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Economics of hybrid pumped hydropower storage in open-pit coal mines: a case study for the Greek energy market

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A dynamic techno-economic simulation model was developed in the present study to assess the capital and operational expenditures (CAPEX and OPEX) as well as economic benefits of a prospective Hybrid Pumped Hydropower Storage (HPHS) installation to be realised in a Greek open-pit coal mine. HPHS is not only limited to store excess energy produced by local renewable energy sources, i.e. photovoltaic and wind farms, but can also be applied to store of excess energy from the grid. The model accounts for losses incurring while charging the upper reservoir with water when excess energy from renewables and the electric grid is available as well as discharging the upper reservoir for electricity generation when the national electricity demand exceeds the energy provided by the grid. A charging and discharging scheme for the HPHS installation was dynamically calibrated by means of historic energy market data, including time-dependent national energy balances and electric grid costs. Revenues, expenditures and profits of the prospective HPHS implementation were calculated, and the key economic parameters Net Present Value (NPV), Internal Rate of Return (IRR) and Discount Payback Period (DPP) determined to account for the overall system profitability during its' entire operational time. The model's technical implementation and applicability for system performance optimisation are discussed in detail, especially in view of a profit-maximising energy storage scheme, which was developed and applied to stochastic grid cost development predictions to account for the HPHS installation's potential future benefits. The model can be integrated with online real-time data to economically schedule HPHS operation in highly dynamic energy systems.

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