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Final Copy of Case Study

Status:
Laureate

Year:
2013

Organization Name:
The Energy Authority

Organization URL:
www.teainc.org

Project Name:
Hydroelectric Optimizer System

Please select the category in which you are submitting your entry:
Sustainability

Please provide an overview of the nominated project. Describe the problem it was intended to solve, the technology or approach used, how it was innovative and any technical or other challenges that had to be overcome for successful implementation and adoption. (In 300 words or less.)

In the Pacific Northwest, approximately 80% of electricity comes from clean, renewable, low-impact hydropower. Managing hydropower involves several factors, especially the complex aspects of power scheduling. The Energy Authority (TEA) supports nine Public Utility Districts (PUDs) in this area by providing hydro optimization services. These PUDs are part of the Bonneville Power Administration's (BPA) control area, using hydropower from the Columbia River Federal Hydro System through BPA's "Slice of the Hydro System" (or Slice) contracts, which require adherence to numerous operational, environmental, flood control, and recreational constraints. Utilities must process these constraints in real time and submit feasible schedules detailing the energy extracted hourly from each of six Columbia River hydroelectric facilities over a multi-day scheduling window. Utilities face significant fines for violating constraints. The short time span to generate feasible schedules and the imperative to maximize the value of their hydro resources present additional challenges. TEA met this challenge by developing the Hydroelectric Optimizer System software application (Hydroelectric Optimizer), which

creates virtual simulations of the Columbia River hydroelectric system and incorporates dynamic programming (global mixed-integer linearization) to generate optimal feasible schedules. The virtual model must address a wide variety of hydro constraints (such as hourly water flow, salmon migration, and flood-control mechanisms) in a way that yields feasible schedules with the highest economic value to the utility. By performing linear optimization on a set of non-linear functions to derive a unique set of optimal feasible schedules within the constraints set by BPA, the Hydroelectric Optimizer calculates approx. 176 different hydrodynamic and electrical constraints from six dispatchable dams for each hour over a 10-day period (~250,000 variables) in under three minutes. The model's high-speed, thorough analysis and accuracy allow the highest value to be extracted from this renewable resource.

When was this project implemented or last updated? (Please specify month and year.) Has it incorporated new technologies and/or other innovations since its initial deployment? (In 300 words or less.)

The Hydroelectric Optimizer was fully implemented in October of 2012. The objectives behind the project were to manage hydroelectric resources within the contractually defined hydro constraints, maximize the financial value of this resource, and meet the accuracy and timing needs of real-time energy trading. While automation was an important step in the system's efficiency, it also had to be flexible enough for schedulers to assess the changing conditions for thousands of variables and make appropriate adjustments to optimize the hydropower resource without violating BPA's parameters. This speed was achieved through two innovative mechanisms. First, the highly non-linear equations that calculate hourly variable solutions were replaced with linear functions. This effectively converted a non-linear problem into a linear problem (increasing speed of the solution) with appropriate finite elements to maintain accuracy. The second mechanism involved minimizing the time span for which an optimal solution is calculated. For each hour, BPA requires feasible solutions to be submitted for the next scheduling hour as well as the upcoming 240-hour (10-day) period. A fully feasible 240-hour optimal solution still took over two minutes to complete. Real-time trading operates on an hourly cycle, so traders must perform a number of trading, scheduling and reporting tasks within a strict one-hour time frame. To speed up performance, the Hydroelectric Optimizer optimally solves for the initial 24 hours (a process which takes only a few seconds) of a schedule, simultaneously "stitching" the feasible 0-24 hour schedule into a fully feasible 25-240 hour optimal schedule. The software imposes additional constraints so the 25-240 hour schedules are not allowed to vary from the previous 10-day feasible schedule, allowing fully feasible 240-hour optimal solutions to be created in seconds as opposed to minutes or tens of minutes.

Is implementation of the project complete? If no, please describe the project's phases and which phase the project is now in. (In 300 words or less.)

