Strengthening resilience to extreme heat: an Adelaide case study

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Acknowledgements

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What is PERC?

The Post-Event Review Capability (PERC) is a systematic framework for the analysis of a disaster event. It focuses on how a specific hazard event became a disaster and what worked and what didn't work in terms of disaster risk reduction, preparedness, response, and recovery with the goal of developing considerations for building resilience to future hazard events. PERCs have been carried out across the globe after floods, bushfires, and tropical cyclones, and have been applied in both urban and rural settings. This study is the first PERC on extreme heat.

Extreme heat is the deadliest climate hazard in Australia—it kills more people than all other natural hazards combined.[1] This PERC, collaboratively delivered by Australian Red Cross, ISET-International, Monash University, the International Federation of Red Cross and Red Crescent Societies, and Zurich Australia explores the effects of ongoing extreme heat events in Adelaide, and in Australia more generally.

The objective of this research is to gain a deeper understanding of how communities adapt to extreme heat, the strain placed on local resources by repeated extreme heat events, and the long-term health and social impacts of these events.

This brief is one of three from the PERC Adelaide study. See also, "Understanding extreme heat and entry points for action" and "Heat stress at work."

Methodology used in this study

This study is based on in-person and online interviews conducted primarily in June and July 2025, complemented by desk research. A wide range of actors—including representatives from local and state governments, researchers, engineers, meteorologists, city planners, educators, emergency responders, health professionals, union representatives, and community organisations—contributed to the study through key informant interviews, offering a rich mix of experience, expertise, and insights.

Over the summer of 2024-2025, Adelaide experienced many hot days and an extended hot season. Overall, 2024 was the second hottest year on record (after 2019), and minimum temperatures were the hottest on record. However, interviewee insights reflected how intangible and fleeting the experience of extreme heat can be. Rather than focusing just on heat experienced in the 2024-2025 summer, what emerged from this PERC was a broader picture, informed by interview experiences of hot summers over the past decade, and of what heat impacts can and might look like as temperatures continue to rise.

Urban Climate Resilience Program

The PERC Adelaide study is aligned with and complementary to the Urban Climate Resilience Program (UCRP). UCRP brings together global actors—including the International Federation of Red Cross and Red Crescent Societies (IFRC), ICLEI, C40 Cities, R-Cities and Plan International—to advance climate resilience initiatives in urban contexts across nine countries. Funded by the Z Zurich Foundation, Australian Red Cross, in partnership with Zurich Australia, is leading UCRP implementation in Australia with a focus on Western Sydney. The PERC Adelaide study highlights shared experiences of extreme heat and common challenges faced by urban communities, which are applicable to both Adelaide and Sydney and demonstrate the broader relevance of the findings for cities across Australia and beyond. In this context, UCRP Australia represents an integrated approach to urban climate resilience, combining community-led, ground-up action with engagement of local governments and city-level actors to drive sustained policy change. Together, PERC and UCRP enable Australian Red Cross to deepen understanding of heat risk through diverse expert and stakeholder perspectives, while building locally led solutions that translate evidence into tangible improvements in people's lives.

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Heat as a hazard

The summer of 2024-2025 in Adelaide and South Australia (SA) was hot, with above average maximum and minimum temperatures. The mean daily maximum temperature for Adelaide in the summer of 2025 was 30.4°C, 2.4°C above the long-term average of 28.0°C.[2] The warmest day reached 43.3°C.[3] Two towns nestled in the Adelaide hills, Mt Barker and Mt Lofty, experienced their hottest days on record.[4] These warming trends are set to continue with the number of days over 40°C projected to double by 2050.[5] The frequency and duration of heatwaves is also projected to increase.[6]

> We're seeing more frequent heatwaves. In South Australia the heat is so dry, it's palpable. You can see the mirages. You know it's gonna be a scorcher of a day. It's more prolonged.
>
> – Local government practitioner

Interestingly, while people agreed it had been a long, hot summer, many people interviewed in this study reflected that people don't consider heat a 'disaster'. This may be in part due to the community's perception that 'summer is hot' and it's just something to be tolerated. Instead, interviewees described a culture where heat and discomfort are seen as a challenge that requires 'toughing it out', where this attitude has become part of the community psyche and even a sense of local pride.

> We [South Australians] live in extremes and we're tough and it's part of our identity, and that's problematic because we lean into that a bit.
>
> – Local government practitioner

Unfortunately, for some people, extreme heat is not just a discomfort, but creates debilitating and even life threatening situations. Heat has caused more deaths in Australia than all other natural hazards combined[7] and studies suggest that existing heat mortality data is vastly underestimated.[8] But the impacts of heat remain insidious - they are diffuse and tend to happen quietly, privately, with damage that can often be attributed to other things like underlying health issues or age. There can also be a lag-effect, with impacts on health and cascading impacts to economic well-being materialising in the days following the end of a heatwave. The extent of losses and damages may not be known for weeks, months, or ever. Yet, as summers get hotter and longer due to climate change—Australia is already experiencing hotter climates—the risks to people and their well-being will grow, requiring increased attention to, and understanding of, the impacts of heat to individuals and the systems upon which they depend.

Box 1. Entry points for heat action across scales

The responsibility for ensuring that everyone is protected from heat is both an individual and collective one. Individuals must know how to respond to heat warnings, take actions like hydrating and seeking shade, understand symptoms of heat illness, and avoid activities that increase their risk, like playing sports in extreme heat. This needs to be coupled with anticipatory action and no-regrets measures, such as early heat triggers for community outreach, cooling interventions, and targeted communications. These are essential to protect people before impacts occur, especially as extreme heat becomes more frequent and severe. Actions must be complemented by governance; communities and decision-makers have critical roles to play in ensuring that heat resilience is considered across sectors and levels. At the community scale it is vital to know who might need extra services in a heatwave to keep them safe, and to equip people with knowledge about why and how to prepare for extreme temperatures and the cost of not doing so. At the city scale, policy makers, planners and private-sector developers must work together to ensure, for example, that all residents have accessible open green spaces and tree cover, which cool neighbourhoods and counter urban heat island effects, and that new housing and developments avoid building in future heat exposure. Schools and workplaces must have policies in place and resources to keep students and workers safe in extreme heat conditions, and plan ahead for how to keep students in school and learning, to minimise impacts on the economy. Providers of essential services and health services must plan for future heat scenarios using science-based climate projections to ensure that they are prepared.

Everyone is at risk to extreme heat, but some factors and behaviours create particular risk. Vulnerability to heat is related to diverse factors such as a person's health, age, social connections, and mobility. For example, having pre-existing medical conditions, being very young or elderly, socially isolated, or unable to move around independently increases people's heat vulnerability. Heat vulnerability is also related to socio-economic status and living conditions, for example the ability to afford insulated housing or to cool rooms, especially for sleeping. During heatwaves people that are disadvantaged or vulnerable may have few options for protecting themselves from heat at work and home, which can lead to loss of income, inability to access health services, illness, and fatalities. If critical systems like energy and transport fail, cascading impacts will fall most heavily on those already at-risk and the economic and social costs of heatwaves will escalate.

An additional challenge is when it's hot, but not hot enough to trigger extreme heat warnings. PERC research highlighted this challenge in Adelaide, where, for example, the long, low-intensity heatwaves throughout the summer of 2024-25 were not enough to reach a threshold that triggered protective action. Nonetheless, it was hot enough to exhaust people mentally and physically, especially people that are highly exposed because they are outdoor workers, live in inadequate housing, don't have access to cooling, or can't afford to run it.

The need to understand the many ways in which people are exposed to heat, who is vulnerable, why they are at-risk, and what can be done to ensure that everyone is heat-safe now and in the future is a pressing one. The aim of this report, and our contribution to this challenge, is to understand the lived experience of heat through a systems lens and present a holistic view of heat impacts and resilience in Adelaide. Understanding the drivers of heat risk can provide insight into the opportunities that exist for heat resilience.

> I worry that when those [extreme climate] events occur we're not saying—ok what are we going to do about the next one?—we are so focused on recovery... I worry that we won't be able to parse out the underlying signals from the immediate crisis of the time.
>
> – Local government practitioner

> In Australia when we talk about dangerous heat, a huge part of the population switches off—summer in Australia is a source of national pride, and toughing it out in the heat is a source of national pride.
>
> – Medical specialist and academic

> **[Heat] is that silent killer. You can see a tornado, you can see a tropical cyclone, you can see a fire... The invisibility is a big part of it, and the impacts can occur after the hazard has finished. I've seen the hospital admission rates go up days, sometimes weeks after a heatwave and sadly there are an increasing number of people living rough, an increasing number of vulnerable communities.**
>
> – Government agency representative

Heat through a systems lens

Building urban heat resilience requires a holistic approach that considers the interactions between heat and the many other components of the urban environment including people, natural and built environments, infrastructure, and the economy. While the direct impacts of extreme heat may originate in isolated components of any urban system, it is the interconnectedness between multiple systems and potential for cumulative or cascading impacts that exacerbates heat risk.[9] For example, heat causes damage to roads and train lines, disrupting transportation and supply chains. Heat damages power transmission lines and stresses cooling systems while power demand escalates, causing blackouts. Power failures during heatwaves are particularly damaging because they trigger disruptions to a wide range of other sectors and services, potentially exposing large populations to elevated health risk or even life-threatening situations. Even when heat doesn't cause abrupt or catastrophic failures, chronic stresses to these systems can erode their reliability, efficiency, and coping capacity. Without adaptation, the economic costs are likely to rise dramatically over the next few decades, especially for health, productivity, and cooling.[10]

In looking at heat resilience as a system the aim is to make the connections more explicit in order to foster thinking about questions such as:

- What areas are currently working well?
- What needs greater attention?
- Who needs to work together?

