BC Hydro
Generation system operation

Columbia Basin Regional Advisory Committee

Renata Kurschner
Director, Generation Resource Management
11 September 2014
Generation System Operation

- Coordination of provincial generation (Heritage resources, IPPs, partner generation under Canal Plant Agreement)

- Operation mainly impacted by:
  - Inflows
  - Market Prices
  - Loads
  - Generation Availability
  - Columbia River Treaty
  - Water Use Plans

- BC Hydro large (multi-year) storage system is operated for long term, as opposed to annual, economic goals on a consolidated basis (domestic and trade activity)
Generation Mix - Energy

Resource Diversity - 2014

Heritage Hydro ~78%
Non-Dispatchable

Majority is Dispatchable

Columbia, Kootenay and Pend d’Oreille ~ 37%
Peace ~28%

Heritage Hydro
Alcan
Hydro IPP
Wind IPP
Biomass IPP
Thermal IPP

Reliable power, at low cost, for generations.
Benefits of System Storage

System Hydro Inflow & Load Obligations
Forecast for 2015

System storage allows BC Hydro to reshape inflows in excess of the load into future periods when inflows are less than the load.

* Inflows are representative of system-normal as of Feb 2014

Reliable power, at low cost, for generations.
Annual Profile of System Storage

Historic System Storage

Historic Maximum
29000 GWh

Historic Minimum
6900 GWh

System Storage (GWh)

Historic Envelope
10 Year Historic Average
30 Year Historic Average

Source: Historic System Storage.xls (jdb presentations)
Generation System Operation

**Planning (IRP)**

- Forecasts future load, determines supply needs (energy and capacity) and acquires resources

**Energy studies**

- Monthly system modeling maximizes long term net revenue from operations and determines:
  - storage operation
  - water values
  - domestic buy/sell
  - system surplus capability for trade

**Operations Planning**

- Short term operations planning
  - detailed operating plans for individual plants
  - considers all risks and constraints, incl. water conveyance, flood control, WUP requirements

**Real Time Dispatch**

- Day ahead operating plan and hourly generation dispatch / water conveyance to meet load requirements and trade opportunities in a most economical manner; manages within the day unexpected events

Informed by forecasts:

- weather and inflows, market prices, loads, unit outages, transmission availability

Timeframe:

- Beyond 3 years
- 3 years to real time
Columbia Basin in Canada

- Operation of Kinbasket, Arrow, Duncan, and Libby reservoirs are coordinated with the US (USAC and BPA) under the Columbia River Treaty: the “Treaty Dams”
- Revelstoke and Kootenay Lake are not directly regulated under the CRT. However, Kootenay Lake is subject to the IJC Order.
What Impacts Columbia Basin Operations?

- Water Licenses (diversion and storage for power generation)
- Inflows (across the system, incl. US Columbia basin)
- Market Prices
- Loads
- Generation Availability (across the system)
- Columbia River Treaty
- WUP constraints and other environmental/social objectives
- Other Agreements
  - Non Treaty Storage
  - Libby Coordination Agreement
  - Non-Power Uses (or “Flow Augmentation”) Agreement
Inflows

Benefit of “Two River” policy is inflows into system reservoirs are roughly independent – but range of variation in system inflows is 16,000 GWh.
Storage operations enable BC Hydro to monetize annual, seasonal and daily price differences in the markets.
BC Hydro Load, Generation, and Import/Export Annual Pattern - 2013

High system storage and relatively high market prices => net exports

Low prices => Net Imports

Mica Plant Outage => net purchases

Generation system operation
BC Hydro Load, Generation, and Import/Export Schedules
(for 28 March 2013)

 Reliable power, at low cost, for generations. Reliable power, at low cost, for generations. Reliable power, at low cost, for generations. Reliable power, at low cost, for generations. Reliable power, at low cost, for generations.
Columbia River Treaty

- Regulate flow for optimum **power and flood control** in both countries
- Creates requirement for:
  - flood control space at Mica, Arrow and Duncan
  - specific flows across the border (Arrow discharges)
- Power generation and flood control are generally well aligned – drafting in winter when load high creates flood control space in reservoirs in expectation of spring flows
- Flood control requirements rarely limiting at Mica & Duncan, but often at Arrow (and Libby)
- Silent on other values (ie fisheries, recreation)
- Entities enter into supplemental agreements to “adjust”, by **mutual agreement**, flows at the border to accommodate other interests
Non Treaty Storage Agreement

