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Optimizing utility-scale photovoltaic power generation for integration into a hydropower reservoir by incorporating long- and short-term operational decisions

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The variability of photovoltaic (PV) power challenges its integration into power grids at the utility-scale. Operating PV power complementarily with hydropower is a promising way for the grid to accommodate more PV energy. This study optimizes the size of a utility-scale PV plant for integration into a hydro plant using cost–benefit analysis and considering variations in downstream water level (VDWL). A nesting model that incorporates both long- and short-term operating decisions is developed to estimate the delivered PV energy. This includes a multi-objective optimization model that provides long-term decisions for the joint operation of the plants. These factors are then incorporated into a short-term simulation model, which produces successive decisions relating to power curtailment and water levels. Finally, the expected net revenue of the PV plant over its lifespan is calculated while constraining the VDWL to protect downstream water users. China's Longyangxia hydro–PV plant was selected for a case study. The results indicate that: (1) the optimal size of the PV plant is 950 MW with a maximum net revenue of 5.2 billion CNY over its lifespan; (2) the optimal PV size is sensitive to financial factors (the feed-in tariff, the initial investment, and the operation & maintenance costs); and (3) a larger reservoir storage capacity tends to be integrated with a larger PV plant. The combination of the cost-benefit analysis and the nesting model appears an effective approach to optimize the size of the PV plant being integrated with hydro plant and could equally apply to integrating other renewable energy sources.