Box 2. Indigenous communities and heat resilience

Aboriginal and Torres Strait Islander peoples across Australia actively engage in climate adaptation through varied approaches, drawing on deep knowledge of Caring for Country, a holistic approach developed over tens of thousands of years, where cultural practices help communities respond to environmental change, including seasonal knowledge and strategic timing of activities to manage heat.[11,12] Research in tropical Australia shows that these social and cultural practices provide strong health protection, with Aboriginal communities showing heat resilience despite significant socioeconomic disadvantage.[13]

Most Aboriginal and Torres Strait Islander peoples live in cities and regional areas rather than remote locations, yet climate policies in these areas rarely include Indigenous perspectives.[14] In New South Wales for example, Aboriginal populations experience greater exposure to extended heatwaves, with far more living in areas affected by prolonged extreme heat compared to non-Aboriginal populations.[15] Engaging Indigenous people in heatwave resilience policy and planning is therefore essential not only because they face specific and heightened risks, but also because all communities should have a say in the policies that affect them, and because Indigenous communities hold deep knowledge about living sustainably and safely in Australian environments. Resources such as the National Indigenous Disaster Resilience Planning Guide provide frameworks for respectful collaboration.[16]

This report

This report provides a picture of what heat looks like in Adelaide and how people experience it through two separate, yet inter-related, narratives:

- Insights gained from qualitative research are outlined in the main text through an exploration of the factors that exacerbate heat risk and support heat resilience and their relationship to key system components, including the way people think about and make sense of heat in their city.
- The experience of a fictional 'Adelaide family' is presented alongside the main insights, which shows how these systems conceivably interact and impact residents of the city during an extreme heatwave.

Drawn from over 40 key informant interviews and desktop research, these narratives highlight what works well, and where strengths can be leveraged to build resilience to heat across contexts. Though the focus of this study and report is the heat risk and resilience system in Adelaide, Australia, the insights presented here are broadly applicable to diverse contexts, particularly urban contexts.

Box 3. Defining resilience

Resilience can mean different things and is used in many ways. In this report resilience is defined as *"the ability of a system, community, or society to pursue its social, ecological, and economic development and growth objectives, while managing its disaster risk over time in a mutually reinforcing way."*[17] This definition emphasises that the goal of disaster resilience is long-term well-being. However, as risk changes, maintaining that well-being may require the ability to take adaptive action and to make fundamental changes to systems to adapt. In Adelaide, the PERC research revealed that people avoided turning on their air conditioning to lower costs and that workers continued to work through extreme heat because workplace policies for high-heat conditions were unclear. Effectively building heat resilience will require adapting these systems too, that is, the regulations, policies, and cultural norms that currently deter people from taking effective action.

A story of heat in Adelaide

This is a fictional scenario based on the 2009 heatwave and Bureau of Meteorology (BoM) modelling. This scenario is neither predictive nor representative of a specific household.

1 The heatwave

It's mid-February and Adelaide is hit by an extreme seven-day heatwave. Temperatures soar above 40°C for six days. On the worst day, it reaches nearly 46°C, and overnight it only drops to 33°C—there's no relief, even at night.

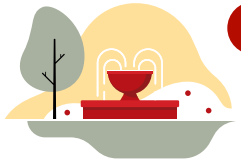
The BoM issues an Extreme Heatwave Warning. They're advising that these conditions are dangerous for anyone who doesn't take precautions to keep cool, and that infrastructure like power and transport could be affected.

The heat just keeps building, day after day, night after night.

A systems view of Adelaide heat resilience

The Adelaide PERC highlights eight core components of the Adelaide Heat Resilience system. These components are drawn from PERC interviews; they are not comprehensive, but provide insight across sectors and scales regarding current heat practices, needs, and gaps in Adelaide, and Australia more broadly. While these components are addressed separately for clarity, they are interlinked and form a systems perspective through which heat should be understood. Defining these components is also an entry point for working across silos—which interviewees noted was a challenge to overcome when addressing heat. Though Adelaide-focused, the same system components are relevant in urban environments globally.

1. **Housing and urban development**, including heat-informed urban planning, climate-resilient building codes, heat resilient housing and construction, and planning that addresses the Urban Heat Island effect.



2. **Urban greening and the natural environment**, including increasing the urban tree canopy, incorporating green space in existing and new development, using water for cooling, and diverse, heat resilient ecosystems.

3. **Heat health**, including heat aware healthcare, heat morbidity and mortality data, and mental health support.

4. **Safety of at-risk populations**, including identifying at-risk populations and reaching them via heatwave response planning and cool spaces activation.

5. **Heat at work and school**, including heat risk in workplaces and erosion of education due to heat.

6. **Heat warnings and disaster risk management**, including heat forecasting, impact-based alerts, tailored heat messaging, and compound heat and bushfire risk.

7. **Energy and critical infrastructure**, including continuity of electrical power, utility management for heat resilience, the transportation network, and infrastructure maintenance, repair, and replacement.

8. **Community awareness and cultural norms**, including heat risk awareness and Australian cultural norms that limit heat risk action.

2 The Adelaide family

Mum, Dad, Grandma and the two kids plus one on the way. They love Adelaide, especially going for bushwalks in the Hills.

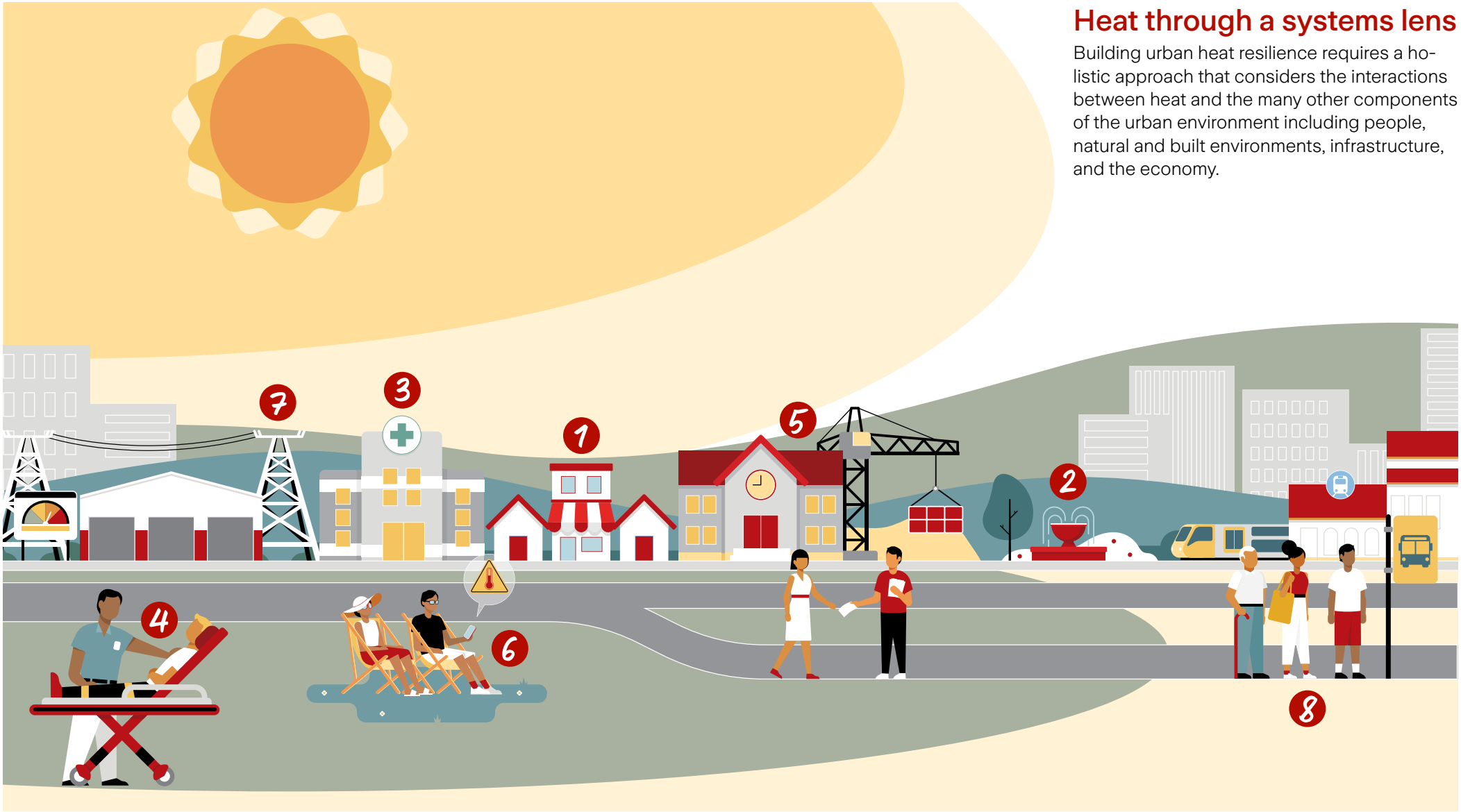
Mum and Dad have their hands full with the kids, juggling casual jobs, school, and the day-to-day. Mum works shifts at her friend's restaurant. Dad works in construction; he's currently studying English at the community centre so he can do a technical and further education (TAFE) course in site management. Grandma is turning the barren backyard into an incredible veggie garden, much to their landlord's delight.

