urban heat controls developed for the Parramatta CBD DCP

Objectives

O1. To minimise the reflection of solar heat downward from the building façade into private open space or the public domain.

Controls

C1. The extent of the vertical façade of street walls (or if no street wall, as measured from the first 12 metres from the ground plane) that comprise Reflective Surfaces must demonstrate a minimum percentage of shading as defined in Table 1 as calculated on 21 December on the east facing façade at 10am, northeast and southeast facing façade at 11.30am, north facing façade at 1pm, northwest and southwest facing façade at 2.30pm and the west facing faced at 4pm (as shown in Figure 1.2).

Table 1
Minimum podium percentage shading

Reflective Surface Ratio (RSR)	<30%	30%-70%	>=70%
Minimum percentage shading (%)	0	1.5*RSR-45	75

Shadow diagrams must be submitted with the development application quantifying the extent of shading at 10am, 11.30am, 1pm, 2.30pm and 4pm on 21 December for each relevant façade. Shadows from existing buildings, structures and vegetation are not considered in the calculations. Refer to Table 2 for sun angles corresponding to shading reference times.

Calculation of RSR for each relevant façade must also be submitted with the development application.

Table 2
Shading sun angles

Façade Orientation	Sun Angles
East ± 22.5°	Reference Time: 10am AEDT (UTC/GMT+11) Sun Elevation: 51° Sun Azimuth: 86°
Northeast/Southeast ± 22.5°	Reference Time: 11.30am AEDT (UTC/GMT+11) Sun Elevation: 69° Sun Azimuth: 66°
North ± 22.5°	Reference Time: 1pm AEDT (UTC/GMT+11) Sun Elevation: 80° Sun Azimuth: 352°
Northwest/Southwest ± 22.5°	Reference Time: 2.30pm AEDT (UTC/GMT+11) Sun Elevation: 67° Sun Azimuth: 290°
West ± 22.5°	Reference Time: 4pm AEDT (UTC/GMT+11) Sun Elevation: 48° Sun Azimuth: 272°

C2. The extent of the vertical façade of the tower (above the street wall or if no street wall, as measured above the first 12 metres from the ground plane) that comprise Reflective Surfaces must demonstrate a minimum percentage of shading as defined in Table 3 as calculated on 21 December on the east facing façade at 10am, northeast and southeast facing façade at 11.30am, north facing façade at 1pm, northwest and southwest facing façade at 2.30pm and the west facing faced at 4pm (as shown in Figure 1.4).

Table 3
Minimum tower percentage shading

Reflective Surface Ratio (RSR)	<30%	30%-70%	>=70%
Minimum percentage shading (%)	0	0.8*RSR-24	40

Shadow diagrams must be submitted with the development application quantifying the extent of shading at 10am, 11.30am, 1pm, 2.30pm and 4pm on 21 December for each relevant façade. Shadows from existing buildings, structures and vegetation are not considered in the calculations. Refer to Table 2 for sun angles corresponding to shading reference times.

Calculation of RSR for each relevant façade must also be submitted with the development application.

C3. Shading may be provided by:

a) External feature shading with non-reflective surfaces;

b) Intrinsic features of the building form such as reveals and returns; and

c) Shading from vegetation such as green walls that is consistent with the controls on Green Roofs or Walls in Section #### Landscaping.

C4. Non-reflective surfaces of vertical facades do not require shading and these areas can be excluded from the calculations.

C5. Where it is demonstrated that shading cannot be achieved in accordance with the above controls, a maximum external solar reflectance as defined in Table 4 and as indicated in Figure 1.1 is generally acceptable.

Table 4
Maximum solar reflectance of Reflective Surfaces.

Reflective Surface Ratio (RSR)	<30%	30%-70%	>=70%
Maximum External Solar Reflectance (%)	No Max.	62.5-0.75*RSR	10

C6. Where multiple reflective surfaces or convex geometry of reflective surface introduce the risk of focussing of solar reflections into the public spaces:

a) Solar heat reflections from any part of a building must not exceed 1,000W/m2 in the public domain at any time;

b) A reflectivity modelling report may be required to qualify extent of reflected solar heat radiation.

HEAT EMITTED FROM HVAC SYSTEMS

City of Parramatta draft urban heat controls developed for the Parramatta CBD DCP

Objectives

O2. To reduce the impact of heat rejection from heating, ventilation and cooling systems from contributing to the urban heat island effect in the Parramatta Local Government Area; and

O3. To avoid or minimise the impact of heat rejection from heating, ventilation and cooling systems on user comfort in private open space and the public domain.

