Multi-objective optimal operation of cascade hydropower plants based on water-energy nexus: a water footprint approach

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Abstract Hydropower is the key component of the water-energy nexus, which can meet the energy demand and mitigate the greenhouse effect. This paper constructs an optimal operation model for cascade hydropower plants considering water footprint, quantifies the tradeoff relationship between power generation and water consumption (reservoir water footprint). The preliminary application in the Yalong River case has shown that (1) there are clear tradeoffs between hydropower generation and water consumption and (2) scheme 2 is the optimal scheme from the water-energy nexus for both two scenarios in a normal year.

Keywords: Multi-objective operation, Cascade hydropower plants, Water footprint, Benefit tradeoffs, Yalong River.

Methods

This study employs the reservoir water footprint (water evaporated from open water surface of reservoirs) and hydroelectric water footprint (the water consumption per unit of electricity production) to evaluate the consumption of water by hydropower for cascade hydropower plants . Also, this paper constructs an optimal operation model for cascade hydropower plants and uses NSGA-Ⅱ algorithm to solve it. The flow chart through the methods used in this study is shown in Figure 1.

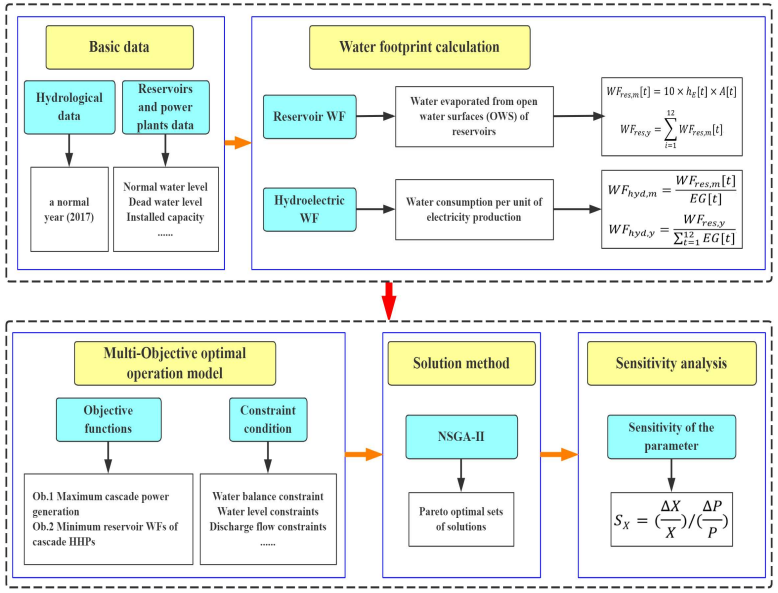

Figure 1: The flow chart through the methods used in this study.

Results

•Scheme 2 is the optimal scheme from the water-energy nexus based on the water footprint approach.

•for scenario S1, the power generation and the reservoir WFs of the cascade HHPs of scheme 2 are 775.23×10^8 kWh and 159803.61×10^3 m3, respectively; for scenario S2, they are 800.65×10^8 kWh and 159922.22×10^3 m^3, respectively.

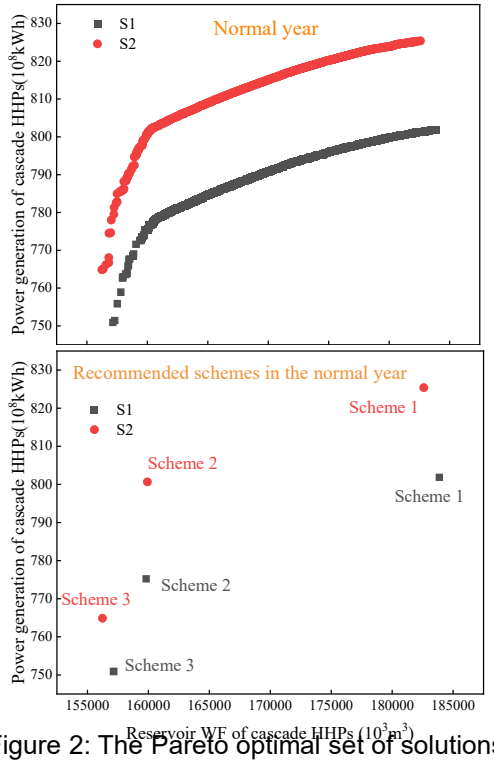

Figure 2: The Pareto optimal set of solutions under scenarios S1 and S2 in a normal year.

Conclusions

The following conclusions are drawn from this study:(1) there are clear tradeoffs between hydropower generation and water consumption and (2) scheme 2 is the optimal scheme from the water-energy nexus for both two scenarios in a normal year.

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