The family doesn't have a car so they rely on public transport. They're managing and the kids have everything they need, but there's not much left over each week.

As newer residents to Adelaide, the family wasn't expecting a heatwave, but they've heard from neighbours that it has happened before, that things seem to be getting hotter, and that extreme heatwaves have become more common.

Heat through a systems lens

Building urban heat resilience requires a holistic approach that considers the interactions between heat and the many other components of the urban environment including people, natural and built environments, infrastructure, and the economy.



1. Housing and urban development
2. Urban greening and the natural environment
3. Heat health
4. Safety of at-risk populations
5. Heat at work and school
6. Heat warnings and disaster risk management
7. Energy and critical infrastructure
8. Community awareness and cultural norms

Housing and urban development

There are a range of housing conditions in Adelaide, from older suburbs with larger lots and older homes, to more densely developed areas, to new suburbs that extend out along the peri-urban regions, expanding the borders of the city. Each of these housing configurations has implications for contributing to, or undercutting, the heat resilience of its inhabitants. Denser neighbourhoods, for example, with more pavement, less airflow and less green space experience higher temperatures due to the urban heat island (UHI) effect.[18]

In South Australia, like in other Australian cities, a crisis in affordable housing is driving housing development that is not heat resilient. The majority of our interviews described new construction as dense, with structures built to minimum or below energy efficiency standards and with little or no green space. They described individual structures as not always well insulated, and perceived preferences for things like conventional black roofs being prioritised over more heat-resilient approaches. In addition, people noted that measures such as installing double-paned windows, an essential feature for insulating against both heat and extreme weather, are often overlooked. In existing neighbourhoods, they described infill as increasing density and reducing greenery and talked of homeowners with little appreciation for trees who remove them for aesthetic reasons or because they are assumed to be shading solar panels and reducing power production. Overall, they painted a picture of limited public awareness of how current development practices are increasing the local UHI effect. Amongst other solutions, interviewees recommended updating the current building code to incorporate contemporary climate projections and future scenarios. This would be a low-cost, proactive move with significant impacts on future heat exposure.

However, the local council members interviewed pointed out that currently, local governments have little planning and regulatory powers and therefore very limited capacity to proactively strengthen the robustness of the built environment. For example, building code is set up to require efficiency and insulation, but planning allows designs to be approved more based on looks than performance.

3 Their home

The family home is in a newer suburb that was built quickly to meet housing targets. The area is very dense with poor airflow, virtually no green space, minimal tree cover, and hard surfaces everywhere. The urban heat island effect means their area is about 4°C hotter than the forecasts.

Their home is built with materials that absorb heat, has poor insulation, and inadequate ventilation, things they can't modify as renters. The lack of shade means the house heats up quickly in the summer, and it doesn't cool down well at night.

With the onset of the heatwave, indoor temperatures quickly become oppressive. The family are concerned about safety so don't feel comfortable leaving the windows open at night to allow air flow. They're using the air con very sparingly because they're concerned about the cost.

Pregnant Mum starts to experience swelling and headaches. Grandma's heart condition really doesn't like this heat. The children become irritable and lethargic. There's nowhere within walking distance to escape the heat.

The family is experiencing the effects of planning decisions that were locked in years ago.

> At the council level, unless there's a strong reason why you must say 'no', you really have to say 'yes' to it—there's no legal basis to refuse fairly minor, but significant from a functional perspective, requirements.
>
> – Local government practitioner

These limitations will impose significant future costs on local governments who are responsible for delivering climate resilience and supporting the heat-safety of residents. One stakeholder noted that educational resources have been developed by agencies at different levels of government to provide guidance on material choices and dwelling orientation, including sustainable housing designs that can be downloaded and adapted. However, it is unclear to what extent these are being used.

An example that came up in multiple interviews was a decision by the state government to exempt some new housing from 7 star energy efficiency standards.[19] This was designed to reduce building costs for the developer in ways that can be passed on to buyers, but creating less efficient housing will also subject people that are already financially stretched to pay for housing with less thermal comfort and higher energy costs. One stakeholder described these types of developments as creating 'hot boxes' that will only be bought or rented by people that have no other affordable options.

Importantly though, building for long term climate resilience means more than just energy efficiency. Participants stressed that Adelaide needs housing and community design that is based on climate-sensitive building principles (see Box 4) and considers house size and access to public green spaces and public transport. Building homes today that do not prioritise heat robustness will exacerbate intergenerational inequality because future home owners and renters will be living in homes that are not well designed for hotter conditions, imposing economic costs and creating risks to their health, safety, well-being, and comfort. Retrofitting to adapt houses to hotter conditions later will be more costly and less effective than using climate-sensitive design principles today. It will also require a large workforce with the capacity and capability to deliver these retrofits in the future.

> Planning systems do not account for heat as a policy enough. We have new developments and infill developments coming on board that don't have to take how they are increasing heat island effects into account in any policy or design framework at all.
>
> – Local government practitioner

Box 4. Heat resilient building design

by Dr. Ehsan Sharifi, University of Adelaide

Smart climate-sensitive building design is one of the most powerful and cost-effective tools to tackle urban heat. Well-designed buildings can keep people safe and comfortable during heat-waves with little or no need for air-conditioning, which means they not only protect the people inside but also help keep our cities cool by reducing the waste heat that air-conditioners pump outside.[20] The good news is that many of these design strategies overlap with energy efficiency measures and don't necessarily cost more to build. Key features include double-glazed low emissivity windows, climate-smart building orientation, appropriate shading and cool materials that reflect rather than absorb heat with proper roof and wall insulation. When these techniques are integrated into new buildings and retrofitted into existing homes, they can create genuinely heat-resilient spaces that keep people healthy and comfortable whilst dramatically reducing our reliance on air-conditioning.[21]

There's a common belief that dark roofs are the problem and light roofs are the solution, but the reality is more interesting. How a building performs in heat depends on multiple factors working together: how much sunlight materials reflect, how well they release stored heat, and crucially, how well insulated the building is overall. Recent advances in paint technology also mean that even darker coloured roofs can now perform well in heat. The key message is that we have many effective options for designing heat-resilient buildings, from better insulation to smart material choices to improved shading. When done well, cool roofs can reduce indoor temperatures by up to several degrees and save substantial energy on cooling. The potential of good building design to make our cities more liveable and heat-resilient is substantial and achievable.

Urban greening and the natural environment

In Adelaide, PERC interviewees repeatedly expressed concern that there has been a loss of green space and shade trees on both private and public land, due to densification of housing, a preference for smaller trees and shrubs, and replacement of grass with artificial turf. As the climate continues to warm and become drier, many current tree species are not likely to be well-adapted to the changing conditions and are likely to become stressed due to heat, drought, and increased susceptibility to disease.

Limited green space and tree canopy, coupled with a dense built environment, lessens air flow and shading and leads to a high UHI effect. In these "heat islands", local temperatures can be elevated by 3°C to 4°C compared to surrounding areas.[22] It's not just about greening, however: it's also about affordable access to greenery. Because heat island areas tend to overlap with lower socio-economic conditions, residents in these areas may not have good options to protect themselves from extreme heat in their homes and communities, leading to a range of health impacts (see next section *Heat health*).

Increasing urban green space and tree canopy is a widely recognised way to address heat in cities. The power of this approach can be easily felt by walking from a sunny, asphalt parking lot which has been soaking up heat from the sun into a well treed park. The park will be dramatically cooler due to shading and evaporation of water from plants. Green Adelaide,[23] a state government urban environmental organisation, was launched in 2021 to increase tree canopy, cool the city, and boost biodiversity across Metropolitan Adelaide.

