

Reliability, Resilience and Values

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Some electric industry history

1990s

- Electric industry starts restructuring – wholesale competition, retail competition in 27 states
- 1992 Energy Policy Act creates Renewable Energy Production Tax Credit
- First Renewable Production Standard enacted (Texas)

2000s

- Creation of regional grid operators (RTOs and ISOs) across 2/3 of U.S.
- Growth of merchant generation, closure of older gas steam plants
- 2003 blackout
- Fracking leads to 2/3 drop in natural gas prices
- Expansion of wind and PV as prices drop
- Electric demand starts flattening
- Average temps every year get hotter than prior years

2010s

- Obama administration continues Bush environmental regs, expands with Clean Air Plan
- Acceleration of coal and nuclear plant retirements
- Climate warming continues
- US DOE staff report on Electric Markets & Reliability (8/17) and Perry Notice of Proposed Rulemaking to subsidize coal and nuclear plants (9/17)*

* Why your organizers noticed & invited me...

Power plant retirements by year (2002-2022)

Total 132 GW retired

- 59 GW coal (531 plants)
- 51 GW natural gas (965 plants)
- 5 GW nuclear (6 plants)

Max year for coal retirements 2015 (MATS compliance deadline)

1,190 GW capacity nation-wide in 2017

Sources: DOE Staff Report (8/17)

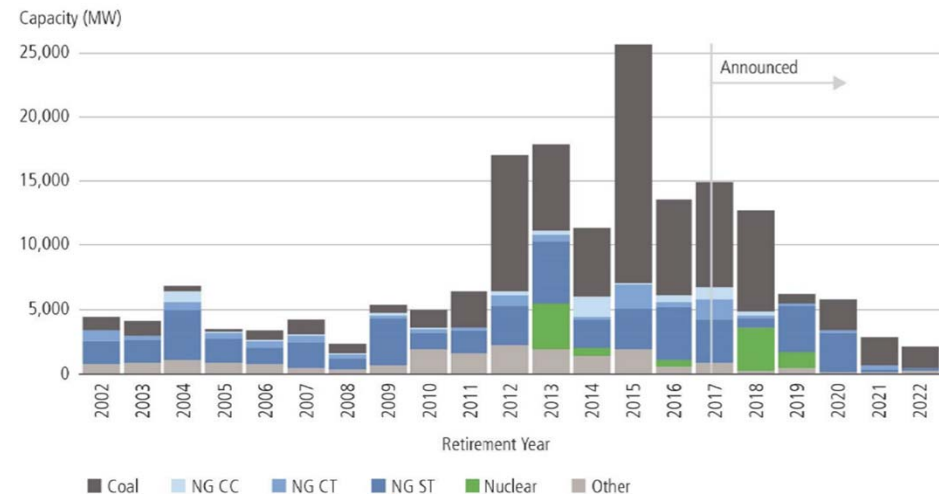
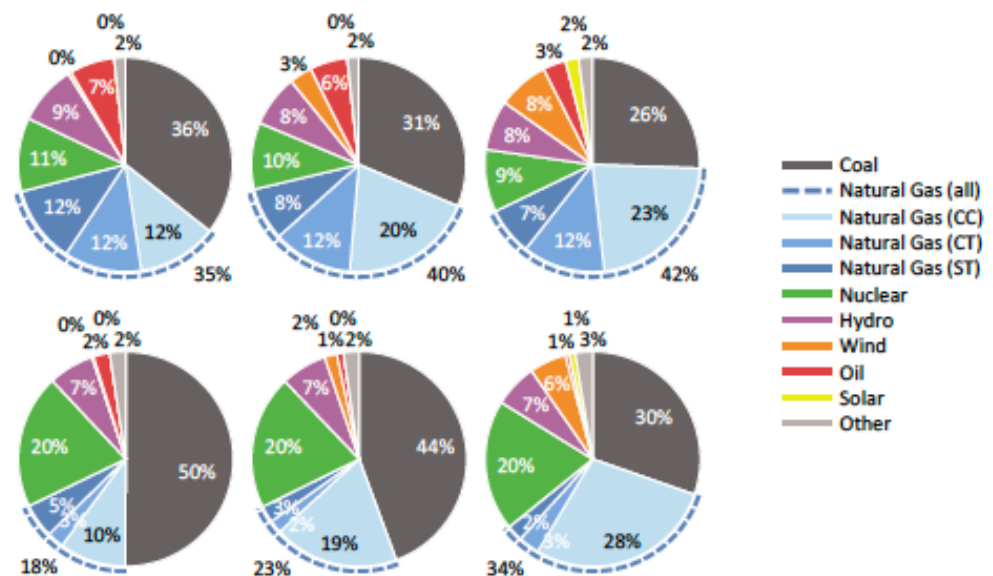


