TIP 342: Framework for Quantification of Risk and Valuation of Flexibility in the FCRPS

Context

Unsteady flows in rivers are typically represented by the Saint-Venant equations, a pair of one-dimensional partial differential equations representing conservation of mass and momentum for a control volume. Due to the presence of non-linear terms, the equations are often solved numerically. In a channel network involving numerous branches, the system of equations that must be solved becomes extremely large and hence computationally intensive.

Small temporal steps are often needed for computational stability and small spatial steps are often needed to achieve a high level of precision

Description

This research will create a computationally efficient framework that can quantify flexibility and its value at various levels of risk in the Federal Columbia River Power System (FCRPS).

To quantify and value the flexibility, the framework will combine statistical analysis, simulation (e.g., hydraulic routing), uncertainty propagation, investment decision concepts (options theory), and robust optimization. Besides the expected value of time varying flexibility, the upper and lower credibility bounds of flexibility for various levels of risk will be produced.

This will be accomplished through the following tasks

1. **Quantification and valuation of flexibility:** develop a framework for quantification and valuation of flexibility in the FCRPS;
2. **Quantification of risk:** includes development of regression-based models that provide quick estimates of market price sensitivity without requiring computer optimization, as well as statistical analysis on other data sets to quantify uncertainties entering the system;
3. **Flexible-robust optimization:** formulate and solve a robust optimization problem to maximize the value of flexibility, including a reduction of the number of decision variables and hybrid optimization;
4. **Visualization:** assemble an easy to understand visualization framework that illustrates the system flexibility at various levels of risk, including the robust-optimal flexibility;
5. **Integration of modules:** integrate the modules developed for each objective into the Oregon State University Optimization Under Uncertainty Model (OSU-OUU);
6. **Application to the FCRPS (ten reservoir system):** apply the integrated model to the FCRPS encompassing the big ten reservoir system.

Why It Matters

The accurate quantification and valuation of flexibility in the FCRPS system will allow BPA to efficiently control hydropower generation, which in turn will reduce the probability of purchasing or selling energy on the market at prices unfavorable to BPA and maximize the probability of higher revenue.

Additionally, this research will provide guidance to BPA on when to optimally move electricity generation from one period to another, which would allow BPA to maximize revenue while fulfilling its obligations as a regulating agency.

Goals and Objectives

The research has six objectives listed above that build upon each other with the ultimate goal of producing a computationally efficient framework that can provide fast results of flexibility and its value at various levels of risk.

Deliverables

The following deliverables will be made available to BPA

- A copy of the developed computer model (compiled model and source code) and user's manual containing tests on stability, accuracy, and CPU time compared to other algorithms. .
- A final report in electronic format and printed copy. This report will include a section with next steps for the project or potential follow-on projects. This report will also include the application to the FCRPS encompassing the ten reservoir system.
- An electronic copy of journal and conference papers that will result from the proposed research.
- A formal close-out meeting will take place at the end of the project. The PIs will present a summary of the deliverables, lessons learned and suggested next steps.

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Project Start Date: October 1, 2015

Project End Date: September 30, 2018

Reports, References, Links

Related Projects

TIP 258: Development of a State-of-the-Art Computational Framework and Platform for the Optimal Control of Multireservoir Systems under Uncertainty

Participating Organizations

Oregon State University, (OSU)

Funding

Total Project Cost:	$2,380,000
BPA Share:	$1,190,000
BPA FY2017 Budget:	$393,000

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