The latest iteration of this work, the Urban Greening Strategy 2025-2030, developed by Green Adelaide, sets out a roadmap that defines six priority areas for action, including a target of increasing canopy cover in the Metropolitan area from 17 percent to 30 percent. The strategy has spurred action like new rules in the building code that require planting of new trees (with size specifications) or paying an offset, and encouraging retention of trees for new buildings. However, PERC interviewees expressed concern that rules are not being enforced or monitored effectively such that trees are dying and not being replaced by developers, or are being removed by residents without consequence. They further noted that in new developments, infrastructure like power lines, footpaths, roads, and sewer lines are prioritised, with space for and positioning of trees left as an afterthought, further threatening tree health and limiting the shade value of the trees that are planted.

To help both facilitate growing the urban canopy and develop an understanding of heat distribution across the

Box 5. Using water to cool urban environments

by Greg Ingleton, Cool by Nature

Strategic water use offers a powerful, cost-effective approach to reducing temperatures in urban environments. Research in Adelaide has shown that parks and gardens with adequate irrigation can be significantly cooler than unirrigated areas, in some cases by more than 10°C, even when tree cover is similar.[29] The cooling effect depends on two processes: evaporation from moist soil and transpiration from plants, both requiring sufficient water in the soil. This means that vegetation alone, without adequate moisture, will not deliver cooling benefits beyond the shaded area below a tree. In Adelaide's climate, where little rain falls from September through April, irrigation is essential for maintaining the cooling capacity of urban green spaces. Different plant types provide varying cooling benefits: counterintuitively, exotic species that use more water generally cool more effectively than drought-adapted native species, because cooling capacity is directly linked to water use through transpiration. Whilst this challenges common assumptions about heat-resilient ecosystems in Australia, combining both native and exotic species can deliver multiple outcomes including cooling and biodiversity support.

When and where water is applied makes a crucial difference to both cooling effectiveness and water efficiency. Irrigating two to three days before forecast hot weather allows water to soak into the soil properly, so that plants are healthy and actively cooling when heat arrives. This

continued →

metropolitan area, Green Adelaide has mapped Urban Heat and Tree Canopy[24] across all council areas. The goal was to develop a regionally consistent, comparable, and scalable dataset that would provide a baseline against which to measure the impact of actions. The urban heat data clearly shows areas that are disproportionately hotter and cooler. The data also show that different surface materials impact temperatures; for example, artificial turf can be over 30°C hotter than natural turf, and parks and trees have a noticeable cooling effect.[25]

Critically, the Urban Heat and Tree Canopy mapping can be used to understand the interaction between heat, urban green spaces, and areas of social disadvantage. For example, the mapping in 2022 showed canopy coverage in Metropolitan Adelaide as a whole is currently at 16.7 percent, but this is not evenly distributed—the tree canopy in local government areas ranges from 8.1 percent to 39.8 percent.[26] The Green Adelaide strategy includes a priority area focused on improving greening equity; the mapping provides the evidence base needed to support the development of policies and actions to reduce existing inequities and track progress and success.

This work across the metropolitan area and individual councils to proactively address urban greening faces several key challenges. Interviewees pointed out that many Adelaide residents prefer smaller tree varieties over large native trees that drop branches and leaves. The tree canopy in Adelaide is already short; 69 percent of the existing canopy is 10 metres or less in height. Ideally, planting would prioritise larger trees to optimise shading. Another challenge is that heat- and water-stress are threatening existing trees. This is particularly concerning because the current Adelaide tree canopy has limited diversity where just 13 species make up 50 percent of all trees.[27] As changes in climate result in longer, hotter, drier summers, low tree diversity creates the risk that entire streets and suburbs could lose trees en masse.

Ideally, the Adelaide tree canopy will move toward a mix of species, including native and non-natives, selected to balance needs and thrive under a range of climate conditions. The Future Trees Project[28] is one effort that is supporting building the resilience of Adelaide's urban canopy to future changes through a three-phased approach of understanding what trees are vulnerable to climate change, trialling new species, and then ultimately planting trees that will thrive amongst changing conditions. More broadly, council park managers and urban foresters are raising the question of whether the tree species being planted now will be suitable in future heat and drought conditions, and are actively selecting different species that they expect will both be better adapted to future climate and support urban wildlife and biodiversity. A next step would be awareness campaigns to increase public awareness of, appreciation for, and active husbanding of trees, including an appreciation for the value of tree canopy in reducing indoor temperatures and cooling demand.

> "If you had really enticing parks that have good canopy that protect you in extreme heat you can still get outside and breathe the air rather than be locked up in the air conditioning, but in my opinion you need to have a water feature too because research shows it changes your perspective on that space.
>
> – Local government practitioner

contrasts with watering during peak heat, when most water evaporates before reaching plant roots. This forward-looking approach not only keeps gardens and parks healthier and cooler, but can reduce peak demands on water and electricity systems by around 30 percent, cutting costs for both utilities and households. Relatively inexpensive interventions like misting systems can cool outdoor spaces at far lower operating costs than air conditioning.

At the same time, however, water is becoming an increasing concern in Southern Australia with dry conditions and reduced rainfall. This has obvious impacts on water availability, farming, and vegetation maintenance, but it also impacts the urban greening efforts described here. Water scarcity has implications for the success of urban greening initiatives. Optimising irrigation across metropolitan areas could make significant volumes of water available for greening additional public spaces, whilst actually reducing total water consumption through better management, as can water sensitive urban design (WSUD) such as rain gardens and tree inlets. These approaches show that thoughtful use of water can simultaneously cool cities, lower energy use, and strengthen community resilience to heat in affordable ways.

Heat health

Exposure to extreme heat has well known detrimental impacts on human health and well-being. Health is directly threatened by heat stress, dehydration, and worsening air quality, while healthcare facilities themselves may face overburdened emergency rooms, or power outages. When people experience more heat than their bodies can handle, it can cause both rapid-onset and slow-onset impacts and can lead to heat exhaustion, illness, injury, and death. It is particularly critical that people understand the signs and symptoms of heat exhaustion and heat stroke, both of which can escalate quickly, with heat stroke being a life-threatening emergency requiring immediate intervention.

At the same time there is also a lot that remains unknown about the impacts of heat on human physiology and mental health, and on the impacts of chronic heat stress even at lower intensities, because data is lacking and difficult to collect. The medical system is the first line of response for presentations of heat health illness. However, beyond this there is a much broader set of issues that need to be integrated into public health and community services to build a more equitable, protective, and responsive system. Interviewees from health and social services organisations consulted for this study discussed various ways that the health and community services sectors need to adopt new, more holistic approaches as heat becomes more extreme. As one medical specialist pointed out:

> “It’s a paradigm shift of our time – thinking beyond the biology of diseases, and even beyond the social determinants that can sit around that. The bit that’s missing there is the environment – a variable that’s bigger than all of us.
>
> – Medical specialist and academic

Interviewees spoke, in different ways, about the lack of integration around health and environmental factors like heat and healthy environments. One practitioner raised the issue that heat, as well as other environmental factors, is generally not included as a variable in health research when looking at disease, including in clinical trials. But as heat and other climate hazards become more extreme, there needs to be a greater recognition of the many interconnections between natural and built environments and health.

4 Health and social services

On day four, Mum’s prenatal appointment at the hospital is cancelled because the hospital is overwhelmed with heat-related admissions.

The family has heard the council is operating cooling centres, but even if they were able to access them the centres close at 5pm—right when the heat is often at its peak —and no one in the family wants to go out in the heat to catch a bus to the nearest centre.

The Australian Red Cross’ TeleRedi welfare check system has been activated and households that are signed up are getting calls from volunteers checking on them and helping them stay safe, but the family isn’t registered.

The signs of heat stress in kids can be subtle and hard to spot. Grumpy kids, coupled with sleep deprivation for everyone and concern about Grandma’s medication mean the family is under increasing physical and psychological stress.

One way to achieve this is through expanded education and training of health professionals on climate hazards, including doctors. One medical practitioner in this study pointed out that within the health system, general practitioners (GPs) could serve a more effective role in prevention of heat illness if more targeted capacity building efforts were in place. They argued that GPs serve as a key entry point for health preparedness and require better training in linking environmental factors to their diagnoses, and communicating the specific risks about heat to their patients. For patients, getting information from GPs about how to manage health issues that are exacerbated by heat would avoid further straining emergency departments during heatwaves.

> Our communities are increasingly at risk from heat and other climate things... and yet our workforce is underprepared and under-educated and that has a detrimental effect on our communities, and we need to get it sorted.
>
> – Doctor

Many stakeholders also mentioned the mental toll of heatwaves due to sleep deprivation, fatigue, discomfort, and lack of exercise, making people irritable and predisposed to poor decision-making. Over the summer, when children and teenagers are on school holidays, staying indoors puts pressure on families, especially when houses are hot. People who live alone or have mobility constraints can become further isolated and vulnerable to heat related-illness if heat prevents them from leaving the house.

Community service stakeholders reported how heat impacts are amplified for people with clinical mental health conditions, drug dependence, and addiction recovery. Heat can make managing these conditions more difficult because it can interfere with the efficacy of medications and make it difficult and unsafe to leave the house to get medications or attend appointments. When people are already experiencing mental health challenges, the added stress of sleep deprivation, deteriorating physical health, and missed appointments compounds the impacts. Community and health sector workers, who may themselves be struggling due to heat, also come under added pressure in these conditions.