• Commercial agreement between BC Hydro and BPA to coordinate use of Mica storage not covered by Treaty for mutual benefit
• Decisions are made weekly by mutual agreement
• Provides for adjustments to Arrow discharges from those required by CRT (store into NTS when discharges reduced and vice versa)
• Optimizes both power and non-power benefits
  ▪ BC Hydro gains better flexibility to create economic value and balance Columbia WUP objectives
  ▪ BC Hydro receives a share of downstream benefits created by improved regulation under the NTSA
  ▪ More flexibility to generate at Mica across fall/winter for system load
  ▪ Reduced spill risk at Mica
• BC Hydro and BPA low water supply event releases – firm energy and fisheries benefit
Short Term Libby Coordination Agreement

- Original LCA (signed in 2000) addressed the impacts of power losses as a result of US unilaterally changing Libby operation in 1993 to support white sturgeon spawning but to the detriment of Kootenay River power generation.

- Canadian Entity objected to further US changes to Libby operation implemented in 2003 and as a temporary and partial mitigation entered into a Short Term (supplemental) LCA that provides additional power loss mitigation and ensures cooperation prior to and during flood events.

- Canada desires to better address flood risk management in any future long term agreement.
Non Power Uses Agreement

• Canadian interests:
  ▪ Decreases Arrow discharges (storage) in Jan and keeps flows more steady until Mar for whitefish spawning
  ▪ Provides flexibility to keep flows steady or increasing from Apr through Jun for trout spawning

• US interests:
  ▪ Release of storage in Jul to supplement Treaty flows for salmon outmigration (hence agreement also called Flow Augmentation Agreement); note that flows may be further augmented in Jul and Aug by release of NTSA if there was NTSA storage during the period of Apr - Jun
## WUP operating constraints

<table>
<thead>
<tr>
<th>WUP Name</th>
<th>Date Signed</th>
<th>Operational Constraints</th>
</tr>
</thead>
</table>
| Columbia River Project (Mica/Revelstoke/Arrow) | 11 Jan 2007 | • MIN and MAX reservoir levels.  
• MIN Revelstoke downstream flow requirements.  
• Soft constraints |
| Water Hardman Project                         | 21 Mar 2006 | • MIN and MAX headpond reservoir levels.  
• MIN downstream flow requirements. |
| Whatshan Project                              | 15 Jun 2005 | • MIN reservoir levels.                                                             |
| Elko Project                                  | 7 Apr 2005  | • MIN downstream flow requirements.  
• Generation station discharge ramping rates. |
| Spillimacheen Project                         | 15 Jul 2005 | • MIN downstream flow requirements.  
• Generation station discharge ramping rates. |
| Aberfeldie Project                            | 6 Nov 2006  | • MIN and MAX headpond reservoir levels.  
• MIN downstream flow requirements.  
• Generation station discharge ramping rates. |
| Seven Mile Project                            | 8 Dec 2006  | • MIN and MAX reservoir levels.  
• Considerations for reservoir recreation/fisheries. |
| Duncan Project                                | 20 Dec 2007 | • MIN and MAX reservoir levels  
• MIN and MAX downstream flow requirements.  
• Dam spill discharge ramping rates. |
# WUP monitoring and physical works

<table>
<thead>
<tr>
<th>WUP Name</th>
<th>Key WUP Monitoring and Physical Works</th>
<th>Total Cost of Monitoring and Works*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbia River Project (Mica/Revelstoke/Arrow)</td>
<td><strong>Physical works:</strong> Boat ramp access, debris removal, vegetation replanting; <strong>Monitoring studies:</strong> Recreation &amp; boat use; Wildlife (birds, amphibians &amp; reptiles); Fish (whitefish, rainbow trout, white sturgeon, and burbot); Vegetation inventory &amp; erosion; Archeological site assessments</td>
<td>$108 M Expected completion in 2019</td>
</tr>
<tr>
<td>Water Hardman Project</td>
<td><strong>Physical works:</strong> Diversion Dam Min Flow Release Facility; Annual Gravel Placement; <strong>Monitoring studies:</strong> Fish ( kokanee, rainbow trout, temperature effects and habitat monitoring)</td>
<td>$973 k Program completed in 2012</td>
</tr>
<tr>
<td>Whatshan Project</td>
<td><strong>Physical works:</strong> Boat ramp access, Habitat Enhancement; <strong>Monitoring studies:</strong> Wildlife; Fish (rainbow trout); Vegetation mapping; Archeological site assessments</td>
<td>$764 k Expected completion in 2015</td>
</tr>
</tbody>
</table>
# WUP operating constraints and works

