Grid reliability & resilience

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Definitions

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 to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to and/or rapidly recover from an event." (162 FERC ¶61,012)

Resiliency ≠ reliability

Reliability v. resilience

- Reliability is defined as balance between supply and demand – so many reliability metrics are generation-related, including reserve margin and ancillary services (frequency response, ramp reserve, voltage control, black-start). But with faster-moving wind and PV and demand-side flexibility, reliability rules need to evolve.
- Resilience is defined as ability to absorb and recover from large, adverse events – but most of those happen to T&D as well as generation, so require T&D as well as generation readiness.
- Better resiliency should improve 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.
- 95+% of customer outages come from T&D failures, not from generation shortages or fuel shortages, so generation "resilience" doesn't do much to help customer resilience.

MY VIEW – we should prioritize reliability and resilience for customers, not just for generation

Coal, nuclear, reliability & resiliency

- Advantages of coal and nuclear plants – fuel on-site and spinning reserve; part of a diverse resource portfolio
- Disadvantages of coal and nuclear plants – slow-starting, slow-ramping, high capital costs, aging, large units create reliability contingencies
- IF coal and nuclear plants are on-line, then they can help with:

Reliability

- Frequency response (some)
- Voltage control
- Regulation (some)
- Load-following (coal – some)

NOT SO MUCH – fast-cycling, fast-ramp, low minimum-load, contingency reserve

Resiliency

- Fuel diversity
- Fuel assurance (on-site)

NOT – black-start, distributed, or T&D-improving, and vulnerable to T&D, weather and climate problems

Major threats and impacts (aka, why we want resource diversity)

RISKS	COAL	NUKE	NAT GAS	WIN D PV	DR	EE	T&D	Com mns
Winter storms	*	*	*	*			oops	
Wildfires	*	*	*	*			oops	*
Floods (coastal & inland)	*	*	*				oops	
Hurricanes	*	*					oops	*
Extreme heat or drought	oops	oops	oops					
Equipment failures	oops	oops	oops	oops	oops	oops	oops	oops
Fuel system delivery failure			oops	oops				
Geomagnetic disturbance	oops	oops	oops	oops	oops		oops	oops
Cyber-attack	oops	oops	oops	oops	oops		oops	oops

Oops = notable problems; * = known dismal occurrences; blank = mostly ok

Coal, nuclear & inertia

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

- Rotating mass-based inertia (as from coal, nuclear, nat gas) works – but those plants not always on-line
- Electronically-coupled inertia (as from wind and solar) works within a narrow (planned) performance range
- Storage & DR can provide large, precise, fast primary and secondary frequency response at lower capital, ops and carbon costs than coal or nuclear

BUT -- we don't know yet how much inertia-based frequency response we need for a grid with higher levels of PV and renewables, and we can get frequency response from other resources – so let's not over-state the need for coal and nuclear plants….

Coal plant capacity and retirements -- the sky is not falling…

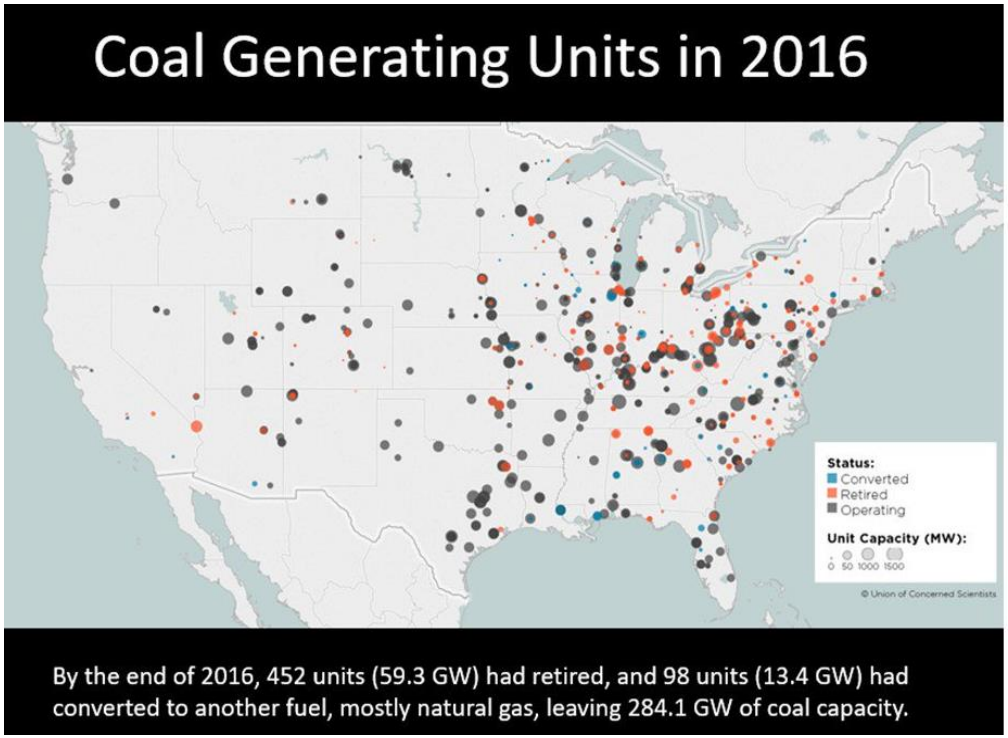
Total U.S. generation capacity
Nov 2017 = 1,190 GW

