Optimal Integration of Hybrid Pumped Storage Hydropower to increase renewables penetration and reduce CO_2 emissions

Helena M. Ramos[1], Jeremy E. Sintong[1], Alban Kuriqi[1]

CERIS, Instituto Superior Técnico, University of Lisbon, 1649-004 Lisbon, Portugal

Corresponding author: alban.kuriqi@tecnico.ulisboa.pt

ABSTRACT: Addressing climate change and energy crises is considered one of the world's greatest energy challenges. The presence of proven and reliable energy storage is fundamental to addressing climate change, which is needed to support intermittent renewable energy for a rapid transition of the energy sector from conventional fossil fuels to decarbonized energy sources. Solar and wind energy are both variable renewable energy sources. Their production is intermittent, which can be seen as an opportunity to be integrated into the pumped storage hydropower (PSH) system. Therefore, the main drivers for the massive development of PSH are the growing demand for variable renewable energy, the increasing demand during peak hours, and the modernization of plants to improve efficiency. This study investigates the benefits of integrating PSH and hybrid systems into the grid. Four schemes were tested in different seasons, including annual and daily distribution. The last scheme of daily simulation with an optimization solver is used to optimize the integration of PSH with a hybrid power system that uses solar and wind energy as primary renewable sources by minimizing the daily operating cost. The optimal value is determined from the minimized operating costs and the incoming and outgoing energy accumulation. The dispatch system includes load demand satisfaction considering the intermittent nature of solar and wind sources and demand fluctuations, presented with a hybrid system consisting of PV solar, wind turbines, PSH, and other power generation as a backup. The results show that using the developed model for optimal scheduling of PSH integration with renewables and the hybrid system each season, a significant CO_2 reduction of up to 84% can be achieved in summer at one of the proposed schemes. In comparison, daily costs can be reduced by more than 90% in all seasons. The two simplified NPV and payback period estimation models have shown that financing the project over 25 years is feasible with an interest rate of 10% for the combined PSH and hybrid system. With an optimized and adjustable scheme, the PSH can also provide a wider range of up and down ramps while modifying the power system in generation and pumping mode. A hybrid system combined with PSH can shift, store, and reuse generated energy until an appropriate load is available for system reserves and variable energy integration.

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