2008 Long Term Acquisition Plan

BC hydro

APPENDIX F15

Resource Planning Models

Table of Contents

1.1 Overview of Portfolio Analysis Modelling

The resource portfolios in the 2008 Long-Term Acquisition Plan (**LTAP**) were developed using a resource planning tool known as the System Optimizer (**SO**) model. This model selects an optimal resource expansion sequence of generation and transmission additions for a given set of input assumptions (e.g. load forecast, schedule of Demand Side Management (**DSM**) savings, natural gas and electricity prices) and constraints (e.g. transmission line limits, annual hydro generation profile). The model minimizes the present value (**PV**) of costs, including the incremental fixed capital and operating costs for new resources and total system production costs (inclusive of trade revenues) to meet a given domestic load forecast net of DSM savings.

In previous resource planning work, BC Hydro utilized the internally-developed Hydrological System Simulation (**HYSIM**)/Multi Attribute Portfolio Analysis (**MAPA**) models to construct and analyze resource expansion sequences. The HYSIM/MAPA combination is not an optimization model and expansion sequences were manually developed and optimized by iteration. However, HYSIM/MAPA has the capability to model detailed operation of major hydroelectric reservoirs on the BC Hydro system under a range of streamflow conditions. The HYSIM/MAPA model has been utilized in the 2008 LTAP for the rate impact analyses, and to provide a consistency check on results from the SO model for selected sequences. In addition, the capability of HYSIM to model the existing BC Hydro hydro-generation system in details was used to provide average monthly hydro generation budgets that were used as inputs for SO.

The primary function of the SO model was to provide an objective way of selecting optimal resource expansion sequences while using the hydro generation budgets input from HYSIM. HYSIM was used to perform the detailed multi-year inflow sequence system simulation.

The concepts used to develop the SO and HYSIM/MAPA models are different. As an optimization model, SO is generally more sophisticated than HYSIM, which is a simulation model. It provides more information on the optimal portfolio selection than the HYSIM/MAPA. The SO provides an optimal portfolio in terms of when, how much and what type of new resources to build along with the optimal costs. The HYSIM/MAPA combination takes the when, how much and what type as an input datum and calculates the portfolio costs and provides the generation distribution in terms how much is generated by the hydro and thermal parts of the system and how much energy is imported and exported.

The purpose of this Appendix is to present major features of the models used for the LTAP analysis.

1.2 System Optimizer Model

SO is a linear and mixed integer programming optimization model whose major characteristics are:

- it was externally developed by Ventyx (formerly Global Energy Decisions, Henwood) - it is a widely recognized decision making support optimization model for energy planning

- Determines when, how much and what type of new generation and transmission resources to introduce, i.e. optimal portfolio (set of selected resources)

- Provides the least PV cost portfolio that satisfies technical, social, environmental, and economic constraints

- Selects the optimal portfolio among the numerous combinations of available resource options

- Provides the comprehensive information needed to answer questions required by the risk framework – determines optimal portfolios for selected risk scenarios to address uncertainties such as gas prices, loads, DSM savings)

- Analysis based on a single average inflow year (generation) for the hydro part of the system

- Uses average monthly hydro generation data provided by HYSIM as an input

- Analysis for capacity and energy are based on three daily load periods (light load hours, heavy load hours and peak load hours), two weekly periods and number of months within the planning horizon.

SO considers the resource portfolio from a planning perspective (meeting the firm energy and dependable capacity reliability constraints), as well as its operating performance under average generation conditions. The planning criteria require that the firm energy of the resource stack be sufficient to meet total energy while the dependable capacity of resources is sufficient to meet peak load including an allowance for the reserve margin. The production costs for the portfolio are also optimized under average generation conditions, inclusive of trade revenues. The portfolio that is selected by SO for a given set of input assumptions, is the optimum that meets the planning criteria and at the same time minimizes the PV of total capital, operating and production costs.

The use of SO allows BC Hydro to take into account characteristics of resources beyond the Unit Energy Cost (**UEC**) or Unit Capacity Cost (**UCC**) merit ranking used in previous methodology (i.e. resources with the lowest UEC and UCC were picked manually in the portfolio analysis to fill the energy and capacity gaps, respectively). 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 also takes into account the total or average energy produced and the monthly profile of this energy. The bulk transmission system is also modeled in terms of path capacity limits and line losses. This allows selection of resources that are located favourably in terms of transmission losses and constraints.

1.3 HYSIM/MAPA Models

Previous resource planning work by BC Hydro has employed the combination of the HYSIM and MAPA models. The key features of each of these component models are discussed below.

1.3.1 HYSIM

- System simulation and production costing model developed in-house.

- Operates on a monthly time-step to simulate system operation under a single user-selected portfolio (sequence of selected resource options) by determining the annual energy generation and production costs of the selected portfolio in meeting monthly energy loads over the planning period, inclusive of trade transactions (i.e. imports and exports from external markets).

- Does not have the capability to select the optimal portfolio of new resources, the portfolio to be modelled is an input.

- Simulates system operation with year-to-year variability of reservoir inflows over a 60-year period of historical record to determine the effect of reservoir operating flexibility on the system production costs (while meeting load and satisfying environmental and social constraints imposed on reservoir operations).

- Models transmission line limits between BC and bordering jurisdictions (Alberta and Washington), but does not model the internal transmission line capacities. The load is increased by 7% to cover the transmission/distribution losses within BC.

- HYSIM generation related outputs (e.g. energy generation and production costs) are used as an input to MAPA.

In summary, HYSIM simulates system operation taking into account the year-to-year variability in reservoir inflow conditions and the energy storage capability of the system. HYSIM is used to determine the expected annual energy generation (dispatch) of resources in the user defined portfolios, along with expected imports and exports.

The expected generation quantities obtained from HYSIM for each load year, along with gas and electricity price forecast data, is used to calculate the annual variable operating costs of gas-fired resources, the cost of imports and the revenues from exports. The expected generation from the hydroelectric system is used to calculate variable costs, which are predominantly water rentals. HYSIM models the transmission and generation constraints on imports and exports in two ways:

- Transmission line limits at the neighbouring jurisdictions of Alberta and Washington State - represented as monthly import and export energy transfer limits during heavy load hours (**HLH**) and light load hours (**LLH**) respectively; and

- Minimum generation constraints for minimum flows required to support fish, reservoir levels for non-power requirements, and generation stability.

- There are some transmission and generation constraints that are not captured by HYSIM, including:

  - Transmission voltage support, which restricts LLH imports in the spring;

  - Transmission path constraints in B.C., such as the Interior-to-Lower Mainland transmission capability, which restricts HLH exports in winter; and,

  - Daily load profile which will restrict capacity available for export in heavy load hours (i.e. when export prices tend to be highest).

  - Requirements for operating reserves and impacts of forced outages which will limit capacity available for dispatch.

As a result of the above limitations, HYSIM likely overestimates the benefits of trade, particularly when there is a large surplus of energy on the BC Hydro system.

1.3.2 MAPA

MAPA is a spreadsheet-based model which performs discounted cash flow (economic) analysis and the tracking of portfolio attributes. MAPA gathers costs and attributes details of each project from a database that contains data for all of the resource options. MAPA imports from HYSIM, production costing data for dispatchable resources and generates a summary of the annual and 20-year performance of each portfolio over the planning period for all of the attributes. Key features include:

- In house developed economic evaluation multi-attribute model that is a financial extension of HYSIM

- Uses the HYSIM energy generation profiles to perform discounted cash flow analysis and tracking of portfolio attributes.