Total U.S. coal capacity
Nov 2017 = 284 GW (24% of U.S.)

- 59 GW retired 2002-2016
- 13 GW converted to nat gas
- additional 21 GW expected to retire by 2020

Total U.S. nuclear capacity
Nov 2017 = 108 GW (9% of U.S.)

- 4.7 GW retired 2002-201
- additional 5.6 GW could retire by 2020



Sources: Union of Concerned Scientists, "A Dwindling Role for Coal", 2017
Power plant data from DOE Staff Report on Reliability, 2017 and FERC OEP Energy Infrastructure Update for Nov. 2017

When you're holding a hammer…

We've designed wholesale energy markets to incent generation resources (and recently, DR)

- Energy
- Capacity
- Some energy-associated ancillary services

But

- These markets still need work, and
- Most customer and resilience-affecting measures aren't effectively incented by wholesale markets (hint – T&D, EE), and are not fully or precisely compensated.

Not everything is a nail…

We get many reliability and resiliency factors through non-market avenues:

- NERC reliability standards (incl cyber-security)
- Interconnection requirements including performance measures (e.g., NYISO dual-fuel requirement, voltage ride-through)
- Grid operator practices including outage scheduling, RMR, planning & preparation (e.g., GMD, plant weatherization, spare equipment inventories)
- Fuel supply coordination and scheduling
- Mutual assistance for restoration & spares10

Most of these affect transmission as much as generation, and they do not receive targeted or market-based compensation even though they enhance reliability and resiliency.

Compensating reliability and resilience

Many important reliability and resilience attributes are not adequately compensated, including:

- Zero emissions (as from nuclear, PV, EE, DR)
- Interial frequency response
- Fast response (as from gas-fired generators, DR, some storage)
- Fuel security (as from on-site fuel storage, firm contract gas plants, DR)
- Hardened infrastructure assets (G,T, D) that can withstand multiple threats

We need better definitions, metrics and products relevant for reliability and resilience, and ways to compensate the attributes that matter.

More to do on essential R&R services

- Study the merits of and need for different types of frequency response (FR) provision and how much we actually need to manage a fast, modern grid
- Identify, define metrics, productize & compensate FR and other essential reliability & resiliency services on a technology-neutral basis (including demand-side and storage as well as generation and T&D options)
- Not all essential R&R services need to be market-competed -- some essential R&R services can be requirements of grid interconnection & participation

Thank you

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APPENDIX

Past power plant retirements (a reminder)

More definitions

Baseload generation – it's an operational pattern (run with limited ramping for a long stretch), not a class of generators (coal, nuclear, natural gas steam).

Premature retirements – no such thing. Premature is in the eye of the beholder….

