Technology Innovation Project

Project Brief

TIP 265: Computationally Efficient, Flexible, Short-Term Hydropower Optimization and Uncertainty Analysis (SHOA) for the BPA System

Context

The Bonneville Power Administration is concerned with the operation of 31 federally owned and many nonfederal projects on the Columbia and Snake Rivers, as well as their tributaries. With the many constraints and objectives, operation of the hydro system is a complex task. BPA is interested in developing a new decision support tool to guide operations and that considers many important issues, including power and environmental flows, and uncertainty in load and flow forecasts.

Moreover, the system needs to generate good proposed solutions quickly so that the proposals are useful to operators who wish to explore the implications of alternative strategies.

Description

BPA intends to build a decision support system that includes descriptions of streamflows, constraints, and demand uncertainty to optimize reservoir operations reflecting that description of uncertainty. The Short-term Hydropower Optimization and Analysis (SHOA) is an open-source short-term reservoir/river modeling system that investigates operation of the Columbia River Basin and its water management facilities. SHOA will be used to explore a range of model structures and computational procedures for addressing BPA's short-term reservoir operation challenges, including (1) use of ensemble streamflow predictions (ESP) to describe hydrologic and load uncertainty, (2) ensemble representations of load scenarios, (3) pre-computed powerhouse energy production functions, and (4) two stage Sampling Stochastic Dynamic Programming (SSDP) with a compact state-space corridor to identify the best possible operations.

The SHOA system allows the investigation of alternative stochastic optimization algorithms and uncertainty representations, and other modeling and optimization innovations, so that BPA can design a new short-term reservoir-operations decision support system that will meet needs of power, environmental conservation, and water management in the Columbia Basin.

Why It Matters

BPA anticipates significant investment in a new, short-term reservoir system operating model for the Columbia River system.

Because of the uncertainties that exists among the primary drivers of the FCRPS operation (hydrology and load-price relationships), understanding and quantifying these uncertainties and their impact on operations will allow BPA to plan, make better-informed decisions, and ultimately operate the system optimally and with appropriate analytical techniques.

This project supports the development and implementation of state-of-the-art water management software consistent with BPA's Mission and Values.

Goals and Objectives

Specific objectives include the following:

1. An optimization-based research and open-source software tool – SHOA – that would allow BPA to explore a range of short-term reservoir modeling configurations describing the joint distribution of forecasts, streamflows, and loads, and the sequential resolution of the uncertainty as successive decisions are made, focusing on methods that are computationally feasible for a 20-day modeling time horizon, and the use of ensemble streamflow predictions (ESP).
2. Develop and evaluate new algorithms for hydropower operation. The evaluation will be based in part on the results of a series of experiments that document the relative advantages and disadvantages of different approaches to optimization and to incorporation of uncertainty based on available data and ensemble predictions (e.g. for streamflow, energy market parameters, and renewable energy generation like wind input).
3. Develop metrics to quantify operational flexibility, and the reliability with which various targets and obligations can be met. Illustrate the values of different metrics via system simulation with informative graphical and quantitative summaries.
4. Explore alternative computational strategies to reduce computational requirements of optimization and uncertainty analysis of the complex BPA system.

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Project Start Date: November 7, 2012

Project End Date: April 30, 2016

Funding

Total Project Cost:	$1,528,821
BPA Share:	$708,519
External Share:	$820,302
BPA FY2014 Budget:	$273,470

Reports & References (Optional)

Links (Optional)

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Participating Organizations

Cornell University

Related Projects

TIP 258: Development of a State-of-the-Art Computational Framework and Platform for the Optimal Control of Multi-reservoir Systems Under Uncertainty

TIP 259: Short-Term Hydropower Production and Marketing Optimization (HyProM)