

# Buena Vista!

*Bonneville Power Administration has invested in a state-of-the-art modelling system that will boost its operation of Columbia river hydro schemes in the US*

**T**HE Bonneville Power Administration (BPA) operates the Federal Columbia River Power System (FCRPS) under multiple objectives, including power, fishery, flood control, recreation, the environment and navigation. The multiple objectives place significant constraints on the operation of the FCRPS. BPA is committed to operating the system in a manner that maximises efficiency and power generation and achieves its business objectives while meeting all other constraints and non-power objectives.

The Pacific North West Regional Power System has a total capacity of nearly 41,000MW (excluding reserves, maintenance and transmission losses). Of that figure, the federal projects have an installed sustained peak (hydro) capacity of 20,475MW, of which approximately 6700MW is firm hydro generation. About 70 different hydro projects are modelled with varying complexity and 45 types of system constraints need to be monitored.

In late 2000, BPA selected Acres Productive Technologies of Ontario, Canada to implement the Vista decision support system to meet their growing needs with regards to efficient operation of the FCRPS. The project comprises significant enhancement of Vista and implementation for the FCRPS; and will yield a state-of-the-art modelling system under the name Columbia Vista.

The main objectives of the project were to:

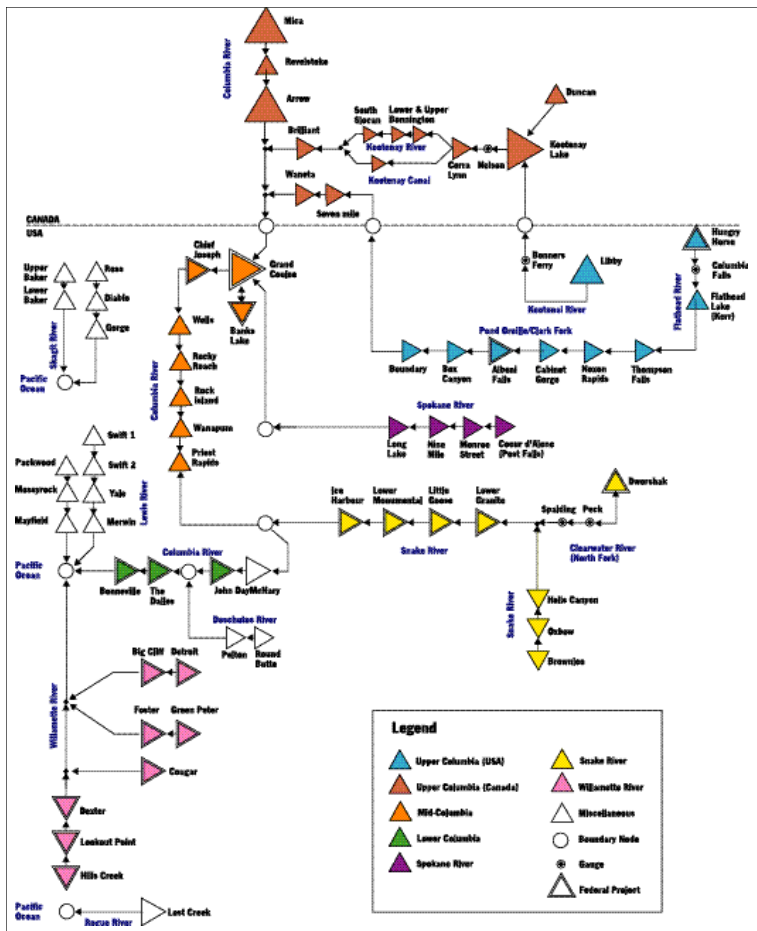
- Improve the quality of studies and data inputs that are used by the models.
- Improve the accuracy and timeliness of model output and sensitivity studies.
- Provide a user friendly environment.
- Compile multiple models into a single model with a common operating platform.
- Add the ability to optimise the generation products.
- Improve the quality and quantity of information available to the hydro projects.
- Improve the tools that O&M managers use to operate and maintain the projects.
- Improve the ability to calculate risks and market generation products.

The schematic diagram above outlines the entire FCRPS system including all rivers, projects and inflow points.

## COLUMBIA VISTA MODULES

Columbia Vista comprises the following models:

**Data Vista**, which enables data input, review and editing.  
**LT Vista**, a long term generation scheduler, guides long term storage management and transactions. LT Vista captures physical and operational constraints imposed on each hydro

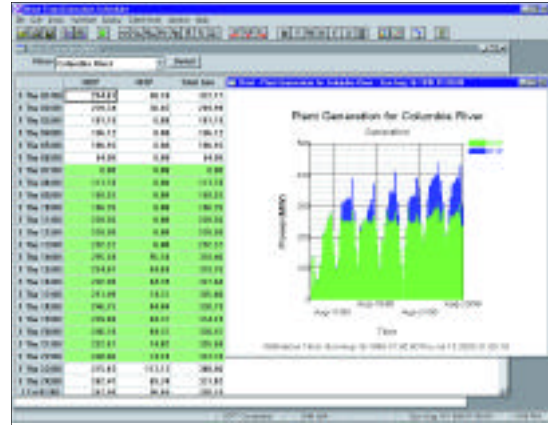


A schematic diagram outlining the entire Federal Columbia River Power System, including all rivers, projects and inflow points

system, including storage and plant facilities as well as environmental constraints relating to flow water level and power limitations. LT Vista produces reservoir release plans, hydro production and transaction plans and reservoir trajectories. Results are then stored in the database. The model employs a variable length time step over the planning period in which each time step can be any multiple of 1-d.

