Midwest Governors' Association Milwaukee meeting

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(all views below are mine alone)

Overview

- Power plant retirements
- Reliability and resilience
- Alison’s biases and suggestions

Power plant retirements

Power plant retirement causes

Root causes

1) Wholesale electric competition worked
2) Coal plants that retired were old and inefficient. Nuclear plants higher-cost and troubled.

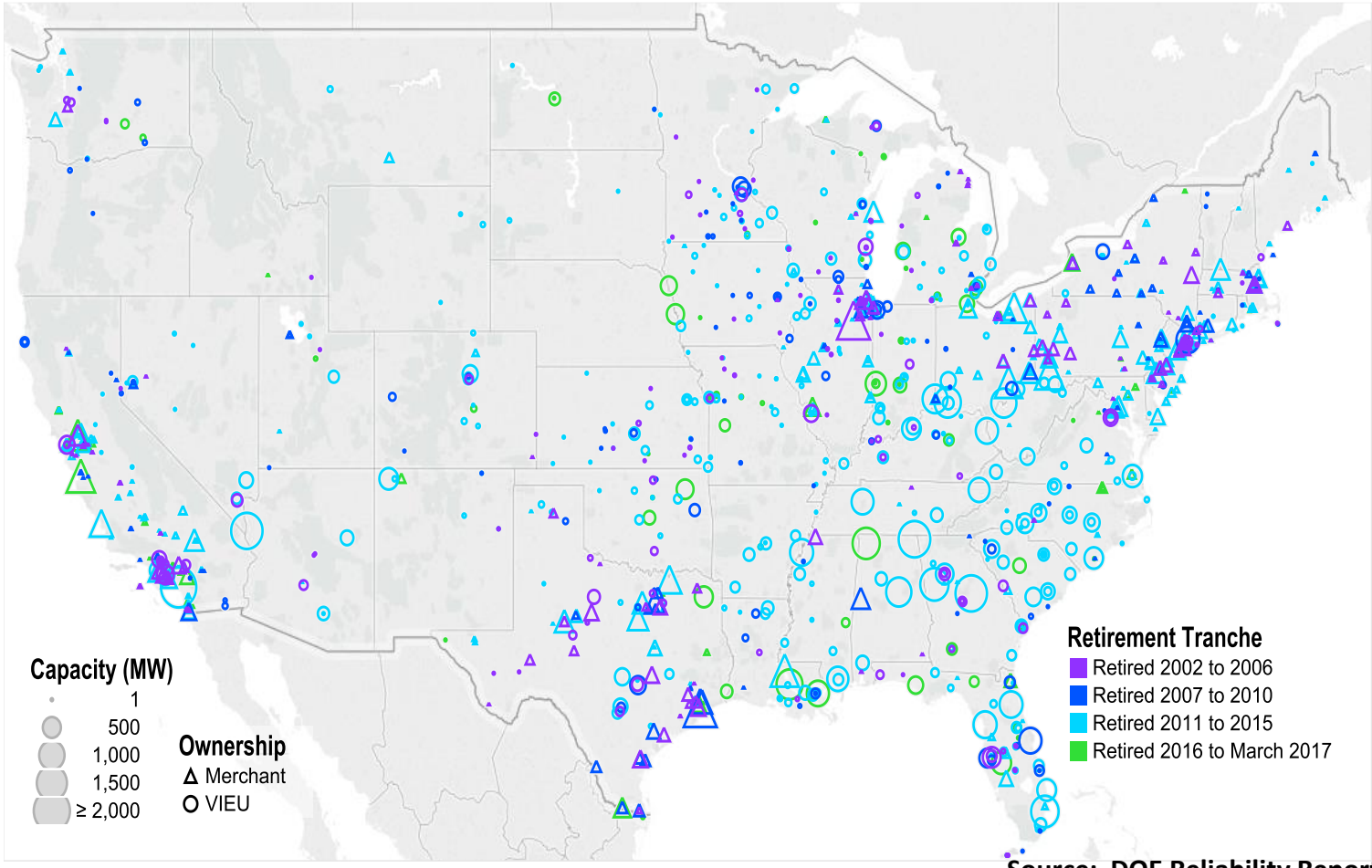
Other causes

3) Low natural gas prices starting 2009
4) Flattening demand for electricity starting 2008

