

Experiences of utilities in managing wind power: Reserves, transmission and dispatching

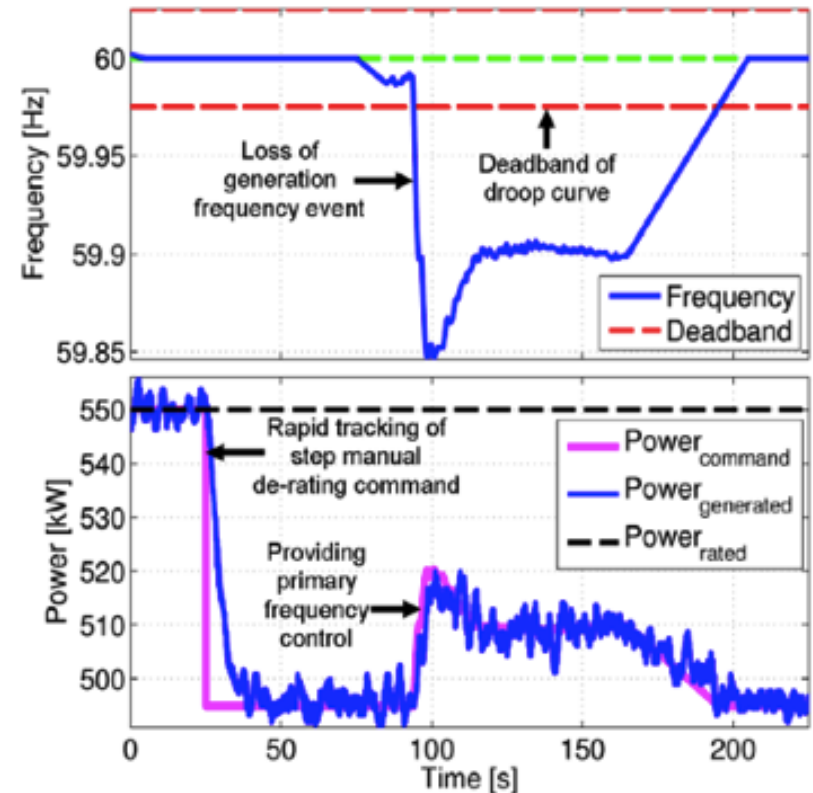
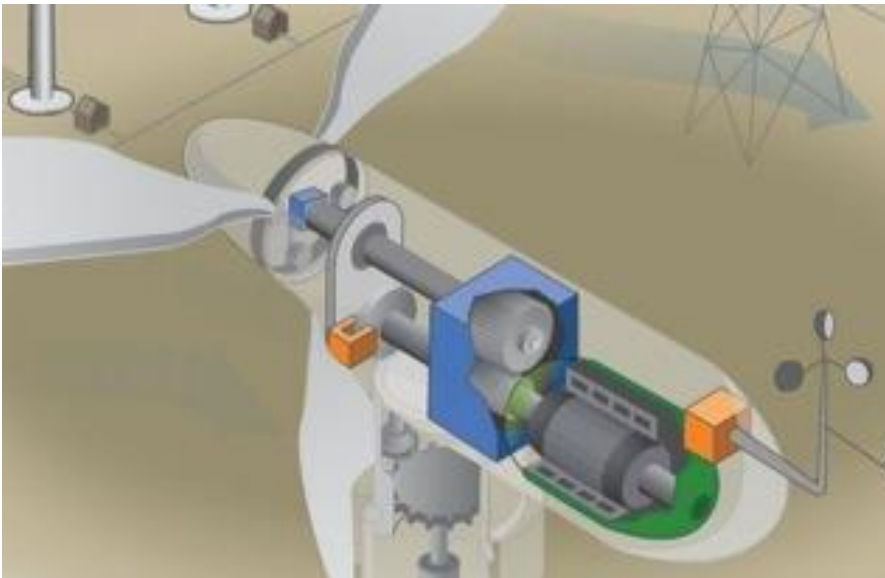
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Reserves: Active Power Control from Variable Gen

- Inertial control, Primary Frequency Control (PFC), and Automatic Generation Control (AGC) from Wind and Solar is feasible with negligible impacts on loading