Causes of past coal & nuclear retirements

Root causes

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

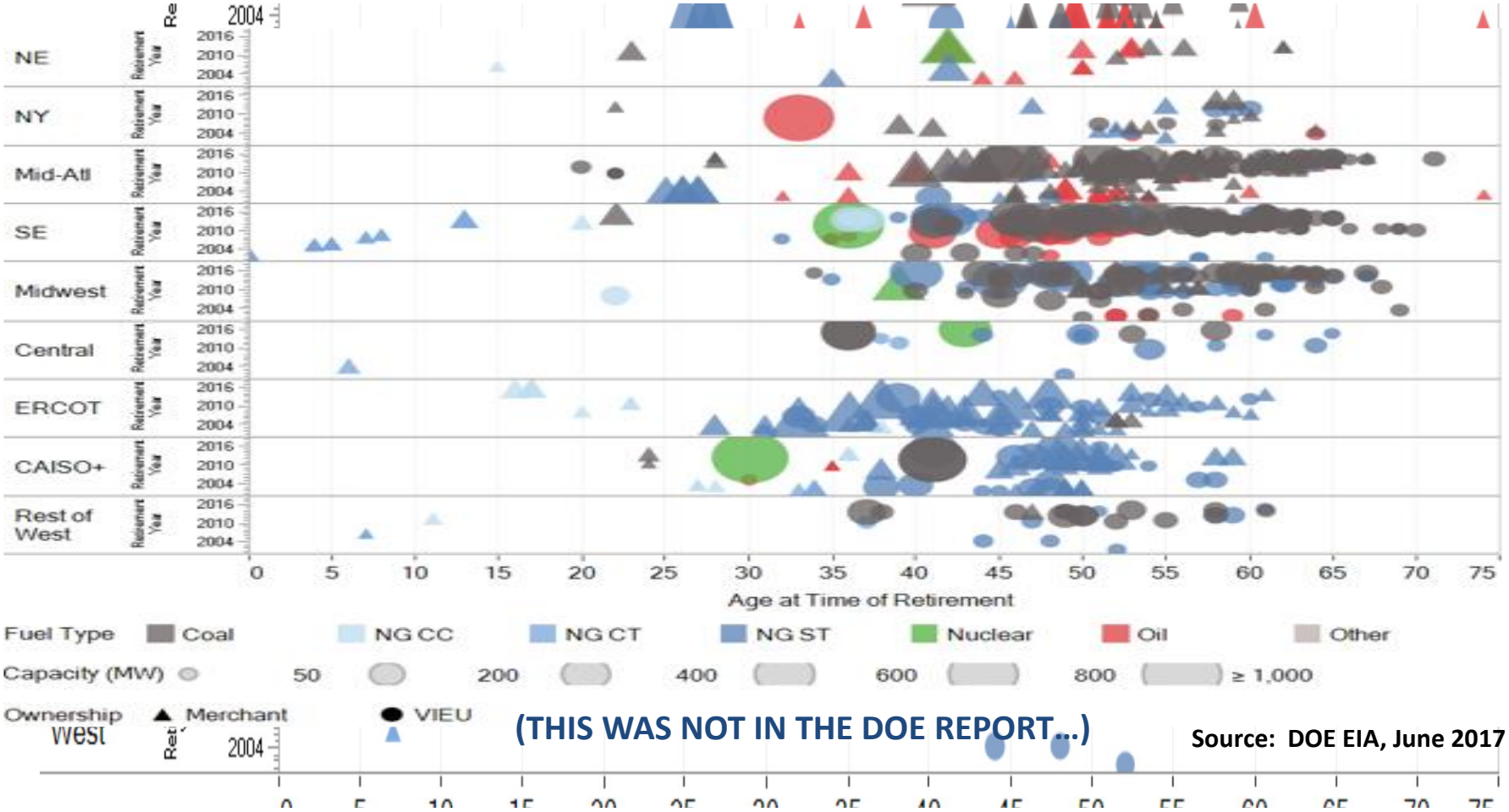
Other causes

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
- Environmental regulations raised costs on non-competitive plants, forcing retirement deadlines

Cause 2 -- coal plants that retired were old



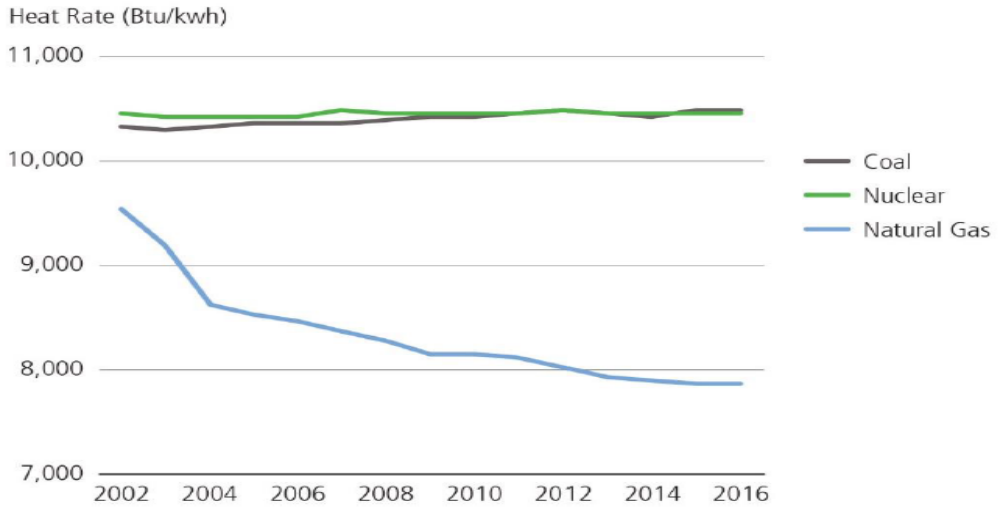
(THIS WAS NOT IN THE DOE REPORT…)

Source: DOE EIA, June 2017

Cause 3 -- Coal and nukes can't compete with natural gas

Low gas prices plus improved nat gas generator heat rates (30% over last 15 years). 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