Controls

C1. Residential apartments within a mixed use development or residential flat building, and non-residential development should incorporate efficient heating, ventilation and cooling systems which reject heat from a centralised source on the upper most roof.

C2. Where the heat rejection source is located on the upper most roof, these should be designed in conjunction with controls in this Section of the DCP relating to Roof Surfaces and the controls on Green Roofs or Walls in Section #### Landscaping.

C3. No heat rejection units shall be located on the street wall frontage on the primary street.

C4. Heat rejection units are strongly discouraged from being located on building facades or on private open space, such as balconies and courtyards. However, where it is demonstrated that heat rejection cannot be achieved in accordance with the above controls C1 and C2 above and these units are installed, the HVAC system must demonstrate:

a) Heating, ventilation and cooling systems exceeds current Minimum Energy Performance Standard requirements; and

b) The heat rejection units are situated with unimpeded ventilation, avoiding screens and impermeable balcony walls; and

c) The area required by the heat rejection units is additional to minimum requirements for private open space.

C5. Where a mixed use development or residential flat building proposes wintergardens as the primary private open space, no heat rejection source from heating, ventilation and cooling systems are permitted to be located in the wintergarden (add Wintergarden cross reference ####)

GREEN ROOFS OR WALLS

City of Parramatta draft urban heat controls developed for the Parramatta CBD DCP

Objectives

O1. To ensure that green roofs or walls are integrated into the design of new development.

O2. To encourage well designed landscaping that caters for the needs of residents and workers of a building.

O3. To design green walls or roofs to maximise their cooling effects.

O4. To ensure green walls and roofs are designed and maintained to respond to local climatic conditions and ensure sustained plant growth.

Controls

C1. Green roof and wall structures are to be assessed as a part of the structural certification for the building. Structures designed to accommodate green walls should be integrated into the building façade.

C2. Waterproofing for green roofs and walls is to be assessed as a part of the waterproofing certification for the building.

C3. Where vegetation or trees are proposed on the roof or vertical surfaces of any building, a Landscape Plan must be submitted which demonstrates:

a) Adequate irrigation and drainage is provided to ensure sustained plant growth and health and safe use of the space;

b) Appropriate plant selection to suit site conditions, including wind impacts and solar access; and

c) Adherence to the objectives, design guidelines and standards contained in the *NSW Department of Planning and Environment's Apartment Design Guide* for 'Planting on Structures'.

C4. Green roofs or walls, where achievable, should use rainwater, stormwater or recycled water for irrigation.

C5. Container gardens, where plants are maintained in pots, are not considered to be green roofs.

C6. Register an instrument of positive covenant to cover proper maintenance and performance of the green roof and walls on terms reasonably acceptable to the Council prior to granting of the Occupancy Certificate.

ENERGY EFFICIENCY

City of Sydney DCP 2012, Section 3.6.1

1) Development is to be designed and constructed to reduce the need for active heating and cooling by incorporating passive design measures including design, location and thermal properties of glazing, natural ventilation, appropriate use of thermal mass and external shading, including vegetation.
2) Lighting for streets, parks and any other public domain spaces provided as part of a development should be energy efficient lighting such as LED lighting.
3) In multi-tenant or strata-subdivided developments, electricity sub-metering is to be provided for lighting, air-conditioning and power within each tenancy or strata unit. Locations are to be identified on the development plans.
4) Electricity sub-metering is to be provided for significant end uses that will consume more than 10,000 kWh/a.
5) Car parking areas are to be designed and constructed so that electric vehicle charging points can be installed at a later time.
6) Where appropriate and possible, the development of the public domain should include electric vehicle charging points or the capacity for electric vehicle charging points to be installed at a later time.
7) Applications for new developments containing office premises with a net lettable area of 1,000sqm or more are to be submitted with documentation confirming that the building will be capable of supporting a Base Building National Australian Built Environment Rating System (NABERS) Energy Commitment Agreement of 5.5 stars with the NSW Office of Environment and Heritage. Such an agreement is to be entered into prior to any construction certificate being issued for the approved development.
8) Applications for developments involving alterations, additions and refurbishments to existing office premises where the estimated cost of works is over $5 million, and contains a net lettable area of 1,000sqm or more, are to be submitted with documentation confirming that the building will be capable of supporting a Base Building National Australian Built Environment Rating System (NABERS) Energy Commitment Agreement of 5 stars with the NSW Office and Environment Heritage. Such an agreement is to be entered into prior to any construction certificate being issued for the approved development. Notwithstanding, a Base Building National Australian Built Environment Rating System (NABERS) Energy Commitment Agreement of 5 stars is not required where the consent authority is satisfied that:
    a) the upgrade works would negatively impact on significant heritage fabric or the heritage significance of a listed heritage item, or
    b) the costs associated with the energy efficiency upgrade works are unreasonable when compared to the overall estimated cost of works for the alterations, additions and refurbishment.
9) Any application which may impact on significant heritage fabric or the heritage significance of a listed item is to be supported by a Heritage Impact Statement prepared by an appropriately experienced heritage consultant.
10) Where it is asserted that the costs are unreasonable under subclause (8) (b) the development application is to be supported by a registered Quantity Surveyor's detailed cost report itemising and verifying the cost of the required energy efficiency upgrade works.

