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Integrated Water-Energy Nexus Analysis: Dynamic Simulation of a Combined Hydro-Thermal Power Plant

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This study presents an integrated water-energy nexus analysis through the dynamic simulation of a combined hydro-thermal power plant, focusing on a case study within the water-scarce region of Iran. The investigation aims to assess the mutual interactions between water resources and energy production, providing valuable insights for sustainable water and energy management practices. The simulation model incorporates system dynamics to capture the complex feedback loops between water availability, energy demand, and the operation of the power plant. The power plant is modeled as a combined hydro-thermal system, where water availability influences both hydroelectric and thermal power generation. The system's response to water availability is further modulated by feedback loops that consider the dynamics of water and energy demand. In the context of the Iranian water plant case study, the simulation is executed over 100-time steps to analyze the dynamic behavior of the system. The water supply response to water availability is characterized by a multiplier, and the energy supply response is modulated by a similar multiplier, reflecting the inherent connection between water and energy in the power generation process. Additionally, the thermal efficiency of the power plant is considered in the simulation to account for the impact of water availability on thermal power generation. The results of the simulation are visually represented through a heat map, providing a comprehensive overview of the temporal evolution of water demand, water supply, and energy supply. The custom colormap enhances visualization, enabling a clear interpretation of the interdependencies within the water-energy nexus [1]. The numerical results derived from the simulation offer valuable insights into the sustainable operation of the combined hydro-thermal power plant. The analysis highlights the importance of considering water availability in energy production decisions, showcasing the impact on both hydroelectric and thermal power generation. Furthermore, the simulation provides quantitative assessments of water shortage and energy shortfall, aiding in the identification of critical time periods and informing strategies for resource allocation and infrastructure planning [2]. By focusing on the Iranian context, where water scarcity is a prevalent concern, this study contributes to the development of region-specific water and energy policies. The findings underscore the need for integrated water and energy management strategies to address the challenges posed by changing water availability patterns and growing energy demands [3]. The presented simulation framework can serve as a valuable tool for policymakers and researchers in optimizing the operation of similar water-energy systems in arid regions, fostering sustainable development in the face of increasing water and energy challenges.

Keywords: *Water-Energy Nexus; Power Plants; Programming; Sustainability; Performance assessment*