Pumped Storage Update

May 16, 2012
Introduction to BPA

- Federal Columbia River Power System (FCRPS):
  - BPA markets power from 31 Federal Hydropower Plants (21 COE/10 BOR)(6,195 avg. MW; about 22,000 installed MW), Columbia Generating Station Nuclear Plant and some non-Federal hydro and wind.
  - More than 80% of the power BPA sells is hydroelectric.
  - BPA accounts for about 33% of the electric power consumed within the Region.
Renewable Energy Growth
Wind started coming back on Jan 26 and peaked at nearly 1600MW on Jan 29.
BPA Balancing Authority Total Wind Generation and Wind Basepoint, Last 7 days

Based on 5-min readings from the BPA SCADA system for points 79687, 103349
Balancing Authority Wind Generation in Green, Wind Basepoint in Red; Installed Wind Capacity=3522 MW
BPA Technical Operations (TOT-OpInfo@bpa.gov)
BPA Balancing Authority Total Wind Generation and Wind Basepoint, Last 7 days

BPA Balancing Reserves Deployed, Last 7 days

Based on 5-min readings from the BPA SCADA system for points 108043, 108044, 108045.
BPA Technical Operations (TOT-OpInfo@bpa.gov)
Pumped Storage Evaluation – Overall Plan

Summer-Fall 2009

1. Evaluate Storage Technology Options (PNNL)
2. Evaluate State of the Art Pumped Storage (MWH/USACE)
3. Pumped Storage Forum (USACE/BPA)
   - Voith, Toshiba, Alstom, Andritz
4. Banks Lake Pumped Storage Evaluation (USBR)

Fall 2009 - Present

Information Gathering

Pumped Storage Evaluation

Specific Build Decisions

- System Analysis, Design Parameters, and Economics
  - Contract Awarded to HDR/DTA

- Add Pumped Storage to an Existing Federal Facility
  - USACE
  - USBR

- New Federal Pumped Storage Project
  - USACE
  - USBR

- Non-Federal Pumped Storage Project
  - Purchase Use
  - Partnering Arrangement

- Banks Lake Pumped Storage
  - Equipment Upgrades
  - Expansion Alternatives
  - Operational Changes

- Banks Lake Pumped Storage Improvements
John W. Keys III Pump Generating Plant

- **Original installation in 1951**
  - Six 50 MW pumping units

- **Upgrade in 1973**
  - Two 50 MW pump/generators installed

- **Upgrade in 1983-84**
  - Four 53.5 MW pump/generators installed

- **Current Capacity**
  - Pumping – 12 Units 614 MW
  - Generating – 6 Units 314 MW
Reclamation’s John W. Keys III Pump Generating Plant at Grand Coulee
Keys Pump-Generating Plant Assessment

NEPA/NHPPA Studies – Reclamation EA complete March 2012

Reclamation’s TSC and HDR Recommendations Under Evaluation:

• Modernization
  – Excitation
  – Governors
  – Unit Controls and Protection
  – PG Phase Reversal Switches
  – PG Unit Circuit Breakers
  – Main Step-up Transformer & Transformer Disconnect Switches
  – Station Service Upgrades
  – Miscellaneous Balance-of-Plant refurbishment

  Preparation of the Specifications are 90% complete – January 2012

• Upgrade of Pump-Generator Units 7-12
  – PG7 & 8 Wicket Gate Operating Mechanism Improvements
  – Increase the operating head range of PG7-12 to be more consistent with the pump head range
  – PG7-12 Rewinds

• Decouple Pumps from GCL Left Powerhouse
  – TSC is studying several options in FY12
Sample Model Run

PG 9-12

Megawatts

Available VERBS  INC  DEC

1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep
Sample Model Run (Continued)

Decoupling

Megawatts

Available VERBS
INC
DEC

1-Oct 1-Nov 1-Dec 1-Jan 1-Feb 1-Mar 1-Apr 1-May 1-Jun 1-Jul 1-Aug 1-Sep
### HDR/DTA Report – Greenfield Pumped Storage Examples

<table>
<thead>
<tr>
<th>Project Feature/Characteristic</th>
<th>Project X1 **</th>
<th>Project X2 **</th>
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</thead>
<tbody>
<tr>
<td><strong>Upper Reservoir:</strong></td>
<td>New off-channel reservoir</td>
<td>New off-channel reservoir</td>
</tr>
<tr>
<td>Storage Volume (ac-ft)</td>
<td>15,000</td>
<td>1,550,00</td>
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<tr>
<td>Active Surface Area (acre)</td>
<td>282</td>
<td>11,750</td>
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<tr>
<td>Dam Height (ft.)</td>
<td>150</td>
<td>780</td>
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<tr>
<td>Max. Water Surface Elev. (msl)</td>
<td>2,436</td>
<td>2,159</td>
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<table>
<thead>
<tr>
<th><strong>Lower Reservoir:</strong></th>
<th>New off-channel reservoir</th>
<th>Existing Columbia River reservoir</th>
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<tbody>
<tr>
<td>Active Storage Volume (ac. ft.)</td>
<td>15,000</td>
<td>1,550,00+</td>
</tr>
<tr>
<td>Surface Area (acres)</td>
<td>209</td>
<td>80,000</td>
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<tr>
<td>Max. Water Surface Elevation (msl)</td>
<td>624</td>
<td>1,290</td>
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<tr>
<td>Approx. Net Head (ft.)</td>
<td>1,700</td>
<td>870</td>
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<tr>
<td>Conveyance Length (ft.)</td>
<td>4,800</td>
<td>10,560</td>
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<tr>
<td>Plant Capacity (MW)</td>
<td>1,050</td>
<td>1,136+</td>
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<tr>
<td>Units Sizes/Number</td>
<td>250/4</td>
<td>282/4</td>
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<tr>
<td>Est. Annual Generation (GWh)*</td>
<td>1,560</td>
<td>1,760</td>
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<tr>
<td>Est. Annual Pumping (GWh)*</td>
<td>1,950</td>
<td>220</td>
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<tr>
<td>Transmission Line Length (ml.)</td>
<td>5.0</td>
<td>7.5</td>
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<tr>
<td>Est. Capital Cost (Million $, 2010)</td>
<td>2,733</td>
<td>2,500</td>
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<tr>
<td>Cost per installed MW (Million $)</td>
<td>2,603</td>
<td>2,200</td>
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Questions?