City of Parramatta draft LEP provisions for the CBD, Clause 7.6A

High performing buildings

1) The objectives of this clause are as follows:
    a) to encourage high performing building design (namely the built form, layout and services) of office premises, large-scale retail premises, hotel or motel accommodation, serviced apartments, residential flat buildings and mixed use development in the Parramatta City Centre that minimises the consumption of energy and water, and
    b) to provide increased amenity to occupants over the long term, and
    c) to ensure the increase in gross floor area is compatible with surrounding buildings in terms of bulk, height and amenity.

d) to ensure high performing building measures improve over time to reflect new technologies and commercial viability.

2) This clause applies to:

a) development for the purposes of office premises with a gross floor area of 1,250 square metres or greater; or

b) development for the purposes of retail premises with a gross floor area of 5,000 square metres or greater; or

c) development for the purposes of serviced apartments or hotel or motel accommodation; or

d) development for the purposes of residential flat buildings and mixed use development that includes residential accommodation, but only where:

i) the lot on which the development will be sited is at least 24 metres wide at the front building line and has a minimum site area of at least 1,800 square metres, and

ii) the lot on which the development will be sited has a maximum floor space ratio of at least 6:1, as shown on either the Floor Space Ratio Map or Incentive Floor Space Ratio Map (as applicable to the development), and

iii) the applicant for the development has chosen to develop their building utilising this clause; or

e) significant alterations and additions (that have a capital value of more than $5 million) to existing retail premises (with a gross floor area of 5,000 square metres or greater), office premises, hotel or motel accommodation or serviced apartments.

3) Before granting development consent to development under this clause, the consent authority must be satisfied that:

a) the part of any building used for the purposes in Column 1 of the table, does not exceed the energy emission in Column 2 of the table and the water usage in Column 3 of the table:

Column 1	Column 2	Column 3
Retail premises (including as part of a mixed use development) – common areas only	< 52.8 kgCO2/m²/annum	< 1.1 kl/m²/annum
Office premises (base building)	< 63.8 kgCO2/m²/annum	< 0.5 kl/m²/annum
Hotel or motel accommodation or serviced apartments (whole building)	< 5,220 kgCO²/guest room/annum	< 76.1 kl/guest room/annum

Note: The energy and water requirements in Columns 2 and 3 were extracted from the Federal Government's National Australian Built Environment Rating System (NABERS) registry on 26February 2020 and represent the 15th percentile of best performance of similar existing buildings of a similar usage type in the Sydney metropolitan region. These requirements will be regularly reviewed by Council to ensure high performing building measures improve over time to reflect new technologies and commercial viability.

b) a report prepared by a qualified consultant to the satisfaction of the Council verifies that:

(a) the necessary annual emissions intensity and water performance targets to meet the requirements under this subclause at the time of application have been established and confirmed, and

(b) the building will meet the annual energy and annual water performance targets established under this subclause, has adequate allowance (including budget) in the design of the building and its services to meet these targets, and is committed to a post occupancy verification against the targets.

4) The part of any building that is a dwelling, including as a part of a residential flat building or mixed use development, complies with the following higher BASIX Energy and BASIX Water standards (shown Column 2) than the minimum

standards as provided in State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004, which correspond to the height of the building (shown in Column 1) and its floor space ratio (also shown in Column 2), as indicated in the table to this subclause.