Exacerbating factors BUT NOT CAUSES

- Renewables are forcing more cycling & ramping, which old coal & nuclear plants can't do
- Environmental regulations raised costs on non-competitive plants, forcing retirement deadlines (except CA)

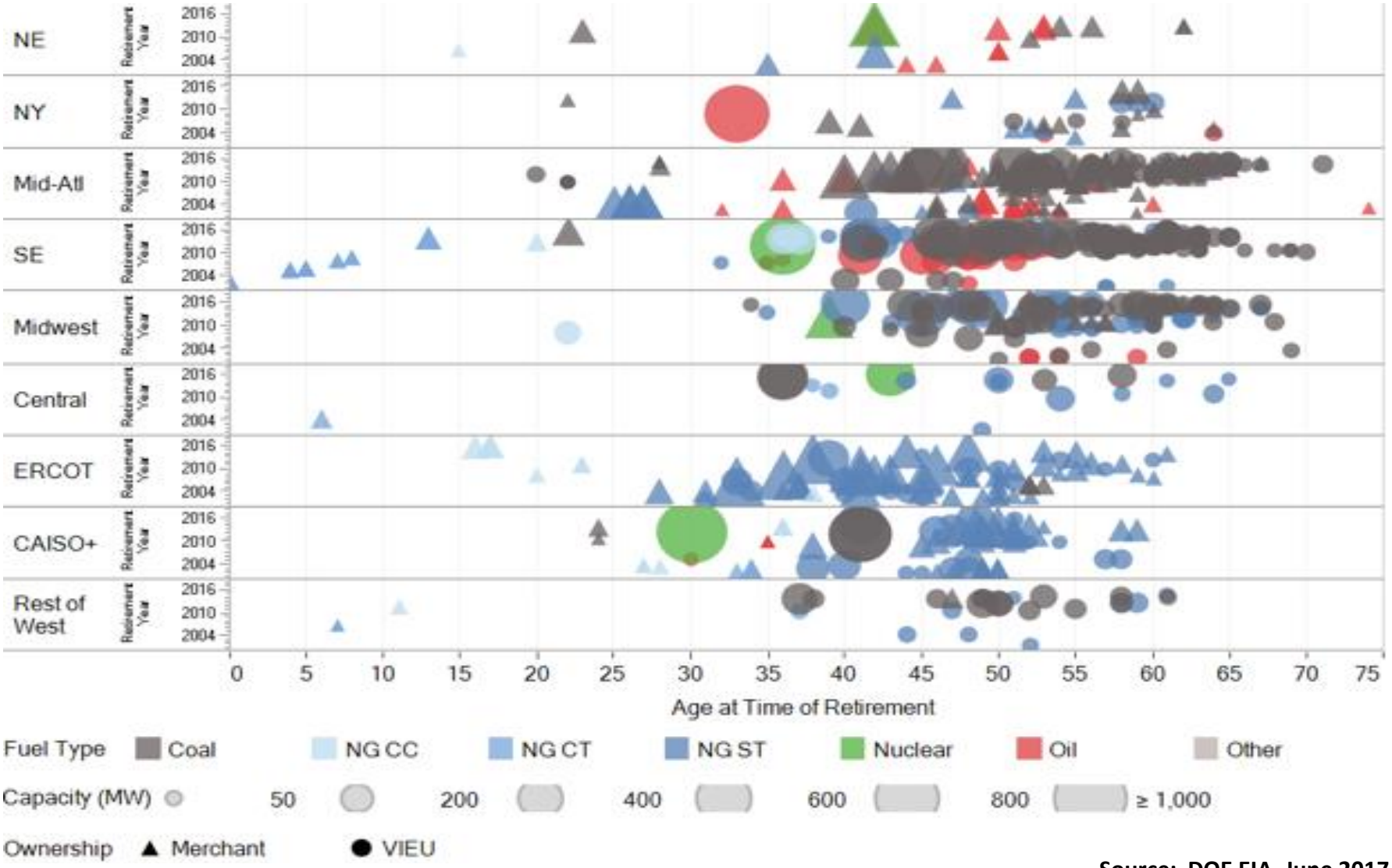
Root cause – wholesale competition worked



Source: DOE Reliability Report 8/17

- 2002-2006: restructuring. Majority of retirements are smaller, older merchant plants
- 2007-2010: economic recession, shale gas, *Mass v. EPA*, strong utility-scale wind growth
- 2011-2015: sustained low electricity demand and NG prices, MATS deadline, CPP finalized
- 2016 on: nat gas & renewables replacing coal & nuclear, even for most coal & nuclear plant owners

