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Dr. Peter Irga

Green Roof and Photovoltaik comparative research in Sydney

Abstract

The integration of greenery into building structures such as with green roofs is a vital component in building resilient cities in a changing climate. However, there is currently a lack of research, especially in Australia, that quantifies many of the well understood (but often anecdotal) services that such systems can provide. In particular, direct and accurate quantitative performance improvements of green roofs relative to conventional building technologies are rarely made, as such tests require urban spaces where comparisons between green and conventional roofs can be made without spatial and temporal confounding.

Here we present a world first opportunity to compare two roofs that are spatially unconfounded, with near identical construction and dimensions, similar age and rooftop infrastructure. With one building hosting a commercial scale bio-solar green roof and the other acting as an independent control roof, we were able to determine the independent performance of a bio-solar green roof installation over several seasonal monitoring periods.

Figure 1: Aerial imagery of study site. Daramu house (green roof) featured in the foreground and International house (conventional roof) featured in the background. The sister buildings are near-identical with differences (excluding greenery) owing to building maintenance unit design, rooftop infrastructure, and solar panel layout.

The green roof was able to reduce surface temperatures by up to 9.63 and 6.93°C for the solar panels and roof surfaces respectively. There was also an average peak temperature reduction of 8°C on the green roof, which has substantial implications for thermal comfort. This reduction in temperature was then demonstrated experimentally to increase the solar performance of the photovoltaic panels on the roof, achieving a maximum increased output of 21-107 %, depending on the month. Additionally, performance modelling indicates that an extensive green roof in central Sydney can produce 4.5% more electricity at any given light level, averaged over the overall output.

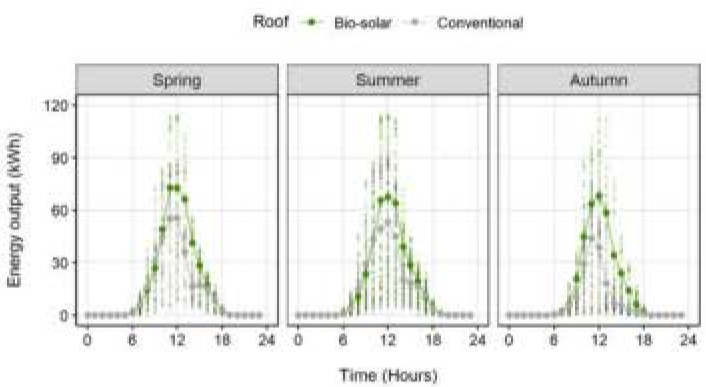

Figure 2: Mean ± SEM hourly energy output (kWh) during each season for green roof and conventional roof. The Bio-solar green roof generated an average 32.52, 21.25 and 107.29% more kWh than the conventional during Spring, Summer and Autumn, respectively. Differences between the two roofs' maximum power outputs were 25.14, 20.35 and 29.8 kWh for Spring, Summer and Autumn respectively.

The biosolar green roof served to reduce the greenhouse gas emissions of the building through off-setting fossil fuel powered energy consumption by 11.55 t e-CO_2, with the potential for up to 1.55 t of additional CO_2 being mitigated by the plants on the roof. This increase in energy output equates to €2,761 and an equivalent of 192.49 "trees planted" and grown over 10 years in an urban setting.

The stormwater and trace metal retention capacity of the green roof was also characterised, with significant reduction in stormwater flow rates (retention) of up to 60% for storms 1 in 10 year storm events observed. Additionally, the green roof achieved a significant reduction in soluble copper, as well as insoluble copper, chromium, and zinc. These results indicate that a significant increase in green roof coverage in the Sydney could facilitate a substantial reduction in stormwater flow rates into the urban stormwater management network

We monitored biodiversity using motion sensing camera traps and regular insect surveys. We found that the green roof supported four times the avian and nine times the insect diversity of the conventional roof. The green roof even attracted cryptic rare species including Blue Banded Bees (Amegilla Cingulata) and Lychee metallic shield bugs (Scutiphora pedicellata). The plant species on the roof also changed over time, with Aptenia cordigolia (baby sun rose) coverage increasing from 6% to 85% in shaded areas beneath the solar panels, showing the plant community's ability to adapt and self-regulate for survival. Semi-quantitative environmental DNA metabarcoding analyses also indicated substantial microbial and macroinvertebrate biodiversity on the green roof. Additionally, evidence of predatory activity suggests the development of a food web on the roof.

The results presented here are significant both for the generation of sustainable energy, but also to demonstrate that building owners/stakeholders should not have to choose between a green roof or a solar roof, and that there and many benefits for bio-solar green roofs.

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