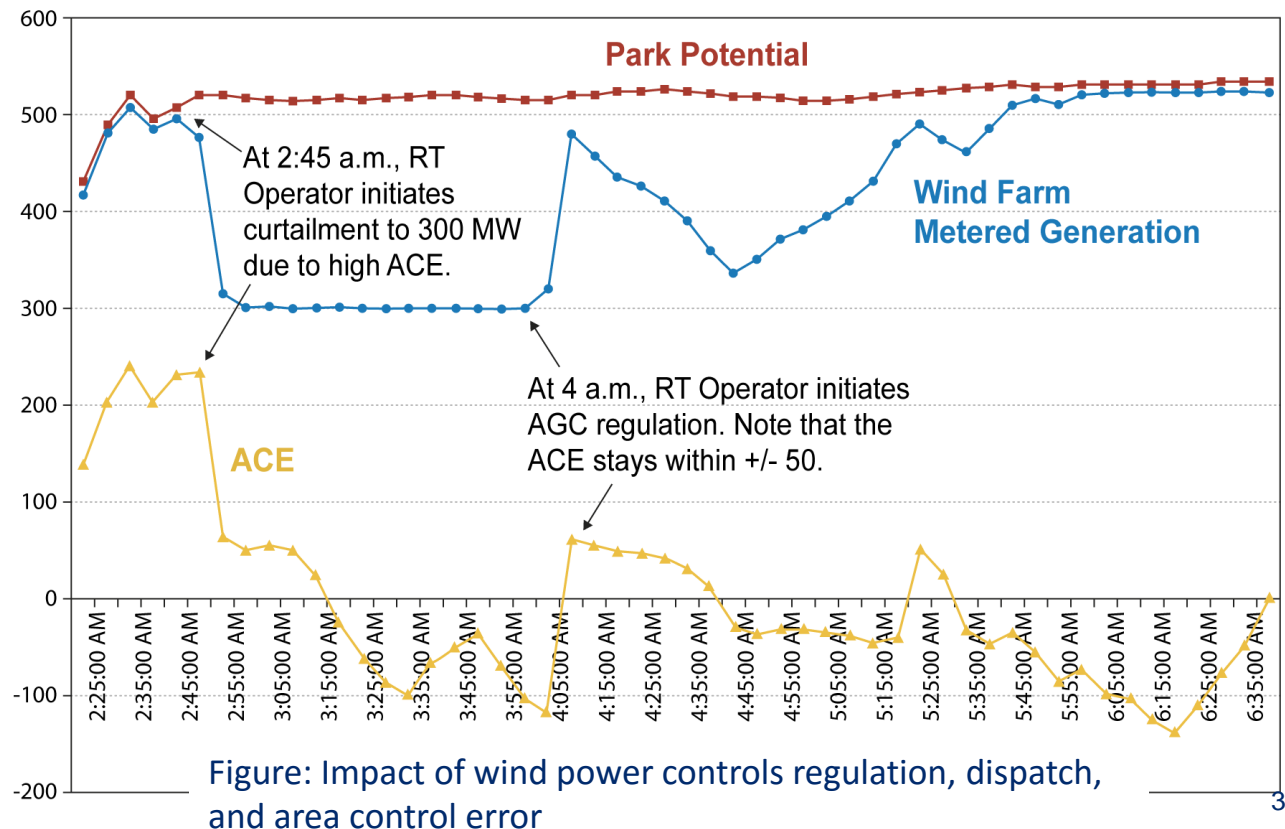


Reserves: Utilizing flexible generation from wind

Wind can:

- provide synthetic inertial control
- provide primary and secondary frequency response
- follow economic dispatch signals
- be incorporated into economic dispatch or market operations

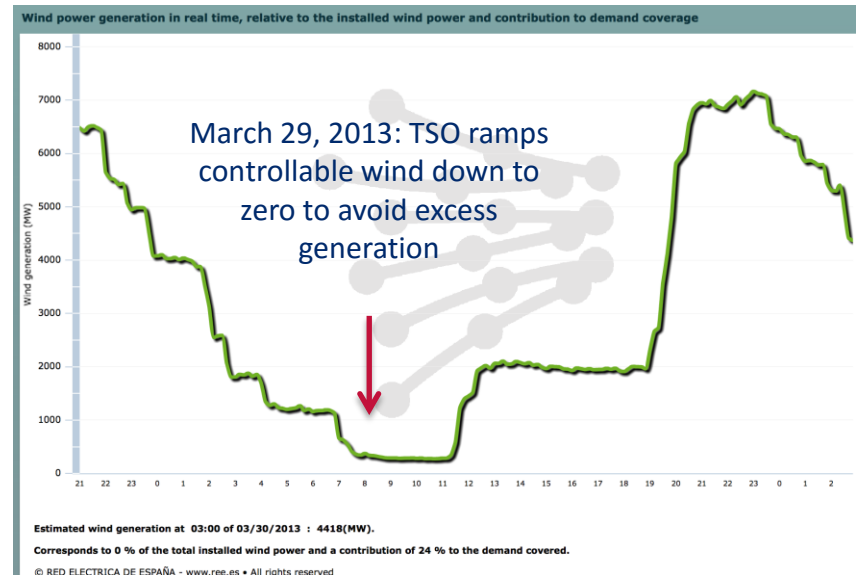
Public Service Company of Colorado improved its Area Control Error (ACE) using controllable wind energy during a period of very high wind and low demand



