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Contrasting non-dynamic and dynamic models of the water-energy nexus in small, off-grid Mediterranean islands

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Water and energy supply in small Mediterranean islands are strictly interrelated and face a large number of challenging issues, mainly caused by the distance from the mainland, the lack of accessible and safe potable water sources, and the high seasonal variability of the water and energy demands driven by touristic fluxes. The energy system generally relies on carbon intensive, expensive stand-alone diesel generators, while potable water supply is provided by tank vessels. Although this combination provides essential services for local communities, it is often economically and environmentally unsustainable due to high operational costs and greenhouse gas (GHG) emissions.

A traditional approach to improve the sustainability and the efficiency of the water and energy systems is to couple renewable energy sources (RES) with water supply technologies (e.g., desalination), in order to obtain efficient planning solutions (i.e. RES capacity, desalination plant capacity) in a least-cost fashion. However, this approach is generally non-dynamic and optimizes the power allocation using fixed electricity loads as a surrogate of the actual water demand supplied by the desalination plant through the water distribution network. Although this load reflects the actual water demand on the long-term (i.e. monthly or annual time scale), it could strongly deviate from the real water demand if we consider shorter time scales (i.e. daily or hourly), over which the water distribution network is able to store and move water in space and time.

In this work, we comparatively analyse this traditional non-dynamic model of the water-energy nexus with a novel dynamic modelling approach, where the operation of both the nexus components (i.e. power allocation and operations of the water distribution network) is conjunctively optimized with respect to multiple economic and sustainability indicators (e.g., net present costs, GHG emissions, water supply deficit, RES penetration).

This comparative analysis is performed over the real case study of the Italian Ustica island in the Mediterranean Sea. Preliminary results show the effectiveness of the dynamic approach in improving the static solution with respect to almost all the system performance metrics considered.