Integrated Resource Plan

Appendix

4C

Resource Planning Models

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1 Introduction

BC Hydro made use of several models in carrying out portfolio analysis for the 2013 Integrated Resource Plan. The resource portfolios were assembled using the System Optimizer (**SO**) model. The Hydro Simulation (**HySim**) model provided input data to SO regarding the monthly generation patterns of BC Hydro's large hydro facilities. The Multi Attribute Portfolio Analysis (**MAPA**) tool was used in calculating the environmental and economic attributes of several portfolios assembled using SO. A brief description of the suite of models follows.

2 Hydro Simulation Model

The HySim model is a system simulation and production costing model developed in-house by BC Hydro. It operates on a monthly time-step to simulate the operation of a given resource portfolio and includes a simulation of market imports and exports. HySim models system operations over a 60-year period of historical water inflows to determine a least cost generation pattern to manage year-to-year variability of reservoir inflows. Detailed logic unique to the BC Hydro system, such as Columbia River Treaty requirements and environmental and social constraints imposed on reservoir operations, has been incorporated into HySim. The average generation pattern of BC Hydro's large hydro facilities, as simulated by HySim, is fed as input to the SO model.

3 System Optimizer Model

SO is a mixed integer programming optimization model developed by Ventyx (formerly Global Energy Decisions, Henwood) and has been adopted by several utilities in North America to aid in the development of resource plans. SO selects an optimal generation and transmission resource expansion sequence given a set of input assumptions (e.g. load forecast, schedule of Demand-Side Management savings, natural gas and electricity prices, available resource options) and constraints (e.g. transmission line limits, annual hydro generation profile). The model minimizes the present value of costs, including the incremental fixed capital and operating costs for new resources and trade revenues to meet a given domestic load forecast net of DSM savings.

The SO model has three primary components: the objective function, decision making variables and constraints.

3.1 Objective Function

The model objective in developing an optimal portfolio is to minimize the present value of the portfolio cost. The cost items that are considered by the model include:

- Operating costs of new and existing generation and transmission assets such as variable and fixed operating costs, fuel costs and emission offset costs
- Capital costs of new generation and transmission assets
- Cost and revenue related to trade with external electricity markets such as electricity purchase costs, sales revenue, wheeling costs, and revenue from the sale of Renewable Energy Credits

3.2 Decision-Making Variables

Decision-making variables are model parameters, the values of which are changed in order to arrive at the optimal portfolio. The variables include:

- New generation assets selected and their timing
- New transmission assets selected and their timing
- Energy generation by station and time period
- Energy transfer through transmission paths, by time period
- Market purchases or sales, by market zone and time period

3.3 Constraints

The constraints place limits on the changes that could be made to the decision-making variables in arriving at an optimum solution. The constraints include:

- Energy and capacity load/resource balance
- Minimum and maximum capacities of generating stations
- Energy generation limit for energy-limited generators such as hydroelectric facilities
- Transfer capability of transmission lines
- Sequential stations investment constraints (e.g., all units of A must be built before first unit of B)

3.4 Model Topology and Inputs

The BC Hydro system is modeled as a set of transmission regions within SO. These regions represent major load or generation centres of the Province, such as the Lower Mainland, Vancouver Island, and the Peace River region. The forecasted load after DSM for each region over the modeling period is fed as input into the model. The load used varies with the forecast (e.g., mid load, high load, low load) and with the DSM option used for the scenario being analysed. The Alberta and U.S. Mid-Columbia electricity markets are also modeled as separate regions. A forecast of the electricity prices and REC prices for these regions are input to the model. Natural gas and Greenhouse Gas offset cost forecasts are among the other inputs to the model. The existing generation stations within the regions, as well as future generation resource potential, are also modeled with characteristics such as capacities and monthly energy limits as input.

The transmission paths between the regions complete the model topology. Capabilities and losses of existing transmission paths and the transmission resource options available to extend the capability of the paths or create new paths are provided as inputs.

The use of SO allows BC Hydro to take into account characteristics of resources beyond the Unit Energy Cost or Unit Capacity Cost merit rankings of resource options. The current analysis allows the optimal selection of the resource options that best complement the existing system and its constraints. SO takes into account the contribution of firm energy and dependable capacity from a resource. It takes into account the total or average energy produced and the monthly profile of this energy and the trade implications of adding resources. The modeling of the bulk transmission system allows selection of resources that are located favourably in terms of transmission losses and constraints.

4 Multi Attribute Portfolio Analysis Model

The MAPA tool is a spreadsheet-based model, which tracks costs, environmental and economic attributes of portfolios constructed by SO. It has been developed in-house by BC Hydro. MAPA gathers relevant attribute details of all supply-side resources, transmission projects, and DSM programs in a portfolio from the resource options database and performs calculations and scaling to derive environmental and economic attributes for the portfolio. It does so over the planning period being analyzed.