Integration of Commodity Risk Management and Operations Planning

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By

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Outline

- Introduction
  - System Overview
  - Provincial Energy Policy
  - BC Hydro Organization
- Decision Support Tools
  - Marginal Cost Model
  - Columbia Simulation Model
  - Allocation Process
- Risk Management
- Summary & Conclusion

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BC Hydro Background

- Provincial Crown Corporation
- Customers:
  - more than 1.5 million customers
  - 94 percent of the population of BC
- Regulated by the
  British Columbia Utilities Commission
- Belongs to
  - Western Electricity Coordinating Council (WECC)
  - North American Electric Reliability Council (NERC)

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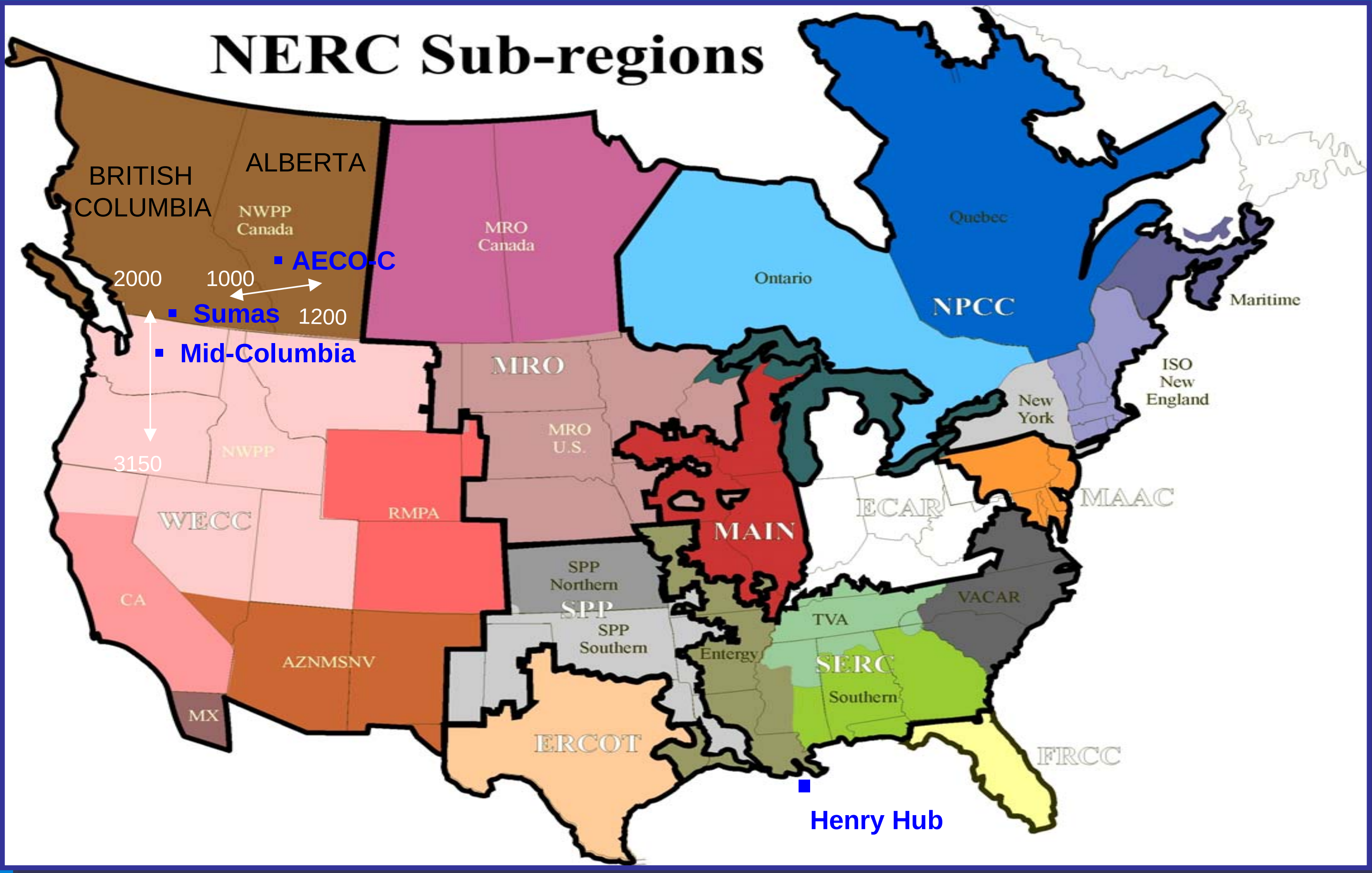
NERC Regions



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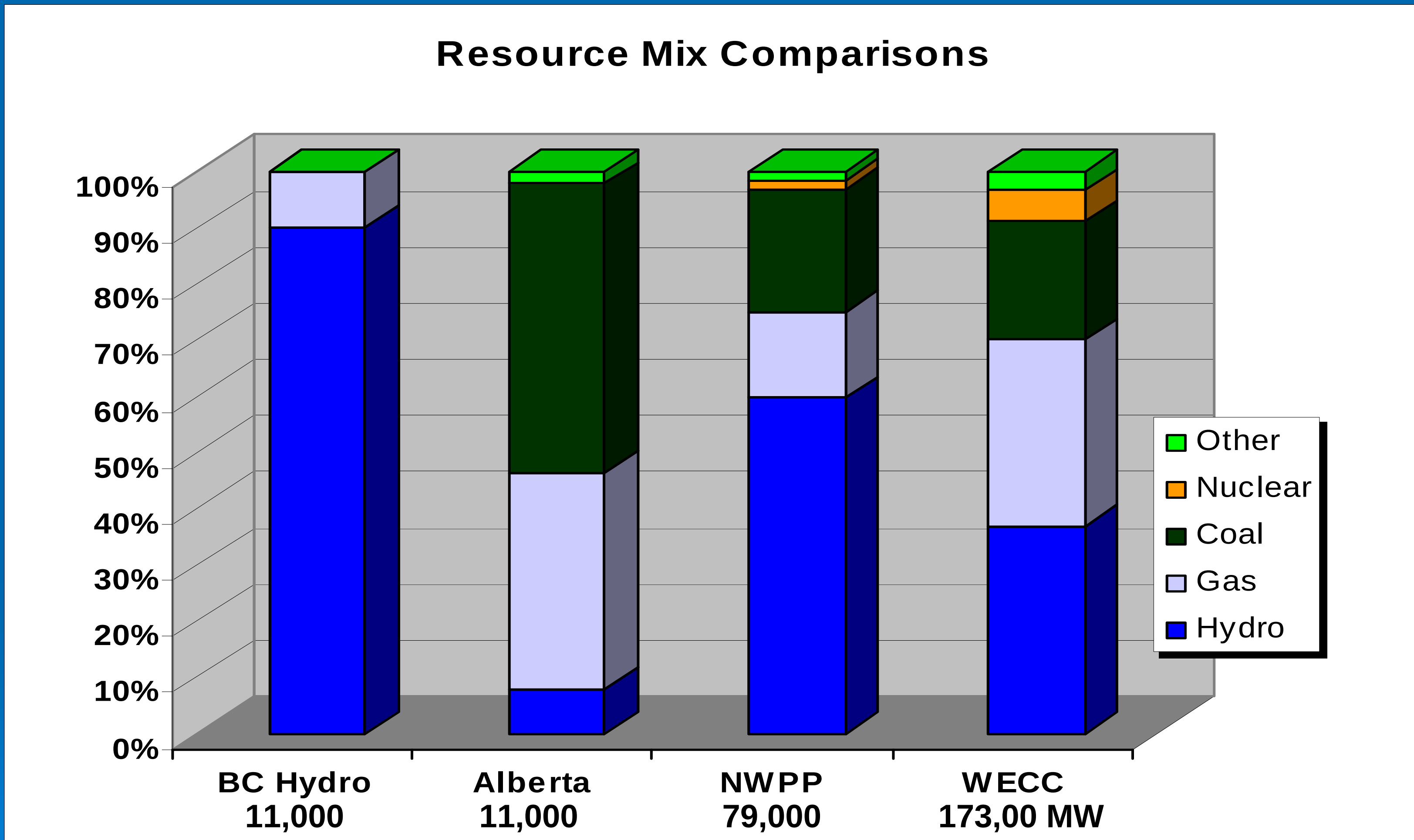
WECC Resource Mix Comparison