**ST Vista** is a short term generation scheduler which directs hourly load dispatch of all generating or pump-generating units. ST Vista schedules hourly generation by plant and unit as well as reservoir storage and releases. Spill discharge and water elevation trajectories for reservoirs and headponds are also determined. The objective is to minimise cost and maximise value of reservoir releases or energy generation in the specified period, while meeting all physical and operational constraints imposed on hydro system operations. ST Vista is linked to LT Vista in that target weekly storage releases and the marginal value of water are determined in LT Vista. ST Vista in turn determines the optimal short term schedule.

**Inflow Vista** predicts inflow to all sub basins on an hourly



basis over the next two weeks (used as input to the ST Vista) and on a daily basis over the next two years (used as input to the LT Vista).

**RT Data Vista** enables access to real-time data and associated review, while **Report Vista** enables the user to develop customised user interfaces and reports, accessing any Vista variable.

**Load Vista** enables definition of system load forecasts and associated review. **Xchange Vista**, a transaction module, provides facilities for defining and reviewing transaction contracts.

**AUTO Vista** is a historical simulator which simulates system response for a range of hydrologic inputs for defined physical and operational constraints. AUTO Vista simulates the operation of the system over a user-defined historical period, using operational procedures analogous to those used in actual practice.

AUTO Vista uses LT Vista periodically to guide long-term water management, and then ST Vista to dispatch generating units on an hourly basis over the selected period to yield realistic time series of water levels, discharges and power output. Traditionally, simulations of the system operation are used to define the water level, flow and power regime for a status quo scenario, and then for alternative scenarios. The differences between the base case and scenario results are then attributed to the changes in input to the model.

This simulator enables the analyst to define physical effects that would result from operational changes that are being considered as a potential mitigation measure, to better balance power benefits with other uses of the water resource. It is also very useful in studying mid-term issues such as the impact of current decisions on reliability of supply during the winter period – the so-called cold snap study.

## HYDRO SCHEDULING AND PLANNING

There are numerous hydro scheduling and planning model features that are influential on the Federal Columbia River Planning System. These features are discussed below.

### *River and reservoir routing*

The routing of water between reservoirs is captured in sufficient detail to enable the determination of optimum water management schedules. To perform this rigorously, hydrologic river routing (Muskingham-Cunge method) has been incorporated explicitly into the optimisation/simulation model.

### *Hydro plant modelling*

Complicated layouts for hydro plants and pump generation stations (PGS) can be represented accurately accounting for net head (headwater minus tail water and head losses), unit characteristics and water control structure characteristics.

### *Scheduling and planning constraints*

Columbia Vista has a large number of constraints to

Above left: a screen capture from Data Vista. Above right: typical tabular and graphical outputs of ST Vista. Seven days of historic operations values are also included in the output.

represent restrictions to operational conditions for water levels, flows and generation such as: rule curve constraints, fishery issues and storage adjustments.

### *Pumping operation*

The formulation allows the definition of a variety of turbine machinery including generating units, pumping units and combined PGS units. The formulation is general in that any combination of unit types can be defined at any power plant in the system. By allowing the definition of the different turbine machinery within the formulation, the models can optimise the combined operations of the different unit types on an hourly basis over a weekly time frame. The optimal operations will outline the generation/pumping schedule over the weekly planning horizon, which will have the greatest economic benefit, while adhering to all the prescribed operating constraints.

### *Transmission zones*

Columbia Vista is a multi-area model, meaning that physical facilities are associated with geographic regions, within which there are no transmission constraints. The HV transmission network in the system connects the various regions which are isolated to some extent from the surrounding regions due to limited transmission capacity. Generation facilities, transaction opportunities and system loads are associated with individual regions. Each region is assumed to have a regional bus and the HV transmission system interconnecting each region is represented, as well as radial interties from the system to neighbouring power sector entities. The HV line limits are defined in a multi-area representation model to ensure that generation schedules obtain an optimal dispatch schedule between generation, transactions, and system load of many interconnected regions subject to congested load paths between these regions.

### *Ancillary services*

Columbia Vista schedules generation on the basis of real power in MW, as well as consideration of reactive power (RP) capabilities of the hydro generating units.

### *Reserves*

There are various types of reserves on the Columbia River Power System such as: spinning, supplemental, operating and regulation reserves. Spinning reserves for each regional load bus can be specified within Columbia Vista as a constraint to the generation dispatch, and the associated schedule will provide the degree of reserve physically possible. The supplemental reserve can be displayed in a user interface as per the spinning reserve. Operating reserve is the total unloaded generating capacity that can be deployed.