Root cause -- coal plants that retired were old

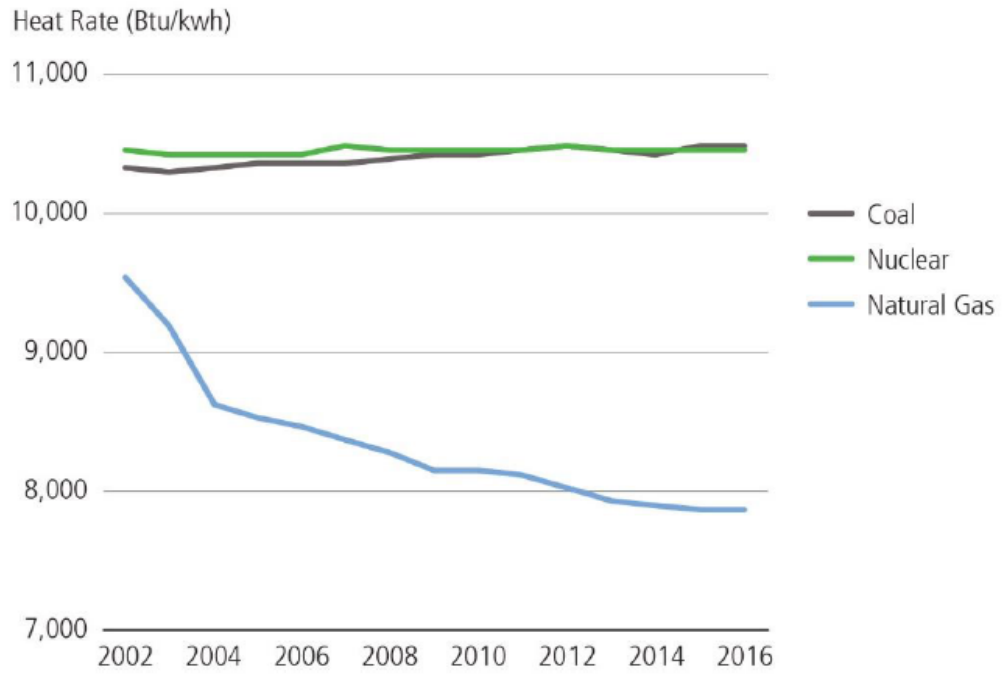


Source: DOE EIA, June 2017

Coal and nukes can't compete with nat gas

Natural gas generator heat rates improved by 30% over last 15 years; coal and nuclear rates stayed flat. (Coal heat rate declines with cycling and ramping.)

Figure 3.20. Heat Rates for Coal, Nuclear, and Natural Gas, 2002–2016[117]