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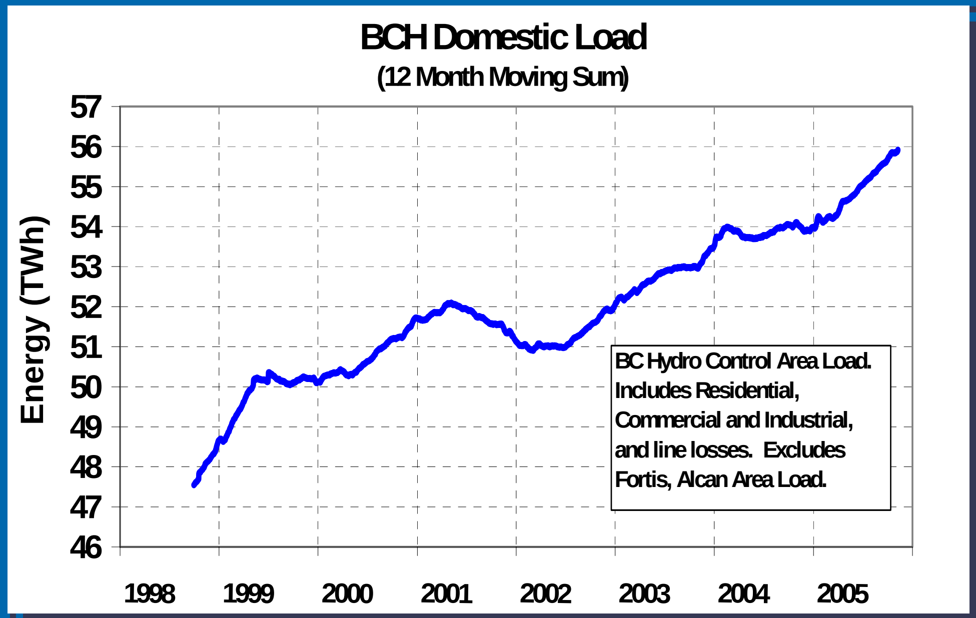
BC Hydro System



- Installed capacity
  11,103 MW
  90% Hydro
  9% Gas-fired
  1% Non-integrated
- 7% of WECC generation
- Domestic load – 57 TWh
- Market Purchases ~ 6 TWh ($380M)

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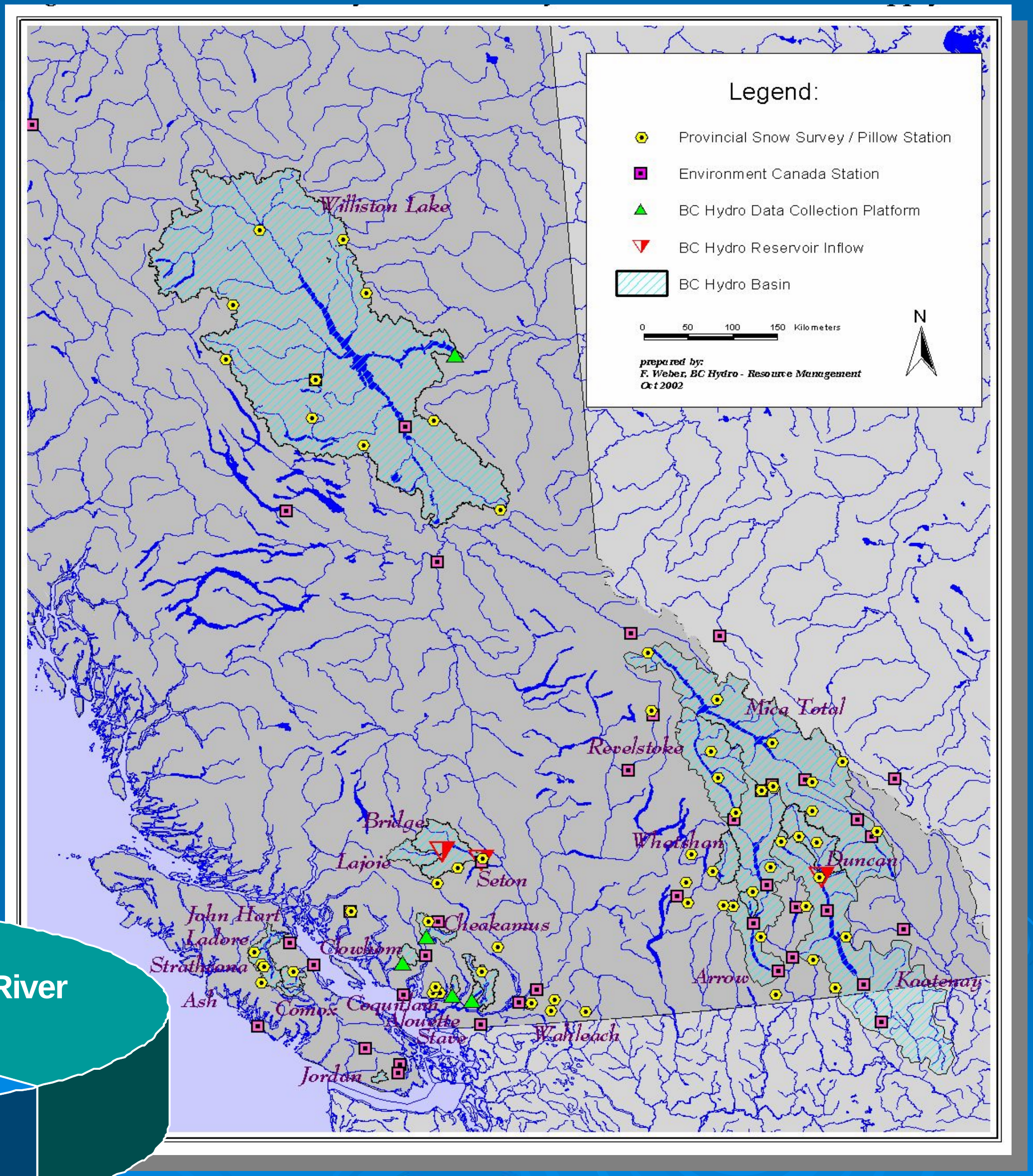
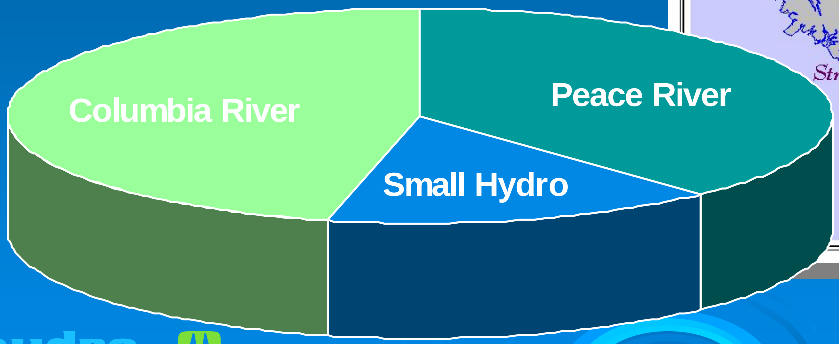
BC Hydro System