Figure 4.17. Changes in U.S. Capacity (Top) and Generation (Bottom) Mix over Time (Left to Right: 2002, 2009, 2016)³¹⁰



DOE rationale for angst over power plant retirements

- High level of recent, “premature” “baseload” coal and nuclear plant retirements due to burdensome environmental regulations and unfair subsidies to other generation technologies
- High level of recent retirements causing less diverse generation mix
- Loss of coal and nuclear plants reducing grid reliability and resiliency, particularly because these “baseload” plants have fuel stored on-site
- Coal and nuclear plants also provide “resiliency” and rotating mass-based inertia valuable for grid operation

Causes of past coal & nuclear retirements

per analysis in DOE Staff Report issued 8/17

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

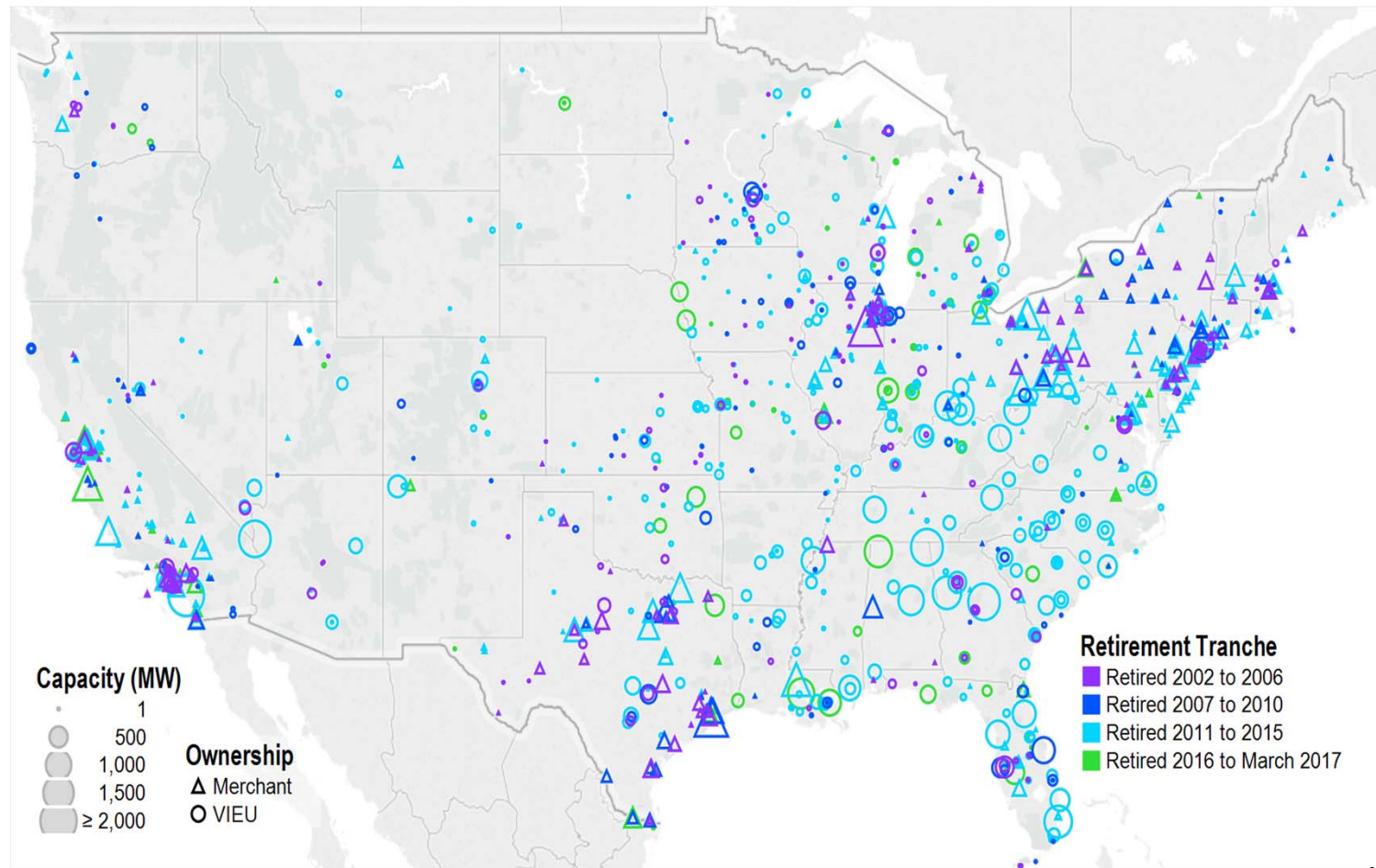
- 3) Low natural gas prices starting 2009
- 4) Flattening demand for electricity starting 2008

Exacerbating factors BUT NOT CAUSES

- Renewables are forcing more cycling & ramping – the whole grid is moving faster today
- Environmental regulations raised costs on non-competitive plants, forcing retirement deadlines

* Actual report analysis showed this but DOE report summary did not...

