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Integrating Economic and Ecological Benchmarking for a Sustainable Development of Hydropower

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Hydropower reservoirs play an increasingly important role for the global electricity supply. Reservoirs are anthropogenically-dominated ecosystems because hydropower operations induce artificial water level fluctuations (WLF) that exceed natural fluctuations in frequency and amplitude. These WLF have detrimental ecological effects, which can be quantified as losses to ecosystem primary production due to lake bottoms that fall dry. To allow for a sustainable development of hydropower, these “ecological costs” of WLF need to be weighed against the “economic benefits” of hydropower that can balance and store intermittent renewable energy. We designed an economic hydropower operation model to derive WLF in large and small reservoirs for three different future energy market scenarios and quantified the according losses in ecosystem primary production in semi-natural outdoor experiments. Our results show that variations in market conditions affect WLF differently in small and large hydropower reservoirs and that increasing price volatility magnified WLF and reduced primary production. Our model allows an assessment of the trade-off between the objectives of preserving environmental resources and economic development, which lies at the core of emerging sustainability issues.
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