Reserves: Spain case study

- Strict grid codes specify:
 - Frequency control (required)
 - Reactive power supply; fault ride through capabilities; plant operation in line with forecast (incentivized/penalized)
- Complemented by the capabilities of the Control Centre for Renewable Energy, which observes generators larger than 1MW in real time and can control generators over 5MW within 15 minutes
- Outcomes:
 - Reduced the number wind power losses of more than 100 MW from 87 in 2007 to 30 in 2009

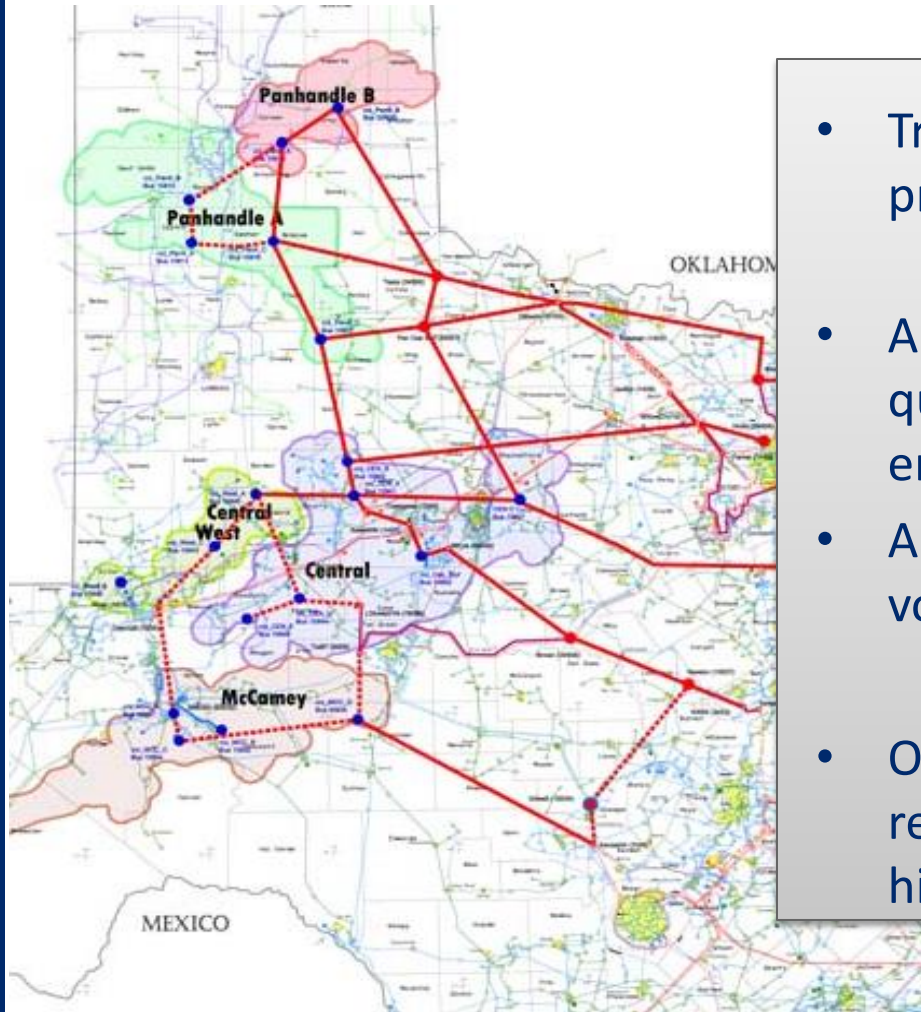
Sources: [Amenedo 2010](#); [Red Eléctrica de España 2014](#); [Milligan et al. 2015](#); [Fichtner 2010](#); [Ackermann et al. 2015](#) (Figure: [Red Eléctrica de España 2015](#))



