Preliminary Assumptions for Natural Gas Peaking Technologies (Revisited)

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GRAC

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At the last meeting...

- Revisited reference plant configurations
- Discussed updated preliminary capital cost and O&M estimates
- Introduced preliminary levelized cost estimates
Today’s Discussion

- Revisit capital cost and O&M estimates for gas peakers (no changes from last meeting)
  - Frame, Aeroderivative, Intercooled
  - Recip
- Discuss capacity factors
  - Actual generation data from PNW
- Discuss updated levelized cost estimates
  - Frame, Aeroderivative, Intercooled, Recip
All Gas Peakers

REFERENCE PLANT
Proposed Configuration for Draft 7th Plan Reference Plants

<table>
<thead>
<tr>
<th>Technology</th>
<th>Proposed Configuration</th>
<th>Capacity</th>
<th>Heat Rate (HHV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame GT</td>
<td>(1) 215.8 MW GE 7F 5-series</td>
<td>~ 216 MW</td>
<td>9801</td>
</tr>
<tr>
<td>Aeroderivative GT</td>
<td>(4) 47.3 MW GE LM 6000PF Sprint</td>
<td>~ 190MW</td>
<td>9048</td>
</tr>
<tr>
<td>Intercooled/Aero Hybrid GT</td>
<td>(2) 100 MW GE LMS100 PB</td>
<td>200 MW</td>
<td>8541</td>
</tr>
<tr>
<td>Reciprocating Engine</td>
<td>(12) 18 MW Wärtsilä</td>
<td>220 MW</td>
<td>8370</td>
</tr>
</tbody>
</table>

Proposing reference plants that resemble capacity of Port Westward II (220MW) – most recent peaking plant to be constructed in the PNW
# Preliminary Reference Plant – All Gas Peakers

<table>
<thead>
<tr>
<th>Year</th>
<th>Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>$</td>
</tr>
</tbody>
</table>

## Capacity Factor
- **25%**

## Capital Cost Escalation
- **-0.5%**

## Economic Life (Years)
- **30**

## Construction Lead Time (Months)
- **18 planning & development**
- **15 construction**
  - (33 months total, ~2.75 years)

No change from last meeting
Capital and O&M

COST ASSUMPTIONS FOR GAS SINGLE CYCLE
Preliminary Draft 7P Capital Cost Estimate for Frame GT

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**OVERNIGHT CAPITAL COST (2012 $/kW)**

- **Generic Studies**
- **Preconstruction Estimates**
- **As-built/Committed**
- **6th Plan Final**
- **7th Plan Draft**

**VINTAGE OF ESTIMATE**

- **NERA NYISO**
- **B&V for NREL**
- **Regional IRPs**
- **EIA F-Class**
- **EIA E-Class**
- **Gas Turbine World**
- **Pastoria Expansion High (CA); Terminated**
- **Pastoria Expansion Low (CA); Terminated**
- **Marsh Landing (CA)**

No change from last meeting
Preliminary Draft 7P Capital Cost Estimate for Aeroderivative GT

No change from last meeting
Preliminary Draft 7P Capital Cost Estimate for Intercooled GT

![Graph showing overnight capital cost (2012 $/kW) vs. vintage of estimate. The graph includes data points for various projects and studies, and a legend indicating different types of estimates such as Generic Studies, Preconstruction Estimates, As-built or Committed Costs, 6th Plan Final, and 7th Plan Draft.]

- No change from last meeting
INFO AND COST ASSUMPTIONS FOR RECIPROCATING ENGINES
Reciprocating Engines

1. Recap
2. Capital and O&M Cost Estimate
3. Levelized Cost of Energy
4. Reference Plant
Reciprocating Engines (Recip)

- Recips are internal combustion engines – an air/fuel mix is compressed by a piston and ignited within a cylinder to drive a piston and turn the shaft.
- Recips can burn a variety of fuels including natural gas, fuel oil, and biofuels.
- Small individual engines are grouped into blocks called generating sets.

