Integration Challenges of Renewable Energy
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26,000+ MWs of generation
Operating in 8 states
No. 1 wind power provider
5,080 MW of wind capacity
Top 10 solar power provider

Customers
3.4 million electric
1.9 million gas

Xcel Energy is dedicated to being an environmental leader at reasonable cost
Retail Electric Rates
All Customer Classes

$0.00/kWh

US - EIA
Xcel Energy

Wind Integration Cost Categories

- Suboptimal system dispatch due to wind forecast error
- Wind curtailment
- Increased O&M on coal and gas units
- Increased regulating & contingency reserves
What has Xcel Energy done?

- Developed state-of-the-art wind forecasting system
- Increased generation portfolio flexibility from both planning and operations perspective
  - Flex Reserve Guideline manages reliability concerns while minimizing customer costs
  - Pioneered the use of regulation capability of wind farms in US
  - Offline cycling of baseload units to minimize wind generation curtailments
  - Clean Air, Clean Jobs in Colorado and Metro Emissions Reduction Program in Minnesota
- Contractual curtailment rights
- Filed Renewable Integration Tariff for PSCo
Forecasting Enhancements

- Wind Ramp Forecasts
- Probabilistic Forecasts
- Extreme Weather Events
- Distributed Solar Generation
- Load Forecasting
60-min wind Ramp in context of PSCo load (2/25/2012)

- Load Ramp = (191)MW
- Wind Ramp = (1035)MW
- Net Load Ramp = 844MW

The graph shows the 60-min wind ramp in context of PSCo load on 2/25/2012, with the load ramp, wind ramp, and net load ramp plotted over time.
### 30-Min Ramps > 300 MW, 10/1/12 - 9/30/13

<table>
<thead>
<tr>
<th></th>
<th>Negative Ramps</th>
<th>Positive Ramps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>115.0</td>
<td>169.0</td>
</tr>
<tr>
<td>Average</td>
<td>(370.3)</td>
<td>410.9</td>
</tr>
<tr>
<td>Max</td>
<td>(646.5)</td>
<td>815.6</td>
</tr>
</tbody>
</table>

### Largest PSCo Wind Generation down-ramps by year

Loss of Wind Generation greater than 300 MW in 30 minutes or less

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Installed Capacity</th>
<th>Number of Ramps</th>
<th>Largest Ramp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1259</td>
<td>13</td>
<td>(469)</td>
</tr>
<tr>
<td>2011</td>
<td>1547</td>
<td>40</td>
<td>(618)</td>
</tr>
<tr>
<td>2012</td>
<td>1855</td>
<td>59</td>
<td>(788)</td>
</tr>
<tr>
<td>2013</td>
<td>2173</td>
<td>119</td>
<td>(646)</td>
</tr>
</tbody>
</table>
## VG Forecast Value for Xcel Energy

<table>
<thead>
<tr>
<th></th>
<th>Forecasted MAE</th>
<th>Total Improvement</th>
<th>Percentage Improvement</th>
<th>Total Savings ($000,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2009</td>
<td>2013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSCo</td>
<td>18.01%</td>
<td>11.03%</td>
<td>6.98%</td>
<td>38.8%</td>
</tr>
<tr>
<td>NSP</td>
<td>15.65%</td>
<td>9.18%</td>
<td>6.47%</td>
<td>41.3%</td>
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<tr>
<td>SPS</td>
<td>16.35%</td>
<td>12.45%</td>
<td>3.90%</td>
<td>23.9%</td>
</tr>
<tr>
<td>Xcel</td>
<td>16.80%</td>
<td>10.64%</td>
<td>6.16%</td>
<td>36.7%</td>
</tr>
</tbody>
</table>
Xcel Energy Solar Generation Projected Growth

Installed Capacity (MW)

- PSCo
- NSP
- SPS

Year:
- 2013
- 2016
- 2019
- 2021
April 14, 2013-2019 PSCo Net Load with Wind and Solar Growth

2013 Min Gen

2019 Min Gen
PSCo Renewable Energy Integration Tariff

- Renewable Energy increases variability
- Regulation and Frequency Response Reserves
- Contingency Reserves
- Transmission-only customers cover their costs
- These new charges will not raise Xcel Energy’s earnings or change the economics of renewable energy for our customers.