Column 1	Column 2		
Building Height	Higher BASIX Energy and Water Standards		
	BASIX standard	Points above minimum BASIX standard for development with a floor space ratio of 6:1 or greater, up to, but not including, 14:1	Points above minimum BASIX standard for development with a floor space ratio of 14:1 or greater
5-15 storeys	Energy	+25	+15
	Water	+15	+15
16-30 storeys	Energy	+20	+10
	Water	+15	+15
31-40 storeys	Energy	+10	+10
	Water	+15	+15
41+ storeys	Energy	+10	+10
	Water	+15	+15

Note. These higher BASIX standards may be subject to review following changes to the State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004 by the NSW Government.

5) A residential flat building or a mixed use development (that contains dwellings) which complies with this clause is eligible for an amount of additional residential floor space (above that already permitted elsewhere under this Plan) equivalent to that which exceeds the floor space ratio as shown on the Floor Space Ratio Map or Incentive Floor Ratio Map (as applicable to that development) by up to 5%, subject to the consent authority being satisfied that this additional residential floor space does not adversely impact on neighbouring and adjoining land in terms of visual bulk and overshadowing.

6) This clause does not apply to land on which development to which clause 13 of State Environmental Planning Policy (Affordable Rental Housing) 2009 applies is to be carried out.

7) In this clause:

BASIX means a rating under State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004.

mixed use development means a building or place comprising two or more different land uses, where at least one of these land uses is dwellings.

TREES

North Sydney DCP 2013, Section 16 [excerpts]

SECTION 16.2, Subsection 16.2.2 Clause P2:

Development Consent or a Tree Management Permit is required in accordance with Clause 5.9 of NSLEP 2013 for the removal or pruning of a prescribed tree or vegetation. The following trees and vegetation are prescribed for the purposes of this DCP:

a) Any tree or vegetation on public land, regardless of size;

b) Any tree or vegetation with a height of 10m, or a crown width of 10m, or a trunk circumference of 1.5m measured at 1m above ground level (existing); or

c) Any tree that is declared a noxious weed and comprises a mature canopy tree;

d) Any tree or vegetation more than 5 metre tall on land identified as a heritage item;

e) Any tree or vegetation that is declared a noxious weed on land identified as a heritage item under cl.5.10 of NSLEP 2013 regardless of size;

SECTION 16.5 NEW TREE PLANTING

16.5.1 Objectives

O1 To ensure that the current level of canopy cover in North Sydney is maintained and enhanced over the long term.

O2 To ensure that sustained amenity is achieved by establishing a range of age classes within the urban tree population.

O3 To ensure a species diversity that maintains or enhances the current urban character of North Sydney.

O4 To enhance biodiversity through the strategic connectivity of canopy and habitat plantings between areas of bushland remnants (i.e. wildlife corridor creation).

16.5.2 Provisions

Species Selection

P1 Species should be chosen after carefully evaluating the site constraints and the desired function of the tree (e.g. habitat, shade, safety, privacy or aesthetics).

P2 When planting is to take place on public land, Council's arborists will advise the appropriate species in accordance with the North Sydney Street Tree Strategy.

P3 When planting is to take place in bushland or bushland habitat areas, Council's Bushland Management Staff will determine appropriate species in accordance with the North Sydney Natural Area Survey 2010 and relevant Bushland Rehabilitation Plans.

P4 When planting on private property Council strongly recommends the use of a qualified arborist when selecting species.

P5 When selecting a species, the physical, ecological and horticultural characteristics should be considered.

a) Physical characteristics include: mature dimensions (height, spread, trunk diameter) foliage density, evergreen or deciduous, tree shape or form.
b) Ecological characteristics include: climatic durability, water efficiency, fauna habitat, invasivity in bushland.
c) Horticultural considerations include: fruit/flower/seed drop, suitability to the site growing conditions, poisonous or allergic qualities, weed potential, suckering, root vigour, structural soundness, and longevity in the urban environment.

Planting Locations

P6 New trees should be located where there is adequate space for the chosen species to grow to its natural mature dimensions, survive in the long term and make a positive contribution to the amenity of an area.

P7 Any new street trees should be located in accordance with the North Sydney Council Street Tree Strategy.

P8 Any new trees on private property should be located in accordance with the objectives of the landscaping provisions throughout this DCP and the North Sydney Urban Forest Strategy.

Planting Techniques

P9 All planting must be carried out in accordance with the detailed specifications appropriate to the site as set out in Council's Infrastructure Specification Manual for Roadworks, Drainage & Miscellaneous Works.