Grid Integration Achievements

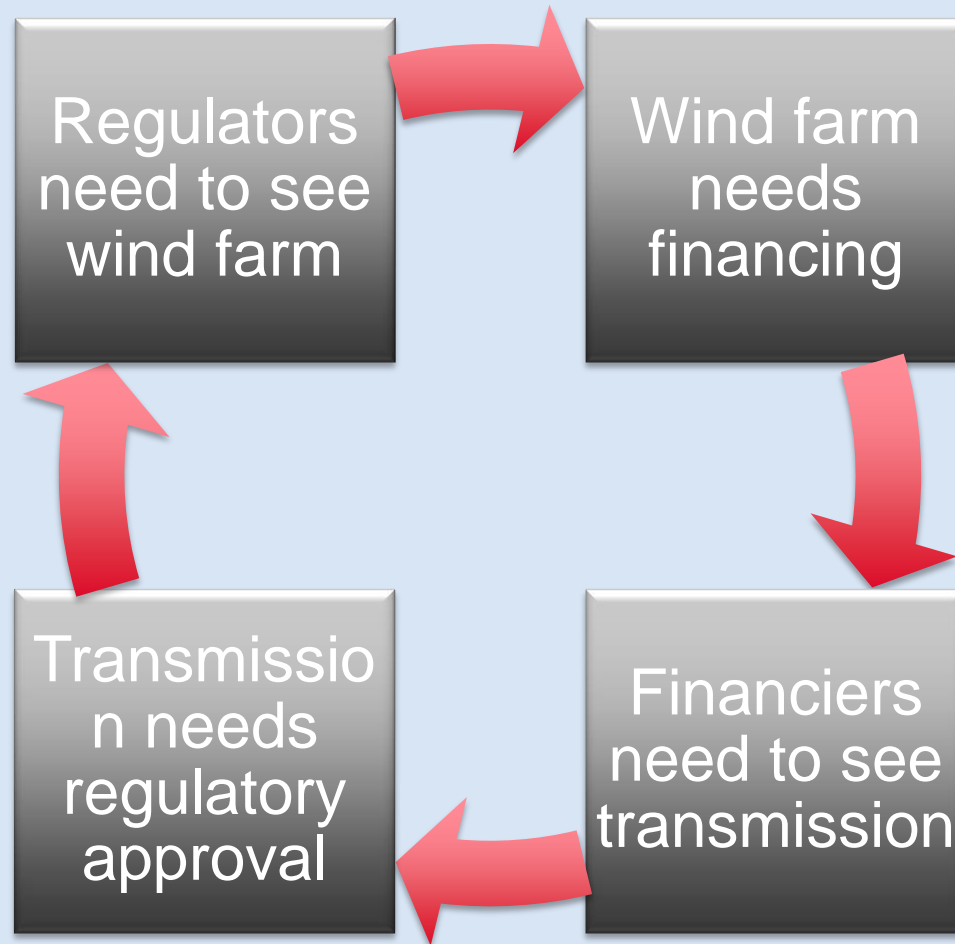
- First country to rely on wind as top energy source (in 2013). Wind energy met 20.4% of demand in 2014.
- Over 2,000 MW solar PV installed, meeting 3.1% of demand in 2014.
- Instantaneous wind penetrations can reach more than 60% of power demand.
- Curtails less than 1.5% of variable RE generation (2013).

Transmission: Renewable Energy Zones



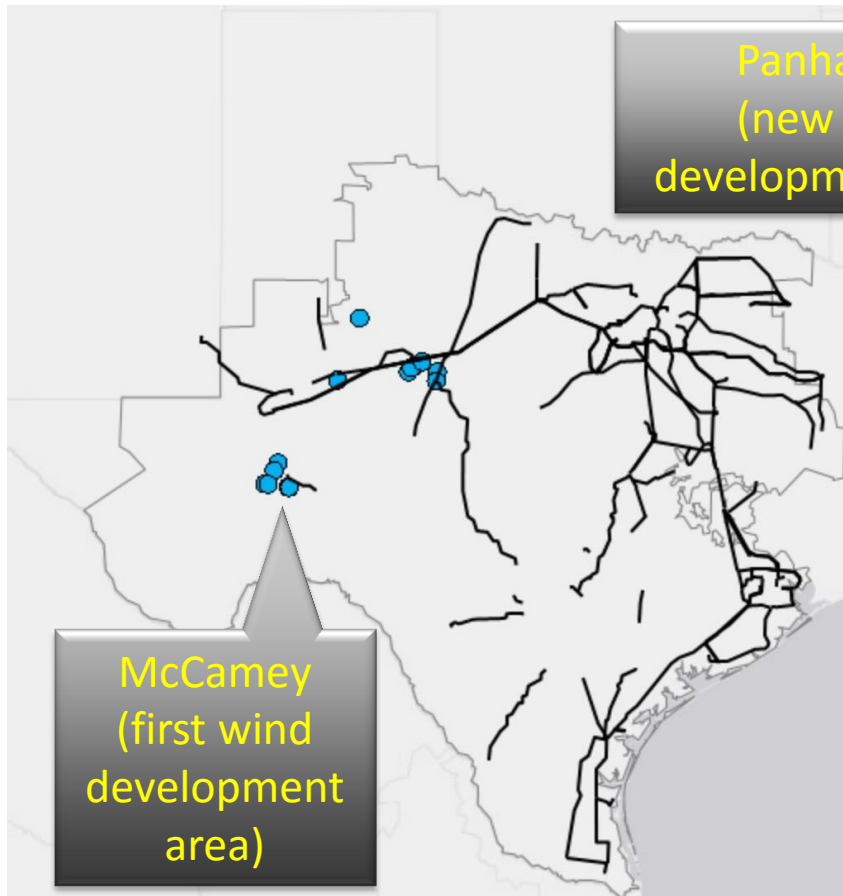
- Transmission planning and approval process customized for renewables
- A zone has a high concentration of high quality, easily developed renewable energy potential
- Aims for fullest utilization of highest-voltage transmission
- Often, minimal new transmission is required to interconnect low-cost, high-quality renewable capacity