Although the evolution of the tools and techniques created to enable the delivery of these services will continue, this project is complete and the nine original public power utility districts are realizing the benefit of having the Hydroelectric Optimizer to manage and optimize the value inherent in the new Slice contracts. In addition, TEA has been able to expand the availability of this tool in a software-as-a-service model that enables

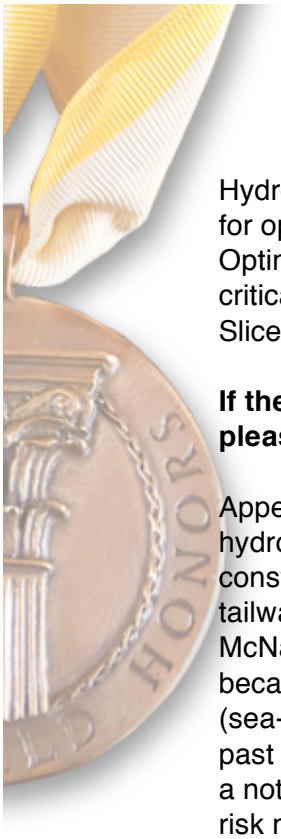
other public power utility districts to self-manage their Slice resources while benefiting from the tools created by TEA.

Please provide at least one example of how the technology project has benefited a specific individual or organization. Feel free to include personal quotes from individuals who have directly benefited from the work. (In 300 words or less.)

"Climate change is leading state and national governments to place new requirements on electric utilities. Franklin PUD chose the Slice product to provide the flexibility it needs to help respond to these changing requirements. Slice enables Franklin PUD to integrate new renewable resources in the most reliable, cost-effective manner possible for the benefit of its customers. Without TEA's Hydroelectric Optimizer, and the economies of scale that it provides, Franklin PUD would not be able to utilize the Slice product, and the impact of responding to these requirements on small, locally-owned utilities such as ours would be much higher." Energy planners and traders can run the Hydroelectric Optimizer under hypothetical scenarios several times each hour to determine how the system can respond to a variety of energy usage plans, and adjust their resource management decisions accordingly to ensure optimized, efficient power generation. Forward traders use the Hydroelectric Optimizer to shape water from one day to the next, effectively capturing economic value as market and river conditions change. Resource planners use the Hydroelectric Optimizer to more accurately assess the state of the hydro system and determine the amount of Slice power that should be delivered to the electric system in conjunction with non-Slice generated power for each of the nine utilities, thus managing the uncertainty inherent in the massive Columbia River drainage system and its tributaries. This drastically improves reliability when guiding river operations. These support functions are vital to utilities looking to provide their rate payers with stable, reliable, renewably sourced power – all at the lowest cost possible.

Would this project be considered an innovation, a best practice or other notable advancement that could be adopted by or tailored for other organizations and uses? If yes, please describe that here. (In 300 words or less.)

The ability of the Hydroelectric Optimizer to interface with and incorporate data from other commercially available scheduling systems is a notable advancement of current hydro scheduling and trading technology. Automated resource planning and management tools combined with global linearization and mixed-integer linear programming create an innovative solution for river system dispatch and scheduling that also conforms to real-time hourly, physical, environmental and recreational constraints. The Slice Optimizer can be modified to address the needs of other Slice utilities in the Pacific Northwest. The innovative software programming techniques could be adapted to provide precise, accurate, and optimized hydropower management in other regions of the world that rely on this type of renewable resource for sustainable, low-cost electricity production. Appendix 1 demonstrates the innovation behind the easy end-user interface. In order to be able to analyze so much data and make it intelligible within the application and within the allotted time windows, the software allows the user to build and save filters to limit the amount of data being displayed at one time, and to load those filters into tabs to enable quick switching between filters. The Hydroelectric Optimizer also provides the capability to select certain schedules and chart them. Appendix 2 illustrates one embodiment of the Hydroelectric Optimizer subsystems and data workflows. The



Hydroelectric Optimizer is completely database driven. Data are stored in the databases for operation, reporting and analytic purposes. The two highlighted subsystems, the Slice Optimization and Simulation and the Resource and Portfolio Management, are the two critical components of managing the Slice contract. These can be customized for any Slice contract utility, with implications for international hydro systems as well.

If there are any other details that the judges should know about this project, please note them here. (In 300 words or less.)

Appendix 3 demonstrates one example of how the software simulates 3D models of hydro system variables that are used to generate schedules that conform to BPA's constraints. This particular image shows a 3D graph of the function used to model tailwater (the sea-level height of the water immediately downstream of a dam) at the McNary Dam. Tailwater constraints are some of the most difficult to deal with, primarily because tailwater value is calculated with a highly non-linear function of the forebay (sea-level height of water behind a dam) and discharge (the amount of water flowing past a dam in a particular hour) of a downstream hydro project. The Energy Authority is a not-for-profit instrumentality of public power serving the wholesale energy trading and risk management needs of public utility districts and municipal organizations across the United States for over 15 years.