



Renewable Energy Evolution in North America

INL Dynamic Line Rating Workshop

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Outline of Topics

- ◆ Introduction
- ◆ Market Design and Operation
- ◆ Forecasting, Curtailment and DLR
- ◆ Closing Thoughts
- ◆ Q&A



Renewable Energy is Very Competitive

- Lazard reports on lowest unsubsidized energy costs at end of 2016 for:
 - Simple Cycle GT \$165/MWh
 - Rooftop residential solar \$138/MWh
 - Nuclear \$97/MWh
 - Coal \$60/MWh
 - Combined Cycle GT \$48/MWh
 - Utility scale solar \$46/MWh
 - Wind energy \$32/MWh

- Other reports from industry pubs on recent PPA prices:
 - Utility scale solar \$34-\$45/MWh
 - Wind energy \$14-\$30/MWh

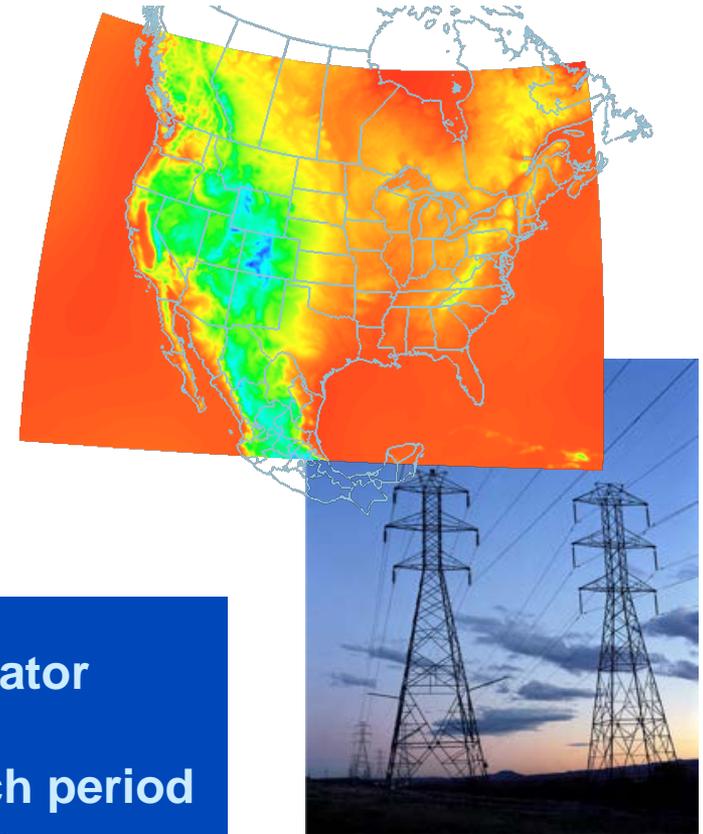


Some Recent Context

- ◆ FERC NOPR on Electric Storage Participation in Markets Operated by RTOs and ISOs to remove barriers to the participation of electric storage and DER aggregations in organized markets
- ◆ Energy Information Administration reports that US received 10% of electrical energy from wind and solar in March 2017, first time in double digits; received 7% in 2016
- ◆ EEI annual meeting: Gerry Anderson, CEO of DTE Energy and chief environmental officer for EEI, says DTE discovered during the CPP planning process that it could affordably cut carbon 80% from 2005 levels by 2050, and that DTE is not an outlier
- ◆ Corporate America demand for clean, carbon-free energy: fifty percent of the Fortune 500 have public sustainability goals, driven by pressure from investors, customers and employees; 93 have 100% RE goals
- ◆ Pushback from corporations, states, cities and universities against President Trump's plans to remove US from Paris climate agreement and roll back the Clean Power Plan

Unit Commitment and Dispatch

- ◆ Unit commitment and dispatch is a rolling optimization process
- ◆ “Dispatchable” does not mean being able to provide any desired amount of power at any specified time



Dispatch is not arbitrarily telling a generator what to produce...
It is knowing what is available for the dispatch period and optimizing the system as a whole