Transmission: The Regulatory/Finance Dilemma

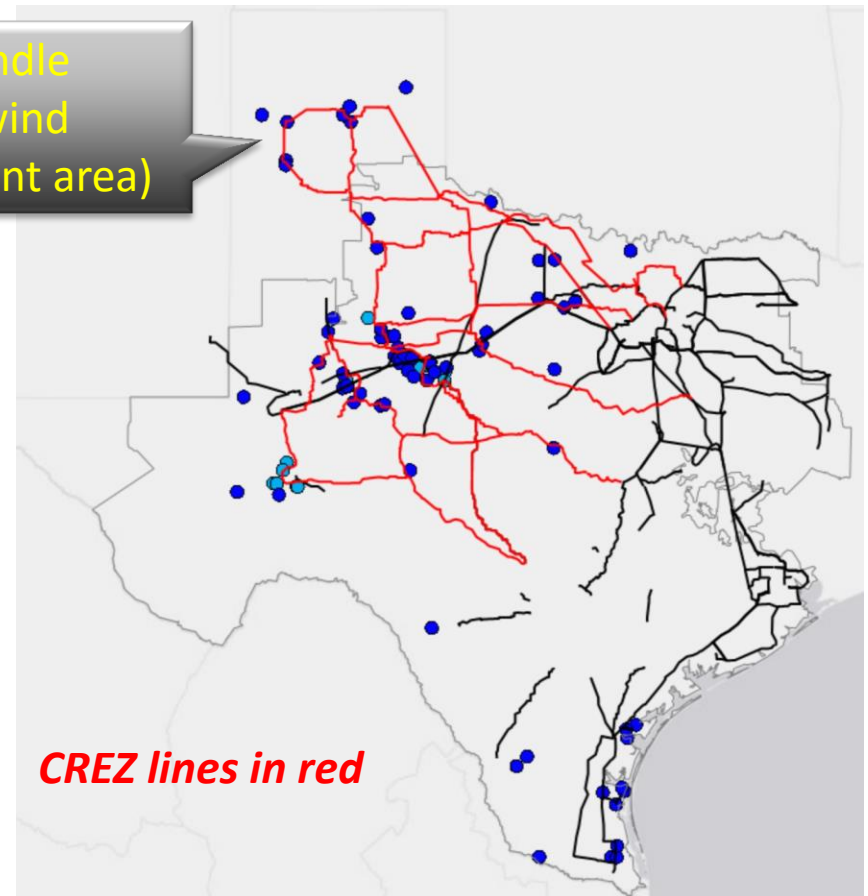


Transmission: Did the Texas REZ experiment work?

Before REZ: wind in 2003



After REZ: wind in 2014



Transmission: Did the Texas REZ experiment work?

	Zone	Year sampled	Average capacity factor
Old turbines (on line 2001-2002)	McCamey	2003	26%
		2014	30%

