Wind and Energy Markets: A Case Study of Texas.

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Abstract

- Many jurisdictions worldwide are greatly increasing the amount of wind production, with the expectation that increasing renewables will cost-effectively reduce greenhouse emissions.
- Discuss the interaction of increasing wind, transmission constraints, renewable credits, wind and demand correlation, intermittency, carbon prices, and electricity market prices using the particular example of the Electric Reliability Council of Texas (ERCOT) market.
Outline.

- Transmission limitations for wind in ERCOT.
- Effect of production tax credits and renewable energy credits.
- Wind and demand correlation.
- Intermittency.
- Putting the cost estimates together.
- Carbon price comparisons.
Zones in ERCOT balancing market:
Peak load 63 GW, Generation 73 GW.

West Zone
Peak load 4 GW, Generation 13 GW, Wind 7.5 GW

North Zone
Peak load 27 GW, Generation 32 GW

South Zone
Peak load 16 GW, Generation 16 GW, Wind 0.5 GW

Houston Zone
Peak load 16 GW, Generation 12 GW

~1.5 GW West to North Export capability
Transmission limitations for wind in ERCOT.

- With limited transmission from West, West zone price is set by wind offers in West.
- If intense competition, West zone price could be as low as effective marginal cost of wind:
  - minus $30/MWh due to production tax credits and renewable energy credits.
- Concurs with recent experience in ERCOT balancing market in West zone:
  - Occurred for over 1000 hours in 2008.

[Graph showing price fluctuations for different zones at various times of the day.]
Apparently analogous experience in South Australia/Victoria.

South Australia and Victoria prices, April 15, 2009, Aus$/MWh.
Transmission prices.

- Differences in zonal (or nodal) prices represent the (short-term) opportunity cost to transmit power from one location to another in limited system:
  - When transmission constraints bind, opportunity cost (and therefore transmission price) can be high,
  - As high as $40/MWh or more from West zone to demand centers in ERCOT, higher between SA and Victoria.
Transmission prices.

- In longer-term, investment in transmission increases capacity to transmit power and reduces short-term transmission prices:
  - In principle, socially optimal investment to bring energy from remote generation resources would trade-off the cost of new transmission (and new wind generation) against production cost savings (possibly including cost of greenhouse emissions),
  - In practice, production cost savings can only be roughly estimated from offers, and transmission planning may be driven by many goals.
Transmission prices.

- Wind is far from demand in US and Australia:
  - Transmission constraints often limit transfers from wind to demand centers, as in West zone wind in ERCOT and SA wind in Australia,
  - Transmission capacity increases require more investment for wind than for thermal.

- ERCOT “competitive renewable energy zones” involve about $5 billion in transmission investment for increase in capacity of 11 GW from West:
  - Approximately $20/MWh average cost.
Wind and demand correlation.

- What happens when transmission upgrades are completed and more wind is built?
- Much more wind power will be produced!
- However, West Texas wind is anti-correlated with ERCOT demand:
  - Wind tends to blow more in Winter, Spring, and Autumn than Summer and more during off-peak hours than on-peak.
- Typical case for on-shore wind in US:
  - Off-shore wind and solar better correlation.
Wind and demand correlation.

- Off-peak wind production tends to decrease need for thermal generation off-peak.
- Again, if there is intense competition off-peak, prices may be set negative by wind.
- Concurs with recent experience in ERCOT balancing market:
  - Additional wind at these times may increase fossil fuel use and increase emissions.
  - Occurred for over 30 hours in 2008.
Wind and demand correlation.

ERCOT balancing market prices, April 22, 2009, US$/MWh.

North Zone Price
South Zone Price
West Zone Price
Houston Zone Price
Wind and demand correlation.

- If off-peak wind can be anticipated in forecast, centralized unit commitment could reduce wind curtailment by de-committing thermal:
  - current ERCOT market does not have centralized unit commitment, but
  - ERCOT nodal market will have centralized unit commitment.

- Might also be better to spill more wind under some circumstances.

- In longer-term, generation portfolio might adapt to “peakier” net load by increasing fraction of peaker and cycling capacity.
Wind and demand correlation.