P10 Planting trees in footpaths adjacent to heavily trafficked streets may need:

a) To be undertaken outside of peak hour traffic times.
b) The approval of the RMS if it involves a state or arterial road.
c) A Traffic Management Plan and/ traffic control depending on the road.

Plant Establishment and Maintenance

To ensure the long term survival of any new vegetation a condition may be imposed on a Development Consent outlining a minimum landscape maintenance period. The length of the landscape maintenance period shall vary according to the specific works carried out and will be generally a minimum of 13 weeks.

P11 Erosion and sedimentation controls may need to be provided subject to the scale of the planting work proposed and the potential of causing pollution. These devices must be maintained regularly. Failure to install and maintain these devices may result in a fine and/or legal action.

P12 It is the responsibility of the developer/applicant to comply with the terms of any Development Consent issued by the Council in respect of maintenance requirements of trees or vegetation within the time stated in the consent.

Cumberland draft DCP 2020, Part G Section 2.3

C2. For existing trees that are approved to be removed by Council as part of a proposed development, the following tree replacement offset planting is required:

- for existing trees removed that are a height of between 4m-9m, a 1:1 replacement offset applies; and
- for existing trees removed that are a height greater than 10m, a 2:1 replacement offset applies.

The preference is for offset planting to be undertaken on the property related to the development application. Any alternate locations are to be considered on merit by Council, with reference to applicable strategies and plans.

C3. Tree species to be used for offset planting must be installed as minimum 45L container stock size and be of a species that is capable of reaching a height greater than 10m, given the proposed location and soil volume.

C4. Landscaping shall be provided to enhance the streetscape and setting of development, incorporating a mix of trees, shrubs and ground covers planted appropriately and where necessary, providing essential screening or solar access roles.

C5. Where trees are to be planted, consideration must be given to the species type, height and size of the tree at maturity and to the distance of the tree to any structure including stormwater pits and services such as overhead powerlines and underground pipework.

C6. Proposed locations for tree species that reach a height of 10m or greater must maintain a minimum distance of 2m from all adjoining boundary fence lines at the time of planting.

ELECTRIC VEHICLES

Waverley DCP 2012, Part B, Section B8

8.8 Electric Vehicle Charging Points

Objectives

(a) To accommodate changing technology in the design of developments to provide services for future users.

(b) To accommodate hybrid and electric vehicles by ensuring that adequate charging points for these vehicles are provided in off-street private and public car parking areas.

Controls

(a) All multi-residential developments, mixed use developments and commercial developments are to comply with this part.

(b) The conditions of consent outlined in Table 6 below will be applied to any commercial, mixed use or multi-residential developments. Applicants are to demonstrate that the power provision on site is appropriate to be able to service these requirements.

Conditions of Consent for EV Charging Points

- All charging point locations are to be identified on CC Plans.
- All electric charging points are to have clear signage identifying:
    - Location;
    - Fees and charges, if any; and
    - Whether the bay is for public or private use only.

- A dedicated space and charging point for electric bicycles and mobility scooters to be charged must be provided.
- The installation of appropriate electrical infrastructure and capacity to allow at least 20% of Lot Owners (Eligible Lot Owner) to charge an electric vehicle at any one time in their own car space. Such infrastructure should:

  (i) Allow for a minimum of 16A single phase charging per Eligible Lot Owner;

  (ii) Be easily accessible for any Lot Owner to run a dedicated circuit to their own car space for the purposes of EV charging;

  (iii) Be monitored by the Owners Corporation or a 3rd party on behalf of the Owners Corporation;

  (iv) Include capacity for a billing system to account for the amount of electricity used; and

  (v) Measure electricity used by using utility grade, NMI registered electricity meters.

- The installation of 'Level 2' AC fast charging EV charging point/s is required in the common or visitor parking areas as follows:

  Residential

  - 1 charging point for developments with 5-10 dwellings; and
  - 1 additional charging point for every 10 dwellings thereafter.

  Commercial

  - 1 charging point for every 10 commercial car spaces.

  The circuit is to be suitably located to provide for convenient, shared access for residential and commercial users. The charging point should:

  (i) Be equipped with 62196-2 Type 2 socket;

  (ii) Provide up to 22kW or 32A three phase charging per port;

  (iii) Be installed on a dedicated circuit;

  (iv) Allow for monitoring and individual billing payment through an OCPP compatible software back end; and

  (v) Provide dedicated space for electric vehicles to park and charge.

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. WSROC has facilitated the development of this toolkit.

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