Wind Energy & Policy

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Agenda

Benefits/Challenges
Wind Technology Basics & Trends
Location of Wind vs Location of Load
Costs
Variability & Grid Integration Challenges
Policy
Benefits/Challenges

Benefits:
- Zero Emissions
- No water consumption
- Zero Fuel costs, zero imported fuel
- Economic development / Jobs
- Payments to Farmers
Challenges:
- Intermittency
- Integration into the grid
- Transmission
- Costs (without incentives)
Wind Turbine
Basics & Trends
Wind Turbine Basics

- Horizontal Axis (such as above) have become dominant over vertical axis
- Technology has improved Capacity Factor (i.e. Yield) & other attributes
Power from a Wind Turbine

\[ P = \frac{1}{2} C_p \rho A V^3 \]

Where

- \( P \) = captured power
- \( C_p \) = max power coefficient, generally 0.25 to 0.45 (Betz limit = 0.59)
- \( \rho \) = air density
- \( A \) = rotor swept area
- \( V \) = wind speed
1st Priority: Sites with Steady/Strong Wind

United States - Land-Based and Offshore Annual Average Wind Speed at 80 m

Source: http://www.nrel.gov/gis/images/80m_wind/awstwspd80onoffbigC3-3dpi600.jpg
Wind Potential vs. Turbine Height

Comparison of the wind energy resource at 50 m, 70 m, and 100 m for Indiana

Wind Turbine Sizes Over Time

The development path and growth of wind turbines
Evolution of U.S. Commercial Wind Technology

Location of Wind Resource vs Location of Loads
Most Americans do not tend to live near many prime wind locations.
(Hence, transmission lines needed for big wind)

Note potential of Coastal or Off-Shore Wind
- Much closer to Loads
- Tends to better align with Peak Demand

But:
- Costs, Aesthetics, Region Specific Issues
Large Scale Grid Generation at ~20kV
Step-up voltage to efficiently transmit power long distances
Step-down voltage to safely distribute power to homes
Transmission Needed
Large Scale Transmission Concept

AEP's conceptual transmission plan to accommodate 400 GW of wind energy

Key Policy Questions:
- Transmission line locations
- Acquisition of right of way
- Allocation of construction costs

Costs
### Generation Costs

**U.S. average levelized costs (2011 $/megawatthour) for plants entering service in 2018**

<table>
<thead>
<tr>
<th>Plant type</th>
<th>Capacity factor (%)</th>
<th>Levelized capital cost</th>
<th>Fixed O&amp;M (including fuel)</th>
<th>Variable O&amp;M</th>
<th>Transmission investment</th>
<th>Total system levelized cost</th>
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1. Costs are expressed in terms of net AC power available to the grid for the installed capacity
2. Hydro is assumed to have seasonal storage and dispatchability, but dispatch constraints existing over the course of a year
3. Tax credits or incentives are NOT included (e.g. PTC or ITC)
Wind Costs: Actual Projects

Note that Power Purchase Agreement (PPA) prices may be higher in some projects to reflect value of meeting RPS/Mandates

Levelized Long-Term Wind PPA Prices in 2011/2012 and Yearly Wholesale Electricity Prices by Region

Source: Berkeley Lab, Ventyx, IntercontinentalExchange

Challenges of Wind Integration into the Electric Grid
Electricity service started as isolated micro-grids (e.g. Edison in NYC) over a century ago.

Isolated grids interconnected into mesh networks over the last century:
- Provides back-up (Reliability) & scale economies (cost)

Independent System Operators (ISOs) responsible for grid reliability & market functions.
Varied Fuels Used to Generate Electricity

2013 High Wind Week - Generation by Fuel Type

Note – no changes to existing reserves required.

