GORDON BUTTE
PUMPED STORAGE HYDRO PROJECT

Absaroka Energy LLC

FERC Project No. P-13642
GORDON BUTTE PSH

Colstrip 500kV Lines
**PROJECT HIGHLIGHTS**

- Installed Capacity: **400 MW**
- Flexible Capacity: **800 MW**
- Estimated storage: **8.5 hours**
- Ternary pump/turbine units: **3**
- Distance from Colstrip twin 500 kV transmission lines: **5 miles**
- Off-stream, closed-loop
- Single private landowner
- Martinsdale, Montana
PROVEN TECHNOLOGY

Ternary unit design

Synchronous generator

Pelton turbine

Valve

Torque converter

Pump

Courtesy of GE Renewable Energy
HYDRAULIC SHORT CIRCUIT
ULTIMATE FLEXIBLE CAPACITY

PSH can move faster (20 MW/sec) than gas (40 MW/min)
MT Alternative provides substantial benefits to PSE ratepayers:

- $300 million reduction in capital costs
- $53 million reduction in levelized annual costs
- $481 million NPV over 25 years
- $24/MWh reduction in levelized energy costs (250 aMW)

Source: Energy + Environmental Economics “Gordon Butte Pumped Storage: Colstrip 1&2 Replacement Analysis”
MONTANA / WASHINGTON WIND COMPARISON
CALIFORNIA DUCK CURVE

Typical Spring Day

- Actual 3-hour ramp 10,892 MW on February 1, 2016
- Ramp need ~13,000 MW in three hours
- Over generation risk
- Net Load 11,663 MW on May 15, 2016
## Nameplate Capacity

- Usable capacity provided by the unit (as listed in the NWE Procurement Plan)
- Reflects the unit's contribution to reserve margins / system capacity
- Amount of capacity available to meet peak capacity needs

<table>
<thead>
<tr>
<th></th>
<th>Capacity Assumptions</th>
<th>Capital Costs (2018 $/kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS</td>
<td>Generation rated power = 150 MW</td>
<td>$2,439</td>
</tr>
<tr>
<td>ICE</td>
<td>Generation rated power = 18 MW</td>
<td>$1,756</td>
</tr>
<tr>
<td>Aero</td>
<td>Generation rated power = 93 MW</td>
<td>$1,684</td>
</tr>
<tr>
<td>Frame</td>
<td>Generation rated power = 79 MW</td>
<td>$1,459</td>
</tr>
</tbody>
</table>

---

*Energy & Environmental Economics*

ABSAROKA ENERGY LLC
Flexible Capacity: Regulation Up/Down

- Secondary control - occurs within seconds to minutes via automatic generation control
- Provided by generators who are online and have capacity to increase or decrease output

<table>
<thead>
<tr>
<th></th>
<th>Capacity Assumptions</th>
<th>Usable Capacity Range (% of Nameplate)*</th>
<th>Capital Costs (2018 $/kW)</th>
</tr>
</thead>
</table>
| PS    | • Capacity to increase/decrease system output by reducing/increasing generation or load  
       | • Fast switching between modes doubles the effective range unit.                     | 200%                                    | $1,220                    |
| ICE   |                                                                                      | 79%                                     | $2,223                    |
| Aero  | Capacity of conventional generators to provide regulation up and down is limited by ramp rate and minimum power generation levels. | 47%                                     | $3,583                    |
| Frame |                                                                                      | 87%                                     | $1,677                    |

*Assuming operating state is at optimal position for providing frequency response [ex. GT at Pmin]

†Frame units are not usually used for Regulation given their limited operating flexibility

Energy+Environmental Economics
Flexible Capacity: Frequency Response

- Primary control - most immediate response to deviations in grid frequency
- Served by generator inertia
- Provided primarily by frequency responsive loads and synchronous generators

