Changing Imbalance Penalties Into Competitive Markets

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Ancillary Services

• "Thirty-One Flavors or Two Flavors Packaged Thirty-One Ways: Unbundling Electricity Service"  
Scheduled vs Delivered Power

Duration of Transaction

Megawatts
Delivering Active Power
Changing Imbalance Penalties Into Competitive Markets

• Electric systems must be continuously in balance
• Electric systems often impose that balancing requirement on their captive customers
• Electric systems often impose that balancing requirement on their captive suppliers
• Electric systems often impose penalties for imbalances greater than a specified tolerance
Bonneville Power Authority (BPA) penalty structure

- Pays surplus deliveries at 75% of standard price
- Charges deficit deliveries at 125% of standard price
- Effectively a 25% penalty for imbalances
- Penalty for any imbalance outside tolerance band
Scheduled vs Delivered Power
Competitive Pricing Concept

• If you are making a problem worse, you shouldn’t like the price paid for the imbalance
• If you are helping to solve the problem, you should like the price paid for the imbalance
When the Problem is a Shortage

• Shortages should produce high prices
• If you are generating less than scheduled, you won’t like a high price for the variance
• If you are generating more than scheduled, you will like a high price for your variance
When the Problem is a Surplus

• Surpluses should produce low prices
• If you are generating more than scheduled, you won’t like a low price for the variance
• If you are generating less than scheduled, you will like a low price for your variance
Fast Response Storage

• During surplus period
  – Charges batteries
  – Pays low price for the electricity

• During shortage period
  – Discharges batteries
  – Paid high price for the electricity
Alaskan Data Sets

- One second generating data from Kodiak wind farm for 24 hours
- Two second ACE data from Anchorage Municipal Utility
Count of Energy Imbalances
By 100 KW Intervals
Figure 1
Count of Energy Imbalances
By 100 KW Intervals
Figure 1

- 15 Minute Variance
- ACE
Count of Energy Imbalances
By 100 KW Intervals
Figure 1
Count of 50/50 Energy Imbalances
By 100 KW Intervals
Figure 2
Energy Imbalances
(KWH)
By 100 KW Intervals
Figure 3

Size of Wind Imbalance

15 Minute Variance
1 Hour Variance
4 Hour Variance
Day Variance
Energy Imbalances
(KWH)
By 100 KW Intervals
Figure 3

Size of Wind Imbalance

15 Minute Variance
Energy Imbalances
(KWH)
By 100 KW Intervals
Figure 4
Energy Imbalances
(KWH)
By 100 KW Intervals
Figure 4
Energy Imbalances
(KWH)
By 100 KW Intervals

ACE and Wind Imbalance Average

- 15 Minute Variance
- Hour Variance
- 4 Hour Variance
- Day Variance
Gross Energy Imbalances
(KWH)
By 100 KW Intervals

ACE and Wind Imbalance Average
## Penalty on 94,749 KWH of Wind Power Depending on Scheduling Period

### Table 1

<table>
<thead>
<tr>
<th>Averaging Period</th>
<th>Schedule Variance</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>7,647 KWH</td>
<td>3,824 KWH</td>
</tr>
<tr>
<td>4 Hours</td>
<td>5,377 KWH</td>
<td>2,688 KWH</td>
</tr>
<tr>
<td>1 Hour</td>
<td>3,705 KWH</td>
<td>1,853 KWH</td>
</tr>
<tr>
<td>15 Minutes</td>
<td>2,228 KWH</td>
<td>1,114 KWH</td>
</tr>
</tbody>
</table>
### Bonus on 94,749 KWH of Wind Power Versus ACE Depending on Scheduling Period

**Table 2**

<table>
<thead>
<tr>
<th>Averaging Period</th>
<th>Negative ACE</th>
<th>Positive ACE</th>
<th>Net Beneficial</th>
<th>25% Bonus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day</strong></td>
<td>4,291</td>
<td>(4,359)</td>
<td>3,356</td>
<td>2,007</td>
</tr>
<tr>
<td><strong>4 Hours</strong></td>
<td>2,636</td>
<td>(3,042)</td>
<td>2,741</td>
<td>603</td>
</tr>
<tr>
<td><strong>1 Hour</strong></td>
<td>1,724</td>
<td>(2,129)</td>
<td>1,981</td>
<td>296</td>
</tr>
<tr>
<td><strong>15 Minutes</strong></td>
<td>1,133</td>
<td>(1,222)</td>
<td>1,095</td>
<td>253</td>
</tr>
</tbody>
</table>
## Bonus on 94,749 KWH of Wind Power Versus 50/50 ACE Imbalance Mix Depending on Scheduling Period

**Table 3**

<table>
<thead>
<tr>
<th>Averaging Period</th>
<th>Negative ACE</th>
<th>Positive ACE</th>
<th>Net Beneficial</th>
<th>25% Bonus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>1,492</td>
<td>-6,998</td>
<td>-649</td>
<td>6,155</td>
</tr>
<tr>
<td>4 Hours</td>
<td>695</td>
<td>-4,918</td>
<td>-459</td>
<td>4,681</td>
</tr>
<tr>
<td>1 Hour</td>
<td>689</td>
<td>-3,227</td>
<td>-478</td>
<td>3,016</td>
</tr>
<tr>
<td>15 Minutes</td>
<td>546</td>
<td>-1,782</td>
<td>-446</td>
<td>1,682</td>
</tr>
</tbody>
</table>
Hyberbolic Sine Price Adjustment
500 KW Divisor
Figure 6
### Bonus Due to Hyperbolic Sine Pricing Versus Normalized ACE Depending on Scheduling Period

**Table 4**

<table>
<thead>
<tr>
<th>Averaging Period</th>
<th>300</th>
<th>350</th>
<th>400</th>
<th>450</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day</strong></td>
<td>$(38,969.31)</td>
<td>$(3,077.82)</td>
<td>$(477.10)</td>
<td>$(114.19)</td>
<td>$(36.14)</td>
</tr>
<tr>
<td><strong>4 Hours</strong></td>
<td>$(493.32)</td>
<td>$(34.98)</td>
<td>$(3.28)</td>
<td>$(0.57)</td>
<td>$(1.11)</td>
</tr>
<tr>
<td><strong>1 Hour</strong></td>
<td>$(1,186.88)</td>
<td>$(84.20)</td>
<td>$(9.59)</td>
<td>$(0.61)</td>
<td>$(0.79)</td>
</tr>
<tr>
<td><strong>15 Minutes</strong></td>
<td>$(460.83)</td>
<td>$(32.94)</td>
<td>$(3.87)</td>
<td>$(0.30)</td>
<td>$(0.29)</td>
</tr>
</tbody>
</table>