CSP AND DESALINATION

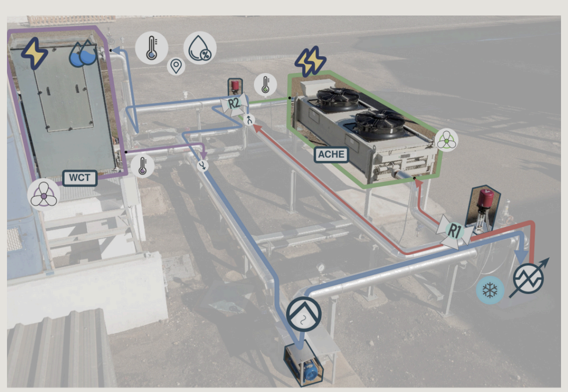
TOWARDS OPTIMAL RESOURCE MANAGEMENT IN SOLAR THERMAL APPLICATIONS

The present manuscript is the result of a PhD thesis research work carried out at the Plataforma Solar de Almería (Spain), under the supervision of Dr. Lidia Roca and Dr. Patricia Palenzuela and is ascribed to the Computer Science Doctorate Program at the University of Almería. The research was funded by a scholarship from CIEMAT, a public research organization attached to the Ministry of Science, Innovation and Universities.

While primarily aimed at researchers and professionals in renewable energy and water treatment, this manuscript is written to be accessible to non-experts. Technical topics such as thermodynamics, mathematical modelling, and optimization are presented clearly and progressively.

Two linked resources Water and Energy

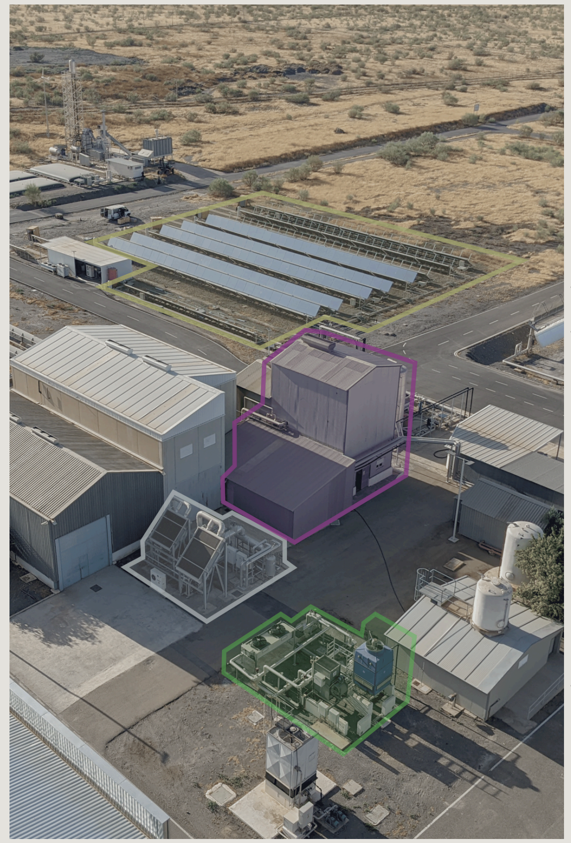
This research encompasses two complementary studies on two intrinsically linked resources: water and energy. The first part focuses on the efficient management of water resources for power generation in Concentrated Solar Power (CSP) plants, while the second explores the efficient use of solar energy for clean water production in a solar-driven multi-effect distillation (solarMED) plant.



Combined cooling experimental facility

KEY COMPONENTS OF THIS RESEARCH WORK

Objective: Automation seeks to develop autonomous systems by integrating modelling, control, and optimization, enabling efficient resource use, adaptability to changing conditions, and reliable operation with minimal human intervention. This work optimizes the operation of two solar thermal systems by solving economic optimization problems that minimize operational costs and, by its integration to the analyzed processes, allows them to achieve near-optimal autonomous performance.


Aerial view of the pilot plants at Plataforma Solar de Almería, Spain

Combined cooling in CSP: This work addresses the challenge of reducing water consumption in CSP plants through the development and assessment of a concept that integrates dry and wet cooling technologies.

A two-stage multi-objective optimization strategy is proposed and applied to a case study of a commercial CSP plant. Three configurations are evaluated under a water-scarcity scenario using annual simulations: the existing wet-only system and the proposed concept with two alternative dry-cooler capacities. The optimized alternatives reduce specific cooling costs by up to 80% and decrease annual water consumption by approximately 48%, with savings reaching 38% during the driest and hottest months.

Thermal desalination: As desalination becomes increasingly important to address global freshwater scarcity, thermal systems —low-temperature MED— offer a robust and complementary pathway for brine concentration and resource recovery, particularly when coupled with waste-heat or renewable energy sources such as solar thermal.

A hierarchical optimization strategy is developed to coordinate the activation, deactivation, and regulation of each subsystem in the SolarMED process, leveraging solar availability and the flexibility of thermal energy storage. In a week-long simulation, the proposed strategy outperforms a heuristic baseline by 32%.

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CSP AND DESALINATION

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