Nuclear Power and Global Warming

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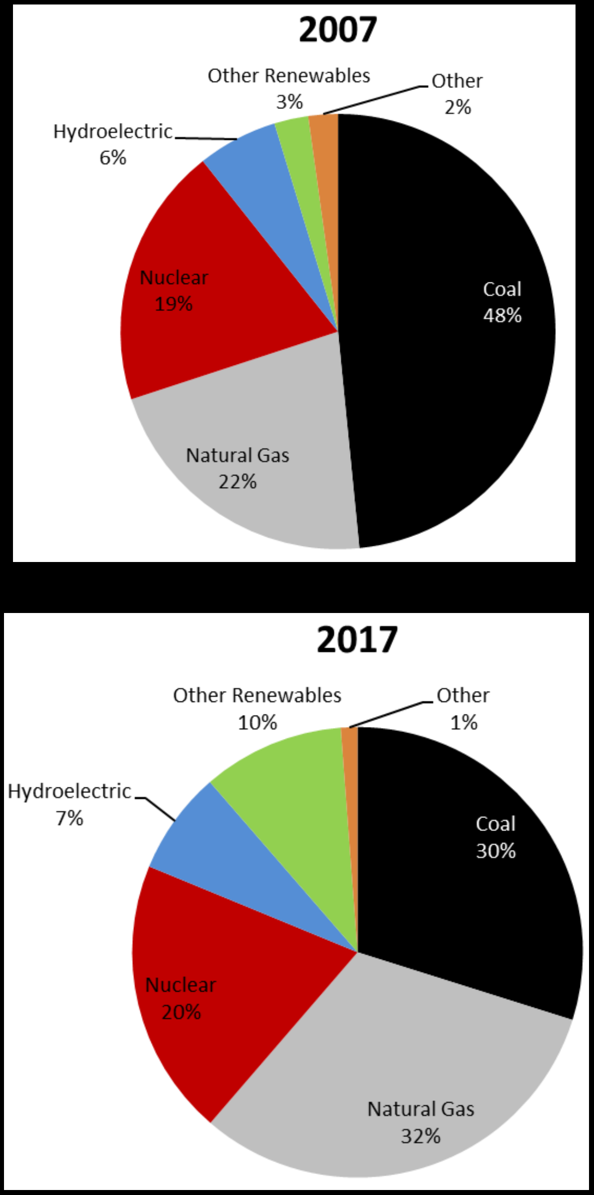
UCS Position

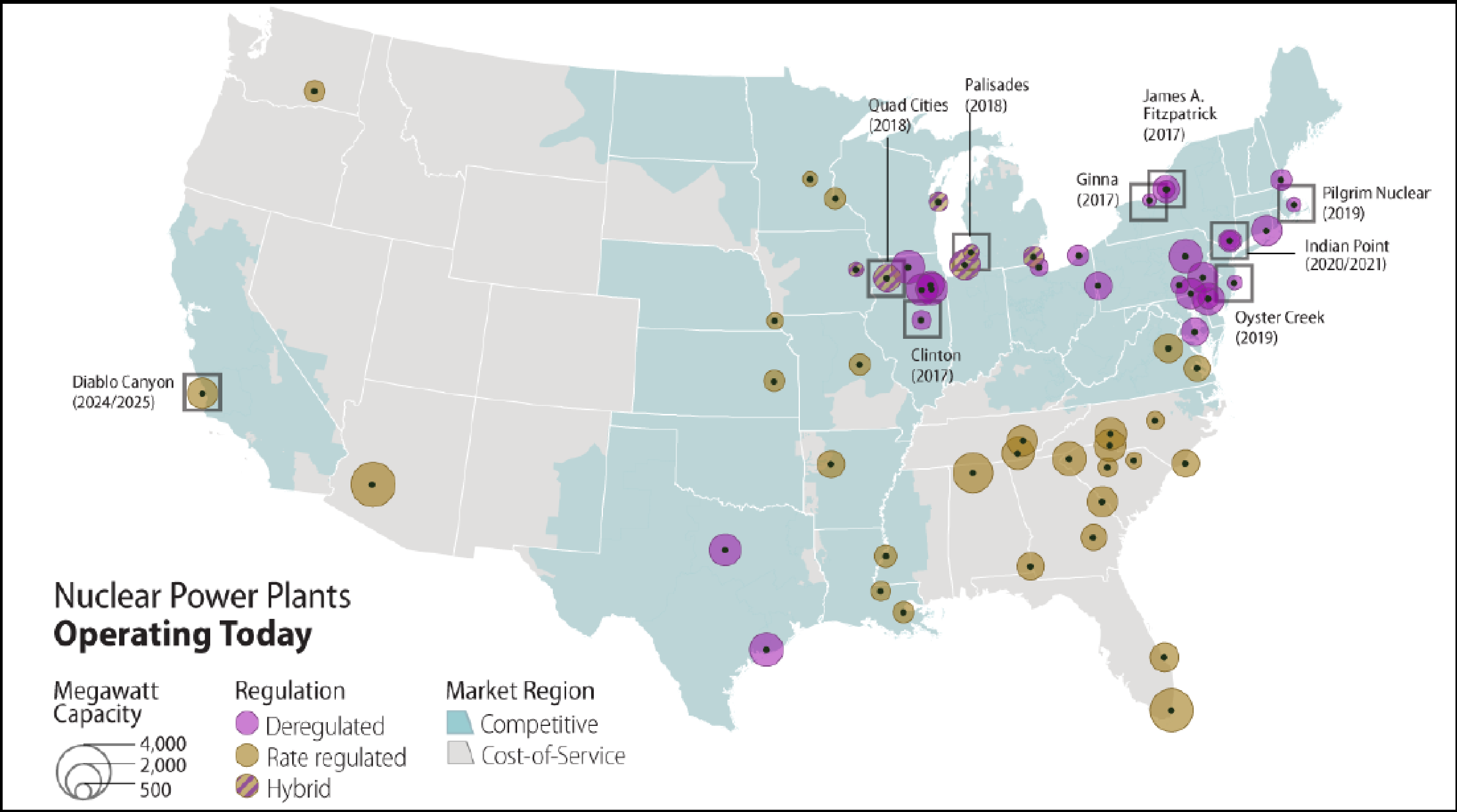
- Limiting climate impacts will require decarbonizing the U.S. power sector by 2050
- Nuclear's role depends on overcoming economic, safety, security and environmental risks
- Existing nuclear plants are at-risk of retiring early due to low natural gas prices that don't include the cost of carbon emissions
- Replacing nuclear with natural gas would undermine emission reduction targets
- Any support should be temporary and part of a broader strategy to reduce emissions and increase renewables and efficiency

