The Curious Rise of Wind in Texas

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Outline

- Electricity and wind in the European Union versus the USA.
- Focus on Denmark, Germany, and Sweden.
- The curious case of Texas and ERCOT.
- Implications for stochasticity and risk analysis.
- Conclusion.

European Union versus USA

- Total EU installed power generation capacity approximately 932 GW (EWEA 2013),
- Total EU installed wind power generation capacity approximately 106 GW, **11.4%** (EWEA 2013),
- EU wind energy production as fraction of electric energy consumption approximately **7%** (EWEA 2013).

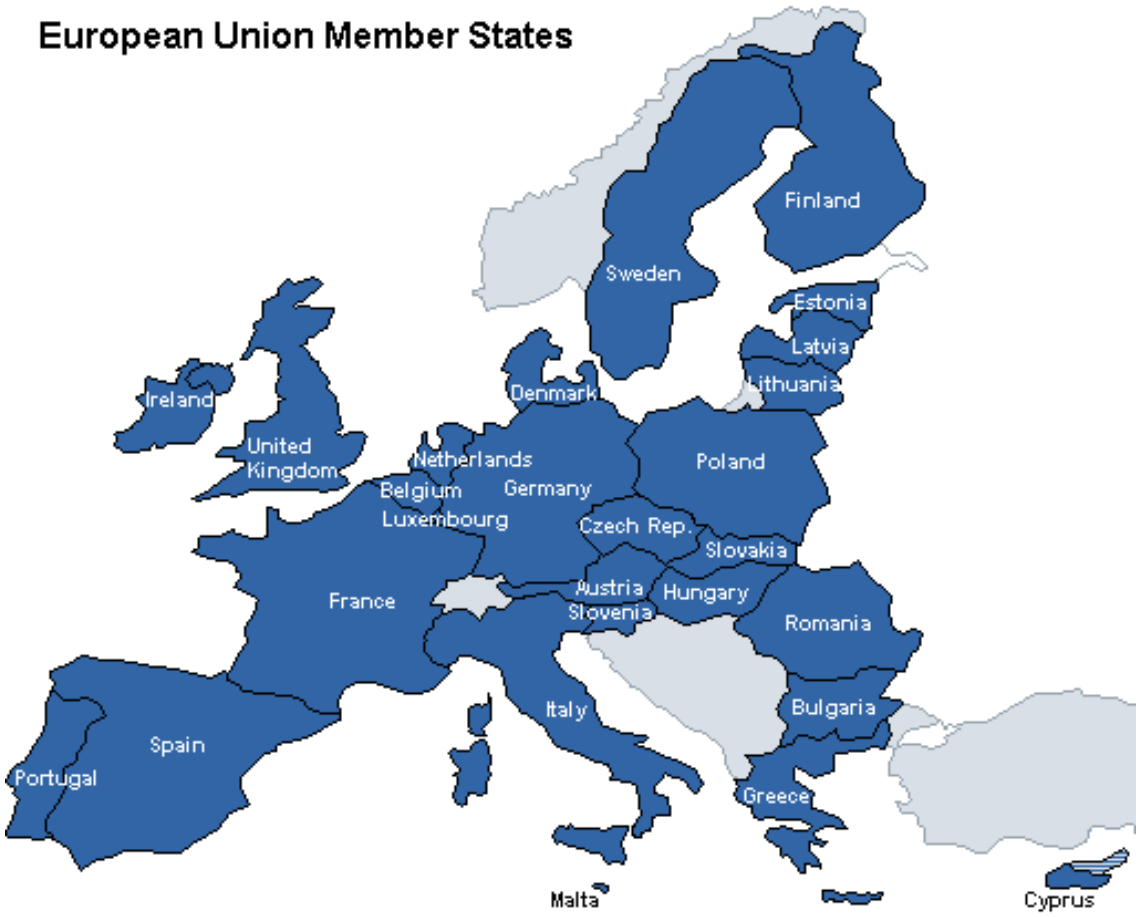
- Total USA installed power generation capacity, approximately 1,050 GW (USEIA 2013a),
- Total USA installed wind power generation capacity approximately 60 GW, **5.7%** (USEIA 2013c),
- USA wind energy production as fraction of electric energy consumption approximately **3.2%** (USEIA 2013a).

