Nicosia pumped hydro storage

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where V (m/s) is the wind speed at height y (808 m), V0 (m/s) is the wind speed at height y0 (27 m), and n is the Manning coefficient, which takes different values depending on the natural surface of the installation. In the case of Mount Kochilas, the value of n is 0.20. The equation that calculates the power of a hydro turbine is as follows (Acharya et al. 2015):

where r is the density of water (1000 kg/m3), g is the acceleration of gravity (9.81 m/s2), Q (m3/s) is the water supply, H (m) is the total height, n is the output coefficient of the hydro turbine (0.85), and P is expressed in W (watts). The reservoir''s altitude and the amount of water that is accessible determine how much electricity is produced. The type of hydro turbine selected is the Pelton (Hatata et al. 2019).

The energy requirements for RO desalination vary between 2.5 and 7.0 kWh/m3 (Fornarelli et al. 2018) and depend on the quality of the water and the size of the RO system (Bertsiou and Baltas 2022a). In this case, it is considered to be 5.0 kWh/m3 when utilizing the seawater that surrounds the island.

Proton Exchange Membrane (PEM) electrolysis is used to produce green hydrogen (Zeng and Zhang 2010) utilizing the excess wind energy from the WTs. The production of 1 kg of hydrogen requires 9 kg of clean water and 0.06 MWh of electrical energy (Rievaj et al. 2019). The heating value of hydrogen is 33.4 kWh/kg (at a temperature of 25 ?C and pressure of 1 atm). The efficiency of a PEM fuel cell is 47.6% (Taner 2018). Finally, 1 kg of hydrogen produces 15.9 kWh of energy. The hydrogen is stored as gas in tanks.

Three scenarios have been analyzed to investigate the response of the HRES. The model simulation uses 88,081 hourly time steps (10 years). The input data inserted into the simulation are the wind speeds at the time steps. Each wind speed is converted to the wind energy by applying Enercon''s power curve for the WT (ENERCON 2015). The equation that converts wind speed into wind energy arises as a numerical approximation of the power curve and is as follows:

where V (m/s) is the wind speed at the height of the WTs and E is expressed in MWh. The three scenarios correspond to different usages of the produced wind energy.

The first scenario only depends on pumped-storage hydroelectricity technology. If there is a lack of energy produced by the WTs, water is released from the upper reservoir into the sea, and the hydro turbine produces hydroelectric energy to cover the electricity demand. In the case of an excess in energy, this is used to pump water into the reservoir. The equation that calculates the volume of the water that is pumped into the reservoir is as follows:

where E (MWh) is the energy for pumping, n is the output coefficient of the pumps (0.80), r is the density of water (1000 kg/m3), g is the acceleration due to gravity (9.81 m/s2), H (m) is the total height, and V is expressed in m3.

The second scenario uses hydrogen storage technology. If there is a lack of energy, electrical energy is produced from hydrogen through the fuel cells. If there is an excess, it is used to produce hydrogen in a gaseous form through the process of PEM electrolysis, which is then stored in hydrogen tanks.