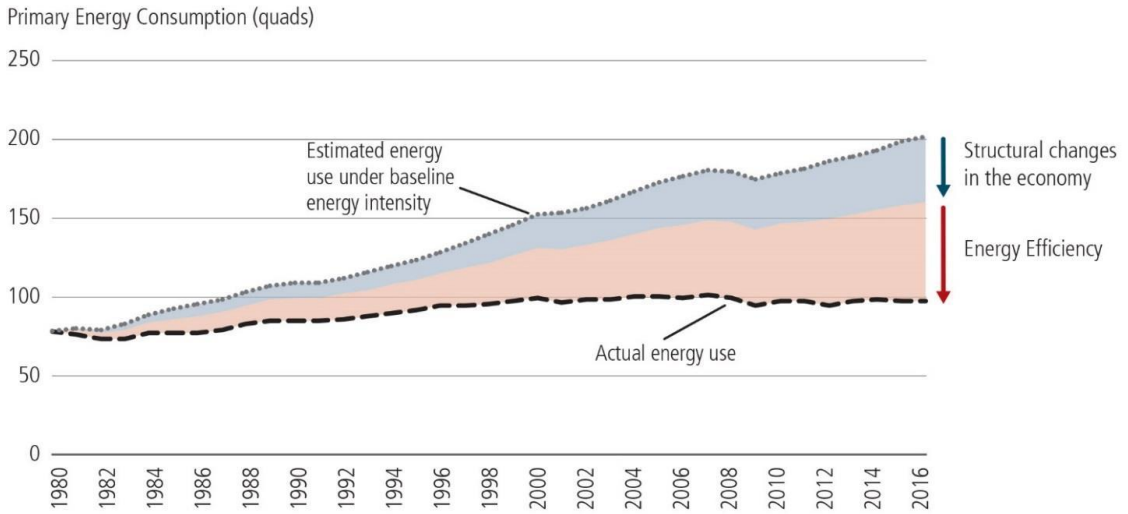
Source: DOE Reliability Report 8/17

Flat demand changes things

Electricity demand growth = 2.7% CAGR from 1970-2005, but has grown at only 0.05% CAGR from 2005-2015 even as GDP grew by 1.3%/year.

- Industry projections slow to recognize this
- Flat demand hurts higher-cost plants

Figure 3.29. Gross Domestic Product and Net Electricity Production, Historical (1950–2016) and Projected (2017–2027)



Source: DOE report, August 2017

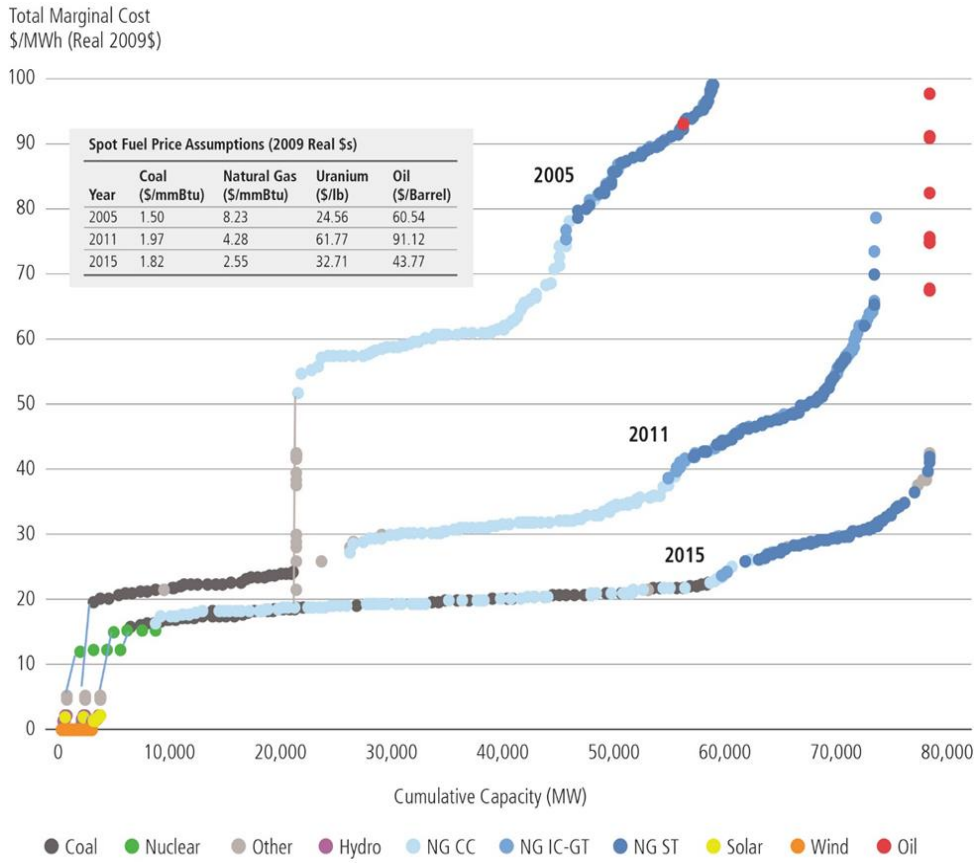
Summing up retirements

In supply curves over decade:

- High-efficiency nat gas plants move into curve, displacing other plants (coal, nat gas steam, nuclear) in baseload dispatch role
- With lower nat gas prices, everyone's revenue drops
- Wind & solar come in at bottom of stack
- Picture flattening demand curve cutting out revenues for generators on the outer end of the supply (dispatch) curve