- Hydroelectric Capacity
  - Peace River
    37% system capacity
    in 2 plants
  - Columbia River
    47% in 4 plants
  - Small Hydro
    16% in 23 plants





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Williston Reservoir

- Williston Reservoir
  and the Peace River plants
  - provide the majority of the operating flexibility for the BC Hydro system
  - Storage 58% of system energy storage
  - Storage capacity ~ 113% of average annual generation on Peace River
- Frequently used to balance loads and resources
  - over time periods ranging from minutes to years

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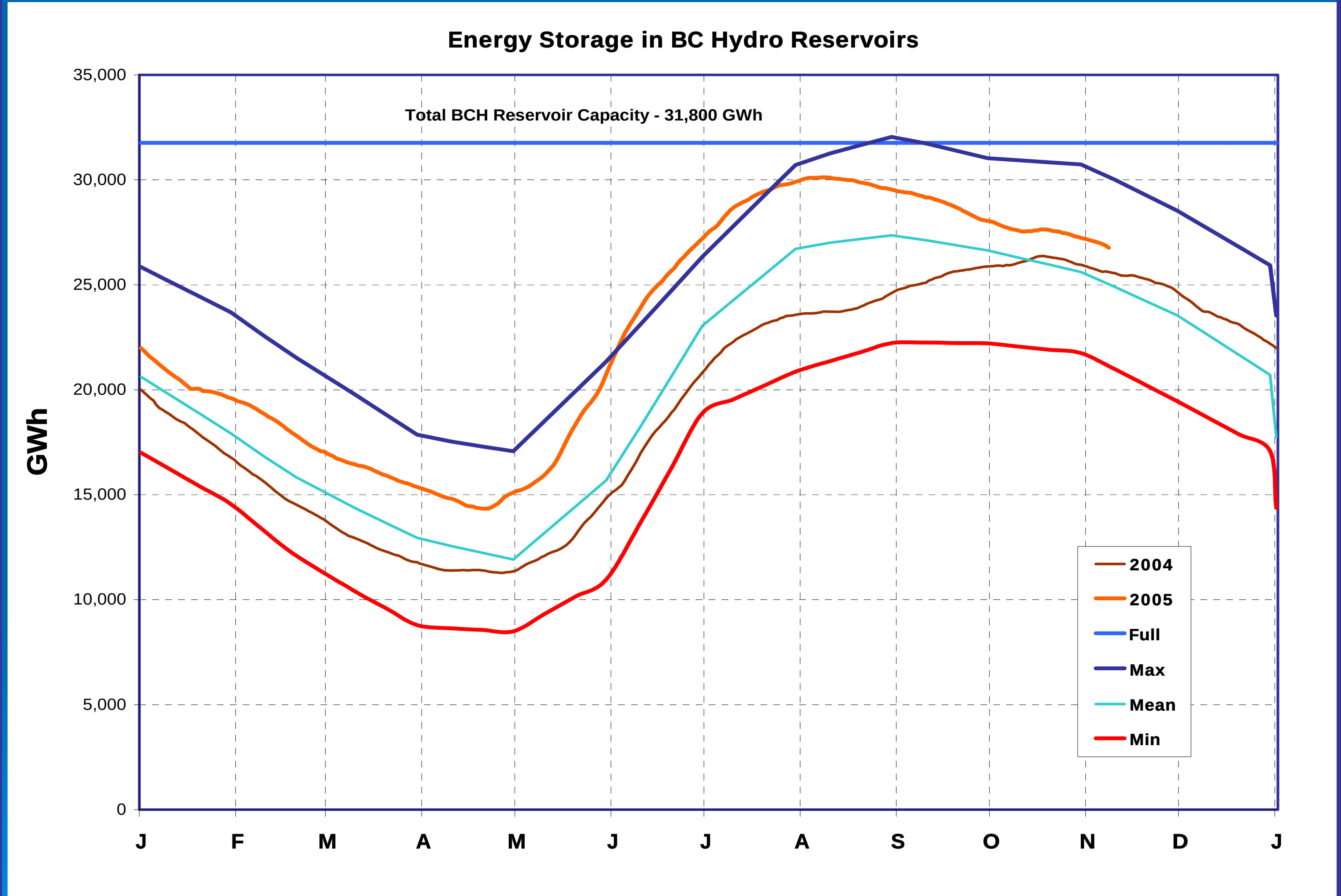
Columbia River System

- Constrained by Columbia River Treaty
- Treaty Storage in Mica, Keenleyside and Duncan Reservoirs
- Mica & Revelstoke
  - 15 TWh/year
- Mica Storage
  - 35% of system energy storage
  - 74% of annual average generation of Mica & Revelstoke