Most Wind in North America is Dispatched Today

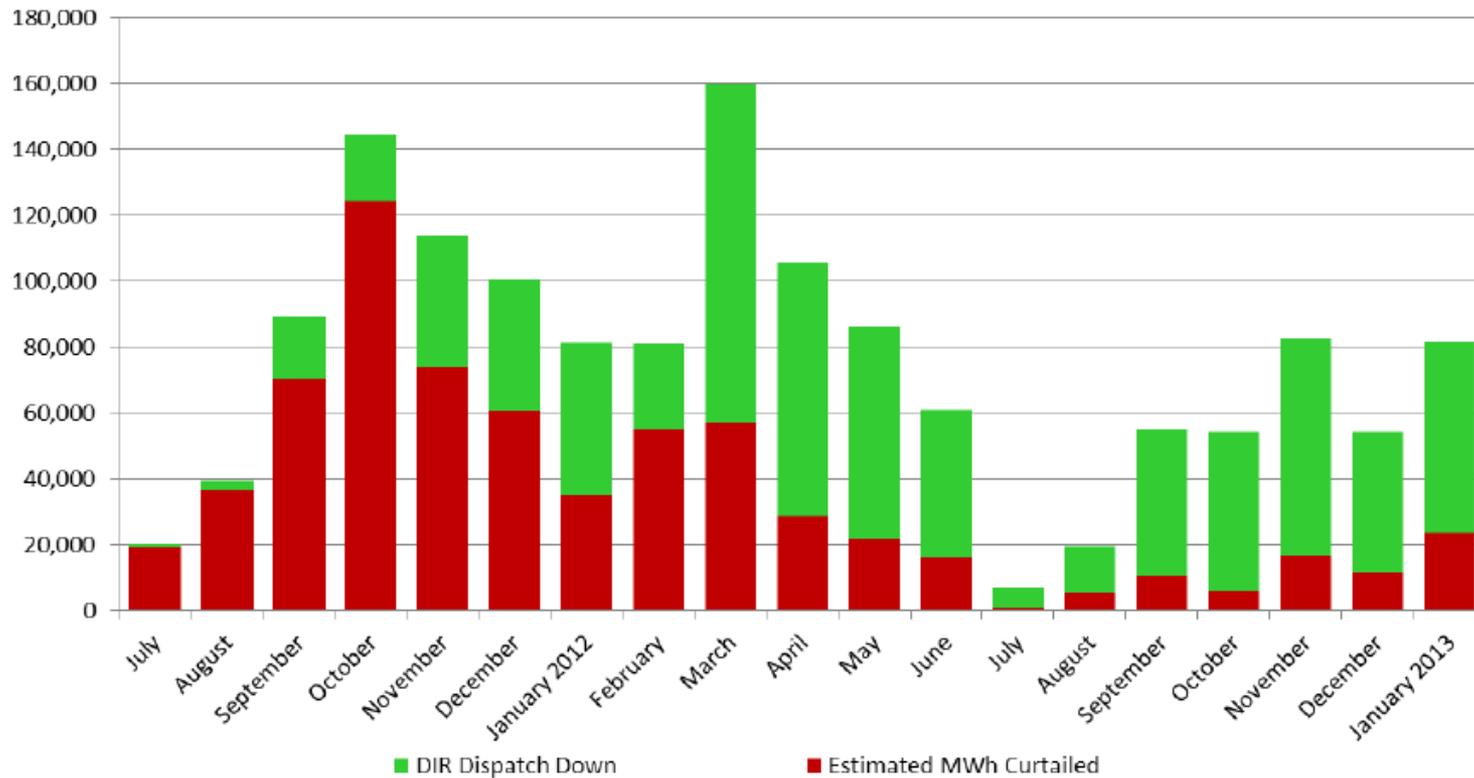
Most ISO/RTO systems now include wind in Day Ahead Unit Commitment and Security Constrained Economic Dispatch (SCED)

- ◆ Wind dispatch done with a 10-minute-ahead forecast or faster
 - Using the current telemetered value (“persistence” forecast)
 - » NYISO, ERCOT, SPP
 - Using a rolling five-minute forecast (“persistence + model” forecast)
 - » MISO, PJM, IESO
- ◆ Not a markets issue (markets may help, but this works anywhere)
 - Forecast wind into day ahead unit commitment
 - Dispatch the entire system (including wind) every five minutes using a very short term wind forecast or the current telemetered output value

