Optimized energy management strategy for grid connected double storage (pumped storage-battery) system powered by renewable energy resources

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Abstract:

This paper presents a grid-connected double storage system (DSS) consisting of pumped-storage hydropower (PSH) and battery. The system is supplied by photovoltaics and wind turbines. In the proposed hybrid system, batteries absorb excess renewable energy that cannot be stored in PSH and they cover loads that cannot be supplied from the water turbine. To improve the system performance, a novel energy management strategy for the DSS is proposed. The strategy is based on an optimized factor that governs the charging process of the DSS. The problem of the optimal system design is solved by a non-dominated sorting genetic algorithm (NSGA-II). The multi-objective function considers simultaneously the minimal investment cost and minimal CO2 emissions. A comparative study of photovoltaic/wind/pumped-storage hydropower and photovoltaic/wind/double storage system is performed to show the effectiveness of the proposed strategy in terms of system economic and environmental performance. The considered location of the PSH station is on Attaqa Mountain at Suez (Egypt). The results indicate the effectiveness of the proposed energy management strategy for the storage system from economic and environmental perspectives. Coupling the battery with the PSH reduces the electricity cost by 22.2% and results in minimal energy exchange with the national grid (5% of the annual demand). A sensitivity analysis shows the largest variation of the electricity cost with changing the capital cost of the solar and wind generators. Also, it is observed that when the load increases, the optimal size of the system components increases, but it isn't proportional with the demand increase as could be expected.

Keywords:

Pumped-storage hydropower, Battery, Double storage system, Renewable energy sources, NSGA-II, Hybrid energy system

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