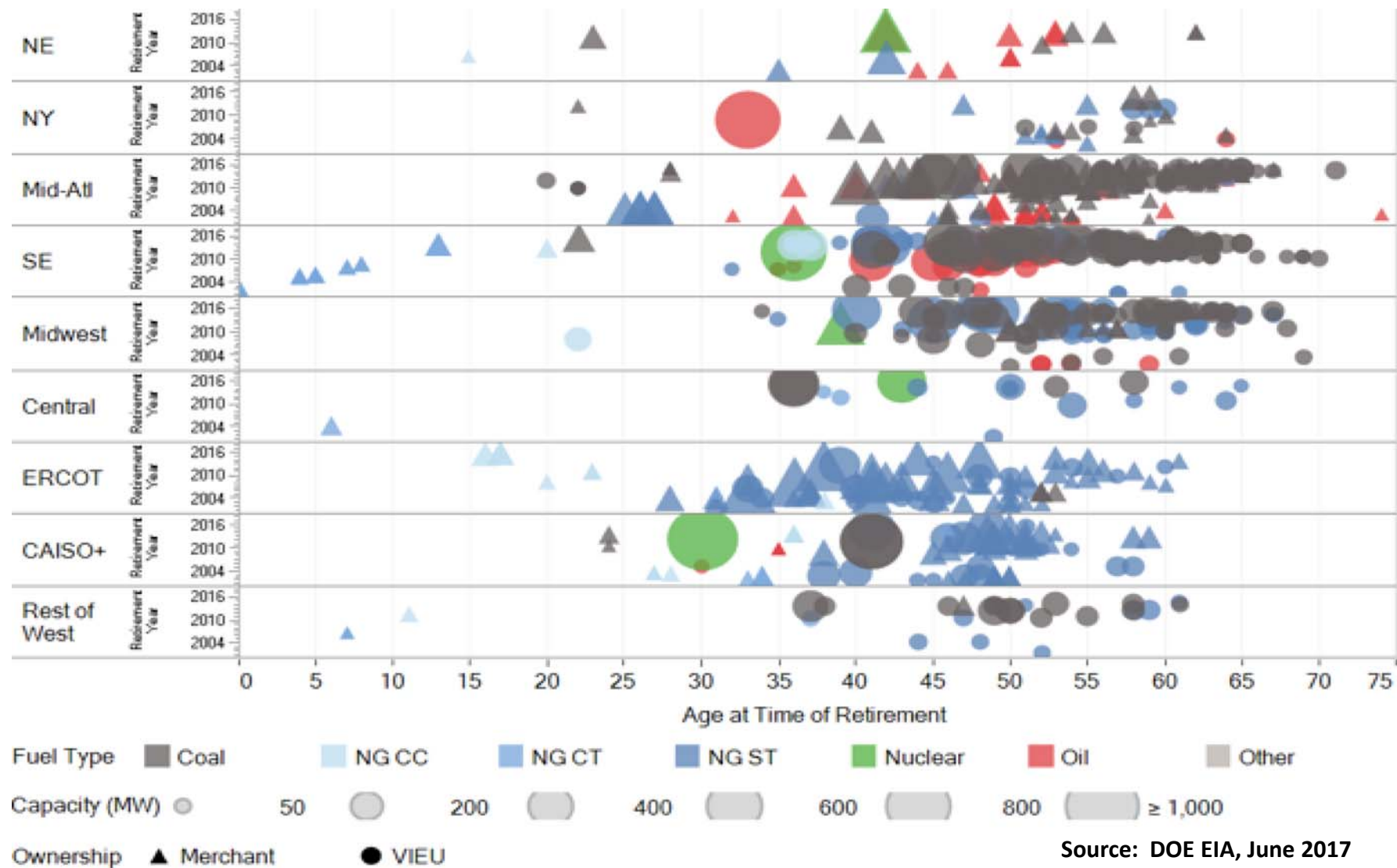
Cause 1 – wholesale competition worked



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

Cause 2 -- coal plants that retired were old



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....

