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# An experimental method to quantitatively analyse the effect of thermal insulation thickness on the summer performance of a vertical green wall

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ABSTRACT

Green façades and walls greatly contribute to reducing solar gains and dispersion through the building envelope. This implies a lower energy load for both heating and cooling and the mitigation of thermal conditions in outdoor areas. Despite this, more studies are needed regarding the influence of these systems on the thermal behaviour of insulated façades. In this manuscript, we report the results of experimental research carried out on a vertical green wall in a continental Mediterranean climate. The main goal of the research is to establish a thickness above which the behaviour of the green façade becomes isothermal and its performance do not improve. To this end, we analyze and evaluate the effect of insulation thickness on the energy performance of a green wall using a new methodology called green façade optimization (GFO). Comparing the simulations to experimental data, collected in a full-scale experimental box during the summers of 2011 and 2012, allowed the model to be validated. The results show that a green wall acts as a passive cooling system when the façade is moderately insulated, up to an insulation thickness of 9 cm, above which more insulation becomes redundant and inefficient.


## 1. Introduction

International and European regulations for energy efficiency are becoming increasingly rigid, and this often translates into greater thermal insulation thicknesses for both roofs and walls.

On the other hand, research has demonstrated that green walls can be an effective strategy to cool interiors in the summer and insulate in the winter [1–3,4–13]. In fact, the presence of vegetation greatly contributes to the reduction of solar gains and dispersion through the envelope [14–16,17–20]. This translates into a lower energy load for both heating and cooling and to mitigate thermal conditions in outdoor areas [21–23]. During the hottest hours of the day, bare walls accumulate and release more heat to the environment than green walls. On the contrary, during the cool night-time hours and in conjunction with the period of natural ventilation, green walls absorb more heat from the internal environment, favouring cooling and contributing to lowering the operational temperature. This is particularly important in the hottest climates [1,14,24,25].

A lot of research has demonstrated that the use of green walls also reduces the urban heat island effect (UHI) [26–29], improves outdoor thermal comfort [30], and has a positive effect on the filtration of air-borne pollutants [31,32]. In addition, all of these aspects have been considered within the context of wider urban ecosystem services provided by vegetation. In this respect, it is increasingly likely that the design of new buildings in the future will focus on the simultaneous presence of classic thermal insulation solutions and green walls.

With regard to reducing a building's energy demand, the majority of research has focused on hot climates or summer conditions. Haggag and al. [14] experimented with a green wall installed in a school building located in the city of Al-Ain, in a hot, arid climate (United Arab Emirates). The green wall was monitored and com-

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