Currently, the scale of most heat impacts on health is largely unknown, because they are usually not reported and there is no systematic data collection to support analysis.[30] Individuals can suffer long term health consequences that result from cumulative exposure to excess heat over longer timeframes; when these impacts are not clearly linked to any particular heatwave or heat event, they become especially insidious and lead to an underestimation of the impact of heat on morbidity and mortality. Similarly, domestic violence has been documented to increase during warmer weather[31] but interviewees did not have data on domestic violence and heat for South Australia, or any resource capacity to collect such data. The overwhelming message from interviews within the health and community service sectors was a desire for improved data collection, sharing, and cross-sectoral integration between health and other domains such as crime and urban planning.

> **There are strict clinical guidelines for attributing death to heatwaves. What this means is the number of actual deaths is a gross undercounting, and this hides the true impact of heatwaves. It's this type of data that then has policy impacts across the board—government is making policy to manage the risk from a natural hazard that is undercounted.**
>
> – Doctor

Safety of at-risk populations

The issue of protection of the most vulnerable from the impacts of extreme heat is paramount, and the challenge crosses all sectors. Heat impacts are borne most heavily by those who are already disadvantaged and have the least capacity to take protective actions. When it comes to heat, however, interviewees noted that energy insecurity and social isolation are key risk factors. The increasing cost of energy and cost of living, inadequate cooling, or unwillingness to run cooling because of the cost, increase peoples' exposure to the impacts of heat. Those who are the least connected to other people and support services (whether due to being new to the community, elderly, inability to drive, language barriers, etc.) are some of the most at-risk.

Over the last few years there has been improved cross-sector collaboration on disaster preparation and response across community services, emergency management, health sector organisations, and SA Red Cross, which has led to the development of a new state framework (yet to be endorsed). The partnership is now working to engage and strengthen relationships with other sectors including local governments and essential services. For heat there has reportedly been an increase in awareness in the community sector around heat risk which has resulted in new policies around staff and client safety for delivering services during heatwaves. While stakeholders from this study pointed out that there is much work yet to be done on heat to support at-risk populations, there were also examples of programs run by state and local governments, NGOs, peak bodies,[32] and community organisations that are actively working to build awareness and improve heat resilience. Some key programs are outlined below.

The South Australia Government Code Red programme coordinates support for rough sleepers (i.e., people experiencing homelessness) during extreme heat. The programme can declare a Code Red which triggers an outreach effort, including the provision of water, sunscreen, hats, information and short-term accommodation when the nights are declared hot. Notifications are sent out from the department to NGOs who actively walk the streets; staff have good knowledge of the constituency they serve and are able to get information to them. There are two tiers, one for outreach only, and one for accommodation. The programme has a lot of discretion about when to declare a Code Red, and will reportedly take action when needed, prioritising the health and safety of people over all other criteria.

Box 6. Campbelltown cool spaces

The Cool Spaces in Campbelltown initiative is a flagship cooling project led by the Campbelltown City Council in the inner eastern suburbs of Adelaide. Campbelltown is the highest percentage culturally and linguistically diverse (CALD) community in South Australia and has a mixed socioeconomic profile. Cool Spaces supports two venues in the local government area, a library and a recreation centre, to remain open and air conditioned for extended hours during declared heatwaves. The spaces provide drinking water, amenities, and activities so that people of all ages can spend time there comfortably. Transport is provided to the Cool Spaces for people that are registered with the service. Centres were selected based on having accessible facilities, and staff received First Aid training, including how to identify heat-related health issues. To ensure energy reliability during potential outages the centres were upgraded with renewable energy, batteries, and a generator.

A key enabler for this initiative was grant funding from Australia's Disaster Ready Fund, which provided resources for community engagement both before and after the programme was set up. The development of the programme was informed by active community engagement to ensure the initiative was designed to meet community needs; ongoing engagement has increased awareness of the service so people of all ages and backgrounds know it is there and can receive alerts for when the cool spaces are activated. An interviewee highlighted that early preparation and engagement have been key success factors for the programme. Though the Cool Spaces in Campbelltown programme required external support for programme development, now that the model exists, it could be scaled up and adopted by other councils with significantly less effort.

Red Cross TeleRedi program me is a phone support service that checks in on vulnerable people, especially those who are isolated in heatwaves. Prior to the start of the heat season the Red Cross communicates with each person registered for the service to confirm their details and emergency plans. There are approximately 500 people in Adelaide currently registered for the service which is staffed by trained volunteers making calls. If escalation is required, the caller will notify the person's emergency contacts or an ambulance, depending on the severity. In addition to the direct safety benefits to vulnerable people, the programme has encouraged protective behaviour changes around community heat safety actions by neighbours, family, and friends of the registered person. According to the Red Cross, the integration between themselves, the SA Police, and the ambulance service is critical to the programme's success. In the future they hope to see continued integration with health services to ensure all people that could benefit from the service are connected to it.

Overall, there is evidence of a growing recognition about the impacts of heat on vulnerable populations, and who falls into these categories. However, the stakeholders working in these sectors report feeling like they are 'picking up the pieces' rather than targeting the underlying drivers of heat risk. While a lot of work is being done by many people in the response space, there is still much work to be done to reduce risks, as one stakeholder noted:

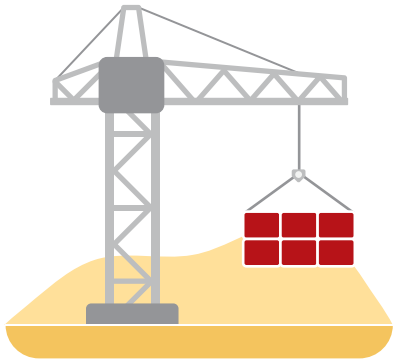
> "It's hard to be the stop gap, to help them be better prepared, when the things that are making them more vulnerable are only getting worse.
>
> – Community outreach practitioner

The underlying vulnerabilities are still there and current investment is not commensurate with the scale of the challenge. Interviewees encouraged complementing existing initiatives with increased targeting of the underlying drivers of heat vulnerability, such as affordable cooling and energy-efficient heat adapted homes and communities.

Box 7. Heatwave costs

In studying a whole system, often the 'gaps' are the most revealing parts—they are harder to identify but require the most attention. This is especially true for heat as an 'invisible hazard' that does not leave an obvious trail of destruction. In this study, interviewees referred to the economic impacts of heatwaves in relation to burdens on at-risk populations and individuals, but much less to the larger scale societal level (e.g., infrastructure damage, loss of ecosystem services) and the cascading impacts of heat damage and disruption.

The direct and indirect economic costs of heatwaves are poorly understood. Impacts are spread across systems, the impact data that is collected is incomplete, and many impacts are not recorded at all. Nonetheless, it is clear that impacts are growing and the economic consequences could be severe. Recent research on the economic costs of heat in Western Sydney concludes that "every time the mercury reaches 35°C, homes and businesses are burning money." Without mitigating actions the study authors estimate the costs of heat will quadruple by the 2070s.[33] Likewise, the Australian Climate Service warns that even in the least extreme climate scenarios, the costs of heatwaves will rise in coming decades, with escalating costs in the highest temperature scenarios.[34] However, making the case for action, and being clear about what action to take, requires a clear understanding of current and future heat impacts and costs. It is critical to close current heat impact data gaps by developing better data collection across sectors.



Heat at work and school

Work and school are places that many people are required to travel to, spend hours at each day, and be productive at. The ability to do this, however, can be compromised by extreme heat, during heatwaves, or when heat is chronic; indeed, the requirement to work can itself become a risk factor. Interviewees in Adelaide reported that working in hot conditions over consecutive days takes an enormous toll on workforces, pushing them to the limits of their ability to cope. The manager of an outdoor landscaping team at a local council explained the challenges his employees face during an extended period of heat:

> There is no way I could work for two weeks straight in 35°C, though I'm still supposed to be doing my work, still supposed to be doing my job. It's the cumulative effect. Slowly getting more and more dehydrated, potentially not sleeping that well. That is something that is tricky to manage because we also still need to get the work done.
>
> – Parks and gardens supervisor, local Adelaide council

Even a single day of extreme heat exposure can be dangerous. One interviewee described getting heat stroke as an apprentice without recognising it:

> It creeps up on you, you stop sweating and you stop being thirsty, so I thought I was fine.
>
> – Former apprentice

Interviewees explained that the heat rules for outdoor workers at their workplaces require extra breaks at 35°C and ceasing work at 37°C. However, prolonged periods of heat that are just below these thresholds still take an enormous toll on the employees. These situations do not lend themselves to easy solutions.

Yet solutions are needed. Outdoor workers who have less ability to avoid heat exposure, workers in the health and

5 School and work

Mum's shifts are cancelled when the restaurant business slows—the patio is too hot for dining and indoor seating is limited. Lost income, combined with a spike in the energy bills, has Mum and Dad nervous; the bank account is getting very low.

