# Climate-resilient ventilative cooling: experimental performance of a renewable hybrid air-cooling technology under heatwave conditions

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## ABSTRACT

Building cooling demand is rapidly intensifying across Southern Europe due to the increasing frequency, duration and severity of heatwaves associated with climate change scenario. This trend is placing unprecedented pressure on conventional mechanical-compression systems, which typically experience reduced efficiency and capacity under high outdoor air temperatures and humidity, while relying heavily on synthetic refrigerants with high global warming potential. In this context, energy-efficient, low-emission and climate-resilient cooling alternatives are urgently needed to support thermal comfort and public health in future urban environments.

This study presents an experimental investigation of a renewable ventilative cooling technology based exclusively on 100% outdoor air and a hybrid desiccant–dew-point cooling process, enabling independent control of supply air temperature and humidity without refrigerants. This hybrid system comprises a desiccant wheel for moisture removal control and a dew-point indirect evaporative cooler for high-efficiency sensible cooling. An 11-week experimental campaign was carried out during summer 2022 in Córdoba, Southern Spain, including 30 representative "summer" and "heatwave" days identified from historical climate percentiles. Instantaneous behaviour and seasonal performance were evaluated in terms of thermal and electrical energy balances, supply air conditions and water consumption.

Results demonstrate stable supply air temperatures of 16–20°C even when outdoor air exceeded 40°C. Under severe heatwave conditions, total cooling capacities reached 421.6 MJ/day, with peak sensible and latent cooling energies of 314.4 MJ/day and 134.6 MJ/day, respectively. The system achieved daily coefficient of performance values up to 15.6 due to low electricity demand, while water consumption remained moderate, with water-to-cooling ratios up to 1.85 MJ/l. Unlike conventional air-conditioning, its performance improved precisely under the most extreme climatic stress. These findings highlight the potential of hybrid desiccant–evaporative ventilative cooling as a robust, scalable and climate-adaptive strategy for sustainable building climate control in Mediterranean and arid regions. The results provide valuable insight for engineers and policymakers working towards low-carbon resilient cooling strategies aligned with EU climate targets.

## KEYWORDS

ventilative cooling, desiccant-based air conditioning, dew-point evaporative cooling, heatwave resilience, renewable cooling