Eric Mork 10/29/2025

Advancing Energy-Water Resilience in California: A Framework for Integrated Water and Power Management Opportunities

Focal Area

This white paper addresses the crucial intersection of water-for-energy and energy-for-water management in California, specifically focusing on the CVP/SWP system as a case study for enhancing regional energy-water resilience through integrated operations and planning.

California's water conveyance system is unique in the world, most notably the Central Valley Project (CVP) and State Water Project (SWP). These projects move significant quantities of water from north to south through the California Delta, while navigating a complex set of regulations and priorities including, but not limited to, flood control, water supply, environmental restoration and protection, recreation, and hydropower production.

Operations of the CVP and SWP have significant impact on energy supply within the California Independent System Operator (CAISO) and Balancing Authority of Northern California balancing authority areas, with an average annual generation of ~4.6 terawatt-hours (TWh) for the CVP and ~6.5 TWh for the SWP. Annual average energy consumption of the projects is ~1.5 TWh for the CVP and ~11.6 TWH for the SWP. The CVP is a net energy producer (3.1 TWh average annual generation) and the SWP a net energy consumer (5.1 TWh average annual energy use). SWP deliveries comprise the largest power consumer in CAISO. Even in a dry year, hydro is the most significant fuel operating on the margin. Additionally, energy impact from water conveyance influences marginal fuel sources.

Coupling flood control, water supply, environmental restoration and protection, hydropower production and grid power system modeling, along with other economic models, will inform better operations of the CVP and SWP. Improvements to operations of the CVP and SWP will yield significant benefits to water and power resource reliability and efficiency.

Existing Challenge

Long-term planning studies and analyses are conducted to evaluate future water supply conditions, potential changes to operational rules, new infrastructure, and impacts of new regulations. Medium-term adaptive management relies on reservoir temperature and other environmental modeling to ensure environmental concerns inform operational decisions. Forecasts of water releases, pumping, and generation provide users of the CVP and SWP system with an estimate of future water deliveries and power production. Water and power operations of the CVP and SWP system are conducted continuously with some coordination.

Power production within the CVP is subordinate to water supply and environmental mitigation requirements (although equivalent to environmental enchantments) in accordance with congressional authorization of the project. Operational tools and methodologies maximize benefit to scheduling of CVP generation in the day-ahead energy market, on an hourly timestep, subject to daily water supply and environmental requirements and electrical loads of the federal power customers.

The independent processes of planning, forecasting, and operations by various agencies and stakeholders lead to siloed decision-making, which impedes overall energy-water resilience by limiting cross-sector optimization and increasing vulnerability to disruptions (due to potential competing interests or priorities).

The current monthly timestep is inadequate to evaluate impacts to hydropower-related costs and benefits. Additionally, the impacts of changes in the timing of hydropower generation dispatch on the grid are not well evaluated with current methodology.

Near-Term Opportunity (3-5 Years)

WAPA identified potential forecasting improvements through implementation of a rules-based, daily timestep model of the CVP and SWP system. Through networking and discussions within the Department of Energy (DOE) Water Power Technologies Office and the DOE National Labs, WAPA was able to identify a partnership with the University of North Carolina at Chapel Hill for application of the California Food-Energy-Water System (CALFEWS) model, which provides a rules-based, daily timestep model of the CVP and SWP system.

The CALFEWS model has now been adapted to improve generation forecasts. This work is described in the manuscript titled, “A systems-based approach for modeling and forecasting hydropower generation in California’s Central Valley Project” (expected release in fall 2025). Future work will involve fine-tuning CALFEWS assumptions for improvements in forecasting project-use pumping loads in the Delta. The upgrade using CALFEWS will have significant utility beyond WAPA’s needs. The improved CALFEWS model will also forecast water deliveries utilizing an improved representation of the interactions between hydrological variability and the evolving regulatory structure that governs joint CVP and SWP operations.

The improved forecasting model can then be converted to an operational tool in which the CVP and SWP operators provide assumptions while inflows are continually updated from the California Nevada River Forecast Center or a similar inflow forecast product. Once utilized as an operational tool, the potential as a planning tool would naturally follow. CALFEWS is well positioned to inform the water supply and grid impacts from improved operations related to: Forecast-Informed Reservoir Operations (FIRO), SGMA, Sites Reservoir, Delta Conveyance, Bay Delta Plan, Shasta Dam Raise, Adaptive Management, B.F. Sisk Dam Raise, or any other pressing study need within the California water system.

The CVP/SWP Model Predictive Control (MPC) framework has demonstrated utility to optimize releases for the full CVP and SWP system.

Together, CALFEWS and MPC provide a valuable platform for California to build and improve upon an integrated statewide framework for water and power management. This could include coupling the framework to power systems models; reservoir temperature models; flood, conjunctive use, and FIRO modeling; and various AI applications and methods.

Success Measure

A quantitative comparison between the status quo and various proposed changes to water and power metrics would allow for better-informed policy, investment, and operations decisions related to reliability and efficiency of water and power resources.

References

Zeff, H. B., Hamilton, A. L., Malek, K., Herman, J. D., Cohen, J. S., Medellin-Azuara, J., Reed, P. M., & Characklis, G. W. (2021). California's food-energy-water system: An open source simulation model of adaptive surface and groundwater management in the Central Valley. *Environmental Modelling and Software*, *141*, 105052. https://doi.org/10.1016/j.envsoft.2021.105052

Presentation, "FIRO for Multi-Reservoir Networks" by Jon Herman of UC Davis, discusses challenges and solutions for managing multi-reservoir networks using FIRO.