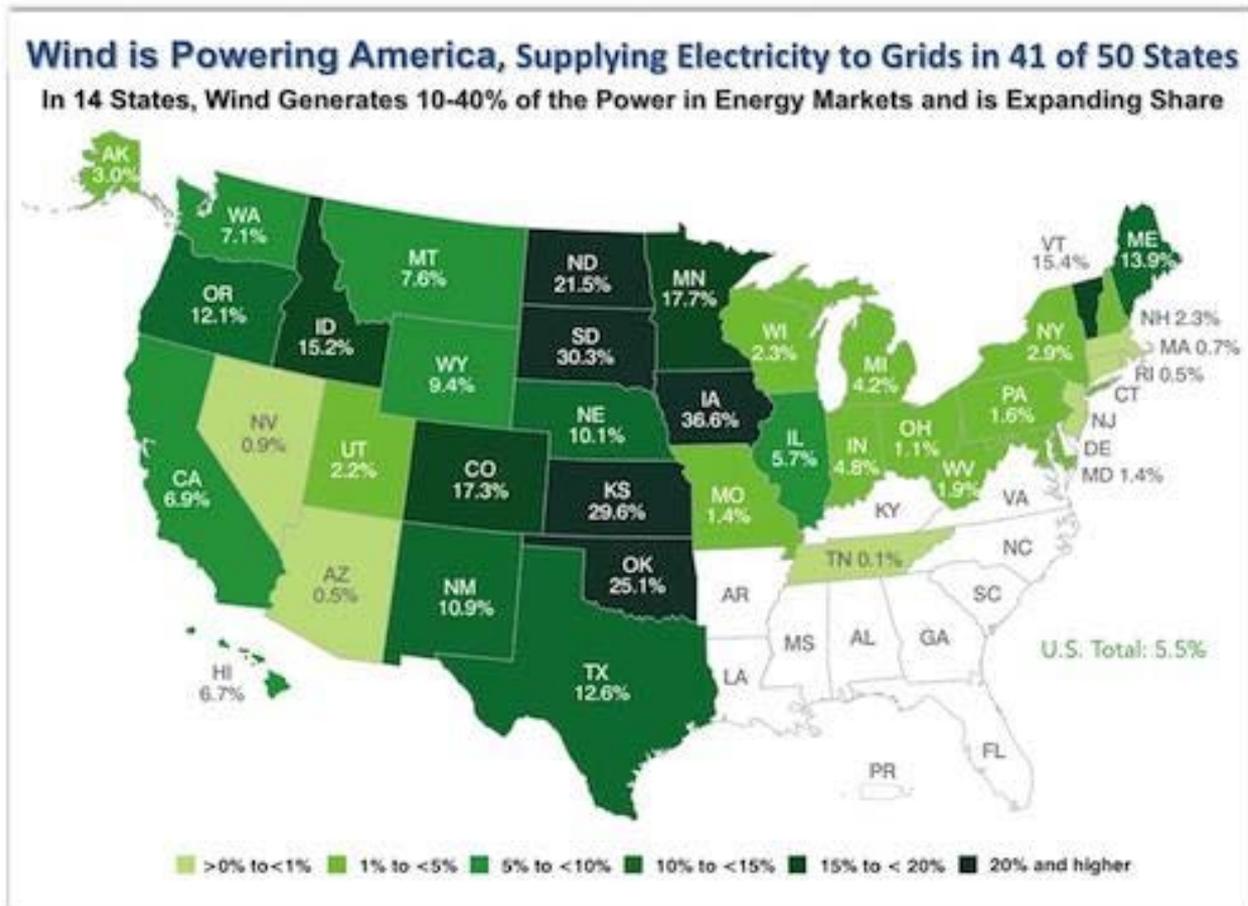


Impact of the DIR in MISO

Estimated Energy Manually Curtailed vs. DIR Dispatch Down



Wind Energy Penetration is Increasing





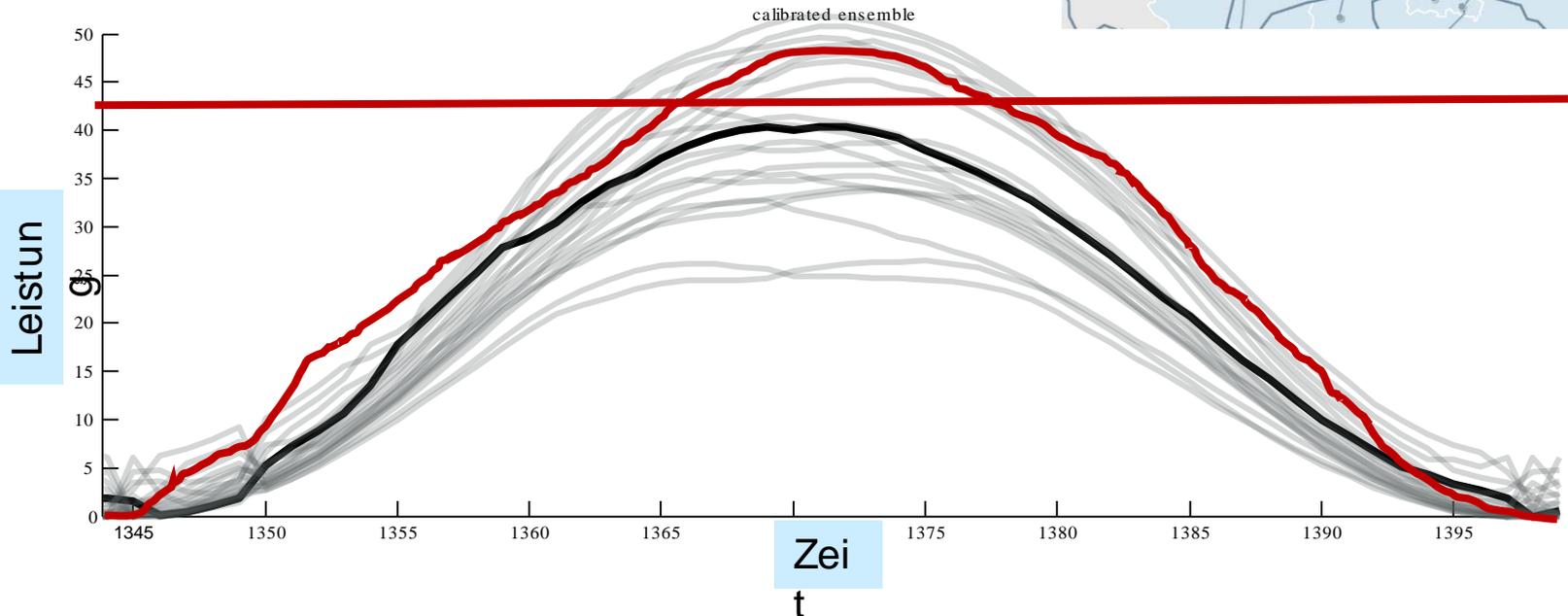
What Is the Value of Improved Wind & Solar Forecasting ?

- For system operators
 - » Better forecasts can be used to reduce reserves and costs, but will not change prudently conservative practices or the pass-through of costs to loads, so the value of incremental forecast improvements is modest
- For wind/solar power plants
 - » Large value in being able to get into the real time market without being subject to unavoidable penalties
 - » Once in the real time market, increasing value in accurate day ahead forecasts to participate in the day ahead market
- Energy traders
 - » Large value due to the impact of VERs on market prices
- Small but growing value from emerging opportunities
 - » Optimizing use of storage, electric vehicles, distributed resources, etc.
- *Is there an angle here for dynamic line rating?*

Stochastic Forecast Motivation: Congestion Forecast

- Thermal overload?
- Deterministic forecast: No
- Reality: Yes
- Ensemble recognizes possible overload

Overload not recognized





Minimum Interconnection Standard

- ◆ This is a tariff requirement imposed by FERC
- ◆ Minimum required upgrades, consistent with:
 - No degradation in all-lines-in-service transfer capability
 - All reliability standards must be met
 - ISO can still operate and maintain the system reliably
 - Maximum one-for-one displacement of existing/proposed generation
- ◆ Minimum Interconnection Standard
 - Does not insure incremental transmission capacity to serve load
 - Does ensure no degradation to load-serving capability of the system
 - Consistent with market and tariff constructs for Network Resources