System Storage



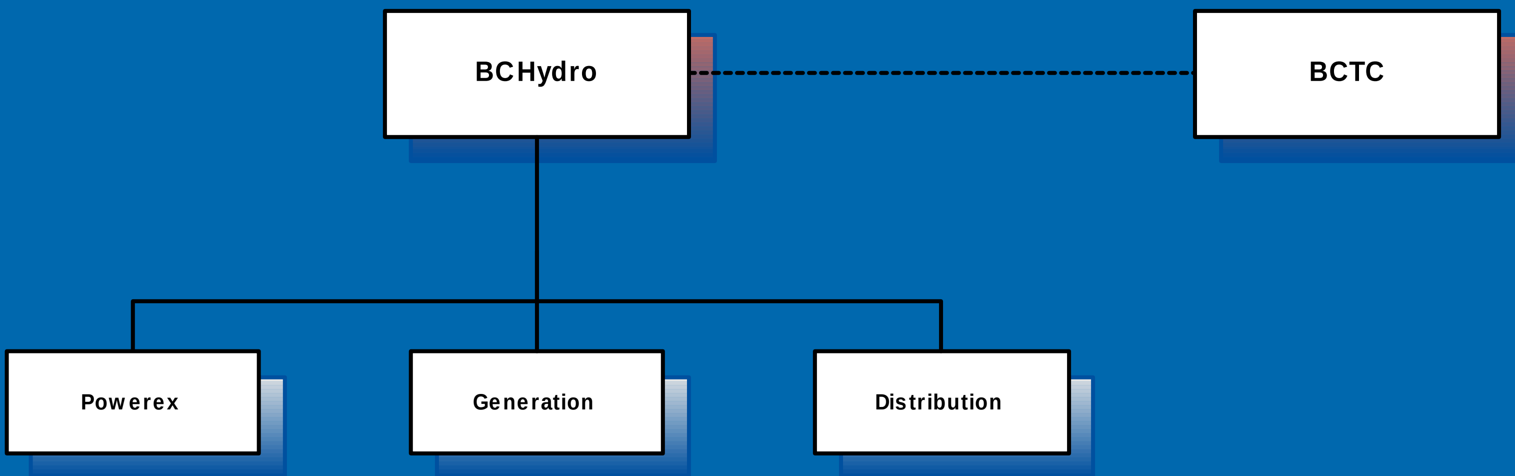
Provincial Energy Policy

- Heritage Contract
  - Protect low cost value of the existing BC Hydro resources for the ratepayer
  - Create an open access for energy suppliers
  - Promote BC energy self sufficiency
  - Promote green energy
  - Preserve BC Hydro as a Crown Corporation

- Consequence for BC Hydro
  - Acquire new supplies from IPP's
  - Maintain and operate low cost Heritage Resources
  - Create open access transmission system

Restructuring of BCH

- BCH Organization & Accountabilities



- Capture market opportunities using BCH surplus capacity
- BCH's face to the market

- Accountable for meeting the load in the near term (<3 yr.)
- System operation.
- Cost of Energy
- Managing Heritage Resources

- Accountable for meeting the load in the long term (>3 yr.)
- Acquire new resources from the market

- Trans Co.
- Transmission system operator
- Independent Crown Corporation
- BC Hydro owns the transmission assets

Generation Line of Business Mandate

- Responsible for operating to meet domestic load
- 3 Year Horizon
- Management of Heritage Resources
- Making surplus resources available for trade
- Commodity risk management in meeting domestic load
- Trade Account Storage

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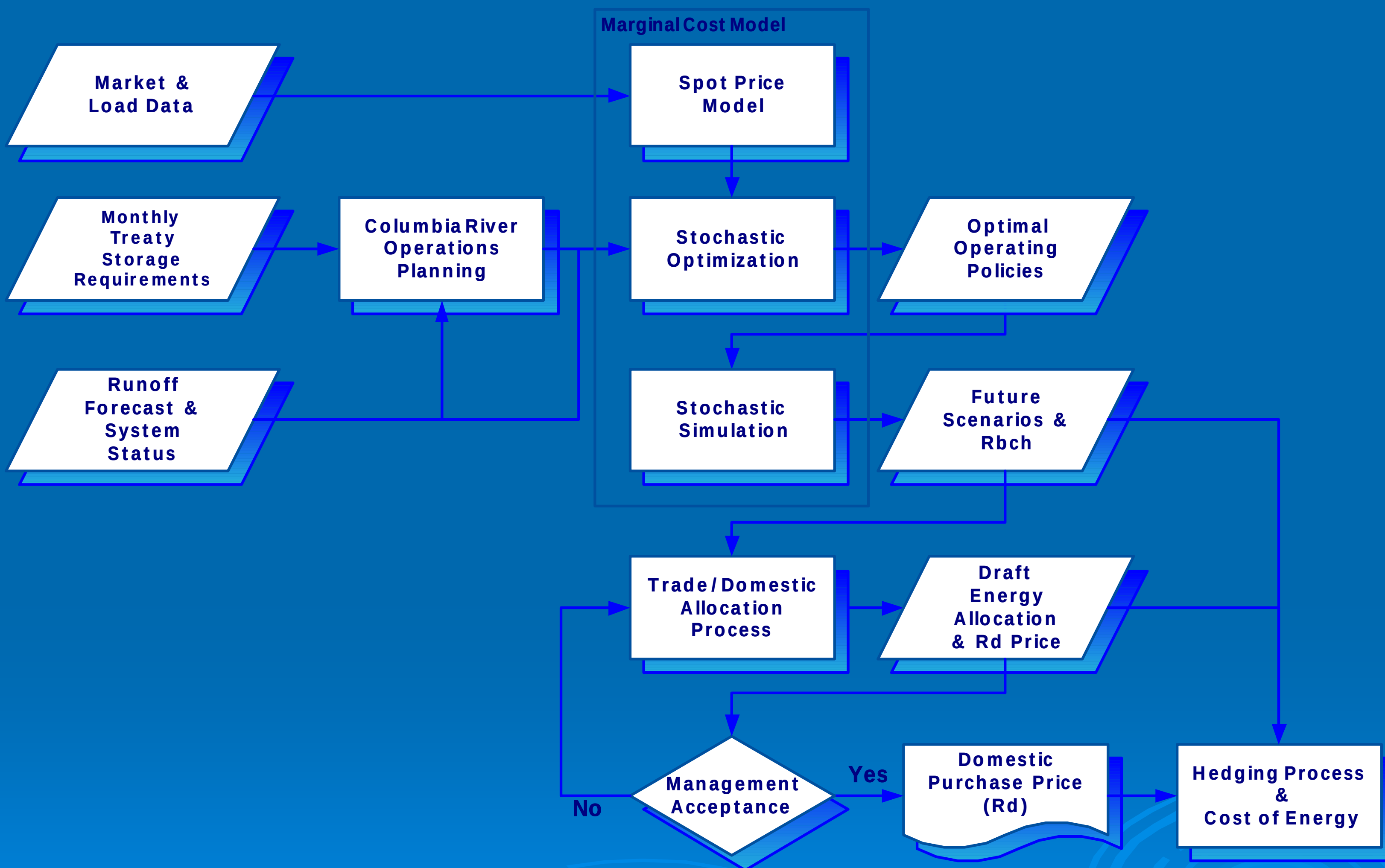
Decision Support Tools

