Wind Energy Update

RMLUI 2008 Land Use Conference
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Presentation by Larry Flowers
National Renewable Energy Laboratory
Capacity & Cost Trends

Increased Turbine Size - R&D Advances - Manufacturing Improvements

*Year 2000 dollars
People Want Renewable Energy!

**Total Installed Wind Capacity**

1. Germany: 21800 MW
2. United States: 16842 MW
3. Spain: 13915 MW
4. India: 7720 MW
5. China: 5000 MW

World total Jan 2008: 90,521 MW

Source: WindPower Monthly
## U.S. Leads World in Annual Wind Capacity Additions; Second in Cumulative Capacity

### International Rankings of Wind Power Capacity

<table>
<thead>
<tr>
<th>Cumulative Capacity (end of 2007, MW)</th>
<th>Incremental Capacity (2007, MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>United States</td>
</tr>
<tr>
<td>21,800</td>
<td>5,144</td>
</tr>
<tr>
<td>United States</td>
<td>China</td>
</tr>
<tr>
<td>16,842</td>
<td>2,406</td>
</tr>
<tr>
<td>Spain</td>
<td>Spain</td>
</tr>
<tr>
<td>13,915</td>
<td>2,300</td>
</tr>
<tr>
<td>India</td>
<td>India</td>
</tr>
<tr>
<td>7,720</td>
<td>1,450</td>
</tr>
<tr>
<td>China</td>
<td>Germany</td>
</tr>
<tr>
<td>5,000</td>
<td>1,178</td>
</tr>
<tr>
<td>Denmark</td>
<td>France</td>
</tr>
<tr>
<td>3,132</td>
<td>1,155</td>
</tr>
<tr>
<td>France</td>
<td>Portugal</td>
</tr>
<tr>
<td>2,624</td>
<td>494</td>
</tr>
<tr>
<td>Rest of World</td>
<td>Rest of World</td>
</tr>
<tr>
<td>19,488</td>
<td>5,248</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>90,521</td>
<td>19,375</td>
</tr>
</tbody>
</table>

Data source: Windpower Monthly Windicator, January 2008
Installed Wind Capacities
(‘99 – Dec ’07*)

1999 Year End Wind Power Capacity (MW)

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

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

Preliminary data
Drivers for Wind Power

- Declining Wind Costs
- Fuel Price Uncertainty
- Federal and State Policies
- Economic Development
- Public Support
- Green Power
- Energy Security
- Carbon Risk
Natural Gas – Historic Prices

Daily price history of 1st-nearby NYMEX natural gas futures contract

NYMEX natural gas futures strip from 07/21/2006

Source: LBNL
Major Market Distortion: External Costs of Fossil Fuels not Reflected in Pricing
(The PTCs are a bargain)

External Costs of Power Stations [Euro-Cent / kWh]
19 Euro/t CO2, Nitrates = 0.5 PM10, YOLL_{chronic} = 50.000 Euro

Sites in Germany;
2010 technologies!
Minimum solar or customer-sited RE requirement

* Increased credit for solar or customer-sited RE

¹PA: 8% Tier I / 10% Tier II (includes non-renewables)

DSIRE: www.dsireusa.org
Economic Development Impacts

- **Land Lease Payments**: 2-3% of gross revenue $2500-4000/MW/year
- **Local property tax** revenue: ranges widely - $300K-1700K/yr per 100MW
- 100-200 **jobs**/100MW during construction
- 6-10 permanent O&M **jobs** per 100 MW
- Local construction and service industry: concrete, towers usually done locally
Windy Rural Areas Need Economic Development
Utilities and wind companies invested $1B in 2001 to build 912 MW of new wind power, resulting in:

- **2,500 quality jobs with a payroll of $75M**
- **$13.3M in tax revenues for schools and counties**
- **$2.5M in 2002 royalty income to landowners**
- Another 2,900 indirect jobs as a result of the multiplier effect
- **$4.6M increase in Pecos County property tax revenue in 2002**
Case Study: Minnesota

107-MW Minnesota wind project

- $500,000/yr in lease payments to farmers
- $611,000 in property taxes in 2000 = 13% of total county taxes
- 31 long-term local jobs and $909,000 in income from O&M (includes multiplier effect)
240-MW Iowa wind project

- $640,000/yr in lease payments to farmers ($2,000/turbine/yr)
- $2M/yr in property taxes
- $5.5M/yr in O&M income
- 40 long-term O&M jobs
- 200 short-term construction jobs
- Doesn’t include multiplier effect
Case Study: New Mexico

- 204-MW wind project built in 2003 in DeBaca and Quay counties for PNM
- 150 construction jobs
- 12 permanent jobs and $550,000/yr in salaries for operation and maintenance
- $550,000/year in lease payments to landowners
- $450,000/year in payments in lieu of taxes to county and school districts
- Over $40M in economic benefits for area over 25 years