Curtailment Status

Curtailment a Growing Issue in Some Areas

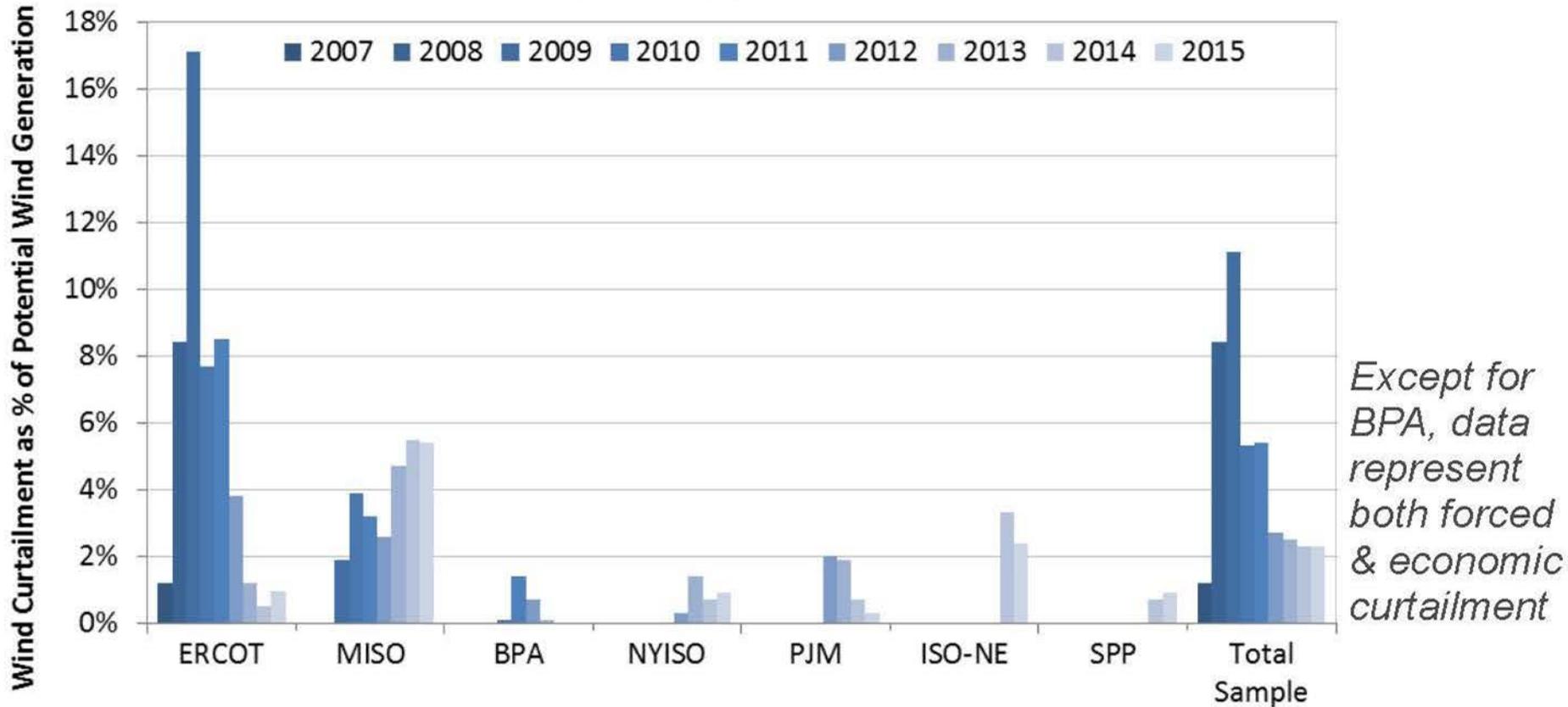
	2007	2008	2009	2010
Electricity Reliability Council of Texas (ERCOT)	109 (1.2%)	1,417 (8.4%)	3,872 (17.1%)	2,067 (7.7%)
Southwestern Public Service Company (SPS)	N/A	0 (0.0%)	0 (0.0%)	0.9 (0.0%)
Public Service Company of Colorado (PSCo)	N/A	2.5 (0.1%)	19.0 (0.6%)	81.5 (2.2%)
Northern States Power Company (NSP)	N/A	25.4 (0.8%)	42.4 (1.2%)	42.6 (1.2%)
Midwest Independent System Operator (MISO), less NSP	N/A	N/A	250 (2.2%)	781 (4.4%)
Bonneville Power Administration (BPA)	N/A	N/A	N/A	4.6* (0.1%)
Total Across These 6 Areas:	109 (1.2%)	1,445 (6.4%)	4,183 (10.4%)	2,978 (5.1%)

Assuming a 30% capacity factor, the total amount of wind generation curtailed in 2010 within just the six territories shown above equates to the annual output of roughly 1,130 MW of wind power capacity



Texas CREZ Transmission

Wind Curtailment Has Generally Declined in Recent Years; Higher in MISO



In areas where curtailment has been particularly problematic in the past – principally in Texas – steps taken to address the issue have born fruit



Study High Penetration Scenarios

- ◆ High penetration scenarios have pushed the thinking and uncovered the next generation of problems
- ◆ We have moved from having people think that 5% annual energy from wind was unacceptable to where 20% annual energy is “no problem” in just 10 years
- ◆ WWSIS has explored 35% energy from VG, and REF has taken a first pass at a 45% VG scenario
- ◆ MN utilities looked at 40% and 50% wind scenarios under state law
- ◆ California and Hawaii are looking at 100%
- ◆ Curtailment increases with increasing penetration



Transmission Adequacy Recommendations

- ◆ Develop adequate transmission capacity – can't meet renewable energy goals without it
- ◆ Comprehensive regional planning processes, i.e. FERC Order 1000 is a good start
- ◆ Inter-regional cost allocation for high voltage lines
- ◆ More certainty of transmission cost recovery
- ◆ Develop and maintain strong grid codes
- ◆ More robust and flexible “smart” grid to enable participation of load and reduce curtailment
- ◆ *Aren't dynamic line ratings a part of the smart grid?*

- ◆ in the words of the great baseball sage Yogi Berra:

**Making predictions is difficult,
especially when it's about the
future!**



For More Information

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