Load-duration without wind.

Net Load-duration with wind.
Net load = load minus wind.

Load, MW

Duration

Baseload

Peaker
and Cycling

Net load, MW

Duration

Baseload

Peaker
and Cycling
Intermittency.

- Various US studies have estimated the “wind integration” AS costs, with estimates varying from a few to around five $/MWh.

- Variation in estimates reflect:
  - Variation in particulars of systems,
  - Lack of standardization in estimating costs, and
  - Lack of representation of intermittency in standard generation analysis tools.

- Proxy upper bound to energy-related AS costs provided by cost of lead-acid battery based energy storage, around $50/MWh.
Intermittency.

- Aggressive portfolio standards in the 20% to 30% range for energy will almost certainly involve significant changes in operations of both wind and thermal to cope with intermittency.

- Example (assuming all renewables are wind):
  - 30% renewable portfolio standard by energy,
  - 40% wind capacity factor (ratio of average production to wind capacity),
  - 55% load factor (ratio of average to peak demand),
  - Ignoring curtailment, wind capacity would be 41% of peak demand and would exceed minimum demand!!
Intermittency.

- ERCOT peak demand is about 63 GW.
- 30% renewable portfolio standard for energy would require around 26 GW of wind capacity.
- But even with 8 GW of wind capacity today, prices are occasionally negative during off-peak in Spring in ERCOT, with minimum demand around 25 GW.
- With 26 GW of wind, would need major changes to: operations; portfolio of generation; storage; and demand!
Intermittency.

- Multiple possible changes to accommodate intermittency:
  - Increased reserves,
  - Relatively more agile peaking and cycling generation,
  - Wind spillage, provision of inertia and regulation,
  - Compressed-air energy storage,
  - Controlled charging of millions of PHEVs,
  - Using off-peak coal generation to power carbon dioxide separation and sequestration.

- Hard to estimate capital and operating cost of optimal portfolio of changes!
Intermittency.

- As a *rough* ballpark proxy for energy-related AS cost due to intermittency:
  - Suppose that lead-acid battery storage for 20% of wind energy production would compensate for intermittency,
  - Would add 20% times $50/MWh = $10/MWh to cost of wind.

- Compares to estimates of up to $5/MWh from integration studies.
Putting the cost estimates together.

- ERCOT charges most costs of transmission construction to demand.
- North American markets generally charge all AS costs to demand, regardless of cause.
- But we will add the wind-related transmission and wind-related AS costs to the cost of wind power:
  - Needs care when comparing to similar figures for other generation assets, particularly given other subsidies in electricity sector.
  - Transmission and AS costs are not reflected in market prices for energy.
Putting the cost estimates together.

- Typical unsubsidized cost of wind energy is around $80/MWh,
- Assume $20/MWh incremental transmission for new wind in ERCOT,
- Assume $5/MWh to $10/MWh proxy to cost of intermittency,
- Total is about $105/MWh to $110/MWh.
- Average balancing energy market price in ERCOT is around $50/MWh to $60/MWh.
- New wind adds about $50/MWh to costs.
Carbon price comparisons.

- US Congressional Budget Office estimates $15 per metric ton of CO$_2$ emissions ($13-14$ per US ton) as initial price under House Bill 2454.
- Ceilings discussed at $30$ to $35$/US ton.
- Assuming 10,000 Btu/kWh heat rate, a little over 1 US ton of CO$_2$ is produced per MWh of coal-fired electricity production, less for gas:
  - Around at most $15$ to $35$ of CO$_2$ is produced per MWh, given House Bill 2454 valuations.
Carbon price comparisons, continued.

- What is value of wind in decreasing greenhouse emissions?
- ERCOT evidence suggests that new wind may not be decreasing greenhouse emissions.
- However, even assuming that wind displaces fossil emissions, it is not “worthwhile” for reducing greenhouse emissions at initial or ceiling CO\(_2\) price.
Summary

- Transmission limitations for wind in ERCOT.
- Effect of production tax credits and renewable energy credits.
- Wind and demand correlation.
- Intermittency.
- Putting the cost estimates together.
- Carbon price comparisons.