Improving Hydroelectric System Forecasting and Management in a Changing Climate

Kevin Richards, Matthew Meadows, Steven Glaser, Peter Hartough, Roger Balas, Martha Cankin
Pacific Gas and Electric Company, Water Management • University of California, Berkeley
University of California, Davis • Sierra Nevada Research Institute, University of California, Merced

About the project
Climate change forecasts for the Sierra Nevada show the potential for significant reductions in snowpack, as well as altered precipitation and runoff patterns. These impacts will affect hydroelectric power generation, an important part of California’s low-carbon energy mix. PG&E’s hydroelectric system has a total generating capacity of nearly 4,000 MW and relies on nearly 100 reservoirs and seasonal snowpack storage.

As part of PG&E’s climate resilience initiative, the company is working with the University of California and the California Department of Water Resources on a multi-year research project to help PG&E better understand how to continue to optimize hydroelectric generation as precipitation patterns are altered by climate change.

Using California Energy Commission funds, the research team is installing a next generation hydrologic observatory near PG&E’s North Feather River facility that integrates variable remote sensing data with a ground-based measurement network. The research will take advantage of new industry advancements in sensor technology and other factors, which will improve PG&E’s monitoring and predictive tools and reduce uncertainty in forecast results and increase confidence in climate change projections. The project will also assess the costs and benefits of using the existing water information system with physically-based forecasting, as compared to current empirically derived forecast models.

Enhanced planning and operation of PG&E’s hydroelectric system is increasingly important as the company expands supplies of variable renewable energy sources, such as wind and solar. Hydroelectric power is a flexible resource that can help integrate these variable renewable energy sources and provide ancillary services. Precipitation-runoff modeling systems help to improve the forecasting of hydrologic conditions for more precise control of available water supplies for hydroelectric generation.

Using a physically based model for mountain hydrology
Developed by the U.S. Geological Survey, the Precipitation-Runoff Modeling System (PRMS) is a distributed-parameter, physical process-based modeling system designed to evaluate the response of various combinations of climate and land use on snowmelt and general watershed hydrology. The California Department of Water Resources Snow Surveys section and PG&E’s Water Management are using the Feather River Basin PRMS to complement empirically derived methods for seasonal runoff forecasting and daily streamflow forecasting.

Sensor design and layout
The project team is deploying groups of sensors at each site in the sensor nodal to form a network to capture variability of landscape features.

Visualizing the data
The Feather River Basin PRMS employs a distributed input scheme for areal extrapolation of point observations between snowpack and surface water storage, accounting for rain, snow, snowmelt, surface water contributions, transpiration, and runoff patterns. These impacts will affect hydroelectric power forecasting, as compared to current empirically derived forecast models.

Physical vs. empirical forecasts
Physically-based models, such as PRMS, offer much promise for capturing spatially important, variability and hydrologic sensor readout that determine runoff dynamics, compared to empirically derived methods which currently are more widely used for water allocation and other hydroelectric power operational decisions.

PRMS performance
Compared to empirically derived methods, the PRMS model captures more details and generates more accurate and earlier determinations of water runoff.

Future directions
An important component of the project is quantifying the economic benefits of the new approach. This will include a comparison between the costs and benefits of current empirically derived forecasts with those of the new intelligent water information system with physically-based forecasts.

Improved predictive planning and scheduling tools may be developed to manage hydroelectric power resources on a more flexible and accurate basis, leading to earlier predictions and increased operational efficiency.

Acknowledgements
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Discussion
The new sensor installations are designed to augment how data in snow and weather are currently collected. Existing snow and weather stations sites are not spatially representative, and tend to be located in flat clearings as opposed to forested and sloped areas, which are important to measurements. Much of the North Feather River Basin is forested, and the new measurement network will sample across aspect, slope and vegetation, as well as altitude differences.

The existing measurement network also lacks data on soil moisture, and has very limited measurement of solar radiation and relative humidity. As new monitoring network data become available, the team will be able to more accurately model snowpack, snowmelt, soil-water storage, water budgets, and solar radiation—all of which may be used in PRMS calculations—to better understand results, and improve inputs to the model.

Forecasts will be improved by the availability of accurate, spatially devoted data on the multiple phases and states of the hydrologic cycle. While hydrologic models can estimate these quantities, only with accurate, spatially devoted data can one improve, evaluate and verify forecasting.

PG&E report on hydroelectric water supply to help forecasters

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