Case Study: Hyde County, South Dakota

40-MW wind project in South Dakota creates $400,000 - $450,000/yr for Hyde County, including:

- More than $100,000/yr in annual lease payments to farmers ($3,000 - $4,000/turbine/yr)
- $250,000/yr in property taxes (25% of Highmore’s education budget)
- 75 -100 construction jobs for 6 months
- 5 permanent O&M jobs
- Sales taxes up more than 40%
- Doesn’t include multiplier effect
Case Study: Prowers County, Colorado

- 162-MW Colorado Green Wind Farm (108 turbines)
- $200M+ investment
- 400 construction workers
- 14-20 full-time jobs
- Land lease payments $3000-$6000 per turbine
- Prowers County 2002 assessed value $94M; 2004 assessed value +33% (+$32M)
- Local district will receive 12 mil tax reduction
- Piggyback model

“Converting the wind into a much-needed commodity while providing good jobs, the Colorado Green Wind Farm is a boost to our local economy and tax base.”

*John Stulp, county commissioner, Prowers County, Colorado*
Local Ownership Models

- Minnesota farmer cooperative (Minwind)
- FLIP structure
- Farmer-owned small wind
- Farmer-owned commercial-scale
Environmental Benefits

- No SO\textsubscript{x} or NO\textsubscript{x}
- No particulates
- No mercury
- No CO\textsubscript{2}
- No water
Sustainable Withdrawal Of Freshwater Is National Issue

Source: EPRI 2003
Change in Annual (PCPN-Potential Evapotranspiration) 2035-2060

Source: NOAA
Key Issues for Wind Power

- Policy Uncertainty
- Siting and Permitting: avian, noise, visual, federal land, radar
- Transmission: FERC rules, access, new lines
- Operational impacts: intermittency, ancillary services, allocation of costs
- Accounting for non-monetary value: green power, no fuel price or carbon risk, reduced emissions, reduced water use
# Integrating Wind into Power Systems

## Table 6. Key Results from Major Wind Integration Studies Completed 2003-2006

<table>
<thead>
<tr>
<th>Date</th>
<th>Study</th>
<th>Wind Capacity Penetration</th>
<th>Cost (S/MWh)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Regulation</td>
<td>Load Following</td>
</tr>
<tr>
<td>2003</td>
<td>Xcel-UWIG</td>
<td>3.5%</td>
<td>0</td>
<td>0.41</td>
</tr>
<tr>
<td>2003</td>
<td>We Energies</td>
<td>4%</td>
<td>1.12</td>
<td>0.09</td>
</tr>
<tr>
<td>2003</td>
<td>We Energies</td>
<td>29%</td>
<td>1.02</td>
<td>0.15</td>
</tr>
<tr>
<td>2004</td>
<td>Xcel-MNDOC</td>
<td>15%</td>
<td>0.23</td>
<td>na</td>
</tr>
<tr>
<td>2005</td>
<td>PacifiCorp</td>
<td>20%</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>2006</td>
<td>CA RPS (multi-year)</td>
<td>4%</td>
<td>0.45*</td>
<td>trace</td>
</tr>
<tr>
<td>2006</td>
<td>Xcel-PSCo</td>
<td>10%</td>
<td>0.2</td>
<td>na</td>
</tr>
<tr>
<td>2006</td>
<td>Xcel-PSCo</td>
<td>15%</td>
<td>0.2</td>
<td>na</td>
</tr>
<tr>
<td>2006</td>
<td>MN-MISO 20%</td>
<td>31%</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

* 3-year average  
** highest over 3-year evaluation period

Source: National Renewable Energy Laboratory.
Installed Wind Nameplate Capacity by State (2030)

Wind Capacity
Total Installed (2030) (GW)
- 0.0 - 0.1
- 0.1 - 1
- 1 - 5
- 5 - 10
- > 10

The black square in the center of a state represents the land area needed for a single wind farm to produce the projected installed capacity in that state. The white square represents the actual land area that would be dedicated to the wind turbines (2% of the black square).
2030 - Between PCA Transfers and In-PCA Use for Wind (All Classes)

Total Between PCA Transfer >= 100 MW (all power classes, onshore and offshore)
Arrows originate and terminate at the centroid of the PCA for visualization purposes; they do not represent physical locations of transmission lines.

Wind (MW) Used Inside the PCA
- 100 - 300
- 300 - 500
- 500 - 1000
- 1000 - 5000
- > 5000

Optimistic Case 05-15-2007 - DRAFT
Ron Lehr

Wind Powering America

www.windpoweringamerica.gov