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Efficient hydropower modeling for medium-term hydrothermal planning using data-driven approaches

A. Ramos Galán; F. Labora Gómez; J.D. Gómez Pérez; J.M. Latorre Canteli

Abstract-

The continuous rise of renewable energy in the global energy mix highlights the need to analyze and enhance traditional energy plants’ flexibility to support integration. Hydropower, with its rapid response capabilities and significant energy storage, plays a vital role in this context. However, simplifications are required due to the complex interconnections among cascaded hydropower plants and the inherent uncertainty of water inflows. This study presents a data-driven methodology for representing hydropower plants physically and through equivalent energy models, accounting for inflow uncertainties implicitly. Using historical data, we apply analytical techniques – including auxiliary linear models, load-duration curves, and filtering methods in linear regressions – to configure key hydropower parameters such as water inflows, reservoir boundaries, and hydropower plant production limits. These methods can be applied across hydro systems of different scales. We have validated our approach for the Spanish system for 2019 and 2025, demonstrating its efficacy.

Index Terms- Equivalent hydropower plants; Mid-term planning models; K-means; Linear regression models; Fourier series filtering; Ridge regularization; Linear optimization models

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