There are three stages of real time trading: modelling, opportunity and evaluation. The LT and ST scheduling

engines of Columbia Vista are formulated to enable the consideration of buy and sell transactions. The opportunities are defined in Xchange Vista, and the optimum utilisation of the opportunities is undertaken as part of the optimisation process.

#### Forward marketing and trading

The concept of surplus and deficit open transaction contracts is also implemented in the LT Vista module for evaluating/monitoring the projected energy inventory in periods over the mid term and long term horizon. These inventory results (excess capability beyond forecasted system load and committed futures contracts), allow the Forward Marketing and Trading group to focus on inventory projections in great detail. Such surplus/deficit values would inherently reflect the hydro system flexibility which allows energy to be moved from one period to another through reservoir storage. The ability to move energy from low values periods to high value ones would be limited by all operational constraints and physical capabilities.

#### Project selection of hydro independents

Columbia Vista has the facility to turn on and turn off portions of the system (including reservoirs, spill channels, power conveyances and river channels) and to define several system configurations that include different groupings of active facilities.

#### Simulation and optimisation models

Columbia Vista employs Optimisation as the primary tool, with the objective of maximising system benefit, although the schedules are subject to all of the operational constraints. Pure simulation is also employed in the short term scheduling exercise. After an optimisation run is executed, the operator may wish to revise the schedule to quickly respond to a change in conditions, or to smooth out the theoretically optimum schedule. The operator can modify or adapt the generation schedule by editing the megawatts by hour, target water level, target flow rate, then simulate to refresh the resultant water storage and releases according to the new generation schedule.

### MODEL INPUTS FROM BPA

There are numerous inputs to Columbia Vista. For stream flow monitoring and forecasting, real time data and inflow forecasts are loaded from a BPA-controlled SYBASE database. Short term inflow forecasts up to 14 days ahead are disaggregated and stored in hourly format. Long term forecasts, extended stream flow predictions (ESP) and synthetic flows will be disaggregated and stored in a daily format.

The load forecast data requirements of long and short term schedulers are different, due to the different time steps and scheduling horizons. The short term scheduler employs an hourly time step and requires a forecast of hourly load for up to two weeks into the future. On the other hand, weekly and/or monthly time steps are used in the long term scheduler and the schedule horizon can be as long as several years. To avoid multiple data definition, hourly load forecasts are generated and stored, and processed in LT Vista, as required, based on the LT study definition.

Firm or fixed interchange loads are defined as loads, but others as transactions using the Exchange module. By defining transaction opportunities, the long and short term schedulers can be used to determine optimum transaction schedules. Once



The types of LT Vista reports are grouped as seen in this screen capture.

transactions have been negotiated they are firm-up and become part of the firm load.

For price forecasting Columbia Vista is formulated to maximise net revenues, which is benefit minus cost, subject to market availability and resource capability. Benefit is defined by revenue from generation, and cost is defined by payments for energy purchases. Both of these are based on the user-defined value of energy for each defined market and transaction. Fundamental price forecasting is undertaken by BPA external to the model, and is automatically accessed continuously by Columbia Vista. Currently, prices are defined on an hourly basis over the entire planning horizon, and Vista processes those as required for the scheduling models.

For each generating unit, outages are defined using a date range (from and to date) and a factor between 0 and 1. The outage definitions are then used by both scheduling modules and processed into availability factors for each time step. Users can define several outage cases and build study scenarios using the various outage cases.

### HYDRO SCHEDULING

Columbia Vista has extensive reporting capabilities in all modules, including tabular and graphical outputs. The predefined tabular outputs cover all variables used as input or computed by the model. All tables can be printed or exported to electronic format, and are activated with Windows editing functions, such as copy and paste.

BPA operates its business from Vancouver Washington, and Portland Oregon. It utilises multiple networks with varying levels of security, which can make it difficult to move data to where it is needed. Acres' Vista has been able to work within these constraints and utilise database replication techniques that will allow maximum uptime with little or no user downtime or administrative intervention.

This 'no single point of failure' model uses multiple sets of servers consisting of database, application, and terminal servers. Separate long term and sort term systems have been identified to minimise performance impact on the more processor intensive short term application.

### IMPROVING EFFICIENCY

The development and implementation of Columbia Vista is a major component of BPA's overall Efficiencies Improvements Plan. Columbia Vista will be fully implemented in BPA's Portland offices by the middle of 2002, and is expected to improve the efficiency of hydroelectric generation and power transactions. Columbia Vista will also play a strategic role in integrating near-real-time optimisation initiatives that are under way.

BPA and the Federal project owners, the Corps of Engineers and the Bureau of Reclamation are faced with multiple competing objectives on a daily and seasonal basis. BPA anticipates that Columbia Vista will be a significant tool in planning and meeting these objectives in a cost efficient manner. IWP&DC

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