Energy Studies Modeling Suite

- Columbia Simulation Model
- Marginal Cost Model
  - Market Model
  - SDP
  - Simulator
- Trade-Domestic Allocation
- Powersim - Risk Analytics

Systems Operations Planning Process



Marginal Cost Model – Overview

- Originally developed in mid 80's
- Stochastic Dynamic Programming optimization of Williston Reservoir operation
  - Maximize expected net value of system operation given monthly water values
  - Considered only hydrologic uncertainty
- Price uncertainty incorporated over last 10 years
- Current version includes:
  - market price uncertainty for gas and electricity
    - In both Alberta and Pacific Northwest
  - Accounts for load factoring within month in response to price duration curves

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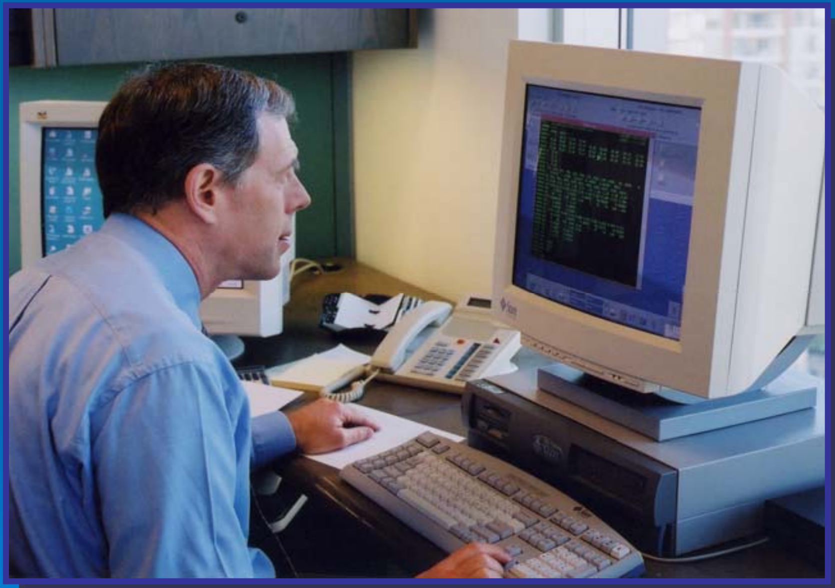
Marginal Cost Model – Market Model

- Purpose is model variability of spot electricity and gas price
- Account for correlation to key structural variables using state space representation
- Key markets for BC Hydro
  - Electricity
    - Alberta Power Pool
    - Mid Columbia (Mid-C)
  - Natural Gas
    - Sumas
    - AECO



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MCM – Market Model Natural Gas

- Henry Hub
  - Major trading hub in North America
  - Long record of forward and spot prices

- Spot prices for Henry Hub gas, $S_{HH}(t_o + \tau)$,
  - is estimated from the forwards $F_{HH}(t_o, \tau)$ using:
  - $HHUB(t_o + \tau) = F_{HH}(t_o, \tau)\, e^{\alpha \tau + \beta + \varepsilon}$
  - where: t_o - time of forward quote

    τ **- delivery month from time t_o**

    - **$t_o + \tau$ - time of delivery**
    - **α, β - regression coefficients,**

    ε **- normally distributed random error**

  - Models backwardation of gas prices

MCM Market Model – Natural Gas (2)

- Sumas and AECO spot prices are estimated by applying forward basis differentials to forecasted HHUB spot prices.
- Basis differentials are stochastic variables and are modeled as:
  - SUMAS basis ~ f(Forecasted Columbia R. flow, Calif. Temp, ε)
  - AECO Basis ~f(Forecasted Columbia R. flow, ε)
- Large sample of future gas price scenarios are simulated
- Group spot prices for each month of next 72 into 5 tranches or states
- Compute monthly state transition probabilities for each month going forward

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Market Model – Alberta Electricity Prices

- Future monthly high/low spot electricity prices estimated for each weather year as a function of:
  - Alberta Load,
  - temperature deviations from 10C
  - AECO gas price
  - Resource additions
  - Probability coal on the margin
  - Probability of bidding behavior

Market Model – Mid-C Electricity Prices

- Future monthly high/low spot electricity prices estimated for each weather year as a function of:
  - Forecasted seasonal inflow forecast for the Columbia River at The Dalles,
  - Deviation of California temperature from 52°F
  - SUMAS gas price
  - Bidding behaviour

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MCM – Stochastic Dynamic Program

- Used to develop an optimized operating policy for Williston Reservoir Releases
- Optimized policy is a function of monthly stage and state variables for:
  - Natural gas price
  - Historical weather year
  - Water condition in the Pacific Northwest
  - Williston Reservoir elevation
- Objective function:
  - maximize the expected value of net income going forward
- Implicit load factoring based on price duration curve
- Marginal Value of water in storage, Rbch

MCM Simulator

- Uses optimized operating policy for Williston Reservoir to dispatch Peace River plants (G.M. Shrum and Peace Canyon)
- Import, export and thermal dispatched based on market price
- Small hydro fixed dispatch based on historical weather year
- Columbia River plants
  - Mica, Revelstoke, Arrow & Kootenay Canal, Seven Mile
  - fixed dispatch by historical weather year
  - based on Columbia Simulation Model/Columbia Coordination Model

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Columbia Simulation Model

- Highly constrained by Columbia River Treaty
  - Flood control
  - Flow augmentation for US plants and fish flows
- Modeled heuristically with using simulation
- Coordination model uses LP to re-dispatch Columbia storage to look for improvements relative to marginal market transactions
  - Revised dispatch sent back to MCM for rerun.
  - Three iterations typical
  - Operating improvements have been as much as $25M/FY

