LOCAL GOVERNMENT NSW

Evidence based interventions for urban cooling

COUNCIL NAME
Blacktown City Council

WEB ADDRESS
blacktown.nsw.gov.au

SIZE
246.9 square kilometres

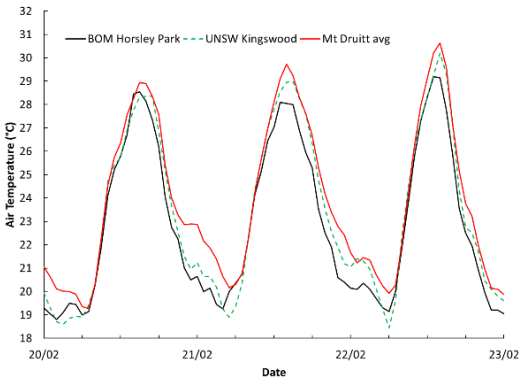
POPULATION
336,962 people

Overview of the project

The combination of global climate change and urban overheating are leading to an increase in peak summer temperatures and intensity of heatwaves, especially in Western Sydney. Urban overheating has consequences for human thermal comfort, health, building cooling energy needs, and even the ability to live outdoors in the public space during significant fractions of summertime, especially for the vulnerable population. Here, we studied heat-mitigation and its benefits on ambient temperature, building energy needs, electricity demand and risk of heat-related mortality in Mount Druitt. We focused on increasing the resilience to climate change of Dawson Mall. This is a popular open-air shopping mall where Blacktown City Council may soon consider designs for urban revitalisation.

Unmitigated local climate in Mount Druitt

With a network of six temperature and humidity sensors, we monitored the local conditions for more than one year and observed that in Mt Druitt in peak conditions is 1.2-1.7 °C hotter than the values recorded at the Bureau of Meteorology's station in Horsley Park, which is approximately 10 km south of Mt Druitt, in a non-urban area at the same distance from the cost. Especially, the air temperature in Mt Druitt is even 2.5 C hotter than in Horsley Park in the evening and night. Then, we performed detailed measurements on a clear sky hot day at 23 locations in Mt Druitt, with mobile weather stations and a drone equipped with a thermal camera. Thus, we used the collected data to validate a microclimate simulation model.



Mitigation scenarios

Upon consultation between Blacktown City Council and UNSW, a microclimate model was calibrated with measured data to assess five design scenarios:

REFERENCES

[1] K. Yenneti, L. Ding, D. Prasad, G. Ulpiani, R. Paolini, S. Haddad, M. Santamouris, Urban Overheating and Cooling Potential in Australia: An Evidence-Based Review, Climate. 8 (2020) 126. https://doi.org/10.3390/cli8110126.

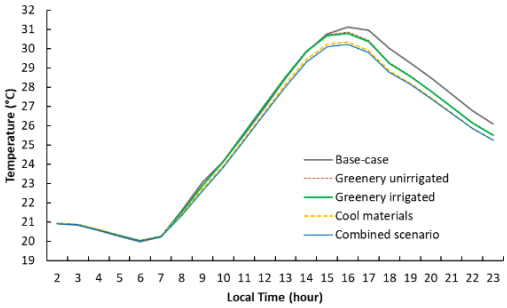
[2] M. Santamouris, L. Ding, F. Fiorito, P. Oldfield, P. Osmond, R. Paolini, D. Prasad, A. Synnefa, Passive and active cooling for the outdoor built environment – Analysis and assessment of the cooling potential of mitigation technologies using performance data from 220 large scale projects, Solar Energy. 154 (2017) 14–33. https://doi.org/10.1016/j.solener.2016.12.006.

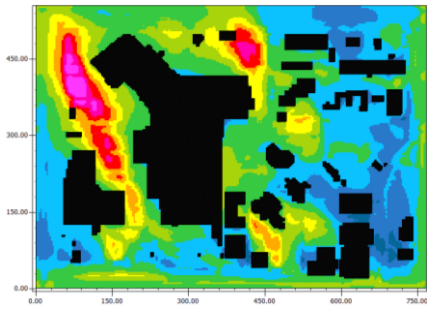
[3] M. Santamouris, R. Paolini, S. Haddad, A. Synnefa, S. Garshasbi, G. Hatvani-Kovacs, K. Gobakis, K. Yenneti, K. Vasilakopoulou, J. Feng, K. Gao, G. Papangelis, A. Dandou, G. Methymaki, P. Portalakis, M. Tombrou, Heat mitigation technologies can improve sustainability in cities. An holistic experimental and numerical impact assessment of urban overheating and related heat mitigation strategies on energy consumption, indoor comfort, vulnerability and heat-related m, Energy and Buildings. 217 (2020) 110002. https://doi.org/10.1016/j.enbuild.2020.110002.