Changes in U.S. Electricity Mix



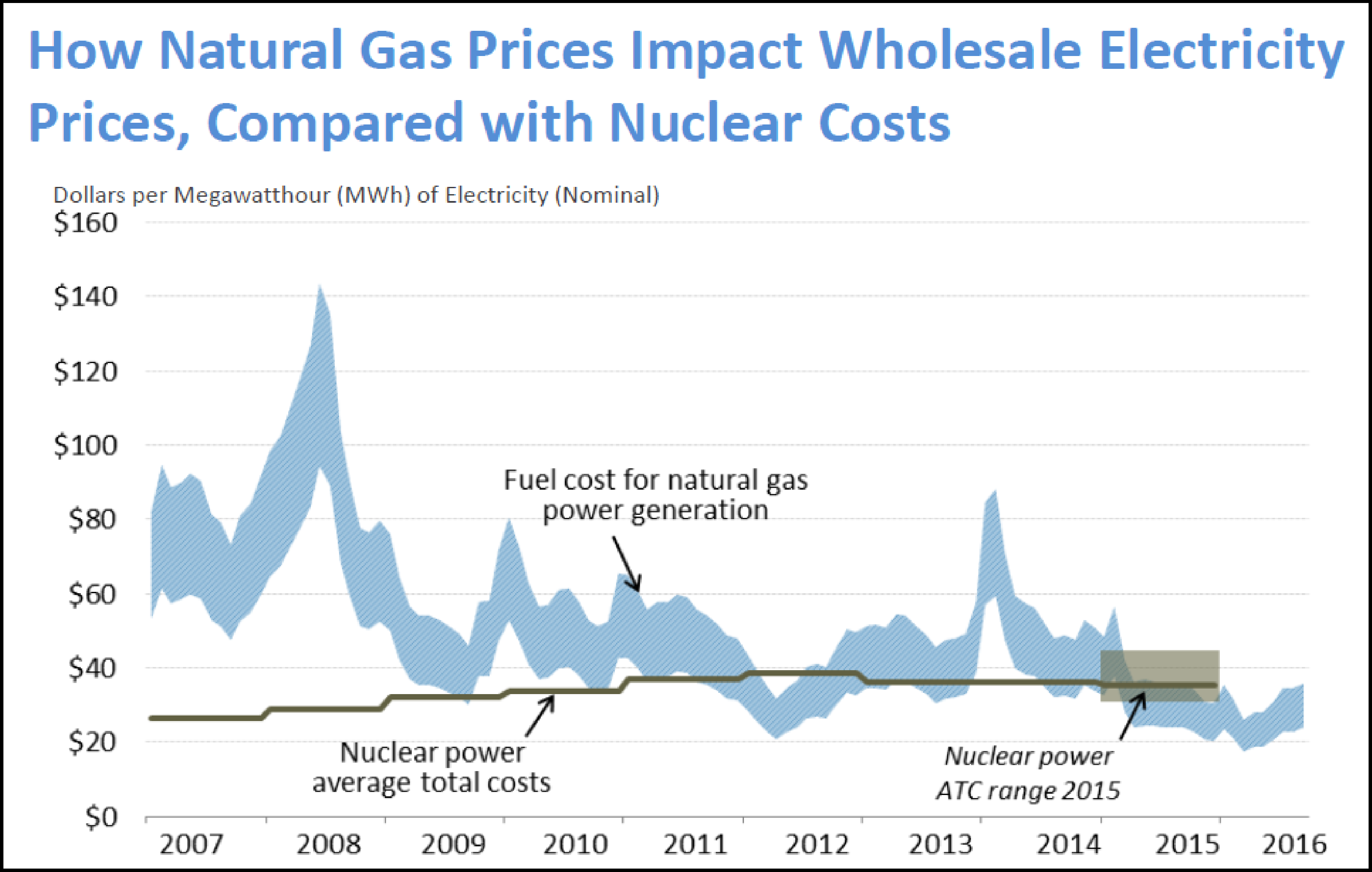
Source: EIA

60 nuclear plants currently operating in US



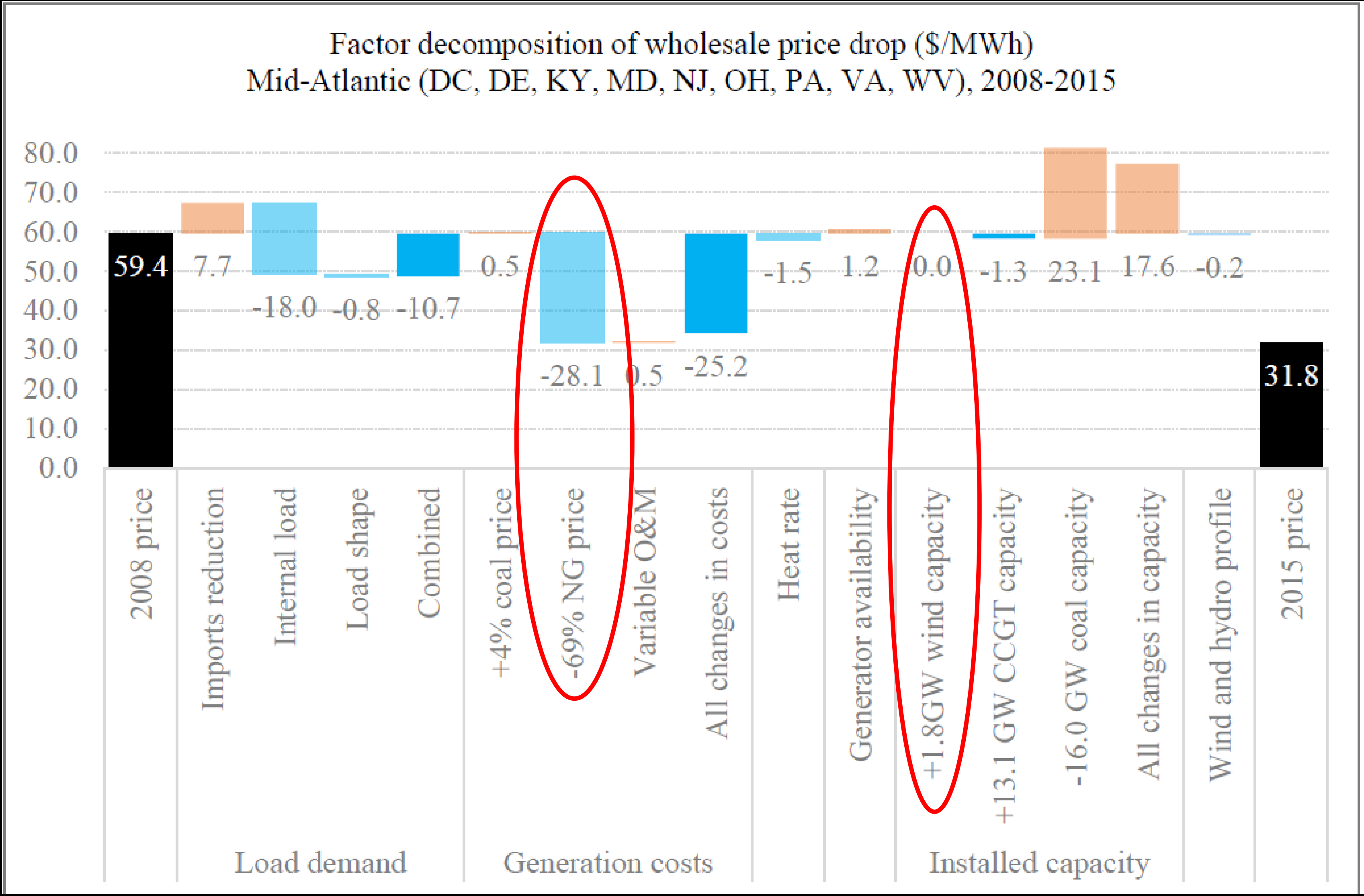
Source: Congressional Research Service, 2017