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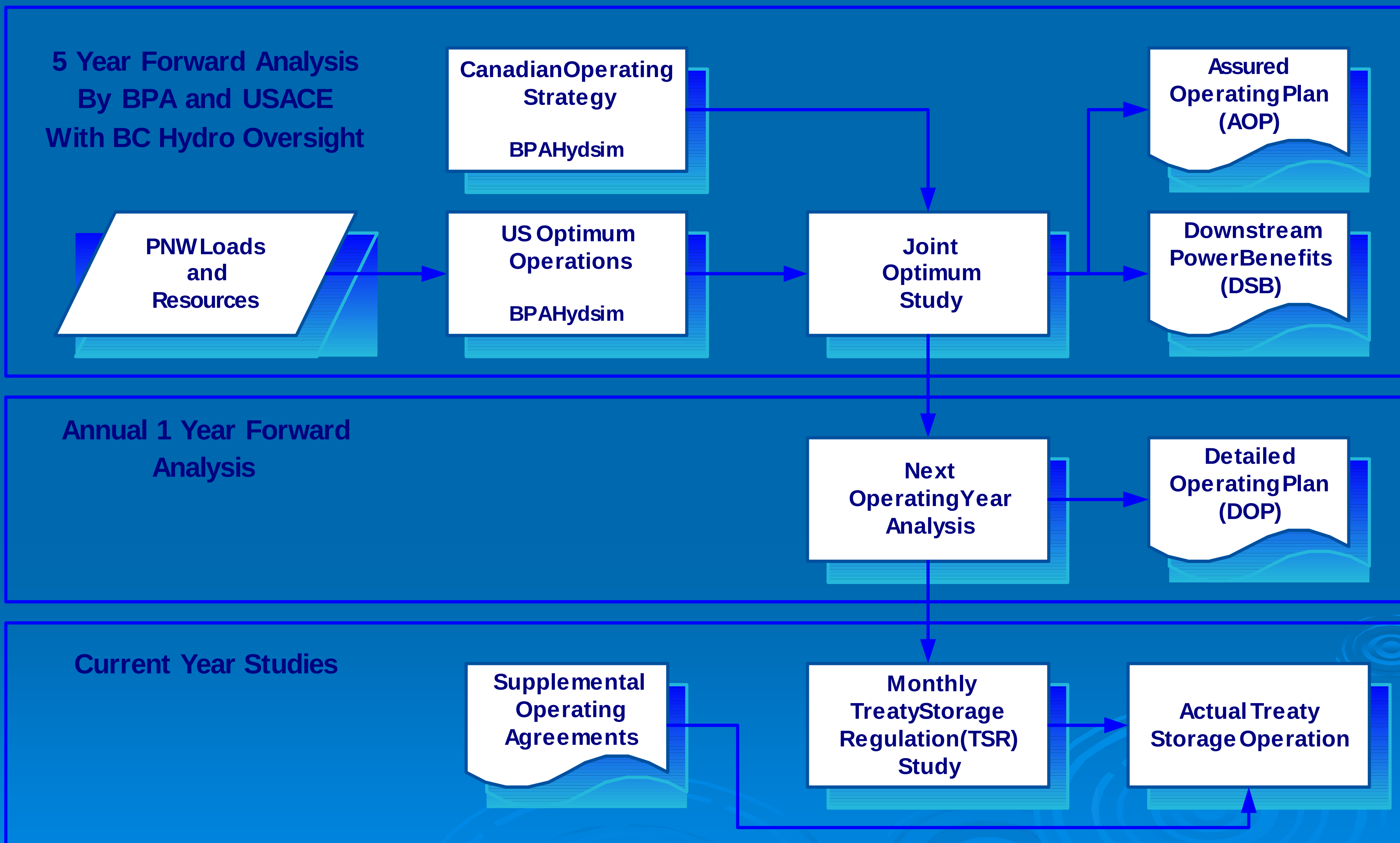
Columbia River Treaty
Operations Planning Process



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Allocation Process

- Accountability Framework
  - Generation responsible for meeting domestic load
  - Powerex realizing market opportunities of surplus capabilities
  - Powerex allowed to store firm energy in BC Hydro storage
- How to separate forecasted future operations into domestic and trade activities?
- Allocation premise: Minimize cost of energy for the domestic load.
- If Rbch represents the marginal value of generation on the system from consolidated perspective then
  - the marginal price of meeting the domestic load, Rd, should be α*Rbch
- Heuristic methodology of testing α such that
  - A stable trade account results
  - Probability of spill is limited to < 10%

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Price Signals

- Price signals are used as key decision points for actual operations

- R_{BCH} – System Marginal Cost
  - Represents the marginal value of water in Williston reservoir
  - Used for trade activity, outage costing, overgating, etc.

- R_D – Domestic Buy Price
  - Used for Domestic and Trade allocation
  - If imports brought in at a price below R_D, they are allocated to domestic. Otherwise, they are allocated to trade

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Commodity Risk Management Policy

- IO&RM is mandated to manage commodity price risk for Generation
  - For near term to end of next fiscal year
  - Commodity price risk for domestic supply
- Performance measure is Cost of Energy @ Risk (CoE@R)
  - 95% FY Total Energy Cost – Expected FY Total Energy Cost
- Approved hedging instruments
  - System storage
  - Fixed for floating swaps for gas, electricity and currency
  - Single counter party
    - Powerex for gas & electricity
    - Treasury for currency
- Limits
  - Gas is prescriptive based on fraction of expected consumption
  - Electricity based on system storage and expected purchases