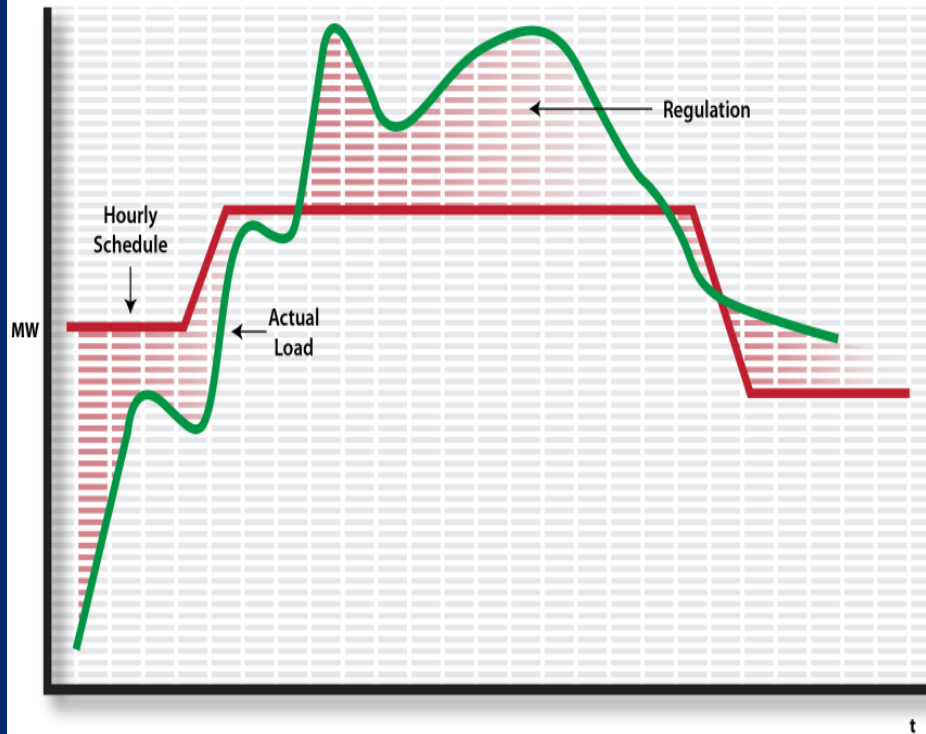
Conclusion: Older wind turbines performed better because of reduced transmission congestion and less curtailment

New turbines (on line 2007-2013)	McCamey	2014	35%
	Panhandle		45%

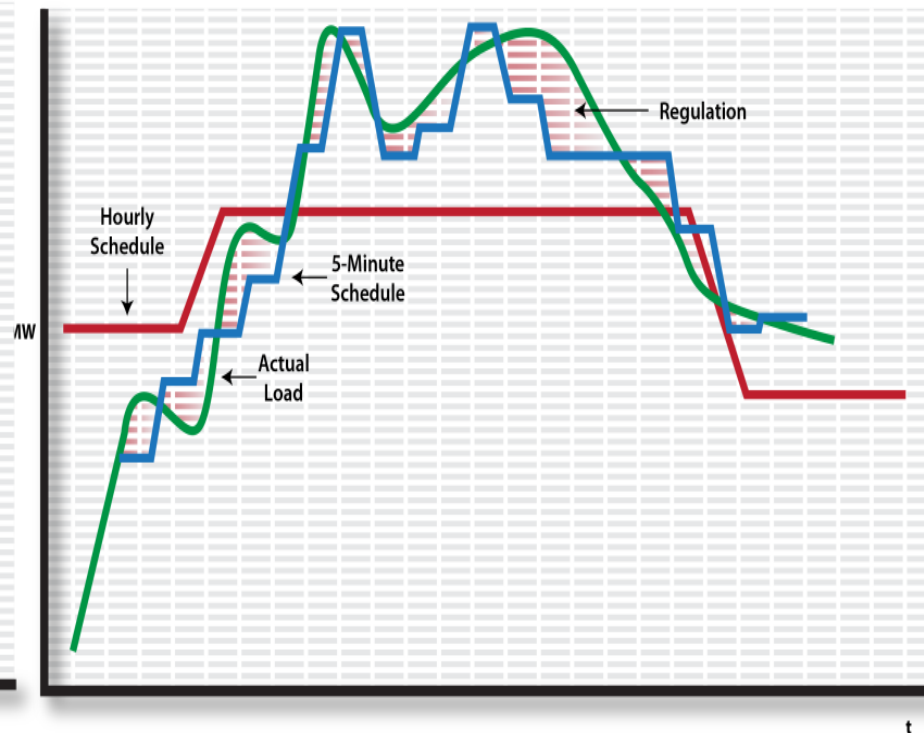
Conclusion: New transmission opened up more productive wind areas