<table>
<thead>
<tr>
<th>Capacity Assumptions</th>
<th>Usable Capacity Range (% of Nameplate)*</th>
<th>Capital Costs (2018 $/kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS</td>
<td>200%</td>
<td>$1,220</td>
</tr>
<tr>
<td>ICE</td>
<td>79%</td>
<td>$2,223</td>
</tr>
<tr>
<td>Aero</td>
<td>47%</td>
<td>$3,583</td>
</tr>
<tr>
<td>Frame</td>
<td>87%</td>
<td>$1,677</td>
</tr>
</tbody>
</table>

*Assuming operating state is at optimal position for providing frequency response [ex. GT at Pmin]

Energy + Environmental Economics
**Flexible Capacity: Spinning Reserves**

- Tertiary control - system operator dispatches reserves in response to contingencies
- Provided by units that are synchronized to the grid and able to ramp up within specified time frame

<table>
<thead>
<tr>
<th></th>
<th>Capacity Assumptions</th>
<th>Usable Capacity Range (% of Nameplate)*</th>
<th>Capital Costs (2018 $/kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS</strong></td>
<td>- Fast ramp rate and mode switching allows for fast response to operator dispatch</td>
<td>200%</td>
<td>$1,220</td>
</tr>
<tr>
<td></td>
<td>- Unit in generation, idling, or pumping mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Can increase/decrease load or generation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Can switch from one mode to another</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ICE</strong></td>
<td></td>
<td>79%</td>
<td>$2,223</td>
</tr>
<tr>
<td><strong>Aero</strong></td>
<td>- Limited by ramp rate, start-up times (hot-start)</td>
<td>47%</td>
<td>$3,583</td>
</tr>
<tr>
<td><strong>Frame</strong></td>
<td></td>
<td>87%</td>
<td>$1,677</td>
</tr>
</tbody>
</table>

*Assuming operating state is at optimal position for providing frequency response [ex. PS pumping, GT at Pmin]

Energy + Environmental Economics
Flexible Capacity: Non-Spinning Reserves

- Tertiary control - system operator dispatches reserves in response to contingencies
- Provided by units that are not necessarily synchronized to the grid, but able to ramp up generation within specified time frame
- Required response time is slower than spinning reserves

<table>
<thead>
<tr>
<th></th>
<th>Capacity Assumptions</th>
<th>Usable Capacity Range (%) of Nameplate</th>
<th>Capital Costs (2018 $/kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS</td>
<td>Unit in standby mode&lt;br&gt; If dispatched, can quickly ramp up capacity</td>
<td>200%</td>
<td>$1,220</td>
</tr>
<tr>
<td>ICE</td>
<td></td>
<td>100%</td>
<td>$1,756</td>
</tr>
<tr>
<td>Aero</td>
<td>Capacity and participation limited by ramp rate, start up time (cold-start)</td>
<td>100%</td>
<td>$1,684</td>
</tr>
<tr>
<td>Frame</td>
<td></td>
<td>100%</td>
<td>$1,459</td>
</tr>
</tbody>
</table>

*Assuming operating state is at optimal position for providing frequency response (ex. PS pumping, GT not on)*

Energy + Environmental Economics

ABSAROKA ENERGY LLC
PROJECT MILESTONES

- Site Control ✓
- Water Right Permit ✓
- Environmental Assessment ✓
- Geotechnical ✓
- 401 Water Quality Certification ✓
- Interconnection Feasibility Study ✓
- EPC Team ✓
- FERC License ✓
Gordon Butte Team

EQUIPMENT

GE Renewable Energy

CONSULTANTS

DOWL
GANDA
McMILLEN JACOBS ASSOCIATES
Stanley Consultants

ANALYTIC ADVISORS

Energy+Environmental Economics
ALEVO

ABSAROKA ENERGY LLC
www.gordonbuttepumpedstorage.com

Carl Borgquist / President
Rhett Hurless / Senior Vice President, COO
(406) 585-3006