Source: John Dumas, ERCOT
Big Wind Impacts on Grid Operations

Time Frames that Wind Power has Most Significant Impact on Current Operations

Wind Power Varies by Region, Season/Day, Hour

Output Pattern (July 03 - August 04)
Diversity Reduces Variability

Aggregation of Wind Power (Seconds)
Methods to Reduce the Impact of Increasing Amounts of Wind

Improved wind forecasting

Improved Balancing Authority coordination

More Flexible Resources: Generation or loads

New Types of Load and Demand Profiles

Deployment of new technologies:
- Energy Storage
- PEVs
- Demand Response (DR)
- Phasor Measurement Units (PMUs)
- Synthetic Inertia

Advances in computer software and Hardware performance
- Decision Support Systems

Improved ISO control mechanisms

New Electricity Market designs

Work Force Demographics and Skills/training

Source: DOE: Wind Energy and Utility Control Rooms in 2030
Policy
Laws/Regulations
Wind Policy: Price Competitiveness
Policy Levers to Jump Start the Industry

**Tax Credits, subsidies, abatements**
- Attempt to nurture over time the industry to competitive costs (without subsidies)

- Policy tools for driving technology need to be *Temporary* and *Effective*
- Can reduce net costs, increase prices, force % or quantities, fix attractive prices

- PTC (Production Tax Credit) & ITC (Investment Tax Credit) examples for Wind
  - PTC pays only on energy production, not investment
    - Early era wind projects more driven from ITC (% of invested capital)
      - Some became examples of tax dodge (vs effective driver of industry)
      - Up-front incentive, no incentive to improve reliability or production

- PTC can drive prices negative which impacts new generation build-out
  - Contributes to low ERCOT wholesale prices, which discourage new generation
  - Contributes to lower retail prices for customers
  - 10 year duration then expires for a particular project

- Also can have State, Local (city, school district) incentives
  - Targeting economic development (job creation)
  - Tax abatements can be important for wind developers’ business case Profit/Loss

- Overall: claim is that PTC costs are fully recovered by increased Federal/State/Local tax revenue over the life of the project (AWEA).
Wind Policy: Price Competitiveness

RPS (Renewable Portfolio Standards) or Mandates
- Typically dictate fraction or quantity of energy production from renewables
- Can be voluntary or firm requirements
- Can increase prices when more renewables are required (Not the case in ERCOT)
- RECs (Renewable Energy Credits) system can be created for trading
- Attempts to enable market forces drive selection, efficiency, & improvements

Feed-In Tariffs
- Guarantee to purchase energy at attractive price with long term contracts
- Used more aggressively in Europe

Source: Berkeley Lab, Ventyx, IntercontinentalExchange

Levelized Long-Term Wind PPA Prices in 2011/2012 and Yearly Wholesale Electricity Prices by Region

Wind Policy: Cost of Grid Integration

Conventional generation needed to back-up wind
- Wind is intermittent & “non-dispatchable” unlike NatGas/Coal/Hydro generation
- Policy Consideration: Society benefits from low emissions, zero water usage, jobs
- Policy dictates how to allocate wind integration costs
  - Costs vary by region, amount of wind integrated, amount of new transmission

Integration Costs at Various Levels of Wind Power Capacity Penetration

Wind Policy: Protected Animals

Threatened or Endangered Species Act (Federal Law)
- Whooping Crane, Indiana Bat

Migratory Bird Treaty Act (MTBA)
- Bald Eagle, Golden Eagle, House Martin bird

Developers/owners of Wind farms may be criminally liable (i.e. Jail Time) for bird deaths under some circumstances

Mitigation Strategies Evolving
- Radar warning of approaching birds
- Turn off turbines during migration
Wind Related Laws/Regulations
Other Considerations “Windcatters” must address

Transmission siting:
- Bulk transmission, or Connection to Bulk Transmission
- Crossing Federal (Bureau of Land Management) or State lands
- Eminent domain, negotiation with critical landowners

Wetlands preservation
- Not a problem in West Texas. But a consideration for attractive coastal wind

Aviation Interference: FAA (Federal Aviation Administration)

Zoning/Land use (Typically local issues and Ordinances)

Historical Location (e.g. Protected Burial Site)
Questions??