Technology Innovation Project

Project Brief

TIP 254: Multi-Unit Optimization of a Hydropower Powerhouse, New Computational Methods for Unit Selection and Load Sharing

Context

The least expensive way to add power to the BPA grid is to adjust assets that are already online to make them more efficient. Hydropower is the largest of BPA's present resources; therefore, any verifiable improvement that maximizes hydropower delivery is hugely significant. This project provides software -- an algorithm -- that rapidly solves real-time models of the hydro projects in the Columbia River system. It uses empirically gathered flow vs. power data for each turbine in a powerhouse, and with a high degree of accuracy determines individual unit set points and unit selection that will provide maximum overall efficiency, with astounding speed of solution -- within a few seconds, or even less. That means additional power for the same amount of water. It also provides increased life for generating units and increased survivability of downstream migrant fish passing through turbines. The program has already been demonstrated to compute a solution as intended. Therefore, the remaining portions of this project have a similarly high probability of success.

Description

This is a one-year project to further develop an optimization algorithm for hydroelectric powerhouses. The goal is to provide proof of concept on an active hydro project, develop a graphical user interface for the powerhouse operator, and increase the software's feature list. The end result will be a commercial solution for flow-to-power optimization. Students from The Oregon Institute of Technology's (OIT) Advanced Hydropower class and follow-on independent study classes created an algorithm that optimizes unit selection and load sharing for the entire range of power output in a multiunit hydroelectric powerhouse. Data from The Dalles Dam has been used to validate the program, and it has been shown to match the best hand calculation by a professional engineer. It is faster than any similar program to date, thanks to an optimization method that offers a more direct solution than the other iterative solutions presently in use. Now the direction is to commercialize the program by comparing the program solution against actual hydroelectric power plant operations. Taking a nonintrusive approach, operating points will be compared with a real powerhouse. The program can be used to validate operator set points against a perfect solution.

Why It Matters

According to a BPA study done by Harza Engineers, Inc., about 18 years ago, "Hydropower optimization provides the lowest cost energy available from any generating resource." Further, this additional energy is firm energy. Example: "In good water years, the Columbia River Basin hydro system can produce about 18,000 average megawatts of electricity, and in poor water years, as little as 11,700 average megawatts" (excerpt from http://www.nwcouncil.org/library/2007/2007-12/power.htm). Consider that at the very minimum this software generates a system-wide, average improvement of 1%. That would amount to 1165 GWh/yr of additional energy, and additional annual revenue on the order of $81,527,727, assuming $70/MWh -- an astounding return for very little investment.

Goals and Objectives

1. Identify a hydropower project for index testing, and collect data
2. Manually determine optimal load sharing and unit selection, for low, medium (if possible), and high head
3. Validate the computer algorithm using the hand-calculated results
4. Modify script to incorporate more features: curvilinear interpolation, block loading, alarms
5. Develop a graphical front end for stand-alone use and also demonstrate as a SCADA solution
6. Documentation, operational instructions, and operator training. Explore commercialization.

Deliverables

1. Updated and modified Type 2 hydropower optimization software
   a. Ownership of previous code is protected. However, the newest version containing all necessary useable code will be made available for use
   b. Several formats/ programming languages available including Web-based program and executable files
   c. Includes user-friendly graphical user interface (GUI)

2. Systematized hydropower optimization, Methodology Type 1 and Type 2
   a. Includes training personnel from BPA and from selected dam
   b. Includes operator manual
3. Standard deliverables as expected by BPA including but not limited to the following:
   a. All supporting data in an electronic format acceptable to BPA
   b. Expected functionality and support of any hardware and/or software as applicable along with full documentation of its use and repair, as acceptable to BPA
   c. Expected performance standards
   d. How the proposed project will be integrated into BPA's Power Delivery System
   e. How established utility processes and procedures will be affected
   f. Appropriate testing and/or evaluation methodology if applicable
   g. A final report including next steps for the project or potential follow-on projects.

Project Start Date: January 2012

Project End Date: September 2012

Funding

Total Project Cost:	$208,695
BPA Share:	$100,673
External Share:	$108,022
BPA FY2012 Budget:	$100,673

Participating Organizations

Oregon Institute of Technology Hydropower Group

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