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A Comparative Assessment of the Impact of Climate Change and Energy Policies on Alpine Hydropower

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Scientific literature has mostly focused on the analysis of climate change impacts on hydropower operations, underrating the consequences of energy policies, for example, increase in Variable Renewable Sources (VRSs) and CO2 emission permit price, on hydropower productivity and profitability. We contribute a modeling framework to assess the impacts of different climate change and energy policies on the operations of hydropower reservoir systems in the Alps. Our approach is characterized by the following: (i) the use of a physically explicit hydrological model to assess future water availability; (ii) the consideration of electricity price scenarios obtained from an electricity market model accounting for the future projected European energy strategies; and (iii) the use of optimization techniques to design hydropower system operations in response to the projected changes. Through the application to the Mattmark system, a snow- and ice-dominated hydropower system in Switzerland, we demonstrate how the framework is effective in exploring the sensitivity of Alpine hydropower to changes in water availability and electricity price, in quantifying the uncertainties associated to these projections and in identifying the value of reoperation strategies. Results show that energy policies may have more significant impacts on hydropower operations than climate change and, as such, are worth considering in impact assessments studies. The reduction of water availability due to climate change is expected to induce a loss in electricity production down to − 27% by 2050. Changes in electricity price, instead, may have up to 6 times stronger impact than climate change, leading to an increase in hydropower revenue up to about +181%.
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