Low natural gas prices is primary driver for early nuclear retirements

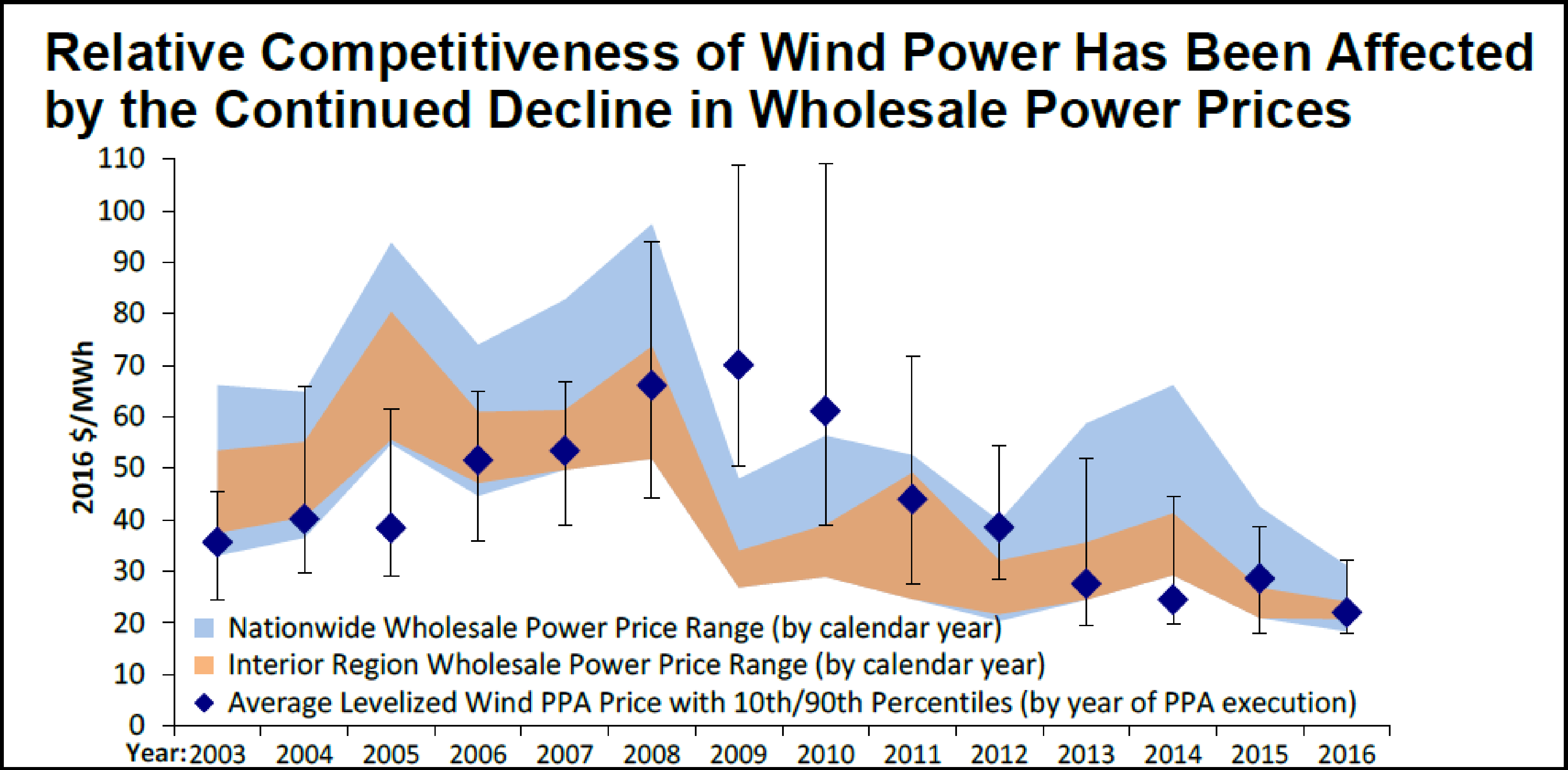


Source: Congressional Research Service, 2017

MIT: Drop in wholesale electricity prices in PJM due to low natural gas prices, not renewables