Same patterns in your region…

ERCOT Simulated supply curves -- 2005, 2011, 2015

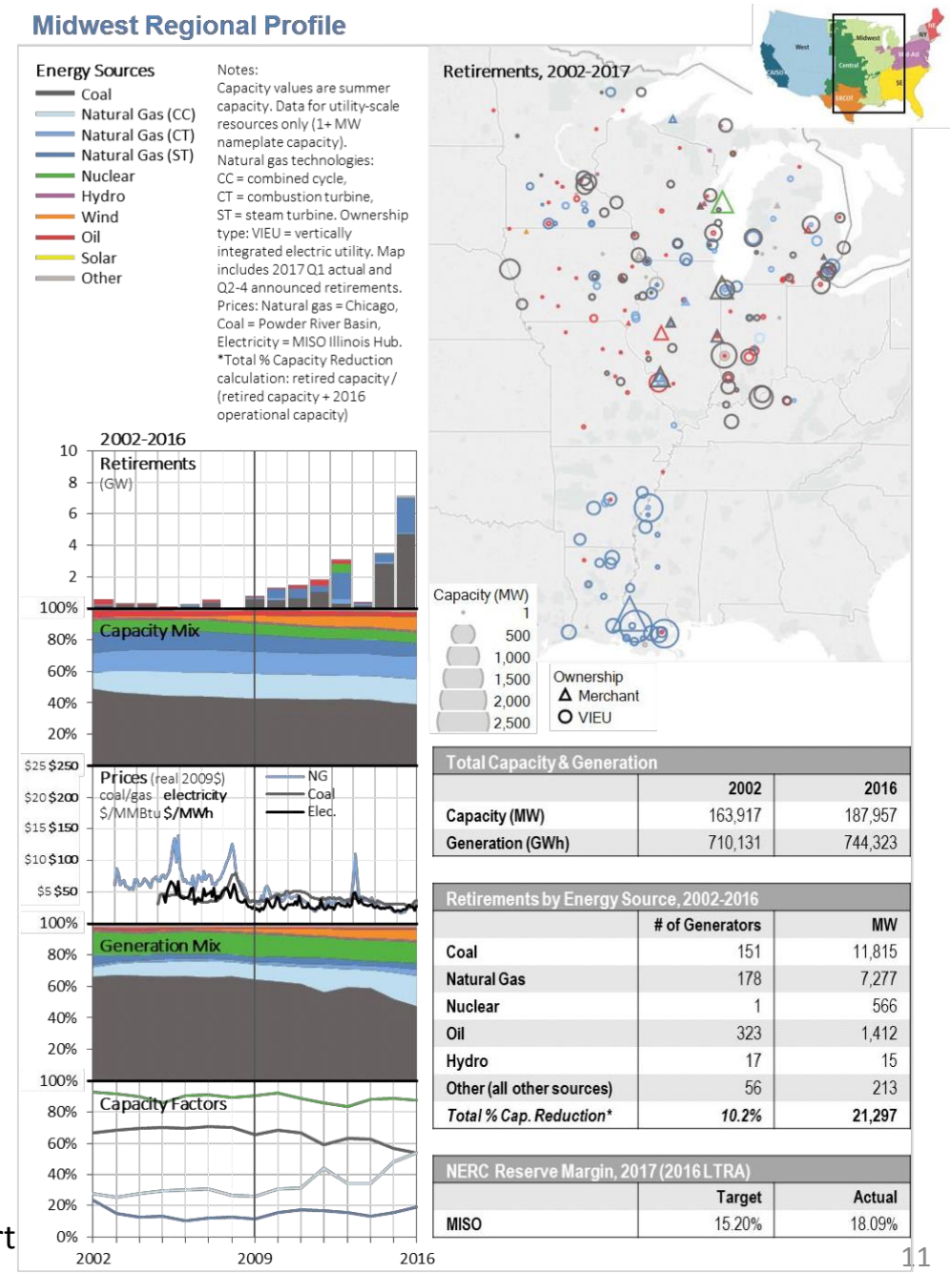


Source: DOE Reliability Report 8/17

Details for the Midwest
Hint – details differ by region

Things to note

- Mostly vertically integrated
- Retirements -- Lots of nat gas steam, , most small (inefficient), mostly utility-owned. Most coal retirements in 2014-15.
- Changing generation mix – fast growth of wind & nat gas CC
- 18% reserve margin in 2017



Total Capacity & Generation	2002	2016
Capacity (MW)	163,917	187,957
Generation (GWh)	710,131	744,323

Retirements by Energy Source, 2002-2016	# of Generators	MW
Coal	151	11,815
Natural Gas	178	7,277
Nuclear	1	566
Oil	323	1,412
Hydro	17	15
Other (all other sources)	56	213
*Total % Cap. Reduction**	***10.2%***	**21,297**

NERC Reserve Margin, 2017 (2016 LTRA)	Target	Actual
MISO	15.20%	18.09%

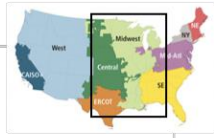
Source: DOE Reliability Report

Note shift in resource mix over 2002-2017.