The kids aren't sleeping well and fuss about having to go to school. Mum sends them anyway, but they fail their quizzes that day—they complain they were just too hot to think. They drive everyone crazy at home because of pent up energy; they weren't able to play outside during recess.

Dad's construction site has no clear heat policy or temperature threshold for stopping work. He's working in direct sun, on hot surfaces, wearing protective equipment that traps heat.

The culture in Australia and Adelaide in particular—a place with a long history of heat—says you 'push through' and 'don't complain'. Dad keeps working despite dizziness and nausea (heat exhaustion symptoms), and has a near-miss accident due to impaired concentration.

Eventually, he develops potentially life-threatening heat stroke, requiring an emergency hospital visit and forcing him to take a couple days off work.

social services sector who provide services such as care work, cleaning, and food delivery, frontline and emergency responders, and gig workers in low paid, casual roles are all disproportionately at risk, and heat challenges are likely to grow over the coming decades. If people are unable to travel or work in the heat, there will be ripple effects across entire sectors and the economy as a whole. This, in turn, will impact people who rely on these services.[35]

Female workers often carry an additional burden from being disproportionately engaged in unpaid household and care work in addition to work outside the home. These combined responsibilities, along with women's over-representation in lower-paid, part-time, and insecure forms of work, reduce their financial flexibility and access to paid leave. Pregnant women are more vulnerable because heat puts additional demands on a body that is already working hard and is less able to regulate temperature, and excess heat exposure can contribute to pregnancy complications including low birth weight and premature birth.

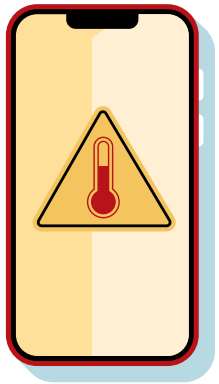
Heat challenges are not limited to adults at work. South Australia does not have a policy to protect schoolchildren from the impacts of heat beyond a potential for early dismissal at temperatures of 36°C and above or when heatwave warnings are issued.[36] Teachers interviewed for this study reported that schools are putting in place many strategies to keep children safe from heat; nonetheless, they are seeing increased absences on hot days and students who attend are fatigued from poor sleep, irritable, and less able to learn. Many schools in Adelaide suspend outdoor play once temperatures reach 36°C or 38°C, which prevents heat exposure but has the unavoidable impact of limiting children's opportunities for movement and social interaction. Older school infrastructure, particularly in less affluent areas, compounds the problem. As one educator noted:

> "Even with schools being air conditioned, the cooling isn't going to sustain a room of 20 or 30 plus kids.
>
> – Educator

Teachers and staff feel the strain too—especially with an aging workforce, limited funding for retrofitting, and classrooms that are not designed to stay cool. There are physical and mental tolls of trying to manage behaviour and keep children safe and engaged in their learning, even as teachers themselves are dealing with oppressive heat. A principal reported that school events have been disrupted; graduations and formals have become so hot that students have fainted, and end-of-year exams are often held under oppressively hot conditions. Nonetheless, in our discussions with educators the disruption of education due to extreme heat was still being perceived as uncomfortable for a few weeks, rather than a growing challenge that might require rethinking school day timing, school year timing, or other significant shifts to ensure educational continuity.

Especially over the long term, chronic heat at work and school puts individual incomes and learning outcomes at risk and threatens all of society. In aggregate, even just a few days of work and school missed because of a heatwave has implications that add up to millions of hours and dollars lost. Over time, the risks to economic productivity and educational attainment are even more stark. In addition to new strategies for heat and work, new strategies for heat and education will increasingly be needed to avoid long-term erosive impacts.

> **"The problem with regulations is... people always want an absolute number and there isn't an absolute number and people just have to recognise that the hotter it is the worse it is, but that some people are vulnerable in the high 20s [°C]... to address this, it's going to take a big cultural shift for people to accept it.**
>
> – Doctor



Heat warnings and disaster risk management

Effective warning for heat requires strong forecasting and warning capabilities coupled with impact-based alerts that result in people taking proactive and protective action.

In Australia, the Bureau of Meteorology (BoM) is responsible for calculating and issuing heatwave warnings, which they base off of an 'excess heat factor index.[37] [38] [39] Excess heat factor is location specific, and compares a running three-day average of maximum and minimum temperatures with both recent conditions (an 'acclimatisation index' based on the average temperature for the previous 30-day period) and historical norms (the 95th percentile temperature for all days in a thirty year climate period). When BoM heatwave warnings are released, states and territory authorities are responsible for further dissemination of local heatwave warnings to impacted regions and populations. For South Australia, the control agency for extreme weather emergencies is the South Australian State Emergency Service (SASES), which has an automated process with the BoM where warnings go out automatically as thresholds are reached.

While the BoM issues heat warnings, it is not in their remit to tell people what to do with those warnings. Instead, they liaise with other more local service providers who provide impact warnings. Given how heat manifests differently in different locations, these types of localised action messages are critical for heat awareness and taking protective action.

All agencies use the same Australian warning standards; however, because potential heat impacts vary depending on exposure, vulnerability, and capacities, different populations need different warnings. South Australia uses a three-tier system for heatwave warnings (see Box 8). The name of each tier clearly indicates the level of caution *(Advice, Watch and Act,* and *Emergency Warning)* that is generally warranted, but each tier also indicates specific vulnerable groups that may need to pay greater attention to the heat and take added precautions.

Equally important to the warnings themselves is the content of these messages, the language they are provided in, and how they are disseminated. PERC interviewees noted that language barriers, being new to the community, or social isolation often resulted in heat warnings not reaching everyone. Further, interviewees highlighted that often, media reporting of heat does not accurately communicate the risk. Sharing heat warnings alongside images of people enjoying themselves at the beach, for example, creates a dissonance between images of heat and the

Box 8. Australian heatwave warnings[42]

Advice: An incident has started. There is no immediate danger. Stay up to date in case the situation changes.

Watch and Act: There is a heightened level of threat. Conditions are changing and you need to start taking action now to protect you and your family.

Emergency Warning: An Emergency Warning is the highest level of warning. You may be in danger and need to take action immediately. Any delay now puts your life at risk.

impacts authorities warn about and contributes to people receiving but not acting on warnings.

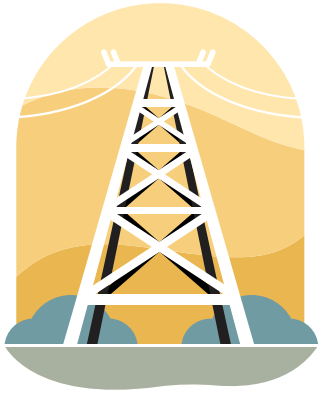
A comprehensive understanding of both short- and long-term heat impacts is also lacking. One of the messages interviewees said is particularly missing is that the effects of heat can be cumulative and impacts often continue to occur for days after the "end" of a heat event. While the emergency management sector recognises this, many communities do not.

Adelaide is a confluence between extreme heat and bushfire risk, which can further complicate messaging and the weight people give to different hazard events. Recent bushfires and floods, for example, might overshadow consideration (and resources) for heatwave preparedness. In addition, while different agencies are responsible for messaging for bushfire (Country Fire Service) and heat (State Emergency Service) and use the same warning system standards, the public does not always fully understand how the two are interrelated. Part of the challenge with messaging stems from the fact that responsible agencies want to be careful about not overloading the public with messages, and so they coordinate to prioritise the messages they feel are most critical. This can result in, for example, messages being pushed out about bushfire risk, which also imply heat risk, but the heat threat is not explicitly stated.

The challenge of extreme heat has changed over the past several decades and heat warnings have evolved to meet this challenge. Advances have been made to incorporate high nighttime temperatures and to account for acclimatisation and average minimum and maximum temperatures through the development of an 'excess heat factor' (EHF) index,[40] [41] which is location-specific, and which the BoM now uses in forecasting and warning for heatwaves. Coordination between the BoM and state agencies responsible for impact-based warnings and collaboration across emergency response agencies has also adapted to meet the growing challenge of heat.

While these improvements in forecasting and warnings for heatwaves over the past two decades have helped to support accurate messaging, how these messages are received and what people do with them requires sustained attention. Continuing to push out consistent and clear messaging to the public and reinforcing cross-sector coordination not just for heat response but also for preparedness and planning are areas of opportunity for leveraging existing strengths to build heat resilience.

> **"I would like to see people have a better understanding of heatwave warnings and messages and services, and ongoing development of heatwave services, working together with health and emergency services. The climate is changing, how does that impact our current level of service? Do we need to look at the service? Do we need to make changes to the thresholds? We need to make sure the system is robust moving into a warmer climate.**
>
> – Government agency representative



Energy and critical infrastructure

Extreme heat places widespread stress on critical infrastructure that communities depend on. Water systems face dropping water pressure due to increased demand, increased evaporation, overheating of pumps and treatment plants, and warmer supplies that reduce cooling and drinking quality. Transportation infrastructure buckles as roads soften, rails warp, vehicles and aircraft require more energy to operate, and waterways shrink from evaporation. Power outages can also contribute to communication (TV, internet, phone, etc.) failures cutting off access to important or emergency messaging (i.e., bushfire, school closure, heatwave escalation) and increasing isolation.