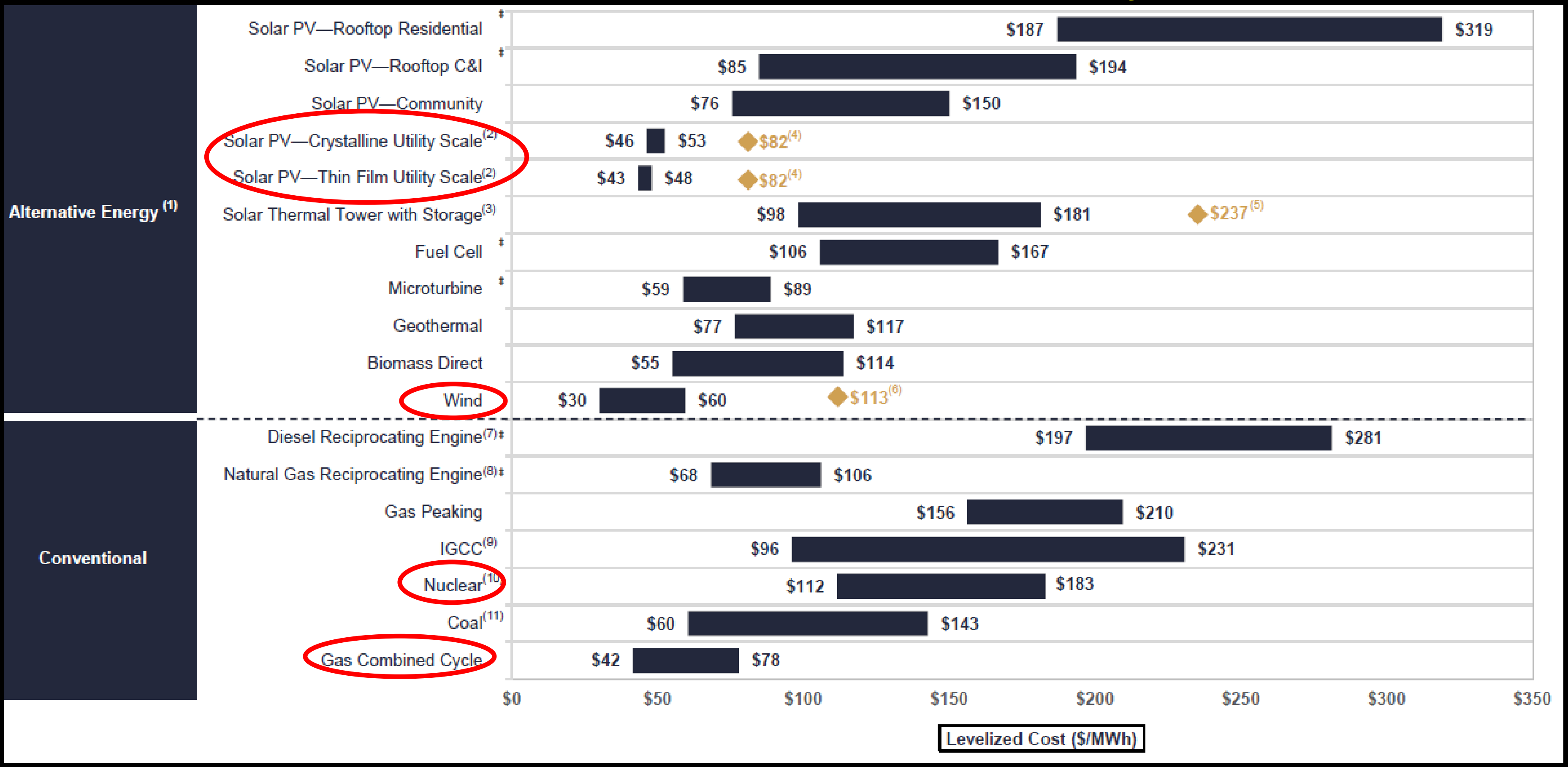
This problem is not unique to nuclear



Source: LBNL, U.S. Wind Technologies Market Report, 2017

A CO_2 price would make low carbon technologies more competitive and address a key market failure

Unsubsidized Levelized Cost of Electricity



Source: Lazard, Levelized Cost of Electricity Analysis – Version 11.0, 2017

This is not about reliability and national security

Assessment Area Reserve Margins

The 20 other assessment areas project sufficient short-term (2022) Anticipated Reserve Margins (see **Figure 3**). **Table 1** on the following page provides the Planning Reserve Margins for 2018–2022.

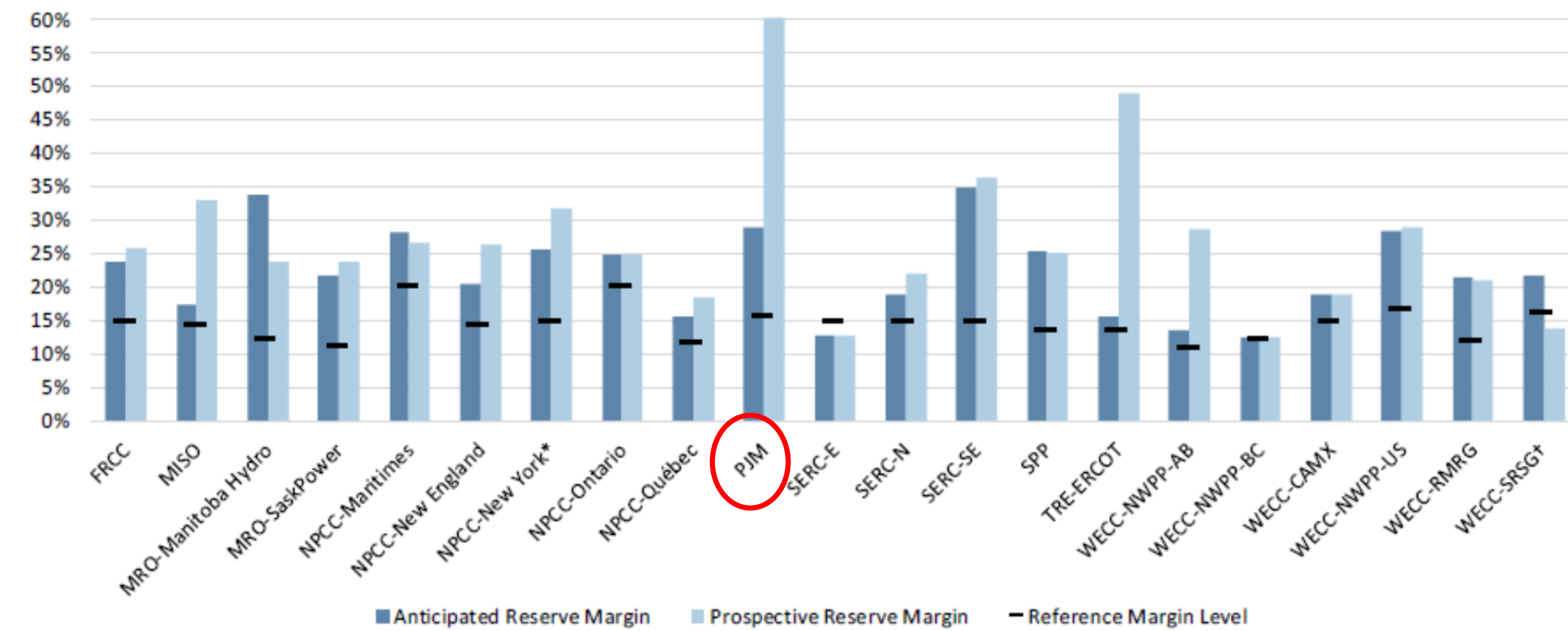


Figure 3: Assessment Area Reserve Margins

Source: NERC

PJM (6/1/18): "Our analysis of the recently announced planned deactivations of certain nuclear plants has determined that there is no immediate threat to system reliability. Markets have helped to establish a reliable grid with historically low prices. Any federal intervention in the market to order customers to buy electricity from specific power plants would be damaging to the markets and therefore costly to consumers."