**Strengths**

1. Excellent for flexibility: start quickly and follow load well, and have good part-load efficiencies.
2. Maintain output at increasing elevations.
3. Reliable and minimal water usage.
4. Multiple engines – maintenance can be done without shutting down entire plant.
Recips in the News

Wärtsilä has announced several new power plant projects – all revolving around renewable development

1. 3 50SG engines – 56MW - in Oklahoma, for wind balancing

2. 12 34SG engines – 112MW – in North Dakota to help power the oil drilling boom

3. 6 34DF engines – 50MW – in Hawaii to balance solar power production
1-Reciprocating Engine Capital Cost and O&M Estimate

- Capital cost estimates gathered from various recip. projects and evaluation reports
- Estimates were normalized to 2012 year dollars, lifecycle degrade, and regional cost (labor index)
- Capital Estimate: \(1,300 \text{$/kW 2012$}

- Fixed and Variable O&M cost estimates from two primary sources:
  - NERA 2013 Study for NYISO
  - PGE Port Westward 2 rate filing
- O&M Estimate
  - Fixed: \(10 \text{$/kW-yr 2012$}
  - Variable: \(9 \text{$/MWh 2012$}
# Summary of Cost Estimates

<table>
<thead>
<tr>
<th></th>
<th>Frame</th>
<th>Aero</th>
<th>Intercooled</th>
<th>Recip</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capital Cost (lifecycle)</strong></td>
<td>$161.6 MM</td>
<td>$198 MM</td>
<td>$187 MM</td>
<td>$286 MM</td>
</tr>
<tr>
<td><strong>Capital Cost (lifecycle) ($/kw)</strong></td>
<td>$800</td>
<td>$1,100</td>
<td>$1,000</td>
<td>$1,300</td>
</tr>
<tr>
<td><strong>Fixed O&amp;M ($/kw-yr)</strong></td>
<td>$7.00</td>
<td>$25.00</td>
<td>$11.00</td>
<td>$10.00</td>
</tr>
<tr>
<td><strong>Variable O&amp;M ($/MWh)</strong></td>
<td>$10.00</td>
<td>$5.00</td>
<td>$7.00</td>
<td>$9.00</td>
</tr>
</tbody>
</table>
Discussion

CAPACITY FACTORS
Dave Gates Generating Station

Designed to provide regulation service to balance generation and load on a moment-to-moment basis and to provide regulation for integration of renewables.

<table>
<thead>
<tr>
<th>Duration</th>
<th>Capacity Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Annual Average</td>
<td>35.3 %</td>
</tr>
<tr>
<td>2012 Annual Average</td>
<td>28.5 %</td>
</tr>
<tr>
<td>2011 Annual Average (Feb – Dec)</td>
<td>27.8 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity</th>
<th>150 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Deer Lodge, MT</td>
</tr>
<tr>
<td>Technology</td>
<td>(3) 50 MW Pratt &amp; Whitney SWIFTPAC</td>
</tr>
<tr>
<td>Service Date</td>
<td>January 2011</td>
</tr>
</tbody>
</table>

Photo credit: PowerMag.com
Danskin CT1 (Evander Anders Complex)

Constructed to help Idaho Power have adequate generating resources to meet present and future energy needs. – from Idaho Power’s website

<table>
<thead>
<tr>
<th>Duration</th>
<th>Capacity Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Annual Average</td>
<td>7.5 %</td>
</tr>
<tr>
<td>2012 Annual Average</td>
<td>2.7 %</td>
</tr>
<tr>
<td>2011 Annual Average</td>
<td>3.4 %</td>
</tr>
<tr>
<td>2010 Annual Average</td>
<td>4.5 %</td>
</tr>
<tr>
<td>2009 Annual Average</td>
<td>5.4 %</td>
</tr>
<tr>
<td>2008 Annual Average</td>
<td>8.7 %</td>
</tr>
</tbody>
</table>

Capacity | 171 MW / 261 MW plant total
---|---
Location | Mountain Home, ID
Technology | (1) 170 MW Siemens-Westinghouse SGT6-5000F
Service Date | June 2008 / Sep 2001

