

A Multi-Agent Approach for Water-Power Resilience Modeling: A Western Irrigation District Jeopardized by Drought

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Background/Objectives. Drought conditions in the western United States have been increasing in frequency and severity over the past decade. Increasing extreme temperatures during the growing season also increase evaporative losses from reservoirs, canals, and fields. This study investigates the joint water–power system resilience of an irrigation district imperiled by drought conditions. As opposed to traditional reliability analysis of such water and power systems, the resilience of interconnected water and power systems can be better analyzed and understood through an integrated approach, using a model that connects the dependencies between the two halves of the system.

Approach/Activities. Using a multi-agent system model capturing both water and power system components, as well as their linkages, we capture the interdependencies of these systems and highlight opportunities for improvement when faced with drought-based disruptions. Noting the interdependencies between the water–power system halves while leveraging an integrated simulation allows for an insightful analysis of the system impacts during disruptions. Disruption scenarios are used to baseline the system performance under changing environmental and climatic conditions. Potential irrigation modernization interventions (such as drip irrigation, optimized scheduling, pressurized pipe systems, in-conduit hydropower, recirculated pumped storage hydropower, etc.) are modeled to observe predicted changes in system performance.

Results/Lessons Learned. Scenario results indicate that the effects of low flow (drought) years are mostly felt in the power system; unexpected increases in water demand marginally impact irrigation system performance; and various interventions can be leveraged to mitigate system impact. Interventions such as increased storage capacity (retention ponds), improved irrigation technologies and policies (drip irrigation, optimized scheduling), modernized irrigation infrastructure (pressurized pipe systems), and increased power system flexibility (recirculated pumped hydropower, in-conduit hydropower) all improve system performance to varying degrees under increasingly difficult environmental and climatic conditions.