ADVANCING HYDRO-ECONOMIC OPTIMIZATION TO IDENTIFY VULNERABILITIES AND ADAPTATION OPPORTUNITIES IN CALIFORNIA’S WATER SYSTEM

ABSTRACT

Long-term shifts in the timing and magnitude of reservoir inflows will affect water supply reliability in California. Hydro-economic models can help explore climate change concerns by identifying system vulnerabilities and adaptation strategies for statewide water operations. This work contributes a new open-source limited foresight implementation of the CALVIN model, a hydro-economic model including roughly 90% of California’s urban and agricultural water demands. The model includes the ability to determine water allocations on an annual basis without knowledge of future availability, and to efficiently evaluate ensembles of streamflow projections representing a range of possible future climates. We then assess the vulnerability of the statewide system to changes in total annual runoff and the fraction of runoff occurring during winter, which primarily depends on temperature. Results are analyzed with a focus on adaptation strategies, aided by the economic representation of water demand in the model. These strategies include changes to reservoir operating policies, and conveyance and storage expansion. As water availability decreases, model results show quadratic increases in shortage cost, and corresponding increases in the marginal costs of adaptation strategies and environmental flow constraints. Reservoirs adapt to warmer climates by increasing average storage levels in winter and routing excess runoff to downstream reservoirs with available capacity. Both small and large changes to reservoir operations were observed compared to historical hydrology, showing that no single operating strategy achieves optimality for all reservoirs. Increasing the fraction of winter flow causes small increases in total shortage cost, indicating the ability to manage a changing hydrologic regime with adaptive reservoir operations. The results of this project improve estimates of the cost of climate change to California’s water system under a range of future conditions and highlight adaptation strategies that minimize costs of increased hydrologic variability.

HIGHLIGHTS
• A new open-source implementation of the CALVIN hydro-economic model has been developed, which includes limited foresight and more efficient runtime for evaluating scenario ensembles.

• A range of plausible future scenarios are developed by sampling changes in water availability, representing changes in annual precipitation, and the fraction of winter runoff, which represents increasing temperature. These scenarios are compared to the Fourth Assessment streamflow projections to understand possible changes to runoff timing and magnitude.

• Water supply vulnerability is examined by considering shortage costs at the statewide and regional level. Water shortage costs are more sensitive to annual water availability than runoff timing, particularly reductions of 20-30%. Results also show an increased sensitivity to changes in runoff timing in very dry scenarios.

• Economical adaptation strategies include substantial changes to optimal reservoir operations in dry scenarios, particularly for the large reservoirs in Northern California. This low-cost adaptation requires little new infrastructure.

• The marginal value of additional reservoir capacity is generally low compared to the value of operational changes. Several conveyance facilities for urban delivery are identified where it may be worthwhile to increase capacity to improve robustness to scenarios with reduced water availability.

ACCESS
For access to the full report, please email Susan.wilhelm@energy.ca.gov

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