Urban cooling – a collective 'must do' in heating cities

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The energy consumption of buildings is the single-largest source of greenhouse gas emissions globally.

Data from the federal government shows that buildings in Australia are responsible for nearly 20 per cent of all direct carbon emissions. Up to half of these emissions are produced through energy use for heating, cooling and ventilation.

Designers, builders and managers of buildings can access a range of programs, guidelines, rating tools and calculators to improve the energy performance of new and existing buildings. Fuelling Australia's love affair with acronyms, we have the NEPP that guides us to net zero, the ABCB that writes the NCC, and NABERS, NatHERS and the GBCA that rate the energy and sustainability performance of our buildings.

A plethora of information is available on the internet that describes how technical, engineered solutions – for example, the shift to LED lighting, more efficient HVAC systems, better glazing and insulation – will decarbonise building performance. This information is important and must be embraced by those that design, build and manage individual buildings. Yet, it misses a crucial point: each building is far more than the physical structure and its functions. It is part of a neighbourhood, embedded in a community and ultimately forming our towns and cities, and it is in this wider context where solutions related to energy consumption and carbon emissions must be addressed better.

In mainland Australia, the cooling energy penalty is far greater than that for heating. Our summers are blistering hot, climate change amplifies summer heat, and towns and cities are exposed to heat island effects. Urban overheating is a contemporary and hazardous phenomenon. Research has shown that extreme heat is a 'silent killer', claiming more lives in Australia every year than all other natural disasters combined.

In this situation, it becomes imperative that each building and the space it occupies provides the best possible cooling outcomes, or, put the other way around, the least additional warming. Regardless of emission pathways, all current climate models predict warming temperatures for decades to come. This will require more, not less, energy for cooling indoor spaces. Consequently, energy needs for indoor cooling in Australia are expected to double between today and 2050.

So, what can be done? A first step is reducing electricity needs to safely operate the inside of buildings. Besides upgrades of technology and optimisation of indoor uses, this also includes reducing thermal load on outdoor HVAC units – misting systems can cool the temperature of air taken in, while shading the units improves effectivity of the equipment. Next is addressing the energy exchange of the building envelope with the environment; and equally important

is to implement measures that will reduce warming around the building. All three issues should be addressed simultaneously. Although individual actions will differ in cost, complexity and effectiveness to generate coolth, the largest impact will be made when combining indoor, building envelope and outdoor actions into a holistic cooling concept for the built environment.

The energy exchange of a building with the environment depends on surface materials, specifically their colour, albedo (reflectivity) and thermal mass. Building orientation and the area exposed to direct solar radiation is also important. Moreover, the energy exchange happens in a three-dimensional space and under different environmental conditions following diel and seasonal cycles. A comprehensive solar radiation analysis is a good starting point when developing a cooling concept.

High-quality shade from trees or engineered structures will lower the temperature of sunlit surfaces close to ambient air temperature. Shade will also limit indoor warming; however, a new generation of super-cool materials will outperform the cooling potential of shade. Tests with coloured photonic and fluorescent coating materials have shown to reduce surface temperatures 15 degrees Celsius below ambient air temperature, leading to a marked reduction of cooling energy needs. While these new materials are in development, cool-roof materials are already available on the Australian market.

A report for the NSW Government has shown that installing reflective cool roofs across all buildings in Sydney can halve the city's cooling energy needs. Another study, recently published in international journal *Nature Cities*, demonstrates the enormous impact of non-electrical cooling strategies. Here, the authors calculated the combined implementation of cool roofs and well-irrigated urban green infrastructure (UGI) on the ground. Their results show that cooling energy use across an entire hot-climate city dropped by 35 per cent.

Focusing on UGI, the use of plants on roofs and facades not only blocks solar radiation from heating the building envelope, but evapotranspiration will also lower the air temperature around the building by up to three degrees Celsius; however, changes to existing structures may be limited due to statics or other physical or legal restrictions.

Many options exist to reduce air and surface temperatures at ground or podium level. Depaving – the process of changing an impervious surface to a pervious one – is the simplest approach to reduce surface temperatures. Typically, an area that is depaved is turned into a green space, adding cooling and other benefits to a place. In fact, addition of any UGI, ideally in the form of long-living trees that form wide and dense crows at maturity, will effectively lower surface temperature by up to 40 degrees Celsius and cool ambient air by two degrees Celsius.

Together with experts from the horticulture, landscape design, planning and built environment sectors, we worked with Standards Australia to produce a planning and decision-making framework for UGI (HB 214:2023). Written specifically for industry professionals across Australia, the framework provides systematic guidance on how to incorporate UGI into new and existing buildings. Plans are now underway to develop nationally accepted UGI performance specifications for asset/facilities managers. Led by the Australasian Green Infrastructure Network, this work brings together key industry bodies (ALIA, AA, PLA, AIH) that collectively represent more than 30,000 UGI professionals.

Even better than UGI is BUGI, where 'B' stands for 'blue', meaning water is involved. Collecting and storing rainwater from roofs, vertical and ground surfaces for irrigation of UGI generates maximal cooling benefits. Wastewater recycled onsite can be used for the same purpose and will further increase sustainable building operations. Bundled under the term 'water-sensitive urban design' is a growing number of solutions that demonstrate how BUGI can be used successfully around buildings to deliver cooling benefits.

Non-electrical options for cooling of buildings and their surrounding spaces must be embraced now. Greater Western Sydney is Australia's third-largest economy and is home to more than 2.5 million people. According to a report from the Committee for Sydney, the impact from extreme heat costs the region $1.5 billion today, and is projected to cost $6 billion by 2050. People die from heat, and this number is expected to rise across both Australia and the globe. Management of the built environment for cooling will be key to limit the enormous human cost that results from urban overheating, and lack of actions to mitigate and adapt to increasing heat.

Direct benefits (e.g., lower costs for electricity and building maintenance, greater resilience of infrastructure during heat events, demonstrated corporate and social responsibility, and improved microclimate) and indirect benefits (e.g., improved public health, recreation opportunity, support of biodiversity and provision of habitat) are the motivators for those that start the journey towards effective urban cooling. Achieving urban cooling will be a collective effort with intergenerational benefits.