This is not about electricity resilience

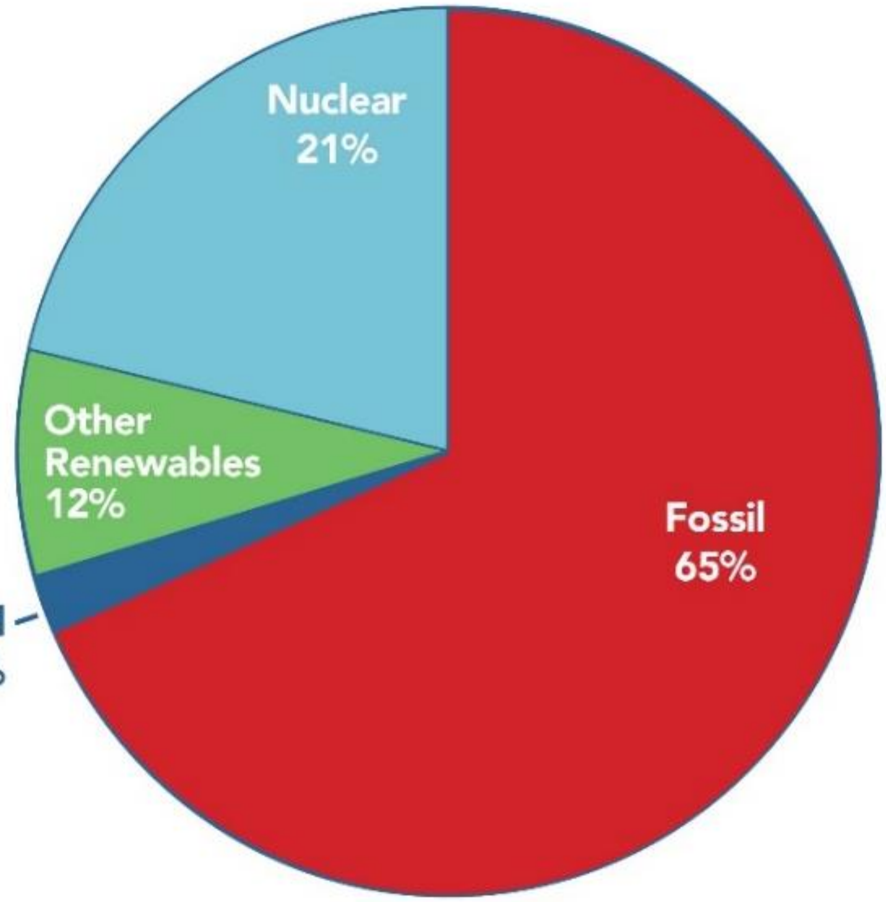
Reliability Service	Wind	Solar PV	Gas	Coal	Nuclear
Disturbance ride-through	Green	Yellow	Yellow	Yellow	Yellow
Note: For the following reliability services, yellow means the resource can provide the service but during many hours it may not be the most economic choice to do so.					
Reactive and voltage control	Green	Green	Yellow	Yellow	Green
Frequency regulation	Yellow	Yellow	Green	Yellow	Red
Flexibility	Yellow	Yellow	Green	Yellow	Red
Primary frequency response and inertial response to disturbances	Yellow	Yellow	Yellow	Yellow	Yellow
Resilience Service	**Wind**	**Solar PV**	**Gas**	**Coal**	**Nuclear**
Note: For the following resilience services, score reflects risk of common mode unavailability reducing fleetwide output below capacity value during challenging time period.					
Cold weather resilience	Green	Yellow	Yellow	Yellow	Green
Hot weather resilience	Yellow	Green	Yellow	Green	Green
Fuel delivery resilience	Green	Green	Red	Yellow	Green
Cooling water resilience	Green	Green	Yellow	Red	Red
Impact on System Variability	**Wind**	**Solar PV**	**Gas**	**Coal**	**Nuclear**
Impact on operating reserves and flexibility needs of other generators	Yellow	Yellow	Yellow	Red	Red

Key: **Green** is positive, **yellow** is medium value, **red** indicates that in most cases the resource does not offer that service.

Source: AWEA

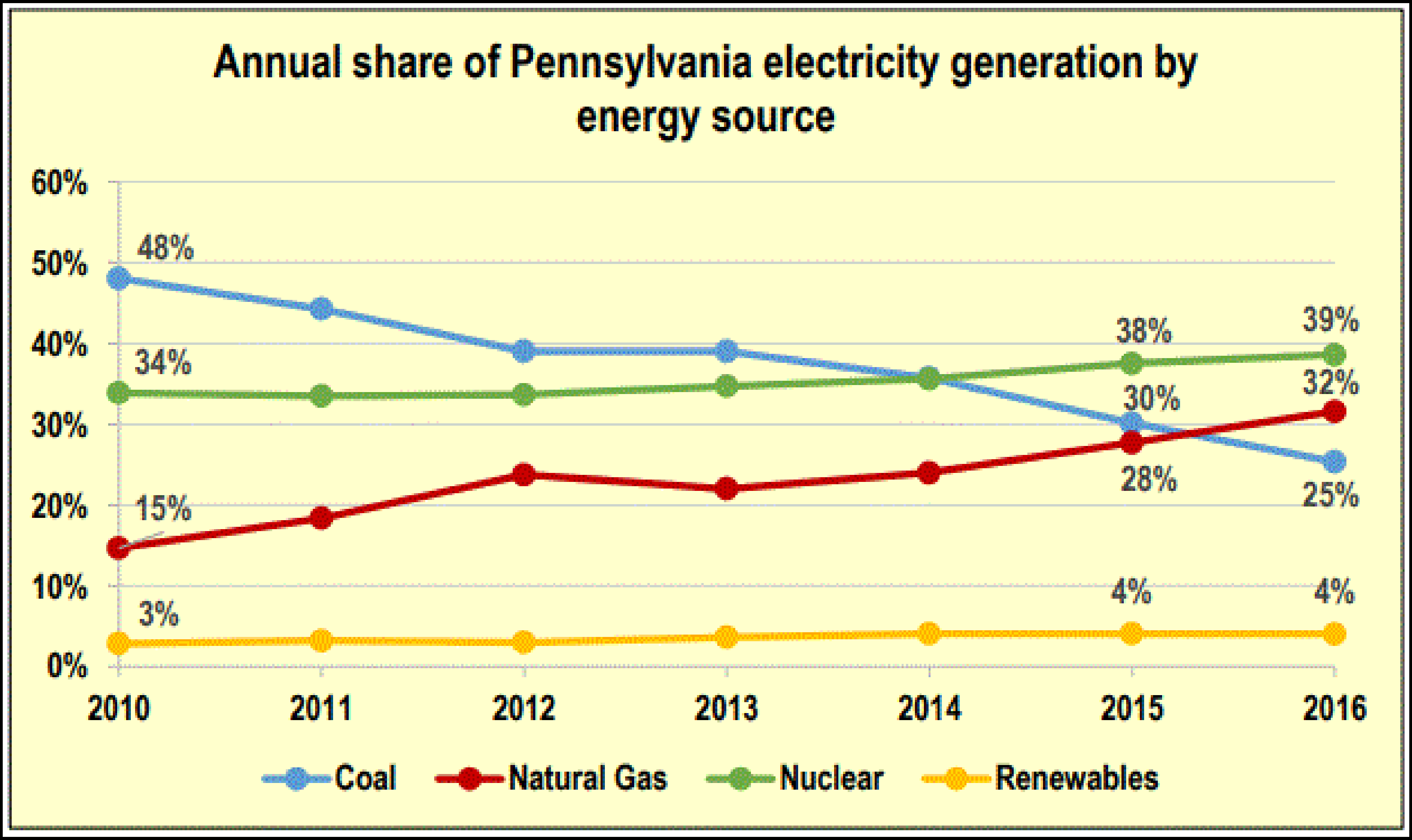
What about subsidies?