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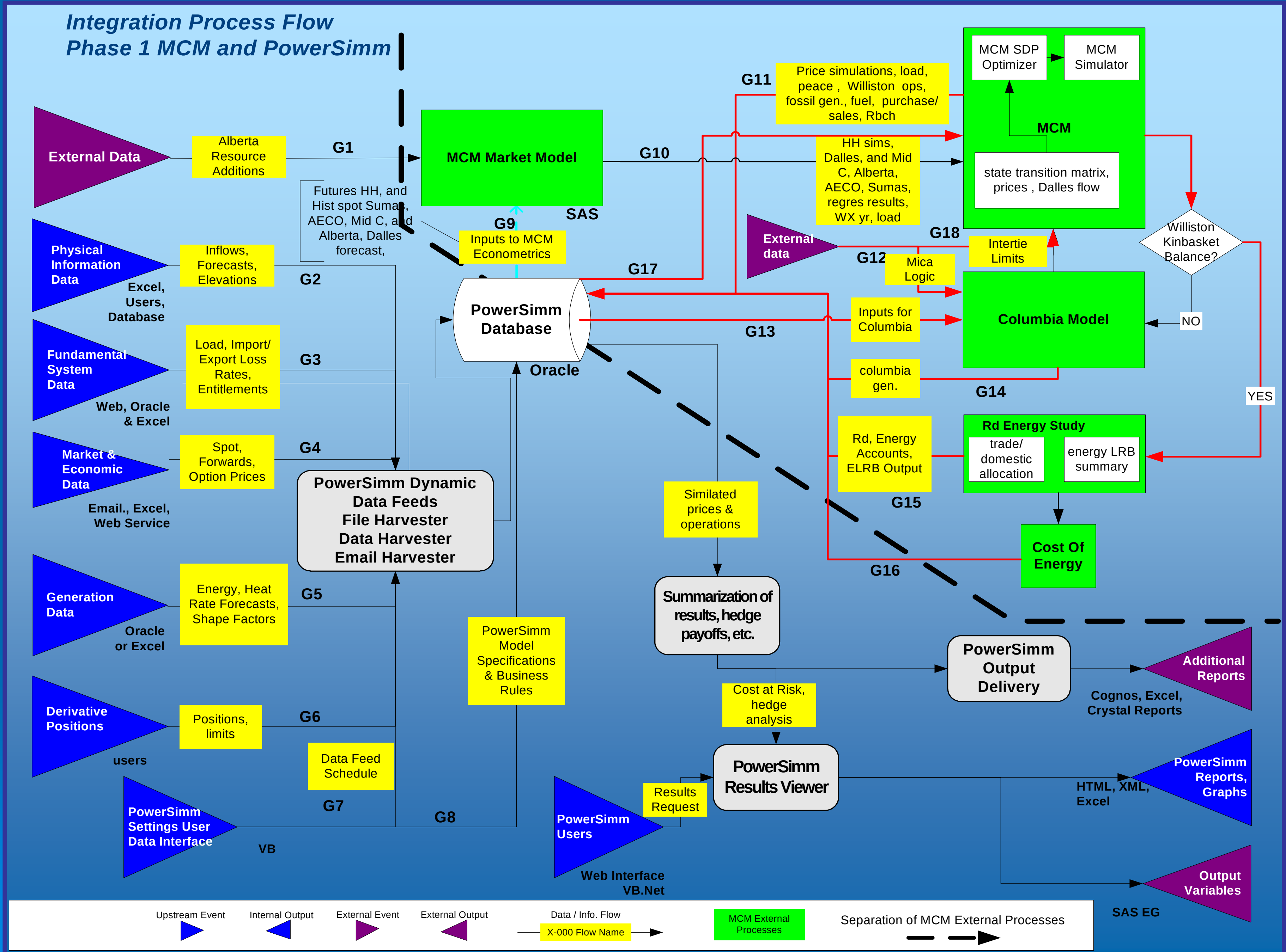
New Analytic Requirements

- Need for hedge evaluation tools
  - Simulate the performance of various hedge portfolios
  - Consistent with system operation and how it responds to key drivers
  - Hedge optimization?
- Reporting and control
  - Conformance to risk management policy
  - Better reporting and presentation of modeling results
    - Higher dimensionality
    - Higher variability
  - Higher reliability of modeling processes
- Alignment of price model with market view

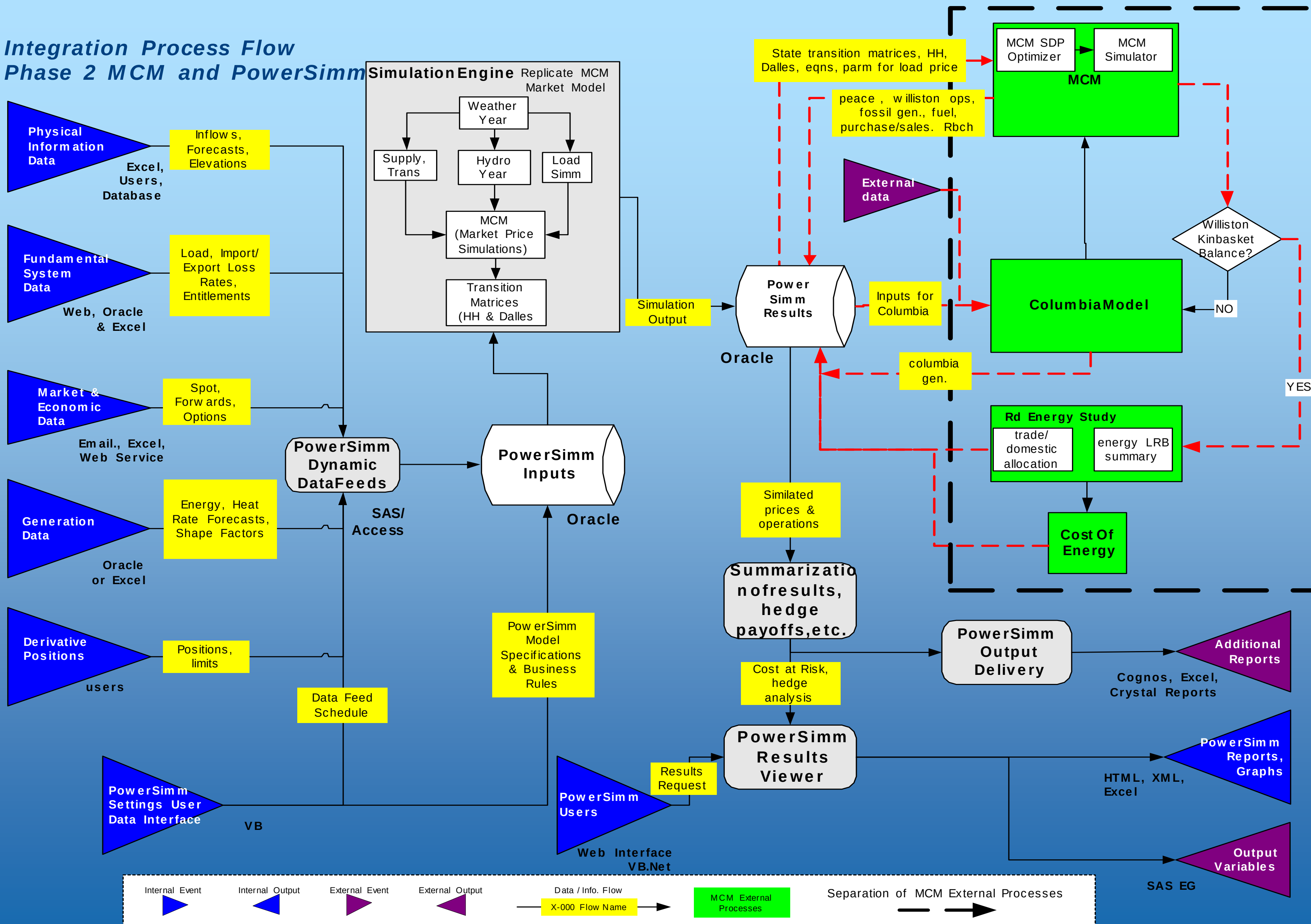
Risk Analysis System

- Significant improvements to Energy Studies Model suite complete
- Integration project underway
  - schedule for Phase 1 in production by mid December
- Scope includes:
  - Automated data feeds
  - Data integration across Energy Studies modelling suite
  - Energy Studies process control
  - Risk analytics and reporting
- Powersim by Ascend Analytics
  - Built on SAS and custom Visual Basic .Net
  - Oracle database backend