<table>
<thead>
<tr>
<th>WUP Name</th>
<th>Key WUP Monitoring and Physical Works</th>
<th>Total Cost of Monitoring and Works*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elko Project</td>
<td>Monitoring studies: Monitoring of Habitat Maintenance Flows; Side Channel Sinkholes, Total Suspended Solids and fish stranding</td>
<td>$89 k Program completed in 2011</td>
</tr>
<tr>
<td>Spillimacheen Project</td>
<td>Monitoring studies: Assessment of Rampdown Rates; Gravel Recruitment; Monitoring of Habitat Maintenance Flows</td>
<td>$68 k Program completed in 2011</td>
</tr>
<tr>
<td>Aberfeldie Project</td>
<td>Monitoring studies: Fish (Habitat; Productivity and Effectiveness of Fish Habitat Works)</td>
<td>$641 k Program completed in 2013</td>
</tr>
<tr>
<td>Seven Mile Project</td>
<td>Monitoring studies: Fish (Stranding and Bull Trout entrainment)</td>
<td>$395 k Program completed in 2009</td>
</tr>
<tr>
<td>Duncan Project</td>
<td>Physical works: Boat ramps &amp; erosion protection Monitoring studies: Wildlife &amp; mosquitoes; Fish habitat &amp; use(kokanee, bull trout, Burbot); Vegetation monitoring; Archeological site erosion</td>
<td>$10.6 M Expected completion in 2018</td>
</tr>
</tbody>
</table>

BC Hydro system operations
Mica operation – typical drivers

Typical Operational drivers:

- Jul to Oct*: discharge adjusted as needed to refill reservoir, minimize spill, & maximize electricity value
- Nov to Mar: high discharge to meet electricity demand, discharge sometimes limited in Feb-Mar by Arrow Reservoir flood control curve.
- Apr to mid-Jul: low electricity value, so discharge reduced to refill reservoir

*Note – Mica discharges during Jul-Oct can be quite variable, depending on spill probability at Mica and other reservoirs (e.g. Williston) as well as market electricity values
Arrow operation – typical drivers

**Typical CRT & operational drivers:**

- **Jul-Aug:** discharge increased to meet CRT needs & release Flow Aug water
- **Sep-Dec:** discharge lower to preserve storage in case of low snowpack. NTSA & STLA activity if economic.
- **Jan-Mar:** higher discharges (if snowpack OK); sup. agrmts manage for steadier whitefish spawning flows
- **Apr-June:** lower, stable discharges to refill reservoir, manage trout spawning

**Note:** Arrow discharge from Jan to July depends on overall basin runoff forecast, and will vary significantly with basin-wide snowpack.
Duncan operation – typical drivers

DUNCAN
Elevation and Streamflow Hydrographs
July 1, 2012 to September 30, 2013

Typical CRT & operational drivers:

- **Jul-Sep**: discharge increased & then adjusted to manage reservoir refill & minimize downstream Can flooding
- **Oct-Dec**: discharge limited to manage fish spawning in Duncan River. Res. level must remain below CRT flood curve.
- **Jan-Mar**: higher discharges to improve Kootenay Lake inflows & meet CRT flood control needs.
- **Apr-Jun**: discharge reduced to refill reservoir, subject to minimum WUP fish-flow needs in Canada
Kootenay Lake operation – typical drivers:

**Typical Operational drivers:**

- **Jul-Aug:** lake drafted in compliance with IJC Order
- **Sep-Dec:** discharges adjusted to keep lake level below IJC Curve, with minimum fish flow downstream at Brilliant
- **Jan-Mar:** lake drafted to meet IJC Curve. Discharge maximized (limited by Grohman Narrows) if lake level above IJC Curve.
- **Apr-Jun:** typically on maximum discharge to minimize peak lake level (and meet IJC Curve)
Libby operation – typical drivers

Typical operational drivers:

- **Jul-Sep**: discharge adjusted to manage reservoir refill & provide downstream fish flows.
- **Oct-Dec**: discharge reduced to minimum, then increased in late Nov to hit 31 Dec flood control level.
- **Jan-Mar**: discharges increased above minimum only if needed to stay at/below flood control curve.
- **Apr-Jun**: discharges increased for fish, then high sturgeon flows in late May or June. Discharges adjusted to maintain flood management space.