Federal Energy Incentives, 1947-2015



* Federal incentives for all energy sources from 1947 to 2015 total $957 billion
Sources: JCT, US Treasury, OMB, DBL Investors, NEI, DOE

PA is under investing in renewables

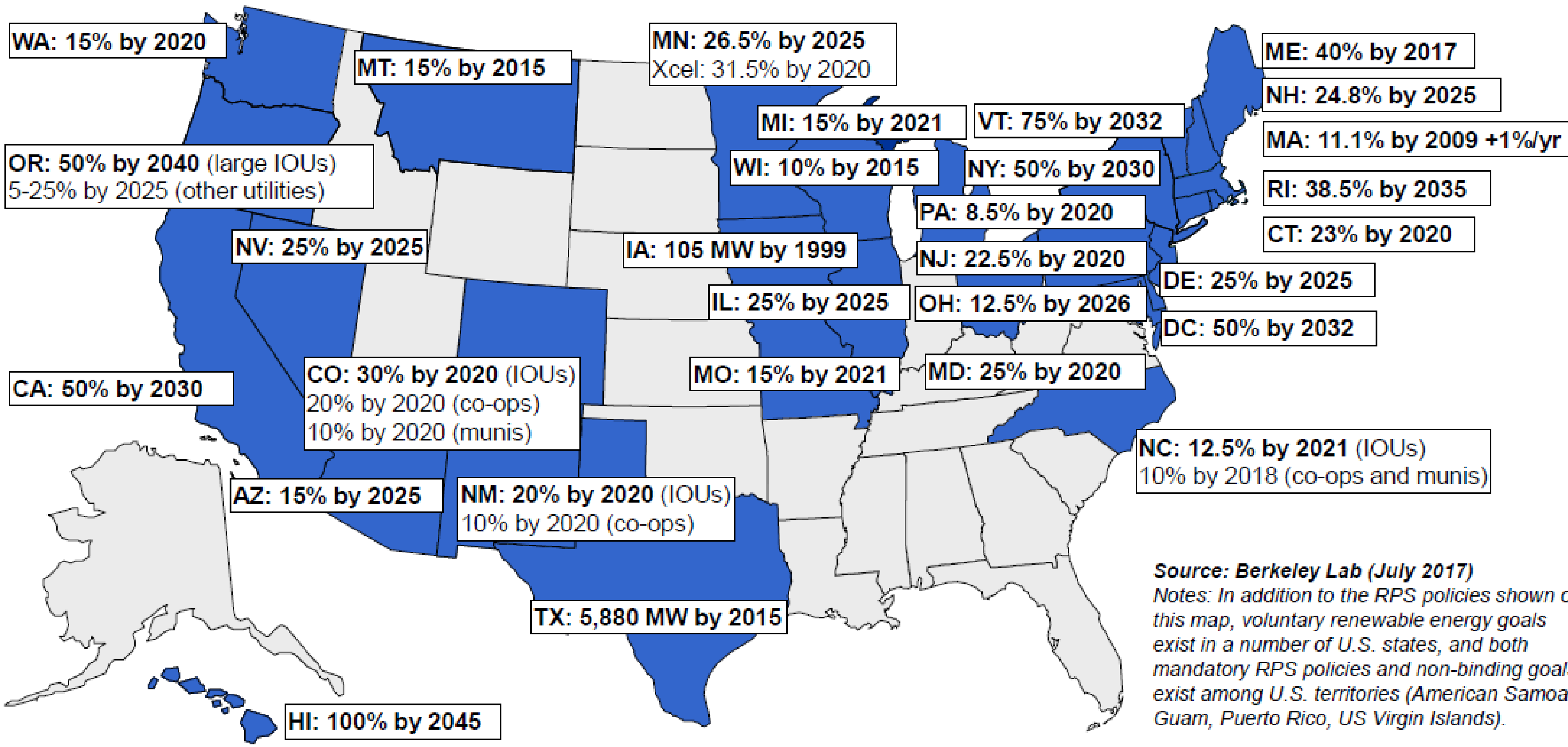


Pennsylvania Public Utility Commission, 2016 AEPS Report

PA has a weak renewable standard

RPS Policies Exist in 29 States and DC

Apply to 56% of Total U.S. Retail Electricity Sales



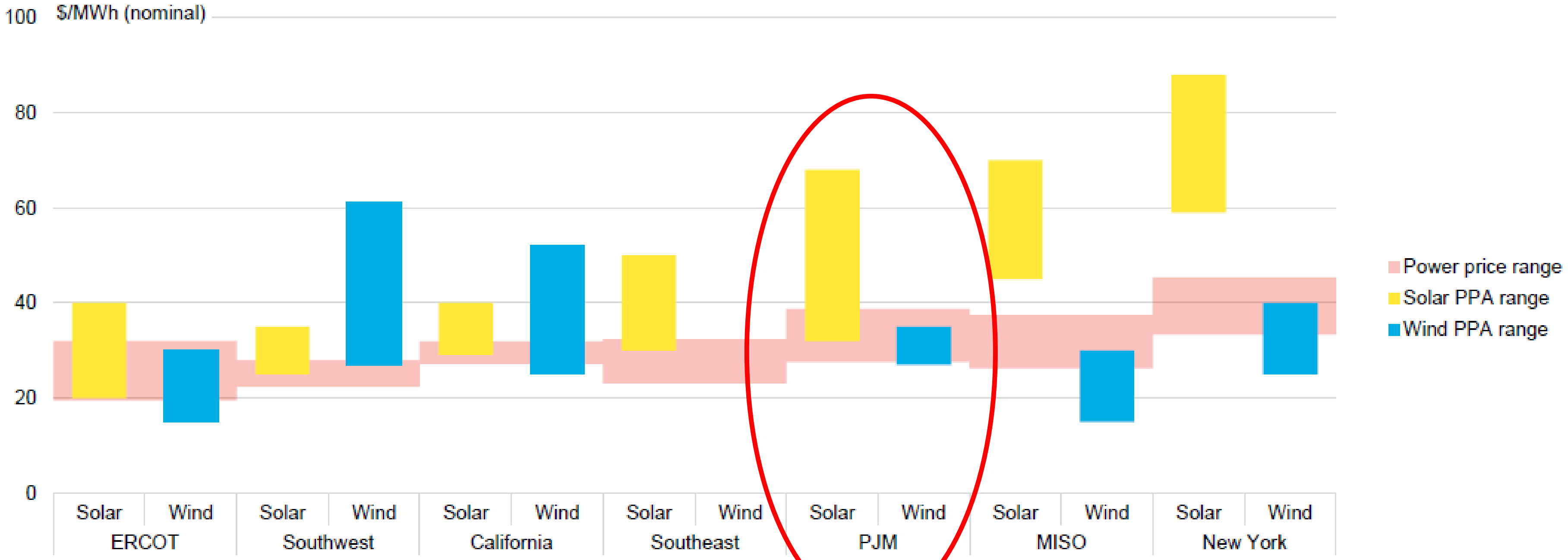
Source: Berkeley Lab (July 2017)

Notes: In addition to the RPS policies shown on this map, voluntary renewable energy goals exist in a number of U.S. states, and both mandatory RPS policies and non-binding goals exist among U.S. territories (American Samoa, Guam, Puerto Rico, US Virgin Islands).

Wind and solar are affordable in PJM

Clean energy is no longer expensive: Wind, solar contracts are economic in parts of the U.S.

