EGU22-5468
EGU General Assembly 2022

Towards energy autonomy of small Mediterranean islands: Challenges, perspectives and solutions

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The energy autonomy of small non-interconnected islands in the Mediterranean, taking advantage of their high renewable energy potential, has been a long-standing objective of local communities and stakeholders. This is also in line with the recently implemented European Green Deal, which has set the goal of increasing the renewable energy penetration in European countries' power systems. However, the islands have further challenges than the large-scale inland areas. On the one hand, their population fluctuates significantly across seasons, as result of tourism, which is their key economic activity. The footprint of tourism is a substantial stress to all associated resources and infrastructures during the summer period. On the other hand, most of these areas suffer from both water and land scarcity. These features raise several challenges regarding the development of really autonomous energy systems, based on renewables and essential storage works to regulate the energy surpluses and deficits in the long run. Taking as example the Cycladic island of Sifnos, Greece, we investigate the design of a hybrid power system, combining wind, solar and hydroelectric energy. A major component of the proposed layout is the pumped-storage system. Due to the limited surface water resources of the island, we configure an upper tank at an elevation of 320 m, recycling seawater. This peculiarity introduces a significant level of uncertainty in hydraulic calculations, as well as various technical challenges, such as the erosion of pipes and the electromechanical equipment, and the waterproofing of the tank. An additional challenge is raised by the peculiar wind regime of the island, that makes essential to choose a hub height of turbines to minimize the frequency of power cut-offs. The basis of a rational design procedure for the main system components is the financial optimization that ensures a desirable level of reliability. This is achieved through a stochastic simulation approach that takes into account the stochastic nature of the underlying hydrometeorological drivers (wind velocity and solar radiation) and the energy demand.