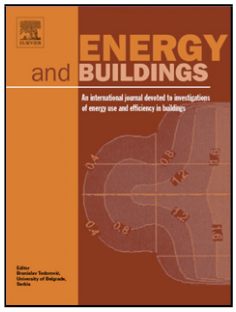

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The use of vertical greening systems to reduce the energy demand for air conditioning.

Field monitoring in Mediterranean climate

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highlights

- Filed measurements allow determining the thermal effects of vertical greening
- A green layer can mitigate air and surface temperatures
- The cooling capacity of vegetation can reduce air conditioning need during summer

Abstract

Green envelopes can provide environmental and ecological benefits in dense urban areas, improving air quality, mitigating Urban Heat Island effect, reducing energy use for air conditioning. The aim of the research presented is to determine the performance of vertical greening systems in the Mediterranean climate of Italy, analyzing a pilot project built in the city of Genoa. The authors performed an experimental investigation to evaluate the cooling potential of a well vegetated vertical greening system during summer. Field monitoring of the pilot project INPS (National Institute of Social Insurance) Green Façade, installed in 2014 on the south wall of an office building built early in the last century and renovated in the 1980's, demonstrates that a green layer can mitigate outdoor and surface temperatures, thus improve conform conditions and reduce building surfaces warming up (contributing to urban heat island mitigation). The cooling capacity of vertical greening systems can be exploited to reduce energy demand for air conditioning (with a theoretical energy saving potential of 26% for summer season). Although the energy saving for cooling strongly depends on several factors, the results obtained show a potential significant reduction of energy need for air conditioning.

Keywords: energy, vertical greening systems, building envelope, air conditioning, cooling

1. Introduction

Green envelopes can provide environmental and ecological benefits in dense urban areas, improving air quality, mitigating Urban Heat Island effect, reducing stormwater runoff, etc. [1]–[6]. This is an important issue since the majority of the world's population today lives in urban areas [7] and is responsible for 70% of global carbon emissions and nearly 70% of energy consumption – an increasing trend for both [8] with land converted to urban areas projected to triple by 2030 [9], [10] . Environmental problems within cities have significant consequences for human health, citizens' quality of life, and urban economic performance [11].
In order to reduce the impact of urban areas, carbon emissions should be reduced, especially the 40% of energy use today attributed to building consumption [8]. Hunter et al. [12] show that green façades, like other forms of green infrastructure, are increasingly being considered as a design feature to cool internal building temperatures, to reduce building energy consumption and to facilitate urban adaptation to a warming climate. Vertical greening systems (VGS) have a positive influence on the building envelope in terms of thermal performances especially in the cooling periods, as demonstrated by several studies [13]. Eumorfopoulou and Kontoleon [14] showed a potential reduction of up to 10.8 ° C in the surface temperature of a façade greened in the Mediterranean area. Another study, conducted in Singapore and based on the evaluation and comparison of different systems for green walls, shows that it is possible to lower the surface temperature to a maximum of 11.6 °C [6]. Hoelscher et al. [15] compared greened (with climbing plants) and bare walls showing surface temperatures of the greened exterior walls up to 15.5 °C lower than those of the bare walls, while it was up to 1.7 °C for the interior wall. The authors conclude that greening can be an effective strategy to mitigate indoor heat stress as long as the plants are sufficiently irrigated with up to 2.5 L m^{-2} d^{-1} per wall area.
The cooling capacity of VGS is related to plants evapotranspiration and shading effect [16], [17]. Cooling is achieved because the leaves receive the solar radiation on the façade (also as a result of phototropism [18]) protecting the wall be-