European Union versus USA

- Greater penetration of wind by capacity and energy in EU is unsurprising given:
  - Higher fossil fuel energy costs in Europe,
  - Acceptance of need to mitigate greenhouse emissions because of climate change,
  - Encouragement of clean technology sector,
  - Significant amount of flexible hydroelectric and pumped storage hydroelectric resources.
- EU overall slightly behind 2012 target penetrations in “National Renewable Energy Action Plans” (EWEA 2013).

Focus on Denmark, Germany, and Sweden

- Several EU countries, particularly Denmark, Portugal, Spain, Ireland, and Germany, have been prominent in wind integration.



Focus on Denmark, Germany, and Sweden

- Denmark (EWEA 2013, USEIA 2013b):
  - 4.2 GW wind capacity, out of approximately 13.7 GW total capacity, **30%**,
  - annual wind energy production as a fraction of electric energy consumption, **27.1%**, highest in EU,
- Germany (EWEA 2013, USEIA 2013b):
  - 31.3 GW wind capacity, out of approximately 153 GW total capacity, **20%**,
  - annual wind energy production as a fraction of electric energy consumption, **10.8%**.

Focus on Denmark, Germany, and Sweden

- Sweden (EWEA 2013, USEIA 2013b):
  - 3.7 GW wind capacity, out of approximately 36.5 GW total capacity, **10%**,
  - annual wind energy production as a fraction of electric energy consumption, **5%**.

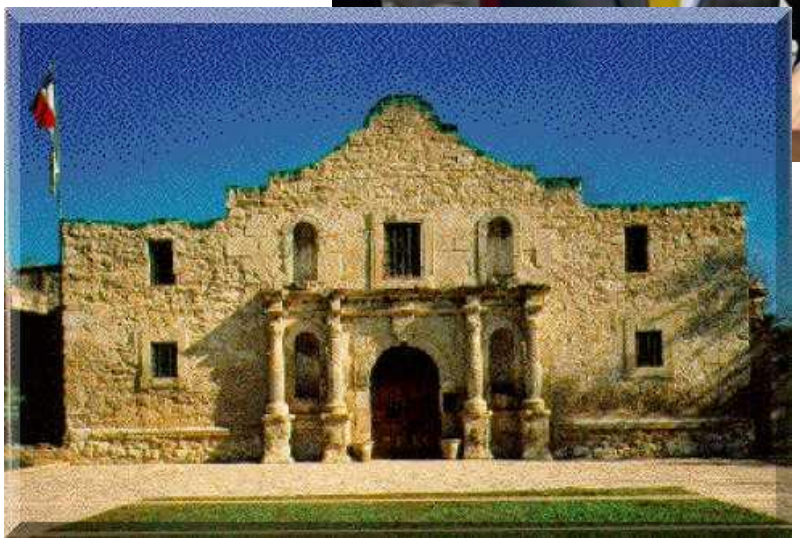
Focus on Denmark, Germany, and Sweden

- But Danish statistics should not be taken as “standalone” values:
  - relative capacity of Denmark system, and
  - integration into EU and Norway.
- Wind energy production in Denmark *and* Germany as fraction of total electric energy consumption in Denmark *and* Germany is around **11%** (USEIA 2013b):
  - Only slightly more than Germany alone.

Focus on Denmark, Germany, and Sweden

- Wind energy in Denmark, Germany, and Sweden as a fraction of total electric energy consumption in Denmark, Germany, and Sweden is around **9%** (USEIA 2013b):
  - Somewhat more than EU average, but
  - Less than Germany alone.

Europe versus Texas



The curious case of Texas

- In contrast to Europe, Texas has:
  - Low fossil energy costs, low taxes on fossil fuels,
  - Extreme skepticism amongst elected officials about climate change: “I do believe that the issue of global warming has been politicized…I think there are a substantial number of scientists who have manipulated data so that they will have dollars rolling into their projects,” Texas Governor and one-time presidential hopeful Rick Perry,
  - Traditional emphasis on fossil fuel sector,
  - Very little hydro and no pumped storage.

The curious case of Texas.

- Expect lack of enthusiasm for renewables!

- Santa Rita No. 1: first proven oil in Texas (on University of Texas land; rig now on Austin campus).

The curious case of Texas

- Yet, Texas has, by far, the most wind capacity and highest wind energy production in the USA!
- Most of Texas is covered by the Electric Reliability Council of Texas (ERCOT).