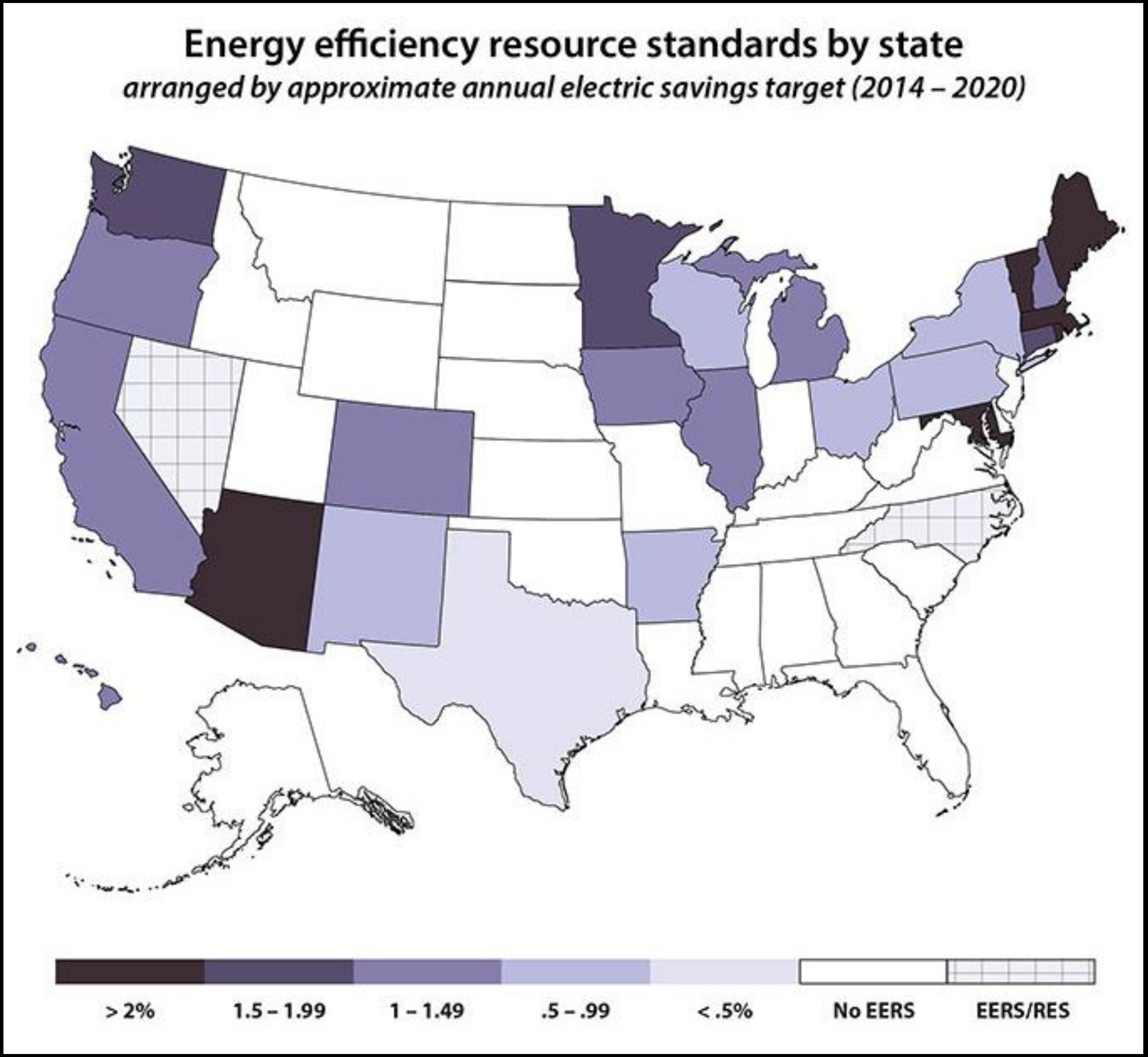
Wind, solar power purchase agreement price ranges (estimated) and power price ranges – by region



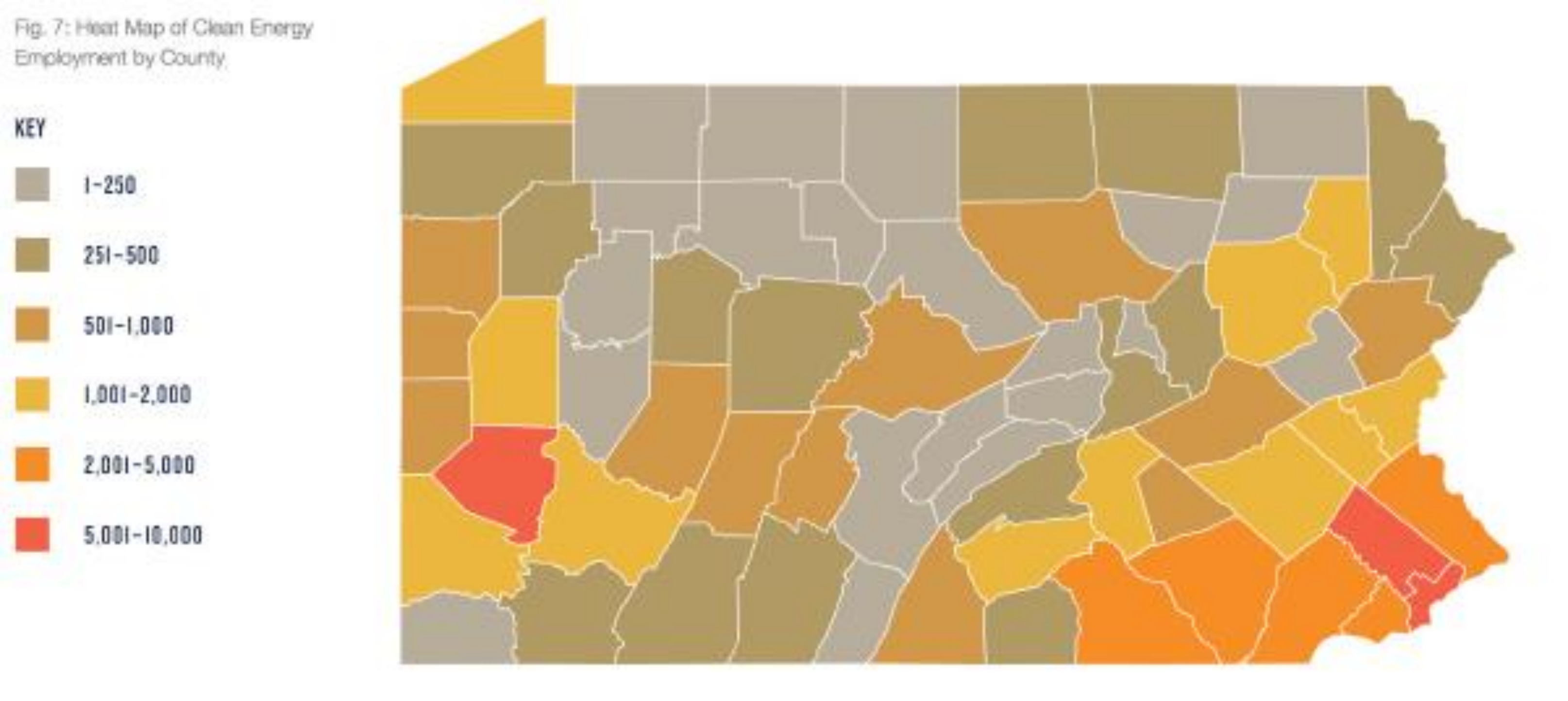
Source: Bloomberg New Energy Finance, SEC filings, interviews, analyst estimates Notes: MISO is the Midwest region; PJM is the Mid-Atlantic region; SPP is the Southwest Power Pool which covers the central southern U.S.; NEPOOL is the New England region; ERCOT covers most of Texas. Wholesale power prices are based on market-traded futures for calendar year 2018 for select nodes within each region.