[4] S. Garshasbi, S. Haddad, R. Paolini, M. Santamouris, G. Papangelis, A. Dandou, G. Methymaki, P. Portalakis, M. Tombrou, Urban mitigation and building adaptation to minimize the future cooling energy needs, Solar Energy. 204 (2020) 708–719. https://doi.org/10.1016/j.solener.2020.04.089.

• Base case – unmitigated
• Unirrigated greenery – 10 unirrigated trees on Dawson Mall and 337 additional trees in other locations
• Irrigated greenery – 10 passively irrigated trees on Dawson Mall and 337 additional trees in other locations
• Cool materials – Albedo of roofs increased to 0.75 and albedo of car parks and pedestrian areas increased to 0.40
• Combined – Combination of all the above mitigation strategies plus shading of car parks.

The design scenarios started from the plan of funded projects for the revitalisation of Mount Druitt (Figure 17), and the consideration of the hotspots identified with the fieldwork, as well as the state-of-the-art heat mitigation technologies applied in Australia [1] and overseas [2], as the research experience previously gathered in Western Sydney [3,4].
The maximum peak air temperature reductions are achieved in the combined scenario and equal to 1.24 °C, followed by the cool materials scenario with a peak reduction of 1.17 °C, and then irrigated and unirrigated greenery scenarios with reductions of 0.76 °C and 0.71 °C. These temperature reductions are in line with results previously achieved with heat mitigation on a small area, while peak air temperature reductions of 2.2-2.9 °C are possible only with a Sydney-wide application of heat mitigation [3,4], including the irrigation of greenery, which can be allowed by the synergy of green and blue infrastructure.





Air temperature difference base case – combined scenario (12 pm)

Trees or other urban shading improve human thermal comfort by reducing the solar radiation directly reaching people and street pavements, and thus reducing their surface temperature. Along Dawson Mall trees can reduce the pavement temperature by more than 15 °C.

Benefits of urban heat mitigation

The cooling energy needs for all simulated buildings is 20-40% higher in Mt Druitt (urban area) than at Horsley Park (non-urban), depending on insulation level and internal heat loads, showing an energy penalty for all urban buildings in Mt Druitt. A reflective roof (albedo = 0.75) instead of a conventional roof (albedo = 0.15) can deliver cooling energy savings in all situations, with the greatest advantage for poorly insulated low-rise buildings (e.g., existing office buildings). Here, we computed cooling energy savings up to 18% for an uninsulated low-rise office building. High roof insulation (as per current building code levels) of a shopping mall was not beneficial, instead, because it reduces heat dissipation, and increases cooling energy needs. Cooling energy savings in the range between 10% and 24% can be achieved with the combination of cool roofing and urban heat mitigation. The electricity demand over the hot period (November-March) for all uses can be reduced by 1.5% with urban heat mitigation. It is to be noted that the modelled electricity demand includes transport and all other uses. Finally, heat mitigation can reduce the risk of heat-related mortality, which remains high in Western Sydney, and significantly higher than in coastal suburbs.

Recommandations

- Heat mitigation should be implemented in the most comprehensive way, with a combination of heat mitigation technologies, as in the combined scenario.
- Heat mitigation of a single hot spot is helpful to improve the local thermal comfort, but in the case of Dawson Mall an advective inflow of hot air due to the north-south axis of the pedestrian mall reduces the air temperature reductions.

- Heat mitigation should be implemented at the regional scale, i.e., Sydney-wide, to achieve reductions in the ambient temperature exceeding 2 °C, thus contrasting the effects of urbanization. A single council cannot alone achieve this level of urban heat mitigation.
- In addition to urban heat mitigation, an improvement of the building performance is also necessary to reduce the cooling energy demand of buildings in the context of global and regional warming.
- Hyper insulation is not the most appropriate strategy, and performance solutions – in compliance with the National Construction Code – should be pursued to reduce the cooling energy needs of buildings in Mt Druitt.
- Reflective roofing is an effective intervention that can deliver benefits at building and urban scale, acting in synergy with other heat-mitigation strategies.
- Reflective roofs and cool pavements are the single most effective strategy for reducing air temperature, and can work in positive synergy with greenery, which provides the greatest improvements on-site improvements in local thermal comfort.

Further research and monitoring should consider:

- Monitoring the effectiveness and performance of interventions in Mt Druitt, also exploiting the network of sensors established in this project.
- The development of synergies between heat-mitigation strategies

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More information

Detailed information can be found in the extended project report.

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