10 FAQ’s (Frequently Asked Questions) About Wind Energy…and Answers

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Michael Milligan, Ph.D. (Consultant)
National Wind Technology Center
National Renewable Energy Laboratory
Golden, Colorado USA

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10 FAQ’s about Wind

1) How much wind is currently installed in the US?
2) What are the benefits of wind energy to the power system?
3) How can wind’s variability be incorporated into power system operations?
4) Does wind plant output start/stop suddenly?
5) Can wind be predicted?
10 FAQ's about Wind

6) Can the power system be reliably operated with wind energy?
7) Does wind need backup or storage?
8) Is there a limit to how much wind can be accommodated on the grid?
9) Can wind power plants be controlled?
10) Can wind energy make effective use of transmission lines?
11) Bonus Question: How can more wind be accommodated on the grid?
1) How much wind is currently installed in the US?

United States - 2007 Year End Wind Power Capacity (MW)

Total: 16,740 MW
(As of 12/31/07)

Data from the American Wind Energy Association (AWEA) and Global Energy Concepts (GEC) database.

Wind Power Capacity
Megawatts (MW)
- 1,000 - 4,400
- 100 - 1,000
- 20 - 100
- 1 - 20
1) How much wind is currently installed in the US?

Colorado/Xcel: Approx 20% wind penetration (wind capacity/system peak)

Iowa: Approx 16% wind penetration (wind capacity/system peak)
1b) How much wind is currently installed in Europe?

European Union: 56,535 MW  
Candidate Countries: 163 MW  
EFTA: 345 MW  
Total Europe: 57,136 MW

<table>
<thead>
<tr>
<th>MW Installed</th>
<th>End 2006</th>
<th>Installed 2007</th>
<th>End 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total EU-12</td>
<td>419</td>
<td>263</td>
<td>675</td>
</tr>
<tr>
<td>Total EU-15</td>
<td>47,651</td>
<td>8,291</td>
<td>55,860</td>
</tr>
<tr>
<td>Total EU-27</td>
<td>48,069</td>
<td>8,554</td>
<td>56,535</td>
</tr>
</tbody>
</table>
2) What are the benefits of wind energy to the power system?

- Wind energy displaces
  - Fuel
  - Emissions; carbon
- Wind provides a hedge against rising fuel prices (natural gas, coal)
- Wind is an energy source with limited capacity contribution → other generation is also required
- Wind can be cost-competitive with other forms of generation and may reduce electricity cost
3) How can wind’s variability be incorporated into power system operations

- Electric load (without wind) varies considerably
- Power system operating practices are built around meeting the variable load with dispatchable generators that can change their output level
- Wind adds more variability to the system
- Existing operating practice can be used/expanded upon with wind
4) Can wind power start and stop suddenly?

- Large wind farms have many individual wind turbines
- The turbines are spread over many miles and do not experience the same wind at the same time
- TX event Feb 24, 2007: drop of 1,500 MW over 2 hours is similar to behavior of load
5) Can wind be predicted?

- Wind forecasts are derived from weather prediction models
- Wind forecast accuracy is improving
- Several wind forecasting firms in U.S.

Courtesy: WindLogics, Inc. St. Paul, MN
6) Can the power system be reliably operated with wind energy?

- Yes – additional flexible generation (operating reserves) may be necessary at higher wind penetrations
- This additional operating reserve has a modest cost, typically about 10% of the cost of the wind energy itself
- Graph shows this level of operating reserve (blue) is a relatively small, varying fraction of wind generation

Figure 30: Illustration of time varying “operating reserve margin” developed from statistical analysis of hourly wind generation variations.
7) Does wind need backup or storage?

- Increased operating reserves may be necessary, but not dedicated backup
- Although new storage has value, it may not be cost effective
- There is typically already storage on the system
  - Natural gas in the pipeline or storage facility
  - Controllable hydro
- A recent study by Xcel Energy in Colorado found
  - existing pumped storage provided $1.30/MWh offset to wind integration cost
  - Enlarging existing gas storage facility was economic at large wind penetration

<table>
<thead>
<tr>
<th>Wind Penetration</th>
<th>10%</th>
<th>15%</th>
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<tbody>
<tr>
<td>$/ MWH Gas Impact No Storage Benefits</td>
<td>$2.17</td>
<td>$2.52</td>
</tr>
<tr>
<td>$ / MWH Gas Impact With Storage Benefits</td>
<td>$1.26</td>
<td>$1.45</td>
</tr>
</tbody>
</table>
8) Is there a limit to how much wind can be accommodated on the grid?

- Current studies in the U.S. have analyzed *up to* 25% of all electric energy from wind.
- Based on work done so far, the question is not *whether* wind can be accommodated at high penetrations, the question is *how* and at *what cost of integration*. 
8) Is there a limit to how much wind can be accommodated on the grid?

- Recent International Energy Agency Report:

  Design and operation of power systems with large amounts of wind power

Table 4. Power system size and wind power penetration studied in national cases.