Hypothesis – Credit MISO role in regional transmission planning and cost allocation, wholesale market operations and reliability management for enabling the Midwest's smooth transition to more renewables and less fossil energy.

Source: DOE Reliability Report

Midwest Regional Profile



Capacity & Generation by Energy Source, 2002 & 2016

Energy Source	Capacity 2002 GW	%	Capacity 2016 GW	%	Generation 2002 thous. GWh	%	Generation 2016 thous. GWh	%
Coal	80.3	*49%*	73.5	*39%*	469.0	*66%*	352.5	*47%*
Natural Gas	58.3	*36%*	73.1	*39%*	101.2	*14%*	204.0	*27%*
Combined Cycle (CC)	16.7	*10%*	30.0	*16%*	43.0	*6%*	143.7	*19%*
Combustion Turbine (CT)	20.5	*12%*	26.9	*14%*	11.3	*2%*	29.8	*4%*
Steam Turbine (ST)	21.2	*13%*	16.1	*9%*	46.9	*7%*	30.5	*4%*
Nuclear	12.8	*8%*	12.9	*7%*	104.3	*15%*	99.7	*13%*
Hydro	2.1	*1%*	2.2	*1%*	9.3	*1%*	9.9	*1%*
Wind	0.8	*0%*	16.3	*9%*	1.9	*0%*	49.8	*7%*
Oil	7.1	*4%*	5.4	*3%*	8.4	*1%*	7.9	*1%*
Solar	0.0	*0%*	0.3	*0%*	0.0	*0%*	0.3	*0%*
Other	2.5	*2%*	4.3	*2%*	16.0	*2%*	20.2	*3%*
Total	**163.9**	*100%*	**188.0**	*100%*	**710.1**	*100%*	**744.3**	*100%*

Impact of DOE's proposed NOPR

If DOE's NOPR were adopted as written:

- Destruction of market principles & operation in PJM and MISO and policy contamination in other markets
- Subsidizing bad plants drives out good plants and makes merchant gen model even harder
- Billions more $ charged to customers (PJM & MISO)
- Lower bulk power system reliability and resiliency because inefficient coal and nuclear plants won't cycle or ramp effectively and don't perform better in emergency situations
- No improvement on customer outage experience because most of that comes from T&D failures, not generation or fuel shortages

Reliability and resiliency

Defining reliability and resiliency

Reliability has short- and long-term dimensions

- Short-term = operational security – withstand a sudden disturbance and still meet load without an uncontrolled cascading blackout or equipment damage. "Work the grid you've got"
- Long-term – resource adequacy -- ability to keep supply and demand in balance. Regulatory and compliance dimensions

Resiliency = the ability of a system to absorb, survive, restore and quickly recover from major adverse events.

- Should be multi-hazard

Resiliency not the same as reliability

What's the goal here?

What's the problem we're trying to solve?

- Resiliency and reliability for generation is different from the grid is different from resiliency and reliability from customers' perspective.
- 99% of customer outages come from T&D failures, not from generation shortages or fuel shortages -- we can buy a lot of T&D improvements and coal miner direct economic support for the $ billions it would cost to subsidize uneconomic coal and nuclear plants…

How to improve resiliency

- Design for multiple hazards – earthquakes, ice storms, heat waves, lightning, blizzards, cyber attack, EMP/GMD, …
- Besides good preparation and good resiliency practices (mutual aid, spares, restoration & recovery process plans)
  - Smart grid – sensors, automation, faster isolation and recovery
  - DG, CHP, microgrids, distributed renewables, aggressive islanding, distributed storage
  - Design system for graceful failure
  - Tree-trimming & vegetation management

Long-term resilience against extreme weather

Severe weather caused 96% of customer outage hours in US between 2012 and 2016. Extreme weather is getting worse, but most of our T&D systems are designed for historic rather than future weather conditions.

