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

Context

Short-term reservoir planning is difficult because future load and production are highly uncertain. Wind power supply in the Federal Columbia River Power System (FCRPS) is uncertain because it depends upon uncertain wind forecasts. Hydropower production is also uncertain as it depends upon precipitation and temperature. Load also depends upon the meteorology as well as numerous non-meteorological factors, like electricity prices. One effective method for quantifying uncertainty is to use ensemble forecasts. By using ensembles, forecasters can assess the impacts of high wind/low wind scenarios and high temperature /low temperature scenarios upon the reservoir operations. While ensembles can help provide users with a range of likely outcomes, they can also offer too much and conflicting information. Integrating all the sources of uncertainty into informative decision guidance is the important leap this project will develop. BPA's current short-term planning modeling software relies on deterministic optimization techniques that do not adequately account for these uncertainties. The increasing numbers of constraints on hydro management, for example; balancing renewable energy such as wind generation, are not well described within BPA's business processes. In order to meet physical constraints, legal operating requirements and to realize business opportunities in this increasingly complex management puzzle, BPA needs to adopt more sophisticated optimization techniques.

BPA has a need to establish a reliable predictive model that integrates the meteorological uncertainty of wind power, water flow, and load demand to support more predictable power marketing.

Description

The project focuses on the integrated short-term management of hydropower production and marketing over a period of up to 20 days ahead. It develops a robust and computationally efficient framework for the real-time operation of multi-objective and multi-reservoir systems that accounts for uncertainty and operational flexibility. That includes devising a novel methodology for the incorporation of uncertainty into the FCRPS computational system, investigating hybrid optimization approaches, allowing for scalable parallelization in numerical methods and combining all components into an integrated platform with a user−friendly graphical interface.

Given a forecast horizon of up to 20 days, one major source of uncertainty in the management strategy is meteorological. Therefore, BPA hopes for intensified, restructured focus on forecasting procedures for transforming probabilistic meteorological predictions into optimized reservoir operations.

Why It Matters

More precise knowledge of future stream flow, wind reserve, and power load, with a user-friendly tool to integrate those entities, is vital to solve the multi-objective problem of reservoir management.

This project contributes to a state-of-the-art software infrastructure for short-term management of the FCRPS. It includes multi-objective deterministic and stochastic optimization techniques with a modular, open-source, computationally efficient and multithreaded IT design.

Goals and Objectives

1. Model Library: Further development and integration of a model library for the process description of hydro power production (including routing in the downstream river reaches), marketing, and energy networks or other processes if they constrain hydropower management.
2. Representation of Uncertainty: Analysis of the system's uncertainty and its description by non-parametric scenario tree methods in particular for describing the meteorological uncertainty derived from ensemble forecasts.
3. Stochastic Optimization: Design and implementation of online optimization algorithms, i.e. algorithms which run in an operational setting, both in deterministic and multi-stage stochastic mode for supporting the short-term management of the short-term planning group.
4. Operational Flexibility: Online assessment of the operational flexibility of the system by analyzing its sensitivity to constraints and related to different stream flow and load scenarios.
5. Advanced Visualization: Setup of demonstrations with a phased integration of all developed components and a focus on the proper data visualization to the operator.

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Project Start Date: October 1, 2012

Project End Date: April 30, 2015

Reports & References (Optional)

Links (Optional)

Funding

Total Project Cost:	$1,166,100
BPA Share:	$577,270
External Share:	$588,830
BPA FY2013	$109,733
BPA FY2014	$281,628*
BPA FY2015 Budget:	$178,000

* Includes accrual estimates for FY14

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Participating Organizations

Companhia Energética de Minas Gerais S.A. (CEMIG), Brazil

Deltares USA Inc, Silver Spring, USA

Deltares, Delft, The Netherlands

Fraunhofer IOSB-AST, Germany

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