Dispatch: Faster dispatch to reduce reserves

Hourly dispatch and interchanges



Sub-hourly dispatch



Source: NREL

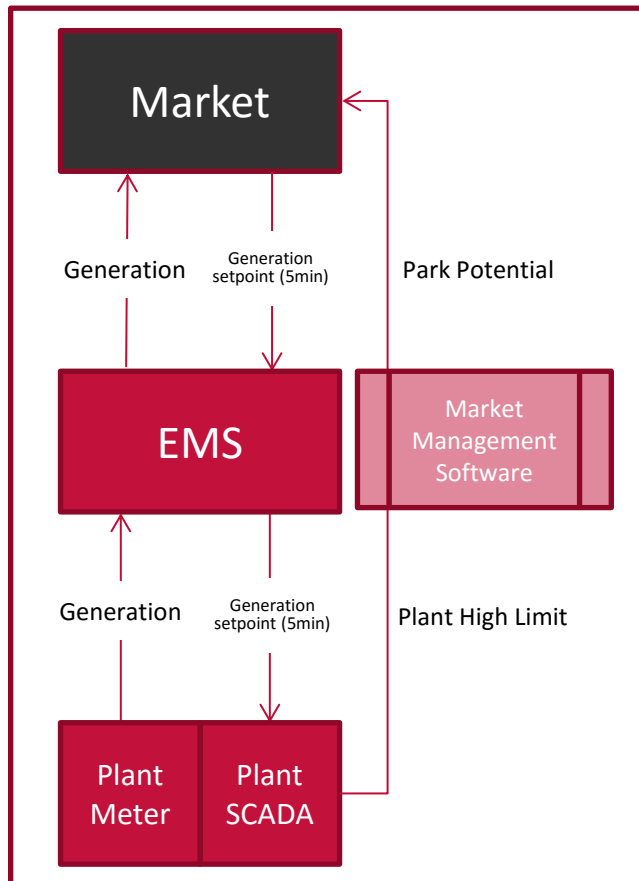
Dispatch decisions closer to real-time (e.g., intraday scheduling adjustments; short gate closure) reduce uncertainty.