Photo credit: Tim Bondy
Bennett Mountain

Both the Danskin and Bennett Mountain plants are "peaking" generating resources, for use primarily in meeting short-duration demands for electricity during hot summer afternoons when air conditioning and irrigation loads reach their highest point. – from Idaho Power’s website

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<tr>
<th>Duration</th>
<th>Capacity Factor</th>
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<tbody>
<tr>
<td>2013 Annual Average</td>
<td>5.3 %</td>
</tr>
<tr>
<td>2012 Annual Average</td>
<td>3.5 %</td>
</tr>
<tr>
<td>2011 Annual Average</td>
<td>3.2 %</td>
</tr>
<tr>
<td>2010 Annual Average</td>
<td>2.8 %</td>
</tr>
<tr>
<td>2009 Annual Average</td>
<td>6.5 %</td>
</tr>
<tr>
<td>2008 Annual Average</td>
<td>3.3 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity</th>
<th>164 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Elmore, ID</td>
</tr>
<tr>
<td>Technology</td>
<td>(1) 164 MW Siemens-Westinghouse W501FD3</td>
</tr>
<tr>
<td>Service Date</td>
<td>April 2005</td>
</tr>
</tbody>
</table>

Photo credit: industcards.com
Fredonia 3 & 4

PSE employs the Fredonia facility primarily to provide back-up “peaking” energy for the utility’s power system during daily or seasonal spikes in customers’ power usage. – from Puget Sound Energy’s website

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<tr>
<th>Duration</th>
<th>Capacity Factor</th>
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<tbody>
<tr>
<td>2013 Annual Average</td>
<td>3.3 %</td>
</tr>
<tr>
<td>2012 Annual Average</td>
<td>1.5 %</td>
</tr>
<tr>
<td>2011 Annual Average</td>
<td>2.6 %</td>
</tr>
<tr>
<td>2010 Annual Average</td>
<td>2.4 %</td>
</tr>
<tr>
<td>2009 Annual Average</td>
<td>5.3 %</td>
</tr>
<tr>
<td>2008 Annual Average</td>
<td>0.5 %</td>
</tr>
</tbody>
</table>

**Capacity**

108 MW / 314 MW total plant

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<thead>
<tr>
<th>Location</th>
<th>Skagit Cty, WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>(2) 54 MW Pratt &amp; Whitney FT8 Twin-pac</td>
</tr>
<tr>
<td>Service Date</td>
<td>July 2001 / May 1984</td>
</tr>
</tbody>
</table>
Representative Capacity Factor(s) for Comparative Levelized Cost Estimates

- Actual generation of peakers in past several years has averaged around 5-7% (with exception of Dave Gates GS)
- PGE anticipates 40% CF for PWII
- For comparison purposes only (not a direct input into the Draft Seventh Plan or RPM) – using a 25% CF as representative of future new gas peakers
  - Can also model levelized cost at various CFs (i.e. 10% and 40%)
Levelized

COST ASSUMPTIONS
Gas Peakers - Levelized Cost of Energy (Cap Factor 25%)

- Gas Fired Recip Eng
- AERO Gas Turbine
- Intercooled Gas Turbine
- Frame Gas Turbine

$/MWh 2012 dollars

- Capital
- O&M Fixed and Var
- Fuel Fixed and Var
- Trans. Fixed/Integ/Losses
Levelized Cost of Energy - Gas Fired Peaking Technologies by Gas Price Forecast (Cap. Factor 25%)
Levelized Cost of Energy - Gas Fired Peaking Technologies by Capacity Factor (Eastside Med Fuel Forecast)

- Gas Fired Recip Eng
- AERO Gas Turbine
- Intercooled Gas Turbine
- Frame Gas Turbine

$/MWh 2012 dollars

10% 25% 40%
Transmission Cost

- Fixed Levelized Cost ($/kW-yr) estimates include a transmission charge to bring power to the market
- Currently the BPA point-to-point cost is used ~ $20/kW-yr
- Are there other simple transmission cost estimations to use to reflect incremental system cost?