When thinking about extreme heat and critical infrastructure, however, the most critical single system is power because the power system underpins the functioning of other key systems. When power fails, it causes cascading impacts to different facets of daily life and systems. For example, it can cause:

- **Household impacts.** People who don't think about the heat because they have air conditioning can find themselves suddenly more exposed to heat when they lose power and are unable to cool themselves. They may also face the loss of refrigerated or frozen food, which can pose a significant economic burden for many families.
- **Economic impacts.** Even short-term blackouts can be highly impactful for small businesses like restaurants if they are hit during peak service periods.
- **Functional impacts.** If the blackout extends beyond a few hours, there is a risk that even backup power generation will fail due to lack of fuel which can cause a loss of communications, disrupt transportation (particularly electric powered cars and buses) and water supply and/or water treatment, reduce sales at retail outlets, and compromise the provision of health if hospitals and medical clinics are unable to operate.

> "What happens in South Australia when there's a heatwave sometimes? We get a black out."
>
> – Government agency representative

6 Energy, water, and transport

On day five of the heatwave, the electricity grid fails. Peak demand strains the aging system, equipment overheats, and ironically safe work policies prevent repairs during the hottest hours. A widespread blackout hits just when the family had decided enough was enough and they needed to put on the air con.

Food spoils—right after the family had done a really big shop that would last them two weeks.

Phones can't be charged, cutting off communication and access to emergency information.

Grandma's refrigerated diabetes medication is at risk—insulin degrades if not kept cool.

Public transport is cancelled due to track buckling and overheating equipment. Without it, parents can't take the children to cool areas such as the shopping centre.

Water pressure drops due to increased demand across the city.

The family is starting to feel isolated and stressed.

Maintaining the power system during heatwaves is critical. Yet, at the same time, maintaining power during extreme heat events becomes increasingly difficult due to:

- Power usage spikes;
- Reduced output efficiency of solar panels;
- Transformer failures, which put additional load on the sections of the grid that are still operational; and
- Limited ability of line-workers to service the grid as they face extreme heat conditions and need additional cooling and recovery time to stay safe.

Compound risks of bushfire and drought also impact the power system during heatwaves. For example, when power networks' bushfire safety protocols require power cuts because of high bushfire risk, or when power infrastructure becomes more prone to outages from droughts.

SA Power Networks (SA Power) invests heavily in continuity planning for heat. This includes policies for outdoor work on transmission infrastructure and mandatory stop-work policies for non-essential work when temperatures exceed critical thresholds, so that households and businesses aren't intentionally de-powered during extreme heat events. SA Power also prioritises maintaining power for essential services, with redundancies in place to power hospitals and other critical infrastructure. This also includes developing and rolling out time-based plans and infrastructure for electricity use. New smart meters, for example, have time of use pricing (older meters, in comparison, had the same price all day); 10am to 3pm is when power is least expensive because there is so much solar power available in Adelaide. However, not everyone knows about, or has, a smart meter.

A functioning and robust energy infrastructure system is critical for ensuring the functionality of other critical systems. However, it is not the only critical system impacted. Physical infrastructure such as buildings, roads, rail lines, and bridges are also subject to direct impacts from heat. Roads and rail lines have already been observed buckling in extreme heat, bridges can deform in ways that increase stress, accelerate aging, and compromise safety, buildings can expand and contract, resulting in crack and fractures, and increased cooling demand strains heating, ventilation, and air conditioning (HVAC) systems. These impacts will increase maintenance and repair and replacement costs for the public sector, private sector, and individual property owners.

One effort undertaken by the Resilient South Regional Climate Partnership to strengthen the robustness of public infrastructure to extreme events is the Resilient Asset Management Project (RAMP)[43] (see Box 9). The project aims to integrate planning for climate risk into how councils manage local assets. This includes both thinking about physical infrastructure and climate risk, as well as council financial practices.

Box 9. Resilient Asset Management Project

The Resilient South Regional Climate Partnership consists of four councils in Southern Adelaide and the South Australian government who are focused on building climate resilience for their communities, including critical infrastructure assets. Councils own the infrastructure their communities rely on, yet they are limited in how they can raise funds to maintain and upgrade it. As increasing climate stresses reduce the longevity of roads, buildings, bridges, coastal infrastructure, etc., councils face a greater financial burden and growing heat exposure. The Resilient Asset Management Project (RAMP) is one effort undertaken by this partnership where councils can invest in improving existing infrastructure to be climate ready. Rather than replacing like for like, when upgrades are needed, the project invests in renewals that build climate resilience.

This effort aligns with growing public support for climate action and evidence of DRR efficiency: for every 1 dollar invested in DRR, 15 dollars are saved in response and recovery. The RAMP pilot, which began in September 2022, aimed to assess and identify different options for climate adaptation, including developing a risk register that overlaid climate hazards with the location of different types of infrastructure and looked at both physical risks as well as transitional ones such as laws, markets, and stakeholders. Some of the heat impacts identified included loss of power (and its impacts to stormwater system water pumps), damage to bridges, and health-related challenges. The pilot demonstrated that multi-sectoral and regional collaboration is a key aspect of integrating climate resilience into infrastructure management as it helps to create a shared understanding and approach to addressing climate related challenges. It also resulted in the development of a Regional Asset Resilience Plan for Southern Adelaide, which provides a roadmap for building the climate resilience of built assets, and which the Resilient South councils are now working to implement.

Community awareness and cultural norms

Many stakeholders reported that a key driver of heat-related risk in Adelaide is a lack of awareness about the dangers of heat exposure and an underestimation of the severity of heat-related illness. When interviewees were asked to describe their experience of heat during the summer of 2024-25, many struggled to recall the specific impacts. Perceptions varied as to whether the summer had been hotter or cooler than previous years, as can be seen in the quotations below, complicating the path to creating a collective understanding of heat as a hazard:

> Everyone thought it was such a hot summer, they were surprised that there was actually only one severe heatwave.
>
> – Government agency representative

> What's going well is that we've had really favourable weather over the last few years, so we haven't seen the kind of impacts we might be worried about, so that's good news. The worry is that that increases complacency, and we don't see enough attention being put on the challenges that we are likely to have.
>
> – Local government sector practitioner

Interviewees also pointed to a collective tendency to quickly forget heat events because they are so invisible—especially when the last few summers seemed comparatively less hot and other disasters like bushfires have taken centre stage. Several interviewees expressed concern that it would take a mass casualty heat event to trigger coordinated action.

Many people do not view extreme heat as an issue in part due to cultural norms; heat is framed as something that is meant to be dealt with by "toughing it out" or enjoyed, for example with a day at the beach. The idea that people in Adelaide have always dealt with heat and so don't need to change is prevalent; this is reportedly driven in part

7 Community support

Fortunately, the family has strong connections with their local community. Neighbours check on each other during heatwaves, and Mum is in a local WhatsApp group where information is shared about a cool space just a few blocks from their house.

At the cool space there are publicly accessible computers, so the kids can get homework done. Mum connects with other local families and elderly neighbours, building more social connections that will be useful for the next heatwave. They also share ideas about how they are trying to keep safe at home.

Staff let Mum know about a free bus service she can sign up for to take them to the cool centre next time. Later in the evening, the family is invited to a friend's house with air conditioning for a meal and extra relief.

by a lack of awareness of the reality and growing severity of climate change driven increases in heat. This lack of awareness, due to cultural norms and to an underestimation of the risk, leads to unsafe behaviours such as people going to the beach on days of extreme heat where there is no shade; swimming in unsafe locations; combining excess alcohol and heat, which exacerbates dehydration and vulnerability to heat health impacts; and participating in outdoor sports that combine high heat exposure and physical activity.

A study on heat adaptive behaviours in Adelaide[44] found that social and cultural norms are strong indicators of people's decision-making. For example, it found that older generations who grew up at times with greater frugality are less likely to use air conditioning or move to cooler rooms in their homes; families with two or more children were less likely to check weather forecasts or plan for the day ahead; and those with tertiary qualifications (formal education beyond high school) utilised cooler areas at home and were more likely to stay longer at work to make use of air conditioning. This indicates that there is an opportunity for well targeted awareness campaigns to influence behaviour based on understanding what motivates and constrains the actions of different sub-groups in the population.