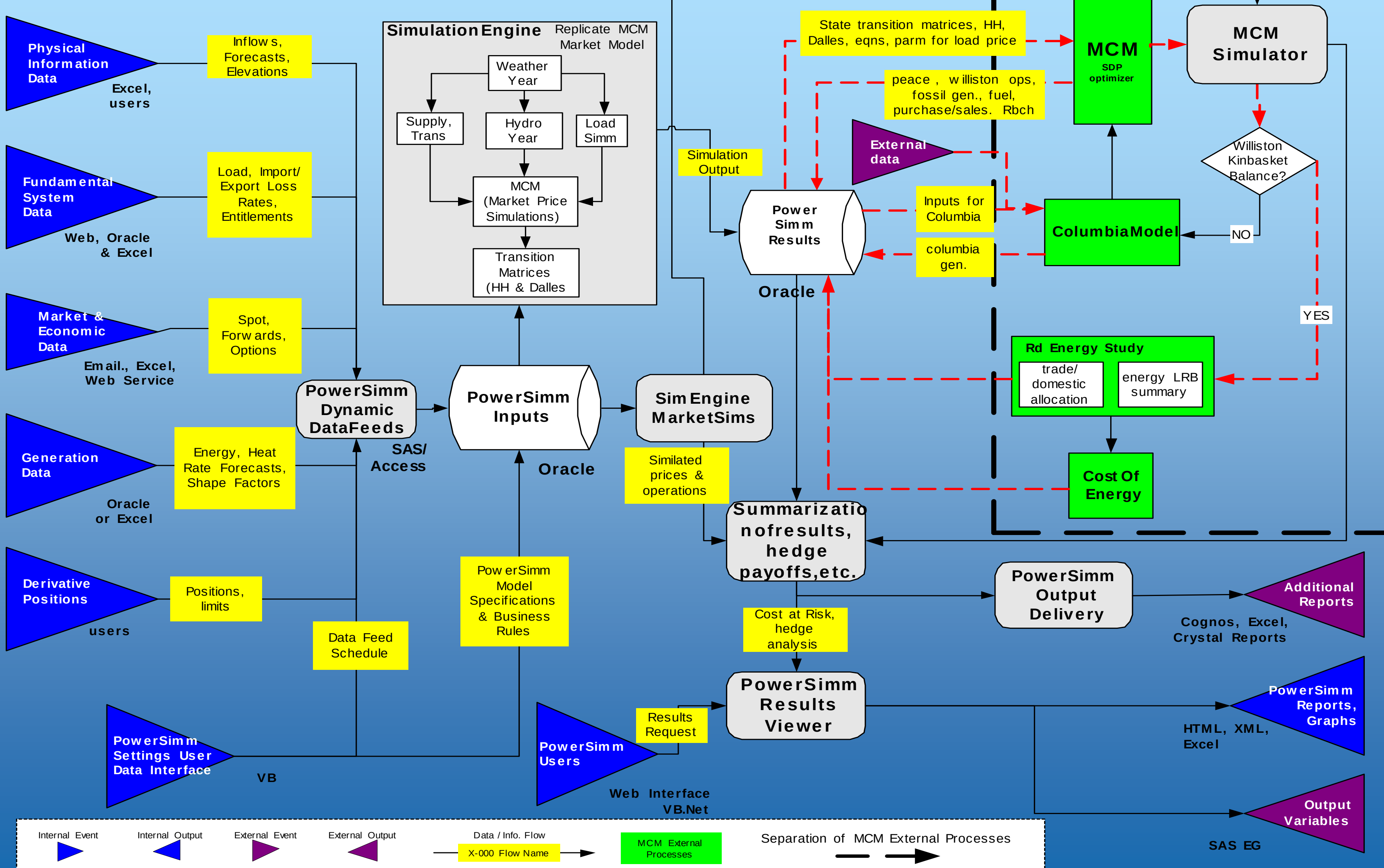


Integration Process Flow
Phase 1 MCM and PowerSimm
External Data
Alberta Resource Additions
G1
MCM Market Model
SAS
G10
G11
Price simulations, load, peace , Williston ops, fossil gen., fuel, purchase/ sales, Rbch
MCM SDP Optimizer
MCM Simulator
MCM
state transition matrix, prices , Dalles flow
HH sims, Dalles, and Mid C, Alberta, AECO, Sumas, regres results, WX yr, load
Futures HH, and Hist spot Sumas, AECO, Mid C, and Alberta, Dalles forecast,
G9
Inputs to MCM Econometrics
Physical Information Data
Excel, Users, Database
Inflows, Forecasts, Elevations
G2
External data
G12
Mica Logic
G18
Intertie Limits
Williston Kinbasket Balance?
NO
YES
G17
PowerSimm Database
Oracle
Inputs for Columbia
G13
Columbia Model
Fundamental System Data
Web, Oracle & Excel
Load, Import/ Export Loss Rates, Entitlements
G3
columbia gen.
G14
Market & Economic Data
Email., Excel, Web Service
Spot, Forwards, Option Prices
G4
PowerSimm Dynamic Data Feeds File Harvester Data Harvester Email Harvester
Rd, Energy Accounts, ELRB Output
Rd Energy Study
trade/ domestic allocation
energy LRB summary
G15
Similated prices & operations
Cost Of Energy
G16
Generation Data
Oracle or Excel
Energy, Heat Rate Forecasts, Shape Factors
G5
PowerSimm Model Specifications & Business Rules
Summarization of results, hedge payoffs, etc.
PowerSimm Output Delivery
Additional Reports
Cognos, Excel, Crystal Reports
Derivative Positions
users
Positions, limits
G6
Data Feed Schedule
Cost at Risk, hedge analysis
PowerSimm Results Viewer
PowerSimm Reports, Graphs
HTML, XML, Excel
PowerSimm Settings User Data Interface
VB
G7
G8
PowerSimm Users
Results Request
Web Interface VB.Net
Output Variables
SAS EG
Upstream Event
Internal Output
External Event
External Output
Data / Info. Flow
X-000 Flow Name
MCM External Processes
Separation of MCM External Processes

Integration Process Flow
Phase 2 MCM and PowerSimm



Integration Process Flow
Phase 3 PowerSimm and MCM



Summary & Conclusions

- Decision support requirements have changed substantially over the last few year
  - Market developments
  - Government policy
- BC Hydro system originally developed to control load and hydrologic variability
- Now substantial benefits are derived from capturing market value and controlling market risks
- This has added significantly to the analytic and data management effort in operations planning
- Sophisticated data management and reporting systems are essential