<table>
<thead>
<tr>
<th>Region / case study</th>
<th>Load</th>
<th>Inter-connect. capacity</th>
<th>Wind power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak MW</td>
<td>Min MW</td>
<td>TWh/a</td>
</tr>
<tr>
<td>West Denmark</td>
<td>3700</td>
<td>1400</td>
<td>26</td>
</tr>
<tr>
<td>Nordic 2004</td>
<td>67 000</td>
<td>24 000</td>
<td>385</td>
</tr>
<tr>
<td>Nordic+Germany / GreenNet</td>
<td>155 500</td>
<td>65 600</td>
<td>977</td>
</tr>
<tr>
<td>Finland 2004</td>
<td>14000</td>
<td>3600</td>
<td>90</td>
</tr>
<tr>
<td>Germany 2015 / dana</td>
<td>77 955</td>
<td>41 000</td>
<td>552,3</td>
</tr>
<tr>
<td>Ireland / ESBNG</td>
<td>5000</td>
<td>1800</td>
<td>29</td>
</tr>
<tr>
<td>Ireland / SEI</td>
<td>6500</td>
<td>2500</td>
<td>38,5</td>
</tr>
<tr>
<td>Ireland / SEI</td>
<td>6127</td>
<td>2192</td>
<td>35,5</td>
</tr>
<tr>
<td>Ireland / SEI</td>
<td>6900</td>
<td>2455</td>
<td>39,7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>15 500</td>
<td>100</td>
<td>12 930*</td>
</tr>
<tr>
<td>Mid Norway / Sintef</td>
<td>3780</td>
<td>21</td>
<td>1062</td>
</tr>
<tr>
<td>Portugal</td>
<td>8800</td>
<td>4560</td>
<td>49,2</td>
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<tr>
<td>Spain 2011</td>
<td>53 400</td>
<td>21 500</td>
<td>246,2</td>
</tr>
<tr>
<td>Sweden</td>
<td>26 000</td>
<td>13 000</td>
<td>140</td>
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<tr>
<td>UK</td>
<td>76 000</td>
<td>24 000</td>
<td>427</td>
</tr>
<tr>
<td>US Minnesota 2004</td>
<td>9933</td>
<td>3400</td>
<td>48,1</td>
</tr>
<tr>
<td>US Minnesota 2005</td>
<td>20 000</td>
<td>8800</td>
<td>85</td>
</tr>
<tr>
<td>US New York</td>
<td>33 000</td>
<td>12 000</td>
<td>170</td>
</tr>
<tr>
<td>US Colorado</td>
<td>7000</td>
<td>36,3</td>
<td>1400</td>
</tr>
</tbody>
</table>

* The use of interconnection capacity is not taken into account in these studies. In Nordic 2004 study the interconnection capacity between the Nordic countries is taken into account.

8) Is there a limit to how much wind can be accommodated on the grid?

Denmark has access to large export markets

9) Can wind power plants be controlled?

- New low-voltage ride-through (LVRT) grid codes in the U.S. will help wind turbines contribute to grid reliability
- Wind turbines can be controlled but not to the extent that conventional generation can be controlled
  - Ramp rate limits
  - Up-regulation (operate below potential so that wind output can be increased if needed)
  - Curtailment, if necessary and economic, at low-load/high-wind conditions
10) Can wind energy make effective use of transmission lines?

- Conditional-firm transmission tariff (recent FERC ruling)
- Wind does not need transmission all of the time
- Most transmission paths have some open capacity most of the time
- Adding wind can result in more efficient usage of existing transmission
11 Bonus) How can more wind be accommodated on the grid?

- Utility balancing areas can combine or cooperate – large electricity markets (example: Denmark/Europe)
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- Utility balancing areas can combine or cooperate – large electricity markets
- Example: *Ramping*, or changing output of generators that can be eliminated with larger balancing areas

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### Ramping vs. Combined Operations

**Operating separate balancing areas causes extra ramping compared to combined operations.**

- Blue: up-ramp
- Green: down-ramp
- Yellow: combined ramp

**Some areas are ramping up nearly 1000 MW/hour while other areas are ramping down nearly 500 MW/hour.**

**Ramping that could be eliminated by combining operations.**

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[Graph showing ramping and ramp penalty]
11 Bonus) How can more wind be accommodated on the grid?

- Power system operations practices and wind farm control/curtailment
- Integration of wind forecasting and real time measurements into control room operations (WindLogics/EnerNex/UWIG/Xcel study underway in Minnesota)
- Hydro dispatch, pumped hydro
- Longer term: other storage and markets (plug-hybrid electric vehicles, hydrogen)
11 Bonus) How can more wind be accommodated on the grid? What about Storage?

• Storage can have significant benefits to the power system.
• Storage may help integrate wind, but storage is not necessary or economic based on results in the U.S. at low-moderate penetrations.
Large-Scale Studies in Process

- Western Wind & Solar Integration Study
  - 30% Wind in footprint, 20% in WECC
- Eastern Wind Integration Study

Control areas:
- APS
- El Paso
- Nevada Power
- PNM
- Sierra Pacific
- SRP
- Tristate
- Tucson
- Xcel
- WAPA
Increasing Attention in North America

- Updated in 2007
- Wind Power Coordinating Committee Wind Super-Session, Summer 2008
- Utility Wind Integration Group (UWIG): Operating Impacts and Integration Studies User Group
  www.uwig.org