ERCOT

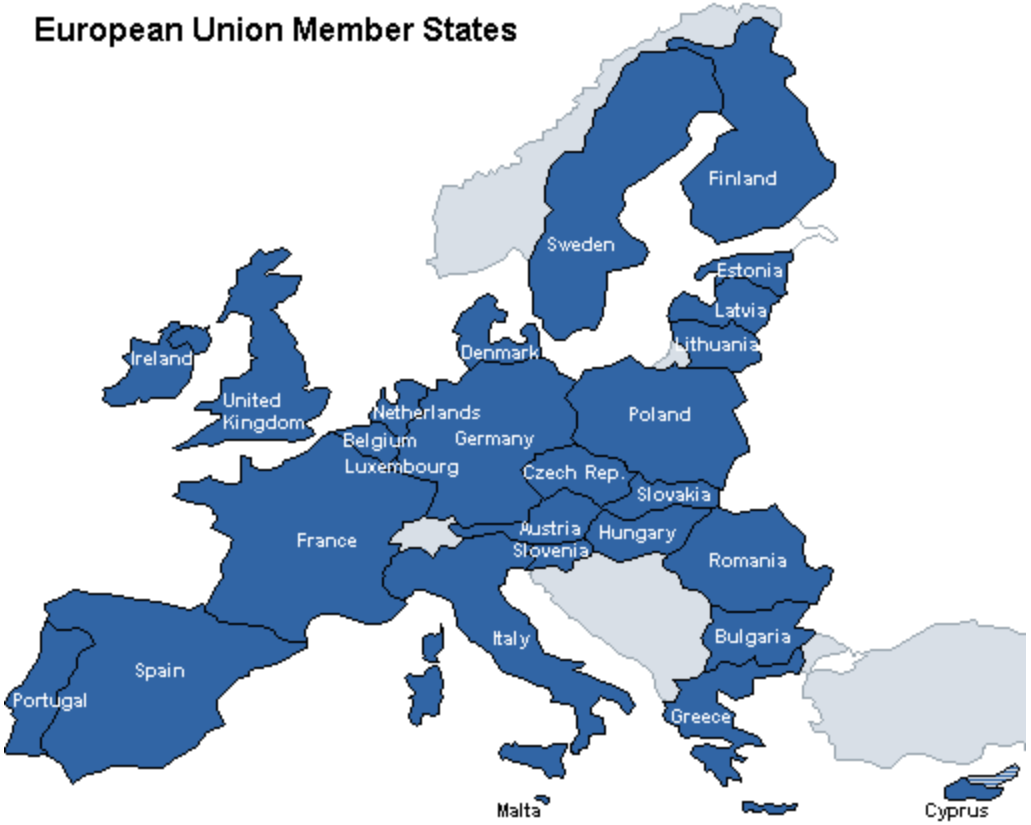
- One of five main synchronous interconnections in North America,
- The smallest of the three synchronous interconnections in USA,
- Covers most of the area and accounts for most of the electric consumption in Texas,
- ERCOT independent system operator (ISO) operates market and coordinates operation of transmission.

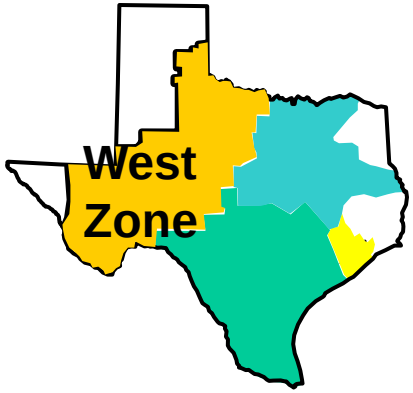
The curious case of Texas

- ERCOT (Potomac 2012; ERCOT 2013):
  - Total installed power generation capacity around 85GW; Peak demand approximately 68GW,
  - Total installed wind power generation capacity over 10 GW, **13%**, (compares to 11.4% in EU, 30% in Denmark, 20% in Germany, and 10% in Sweden),
  - Wind energy production as a fraction of electric energy consumption around **9.2%**, (compares to 7% in EU, 27.1% in Denmark, 10.8% in Germany, and 5% in Sweden).

The curious case of Texas

- Wind in Denmark has analogies with wind in West Zone of ERCOT.