- Project extreme weather out 40+ years, design assets for those conditions
- Build in mods for growing renewables, customer-sited DG, storage, changing business models
- Rethink “hardening” -- sometimes may require disposable assets in weather-vulnerable areas, not just tougher assets
- Max energy efficiency; design appliances and buildings that protect people longer when outages/disasters happen

Inertia and frequency response

We need inertia for frequency response, not for its own sake.

- Rotating mass-based inertia (as from big coal & nuclear plants) is good but slow and expensive
- Electronically-coupled inertia (as from wind and solar inverters) works within a narrow (planned) performance range
- Storage has the potential to provide large, precise, fast amounts of primary and secondary frequency response at lower capital, ops and carbon cost than coal or nuclear – esp if you charge up storage with excess renewables
- We need to study the merits and need for different types of FR provision and how much we actually need to manage a fast, modern grid
- FR and provision of other ancillary services should be compensated requirements of grid interconnection/participation, but maybe not through market competition

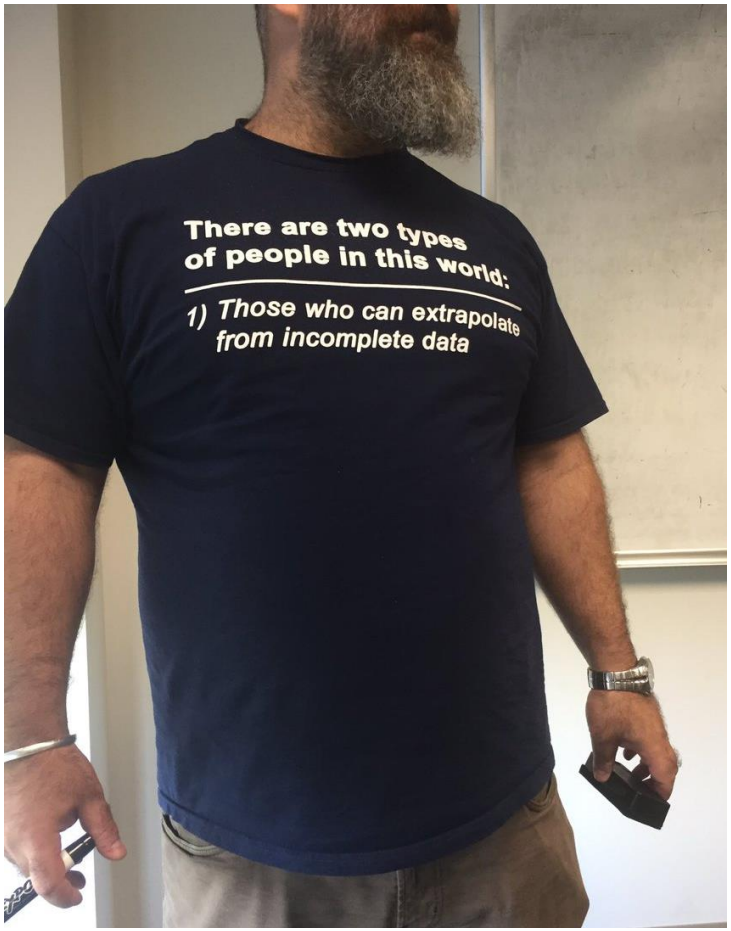
But wait, there's more!

- Capacity- v. energy-based planning and resource adequacy needs
- Electronically-coupled loads, system planning and volt-var optimization
- Automated demand management can solve a lot of problems
  - Absorb renewables (building as a battery, thermal energy storage, buffer fast solar ramps)
  - Rebalance load usage, reduce demand spikes
  - Automated load reductions for primary, secondary frequency response

Things I've learned as a regulator and consultant

Alison's beliefs & biases (1)

1) You'll never have perfect information. Don't wait for it…
2) Be very clear about your goals. Ask, what will success look like?
3) Make your regs and rulings reflect what you want. "Subtle" is over-rated.
4) Most regulatory tools are either carrots, sticks, or sticks painted orange. Most people respond best to sticks painted orange.



Alison's beliefs & biases (2)

5) Don't make assumptions (also, don't blindly trust experts)
6) You can figure out almost anything with good data and graphics
7) Better questions produce better answers
8) Leverage other people's money
9) Good regulators need situational awareness about technology advances, customer trends and threats over a long time horizon
    - Technology and business models let customers and businesses bypass regulators and utilities
10) Your job is to set a vision and LEAD, not tiptoe

Thank you

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