Bloomberg New Energy Finance

PA is lagging behind in energy efficiency



Renewables and efficiency are good for PA economy



Policy Considerations for Existing Nuclear

- Carbon price is most effective and equitable policy
- Must be part of a broader strategy to reduce carbon emissions and strengthen renewables and efficiency policies
- Companies must open up books and demonstrate need
- Any financial support should be temporary and adjusted over time to protect consumers
- Plants should have strong safety records and plan to move waste to dry cask storage
- Companies should develop worker and community transition plans for eventual retirement

Extra Slides

Policies in NY, IL and NJ

	New York	Illinois	New Jersey
Nuclear			
ZEC price	• $17.48/MWh in 2017, $29.15/MWh in 2027	• $16.50/MWh in 2017, $20.50/MWh in 2027	• $10/MWh
Cost	• $483 million/yr in 2017-19	• $235 million/yr	• $300 million/yr
Duration	• 12 years (2017-2029)	• 10 years (2017-2027)	• No sunset
Price Adjustment	• Increased by social cost of carbon; reduced by RGGI CO2 price and when market prices exceed $39/MWh	• Increased by social cost of carbon; reduced when market prices exceed $34.40/MWh	
Other		• Cost cap of 1.65% of 2009 retail electricity costs	• Requires owners to develop transition plans and study best practices for waste disposal
Renewable Energy			
RPS	• 50% by 2030	• 25% by 2025	• 50% by 2030
Wind	• 2,400 MW offshore by 2030	• 1,300 MW new	• 3,500 MW offshore by 2030
Solar	• 0.58% customer-sited by 2015	• 3,000 MW by 2030 • New Community Solar and Solar for All Program	• 2,000 MW by 2030; • Overhaul of state solar incentives program
Storage	• 1,500 MW by 2025		• 2,000 MW by 2030
Energy Efficiency	• Increase electricity savings target to 3%/year by 2025 • 1/3 of state goal to reduce greenhouse gas emissions 40% by 2030	• Increased cumulative energy efficiency portfolio standard to 21.5% by 2030 for ComEd and 16% by 2030 for Ameren • $25 million/year for low-income programs	• Requires utilities to invest in all cost-effective efficiency • Estimated to quadruple energy savings and save consumers $200 million/year

More explanation for slide 9

Reliability Service	Wind	Solar PV	Gas	Coal	Nuclear	Recent Reliability Events Where a Lack of this Service was a Significant Factor
Disturbance ride-through	Excellent voltage and frequency ride-through due to power electronics isolating generator from grid disturbances. Wind meets more rigorous ride-through requirement (FERC Order 661A) than other generators.	Can thanks to power electronics, but standards have prevented use of capability.	Generators often taken offline by grid disturbances.	Generators and essential plant equipment, like pumps and conveyor belts, often taken offline by grid disturbances.	Generators and essential plant equipment, like pumps, often taken offline by grid disturbances.	The failure of large conventional generators to ride-through a disturbance has been a contributing factor in several recent reliability events, including the DC and Florida blackouts.
Note: For the following reliability services, yellow means the resource can provide the service but during many hours it may not be the most economic choice to do so.						
Reactive and voltage control	Provides, and can provide while not generating by using power electronics.	Provides, and can provide while not generating by using power electronics.	Must be generating to provide.	Must be generating to provide.	Must be generating to provide.	
Frequency regulation	Fast and accurate response. Can provide but often costly, particularly for upward response. Provides on Xcel's system.	Fast and accurate response. Can provide but often costly, particularly for upward response.	Provides.	MISO data show a large share of coal plants provide inaccurate regulation response.	Does not provide.	
Flexibility	Fast and accurate response. Can but often costly, particularly for upward response. Provides on Xcel's system.	Fast and accurate response. Can provide but often costly, particularly for upward response.	Most gas generators are operated flexibly.	Many coal plants have limited flexibility, with slow ramp rates, high minimum generation levels, and lengthy start-up and shut-down periods.	Almost never provides.	
Primary frequency response and inertial response to disturbances	Wind regularly provides fast and accurate PFR in ERCOT today. Can be economic to provide upward response if curtailed. Can provide synthetic inertia if economic to do so.	Can provide downward frequency response today, can provide upward frequency response and fast power injection if curtailed.	Only 10% of conventional generators provide sustained primary frequency response.	Only 10% of conventional generators provide sustained primary frequency response.	Nuclear plants are exempted from providing frequency response, but they do provide inertia.	
Resilience Service	**Wind**	**Solar PV**	**Gas**	**Coal**	**Nuclear**	
Note: For the following resilience services, score reflects risk of common mode unavailability reducing fleetwide output below capacity value during challenging time period.						
Cold weather resilience	Wind plants typically have high output during periods of extreme cold, as seen in ERCOT in 2011 and much of the country in 2014.	Solar plants have lower output during the winter.	As noted below, high gas demand can cause low gas system pressure, fuel shortages. Can be mitigated with dual fuel capability or firm pipeline contracts.	Many coal plants failed due to cold in ERCOT in February 2011, polar vortex event in 2014, and other events.	Some failures due to extreme cold.	Polar vortex event in 2014 and ERCOT February 2011 event.
Hot weather resilience	In many regions wind output is lower during hot summer days, though that is accounted for when calculating wind's capacity value. In some regions, like coastal areas or mountain passes, wind output is higher on hot summer days.	Solar plants typically have high output on hot summer days.	Gas generators experience large output de-rates when air temperatures are high.	As noted below, coal plants experience de-rates when cooling water temperatures are high.	As noted below, nuclear plants experience de-rates when cooling water temperatures are high.	
Fuel delivery resilience	No fuel to deliver.	No fuel to deliver.	High gas demand can cause low gas system pressure, fuel shortages. Can be mitigated with dual fuel capability or firm pipeline contracts.	Rail congestion, frozen coal piles, and river conditions preventing barge delivery are all coal supply risks.	Large amount of fuel in reactor.	
Cooling water resilience	No cooling water.	No cooling water.	Gas combined cycle plants require cooling water, while combustion turbines do not.	Generators have been forced offline or de-rated due to insufficient cooling water or cooling water being too hot.	Generators have been forced offline or derated due to insufficient cooling water or cooling water being too hot.	
Impact on System Variability	**Wind**	**Solar PV**	**Gas**	**Coal**	**Nuclear**	
Impact on operating reserves and flexibility needs of other generators	Modest increase in system variability at higher penetrations, though can mostly be accommodated through less expensive, slower-acting reserves.	Modest increase in system variability at higher penetrations.	Contingency reserves; gas scheduling lead time can introduce inflexibility.	Contingency reserves; inflexibility imposes cycling burden on other resources.	Contingency reserves; inflexibility imposes cycling burden on other resources.	

Source: AWEA