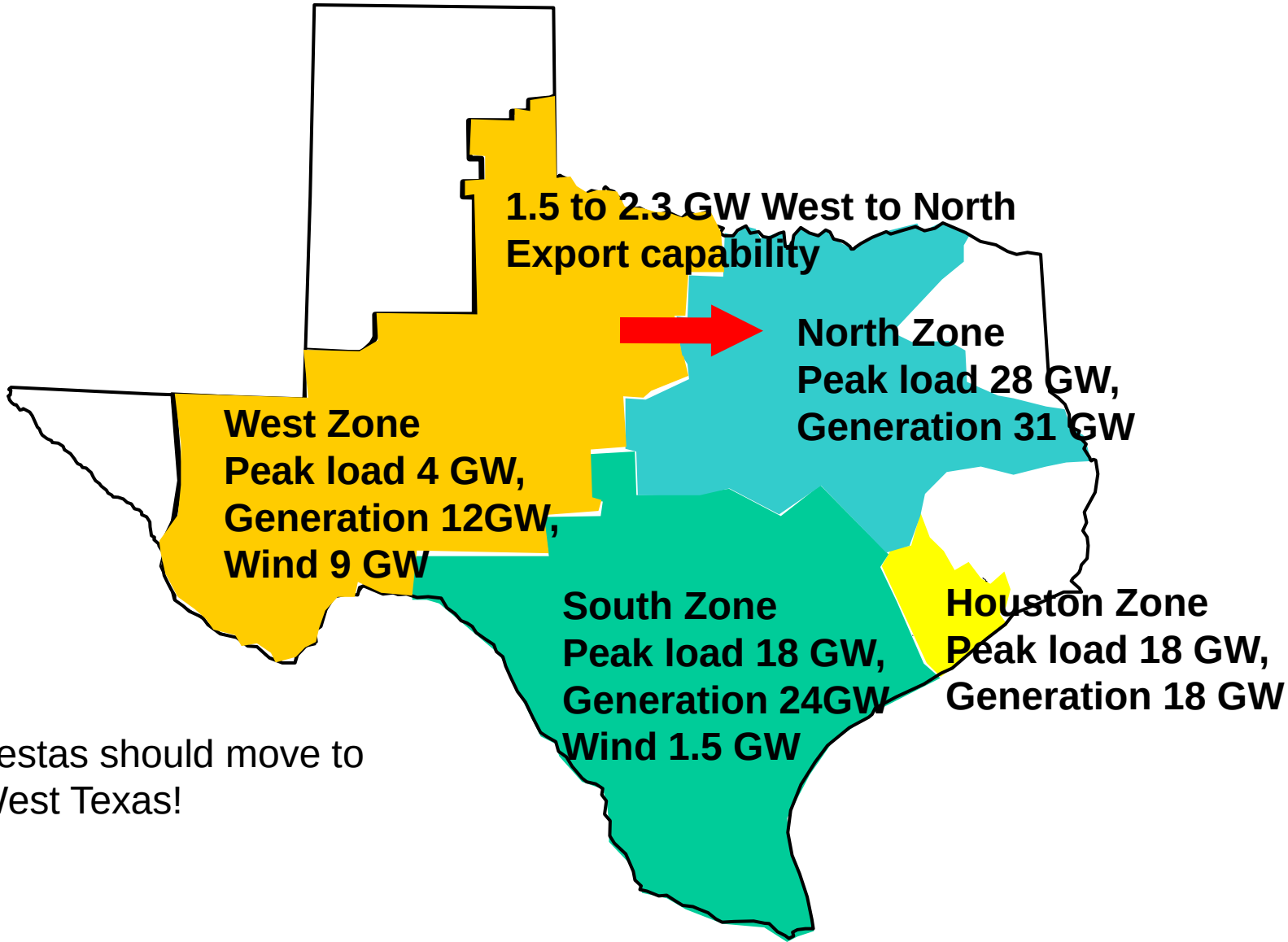




West zone ERCOT

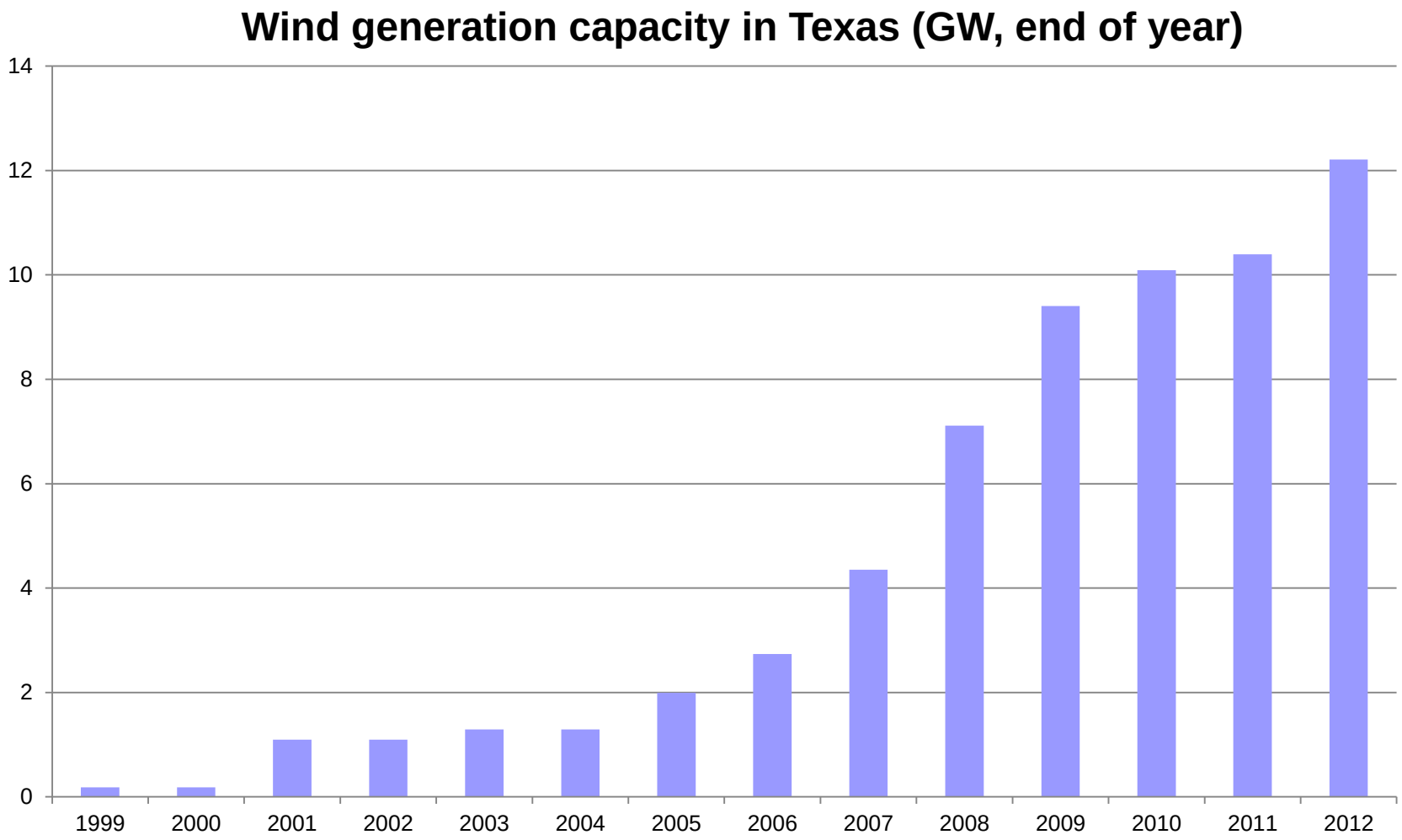
- Total installed power generation capacity around 12 GW, (compares to 14 GW in Denmark),
- Total installed wind power generation capacity around 9 GW, **75%**, (compares to 4GW and 30% in Denmark),
- Annual wind energy production as a fraction of electric energy consumption is more than **85%**, (compares to 27.1% in Denmark),
- Monthly wind energy production above **100%** in some months.

The curious case of Texas.



Vestas should move to West Texas!

The curious case of Texas.



Source: USEIA 2013c.

The curious case of Texas

- Huge growth in wind in Texas despite lack of obvious motivations in terms of:
  - energy prices,
  - climate change policy directives,
  - clean technology industry development (except in Austin).
- Yet, Texas state legislature has mandated renewable energy requirements:
  - So much wind has been built that state mandates are no longer binding!
  - Texas wind capacity exceeds 2025 target!