More 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 \neq reliability

DOE Proposed Rule (9/17)

DOE directed FERC to consider and act on proposal within 60 days, a proposed rule to forestall further retirements:

- Adopt cost-of-service cost recovery for all merchant plants having 90 days of fuel supply on-site, operating in regions with organized energy + capacity markets because they protect diversity and resiliency
- Impact analyses
 - Would apply to merchant coal and nuclear plants, most of which had already recovered asset costs once under original utility owner and continuing as merchant assets before drop in gas prices
 - Mostly affect PJM & MISO markets (northeast, upper Midwest)
 - No time limit on cost recovery; would pay between \$800 million to \$10.6 billion/year to 10 companies for 90 old coal and nuclear plants without improving reliability or resiliency
 - Cost of service payments wholly inconsistent with competitive markets, would blow up those markets and crowd out investment in more efficient, reliable plants

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)

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

Resiliency

- Fuel diversity
- Fuel assurance (on-site)

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

* Average coal plant CF = 56% in 2015; nearly 150 plants ran at or below 30% CF

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

RISKS	COAL	NUKE	NAT GAS	WIND 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...

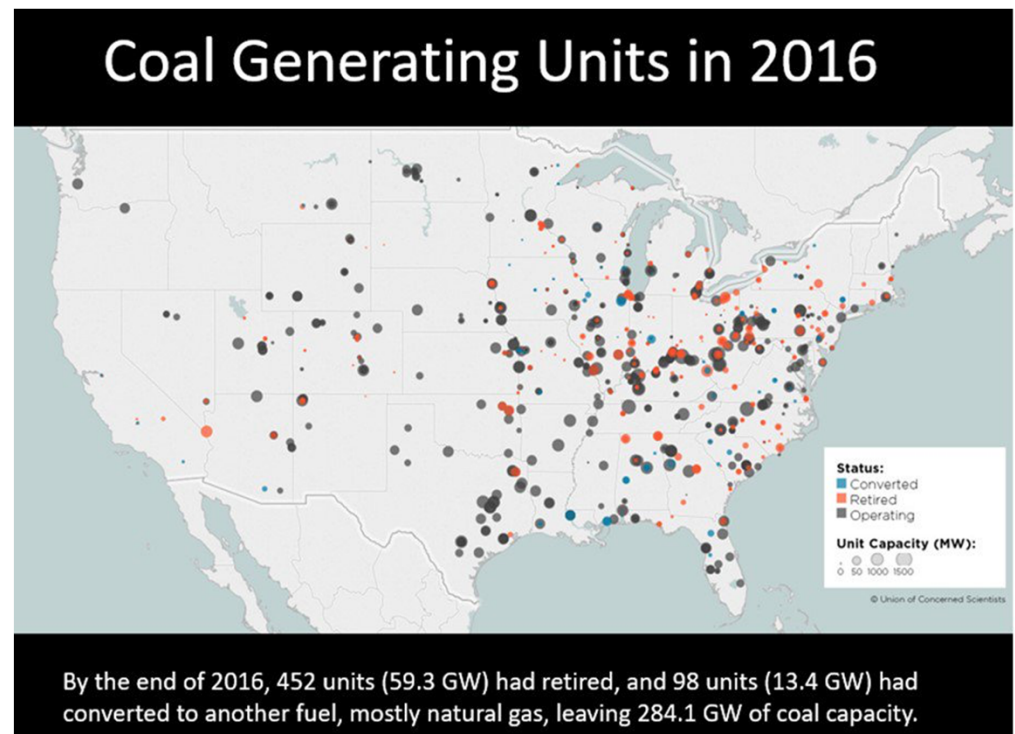
Total U.S. generation capacity
Nov 2017 = 1,190 GW

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
- Old, low CF, high heat rate units

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

- 4.7 GW retired 2002-2016
- 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

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.

We should prioritize reliability and resilience for customers, not just for generation

* Rhodium Group used DOE-EIA data to find that 0.00007% of recent customer outages are due to generation failure or loss of fuel...

Things that improve reliability and resiliency

- Market economic dispatch based on inter-temporal unit commitment
- NERC reliability standards (incl cyber-security)
- Interconnection requirements including performance measures (e.g., 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 & spares

Most of these affect transmission as much as generation, so generation fleet resiliency won't help them. And most of the above are acquired w/o market mechanisms.

