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Social prosperity and natural resource management: Stochastic evaluation of two operational paradigms of pumped-storage hydropower in North Euboea under renewable energy integration and energy market dynamics

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Social prosperity fundamentally relies on the sustainable management of natural resources. In the contemporary world, however, this
perspective has been distorted, as economic optimization increasingly dominates resource allocation decisions, often prioritizing short-term financial gains over long-term societal and environmental benefits. To highlight this distortion, we evaluate a planned pumped-storage hydropower (PSH) project in Northern Euboea, Greece, using two contrasting operational frameworks:

- Resource- and needs-oriented approach (socio-environmental perspective): The PSH system is coupled with renewable energy sources (RES) and operated to optimize water and energy resource use, ensuring stable and reliable energy supply aligned with actual societal demand, irrespective of short-term market fluctuations.
- Market-driven approach (economic optimization perspective): The system exploits price volatility in the energy exchange market by pumping (storing energy) when electricity prices are low and generating (turbine operation) when prices are high, aiming to maximize economic profitability.

We analyze the stochastic properties and dynamics of relevant time series — including RES production, electricity market prices, and
demand patterns — to quantify and compare system behavior under each paradigm. Key metrics include resource efficiency, supply
reliability, economic returns, and alignment with broader sustainability goals. The results reveal fundamental tensions between the two approaches: the market-driven strategy yields higher short-term revenues. In contrast, the needs-oriented operation better supports long-term social prosperity and resource conservation, though at the potential cost of lower immediate financial performance. This comparative analysis underscores how the dominance of market mechanisms can distort natural resource management and advocates for a reorientation of decision-making criteria toward long-term societal well-being and environmental
sustainability in energy infrastructure planning.