The curious case of Texas

- Drivers of renewable growth in ERCOT:
  - Federal subsidies around $30/MWh,
  - Robust wholesale market, operating since 1996, retail open access since 2002,
  - New generation entry facilitated by uniform interconnection agreement mediated by ERCOT ISO,
  - Good wind resources in West (and along Gulf coast),
  - State level desires to foster rural/West economic development,

The curious case of Texas

- Drivers of renewable growth in ERCOT:
  - Landowners willing to sign wind leases,
  - Little not-in-my-backyard opposition to turbines and transmission,
  - Transmission in West Texas traditionally constrained in import direction,
  - Transmission and ancillary services costs socialized.
- Greenhouse issues not typically articulated in public policy about wind in Texas!

The curious case of Texas

- Initial development 1999 through circa 2007:
  - Existing bulk transmission system allowed for considerable West Zone wind with only modest local transmission upgrades, since system was built for *importing* energy *into* West Zone,
  - Wind ramping events such as wind die-offs involved changes in wind production smaller than the spinning reserves carried for the largest thermal generation (2.3 GW),
  - Thermal generation portfolio relatively unchanged, despite changes to operations.

The curious case of Texas

- Subsequent and future development:
  - Transmission:
    - Major upgrades to bulk transmission necessary for significant further integration of wind ("CREZ" transmission upgrades, around $7 billion),
  - Effects on wholesale markets:
    - US Federal "production tax credit" (PTC) subsidies make effective marginal production cost negative,
    - Electricity prices negative in West zone when transmission constraints are binding, occasionally negative throughout ERCOT,
    - Reduce profitability of investment, particularly baseload investment.

The curious case of Texas

- Subsequent development:
  - Wind die-offs and variability will likely increase the need for carrying ancillary services:
    - Large die-offs over 30 minutes now larger than spinning reserves carried,
    - Possible need for additional quantities and classes of ancillary services compared to those needed in context of mostly dispatchable, thermal system.

The curious case of Texas

- Subsequent development:
  - West Texas wind anti-correlated with demand,
  - Peak wind production coincides with minimum of "net load" (load minus wind):
    - Completion of CREZ transmission upgrades circa 2014 will increase incidence of negative prices throughout ERCOT,
    - Further affect operations and baseload investment.
  - More recent coastal wind development has much more favorable correlation with demand:
    - But environmental concerns regarding birds and bats,
    - Coastal property more valuable.

The curious case of Texas

- Subsequent development:
  - Because net load with high wind is “peakier,” expect portfolio to adapt towards less baseload and more peakers:
    - Expect tight capacity under peak demand conditions in Summer 2013 and 2014.
- ERCOT system and market will need to adapt to various challenges of nature of large scale wind integration:
  - Stochasticity and risk issues.

Stochasticity and risk associated with wind

- Explicit subsidies and mandates are major drivers of renewable investment:
  - Each time US Federal PTC has “expired,” renewable growth has fallen to close to zero.
  - Regulatory fiat drives renewable investment and is huge risk for investment in nuclear/fossil generation and new technology development.
  - Concern about policy uncertainties, particularly where transmission infrastructure investment is publicly funded.

Stochasticity and risk associated with wind

- Intermittent renewables have variability and uncertainty on timescales not matched by traditional tools used in the electricity industry:
  - Forecasting of intermittent production,
  - Operations, including commitment of residual thermal system to meet net load and effects on: needs for, types, and cost of ancillary services,
  - Valuation of storage and demand side to compensate for variability and uncertainty.

Stochasticity and risk associated with wind

- Intermittent renewables have locational and temporal characteristics that shift focus of analysis from particular high demand conditions to consideration of locational and temporal distribution of wind and net load:
  - Planning, including new additions of long-distance transmission to access remote wind, must adapt to these changes.

Stochasticity and risk associated with wind

- Long-term adaptation of thermal system portfolio to net load requires less baseload and more agile peaking generation:
  - Lower capacity factors,
  - More agility to cope with wind die-offs,
  - Compensation for reduced inertia of system,
  - Greater variation between on- to off-peak wholesale prices.
- Shift to more explicit representation of stochasticity and risk.

Conclusion

- Texas has experienced huge growth in wind generation almost despite a lack of environmental motivations for renewable integration.
- Initial very favorable circumstances for integration of wind have now given way to relatively higher integration costs for transmission and ancillary services.
- Many issues related to stochasticity and risk need new analysis and tools.

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