**IF SOMETHING HAS VALUE, WE SHOULD SPECIFY IT
AND PAY FOR IT!**

Long-term resiliency and reliability

- Short-term -- since most customer outages occur from T&D problems, not generation, we need more T&D investment – starting with design, asset management and vegetation management relative to generation resources
- Long-term – in a threat-rich environment, the best way to reduce risk and protect customers is to improve the way buildings and appliances protect people from energy system failures.
- Diverse cost-effective technologies and fuels – including supply- and demand-side resources – offer most value and risk reduction.
- Long-lived T&D assets need to be designed to meet 40-year forward climate change threats (extreme heat, drought, violent precipitation, wildfires, ...).

And now to values – human diversity

CATEGORY	STATISTIC
Women among the 899 Grammy nominees in 2013-2018	9.3%
Women among 3,000 attendees at Davos World Econ Forum	21%
Women as share of U.S. workforce, 2017	47%
Women as share of senior managers in US	26%
Women as share of Fortune 500 company CEOs	4.7%
Women as share of total U.S. energy sector workforce	22 - 34% (Depends on sector)
Number of women speakers at UT Energy Week, 2018	7 of 72 (10%)
Hispanics and blacks as share of total U.S. energy sector workforce	14% and 8%
Year when the U.S. will have no single ethnic or racial majorities	2065

What is wrong with this picture?



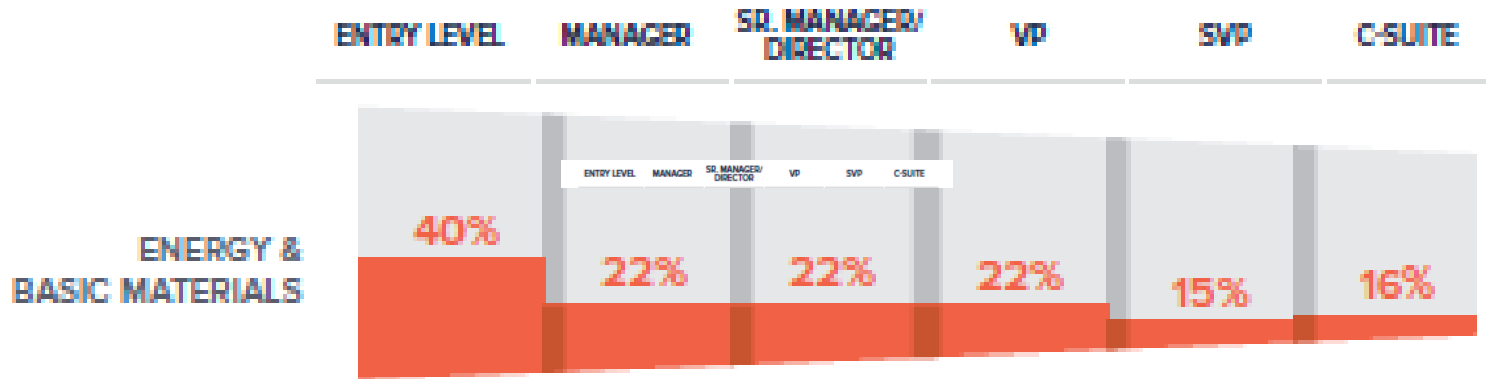
“The subject of tonight’s discussion is: Why are there no women on this panel?”

David Sipress – New Yorker, November 16, 2009

These ideas apply to minorities too, but those data are hard to find...

Women are under-represented in the energy sector

Women in the labor pipeline, energy industry



McKinsey & Co., Representation of Women Across Industries, “Women in the Workplace 2017”

The value of human diversity to business

- Companies with more women and minorities in leadership tend to be more profitable, have higher ROEs than other companies.
- Companies with more diverse workforces have more creativity, innovation, are closer to their customers, and increase market share.
- Customers with more diverse workforces have higher employee productivity and performance, better problem-solving skills.
- Teams where men and women are equal earn 41% higher revenue.

Issues we don't discuss when there aren't many women in the room

- Energy poverty – access to reliable, affordable energy increases human productivity, saves time, enables education and entrepreneurship – better energy access improves societal economic development and stability
- Climate change, its disproportionate impact on women and poor people and their health, well-being and mortality, and ways energy might mitigate this
- People versus things -- people and societies v. companies, products and markets
- Passive v. active views of technology and design – most men view technology as doing things, when we need more things that perform effectively by being rather than acting.
- Why there are so few women and minorities in energy...

Ways to do better on human diversity

Achieving diversity takes work, so choose inclusion, using:

- Blind applications and consideration of capabilities
- Rooney rule – require every candidate pool to have a minimum number of women and minorities
- Create broader networks to find talent
- Look for expertise in wider, associated topic areas
- Know diversity matters and track outcomes

Thank you

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