Dispatch: Now-Casting & AGC

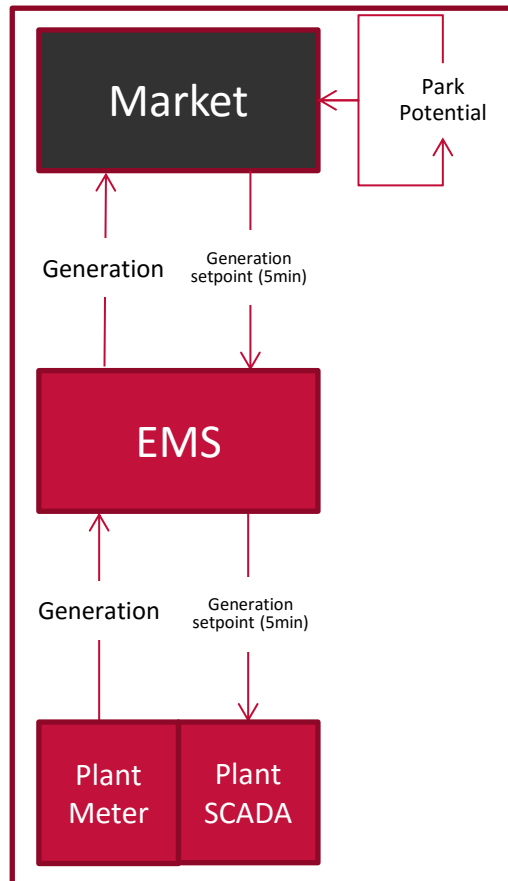


5-MIN ECONOMIC DISPATCH

Participant Forecast

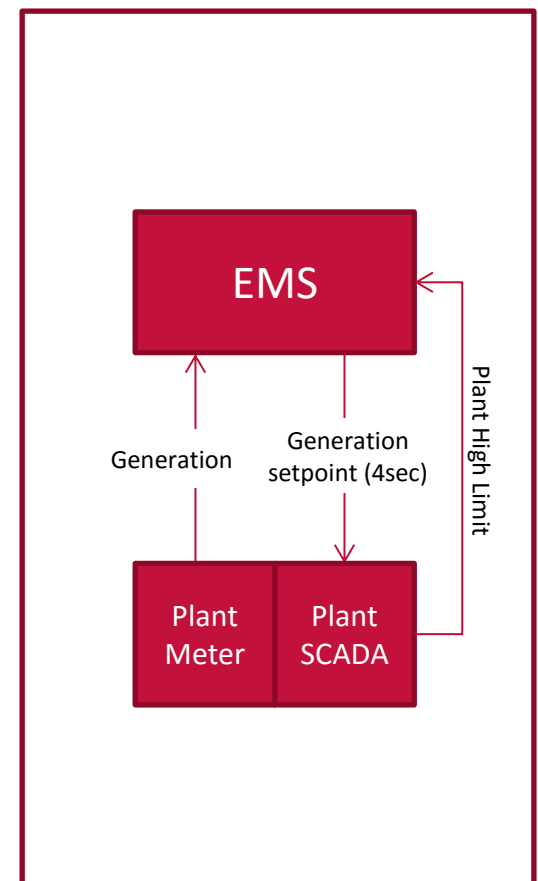


Market Forecast



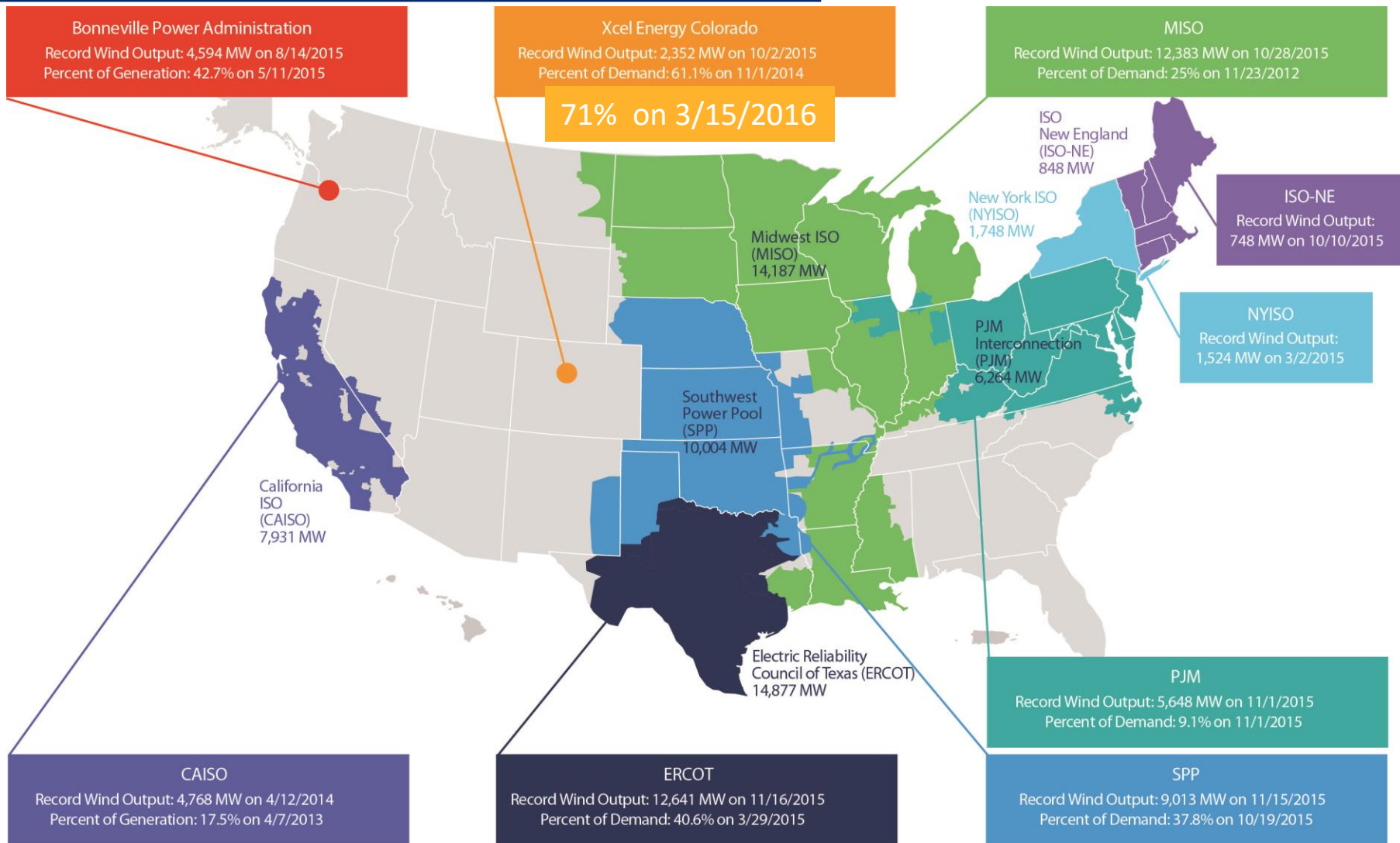
AGC

Balancing Authority



Now-casting (0-60min) – An estimate of the high limit of the wind plant. Typically, this will be the same as the generation value except during periods of curtailment.

Penetration Records in U.S. ISOs/Utilities



QUESTIONS

For more information: <http://greeningthegrid.org>