Stakeholders highlighted that there are resources on heat safety available on websites (e.g., SES, Bureau of Meteorology) and that local governments and community organisations work at the grassroots level to raise awareness. However, influencing behaviour change, and in particular influencing deeply held cultural identification around surviving and thriving in an incredibly harsh and demanding environment, is not easy. PERC interviewees noted that behaviour change would require a coordinated, ongoing campaign focusing on key heat-risk and behaviour change messages, with a significant element of the campaign in person through trusted sources. It would also need to be rolled out over a long period of time via a coordinated, multi-stakeholder collaboration including but not limited to the government. The media also needs to be involved in such a campaign so that it plays a role in accurately representing heat risks rather than using images that convey being out in the heat and having fun.

Currently, however, there is little traction for such a campaign, in part because of the cycle between lack of heat impact data and lack of prioritisation of heat compared to other hazards. As one PERC interviewee noted:

> "How do you get through to people with a hazard that kills the most people but is invisible, that has stats that are very hard to come by?"
>
> – Government agency representative

Interviewees suggested that Adelaide could turn the sense of cultural identity with heat into an opportunity by using a people-centred 'hearts, minds, and values' approach to drive behaviour change and raise awareness; heat resilience could also be framed around improving comfort and well being rather than on building 'climate resilience'. Approaches like this would utilise the same types of motivation used to promote ideas like making communities more friendly for cycling.

> **"I don't think the narrative has ever been severe enough. I only heard about heatwaves being the biggest killer when I started working at [current organisation] and I started talking to my emergency management counterparts and colleagues. I don't think that understanding is in the community that it actually is a killer. Last summer I still had people at my local dog park say, 'I can't afford electricity so I'm not putting my air conditioner on'. There's just not an understanding about how dangerous heatwaves are because I don't think the education has been there and it's not cutting through.**
>
> – Government agency representative

Leveraging learning for future action

This PERC found that while heat is not often viewed as a hazard, there is a growing awareness about the impacts of heat in Adelaide, particularly around direct impacts on health, and a growing recognition about which sub-groups are particularly at-risk. There have been developments in planning and strategic approaches targeting heat protection at state and local government levels, and across the NGO and community sectors. However, while there are individuals and organisations that are addressing heat, it is still largely siloed across different agencies and sectors, and a more collaborative system is yet to develop.

Key insights

Some of the key insights highlighted by PERC interviewees regarding both the challenges and opportunities posed by heat include:

- Heat is currently understood as an individual problem. Systems-wide impacts, including the potential for reduced economic productivity across a community or society, are not yet mainstream concerns. This has resulted in a lack of society-wide action on heat, and people are left to make their own decisions on whether and how to respond. Too often those decisions are swayed by societal expectations of 'toughing it out' or by financial constraints.
- Both individuals and organisations working with communities have limited understanding of heat. This means planning and response decisions are not being made with adequate information.
- People working in heat resilience feel that they are dealing with symptoms while the drivers of heat risk are not being addressed. To reduce heat exposure and enable heat adaptation, existing short-term, response-focused approaches to heat, such as opening cooling shelters and issuing heat warnings, need to be complemented with long-term strategic thinking and action on heat, driven by improved data on heat impacts from across systems and sectors.
- Ongoing, dedicated programs of awareness building about heat risks and safety measures, tailored to the needs of different groups in the community, particularly the most at-risk groups, are urgently needed.
- Decisions made today risk 'locking in' greater heat risk for future generations through the ways cities and communities are planned and developed.

8 A bright future

Ten years later things have changed significantly.

The city has added trees and several green spaces to the neighbourhood, so the family's home stays naturally cool well into the afternoon. The house was retrofitted several years ago with insulation and a reflective roof; they now run the air con only at night so they can sleep.

The family now receives heat warnings in multiple languages with advance warning so they know what to expect.

The restaurants Mum has worked in gradually adopted better cooling and ventilation systems in the kitchens, and backup power sources for refrigeration and cooling in the case of extreme heat emergencies. Dad feels comfortable taking a break at work when it's hot as he is now working in accordance with industry and collective agreement conditions and can access insurance on days that work is cancelled due to heat threshold regulations.

Transportation infrastructure is able to better withstand high heat; heat related disruptions almost never occur anymore.

continued →

Considerations for future action

Given the potential catastrophic impacts to systems and human well-being from future extreme heat events—which, without proactive risk reduction, raise questions about long-term habitability and survivability[45]—action is needed now to prepare Adelaide for future heatwaves and to reduce the risk of cascading economic and social impacts. There are good examples of heat adaptation activities occurring in the response space, such as systems to check on people during heatwaves and targeted heat warning advisories. However, these activities remain reactive; they now need to be complemented with more direct action focused on risk reduction and addressing underlying vulnerability.

None of the five considerations for actions outlined below alone solves the problem—however, together, they can strengthen system-wide resilience that gives communities genuine capacity to cope safely. This is achievable, and it's already beginning.

- **Collaborate cross-sectorally to address the society-wide impacts of heat.** This includes bringing together disparate actors to work jointly to address heat risk. For example, regulatory, public health, labour, and meteorological agencies should work jointly to forecast, monitor, and respond to heat risk for workers.[46] Along the same lines, it is also critical to ensure that heat resilience is embedded into planning across many sectors to ensure that decisions are not being made that create future risk, including the design of homes and communities. Enabling coordination, through, for example, identifying and delegating inter-sector/departmental liaisons, will help to de-silo heat resilience efforts.

> “I think one of the biggest problems we have is siloed thinking, even within government departments. Why isn't energy talking to health when the energy policy has such a big impact on health outcomes?”
>
> – Doctor

- **Invest in heat resilience to address future risk.** This includes increased investment in strengthening critical systems such as health, power, and transportation to heat, supporting the development and enforcement of workplace heat protections, strengthening forecasting capabilities and heat warnings through linking projected weather more firmly to foreseen impacts, urban greening efforts, and supporting green development. Funding is also needed to support new initiatives that address heat impacts. Pilot funding for the Campbelltown Cool Spaces programme discussed in the section *Safety of at-risk populations*, for example, was critical to developing and piloting a successful model.
- **Update messaging to reflect the reality of intensifying heat impacts.** This involves reframing heat as a hazard and developing communication strategies that leverage South Australia's pride around heat even as

Better yet, transportation is free on high heat days, so the family is able to easily access cooling centres. The cooling centres themselves are now open for extended hours; the family often spend evenings there playing games with other families and have expanded their circle of friends.

The family hasn't experienced a blackout in several years because investments were made in building the robustness of the power grid. Energy concession schemes have been expanded for at-risk households.

Emergency departments are not often overwhelmed by visits due to heat anymore because people are more aware of heat risks and taking steps to keep themselves safe is now the norm. Having better adapted homes and workplaces means less ambulance call outs. But just in case, emergency rooms are well prepared and they have developed surge capacity plans. Welfare check programmes like TeleRedi have been scaled up across the state.

heat impact information is shared, so that South Australia becomes a leader in heat safety. This could include declaring major heatwaves as disasters to recognise and fund response and resilient recovery efforts. Additionally, actionable information needs to be more readily available to people in positions of decision making at every level. Building better heat awareness and action and shifting how people view heat requires a dedicated, cross-sectoral approach, including considering novel ways to turn the cultural identification with heat into an opportunity for change rather than a barrier.

- **Collect data on heat impacts so that heat is taken more seriously.** Having data and evidence on heat impacts is the first step to identifying needed action, developing new initiatives, and making the case for funding. Data on heat impacts will also be critical for public campaigns to change heat risk perceptions. Cross-sectoral collaboration for data collection and sharing can ensure the right data is collected and all data is put to multiple uses.

> “If we had the right data, reflecting the reality on the ground, it would rocket up the ladder in terms of importance. If we had the data it would then flow into policies at all levels.
>
> – Government agency representative

- **Act now.** Heat action should be expanded to include both response and long-term risk reduction efforts. Aligning proactive efforts to address heat with current priorities and acting today can help to avoid needless suffering and recovery costs that exceed the cost of prevention. This means, for example, reviewing building codes, zoning, and regulation to move from building in new heat exposure to supporting heat adaptation. Along the same lines, leveraging the reconstruction phase after other disasters to build more resiliently for heat and other hazards can help to reduce risk to future events. Capturing learning from heat disasters and integrating that learning into updated heat action plans and sharing those cross-sectorally and vertically (within departments and across administrative boundaries—city, state, national) will be critical to both short and long-term heat risk reduction efforts.

> “**Strategic vulnerability reduction is not necessarily hard, but requires long-term thinking beyond election cycles, permission, and capacity to accelerate positive impacts, social capital and political will, funding, and courage. Turning data into narratives, and narratives into action, and action into long-term planning and physical interventions is what is required.**
>
> – Local government practitioner

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This report presents a snapshot of heat events and responses in Adelaide, South Australia. It is not comprehensive—much more could be said on the degree of resilience of South Australia during heat events. What this report does provide is a collection of short, field-tested examples of resilient systems and actions and a discussion of what it is that makes those resilient. It also describes factors that limited the ability of people and systems to respond effectively, and highlights what we can learn from this to increase our resilience moving forward.

For a downloadable PDF of this report, please visit: https://www.redcross.org.au/stories/2026/heatwave-research/

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