AEO2019 Electricity Sector Working Group
AEO2018 Results, Policy Assumptions, Key Model Updates

For
EIA Electricity Working Group
May 9, 2018

By
Electricity Analysis Team
Office of Electricity, Coal, Nuclear, and Renewables Analysis

EIA Electricity Pricing Working Group Participants

Invited Guests	
Steve Frauenheim	Edison Electric Institute
Alison Williams	Edison Electric Institute
Mark C Bowles	Entergy
Yanghe Liu	Entergy
Gary Young	Entergy
Mikhail Adamantiades	Environmental Protection Agency
Erich Eschman	Environmental Protection Agency
Thomas Wilson	Electric Power Research Institute
Jerry Eyster	General Electric
Robert Woodfield	General Electric
Mark Strohfus	Great River Energy
Jay Ratafia-Brown	Leidos
Kenneth Walsh	Leidos
Chen-Hao Tsai	Midcontinent Independent System Operator
Harsh Desai	Nuclear Energy Institute
Charles Zelek	National Energy Technology Laboratory
Chris Salmi	NJ Clean Air Council
Jorge Reyes	NJ Dept of Environmental Protection
Leslie Coleman	National Mining Association
Lauren Khair	National Rural Electric Cooperative Association
Michael Leitman	National Rural Electric Cooperative Association
Madelyn Roche	National Rural Electric Cooperative Association

Invited Guests	
Wesley Cole	National Renewable Energy Laboratory
Sharon Showalter	OnLocation, Inc.
Evelyn Wright	Sustainable Energy Economics
Whitney Herndon	Rhodium Group
Justin Baca	Solar Energy Industries Association
Britny Lockridge	Southern Company
Lynsey Tibbs	Southern Company
Jim Moore	Spire Energy
David White	Synapse
Youngsun Baek	Union of Concerned Scientists
Sandra Sattler	Union of Concerned Scientists
Wesley Cole	National Renewable Energy Laboratory
Sharon Showalter	OnLocation, Inc.
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Jim Moore	Spire Energy
David White	Synapse
Youngsun Baek	Union of Concerned Scientists
Sandra Sattler	Union of Concerned Scientists
Bill Stevens	

EIA Electricity Pricing Working Group Participants

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Jim Diefenderfer	EIA
Kenneth Dubin	EIA
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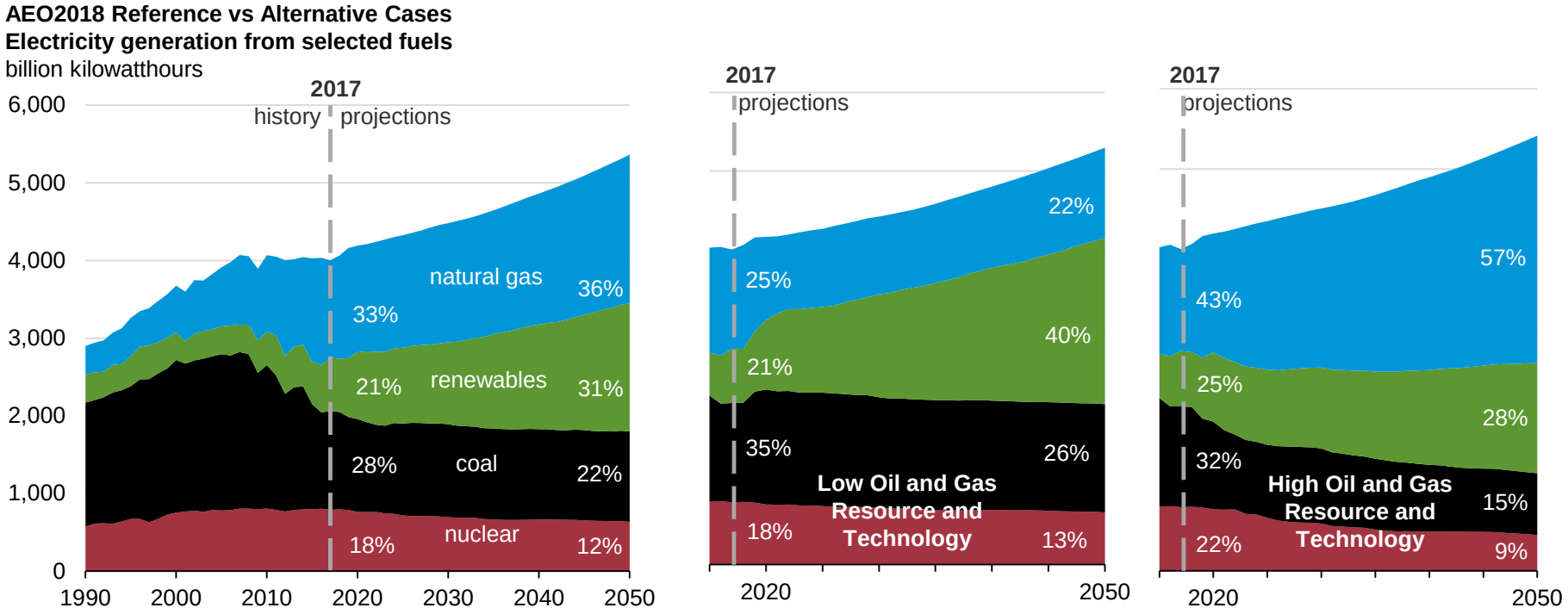
Laura Martin	EIA
Christopher Namovicz	EIA
Michael Scott	EIA
Paul Donohoo-Vallett	Dept Of Energy
Sarah Forbes	Dept Of Energy
Robert Schmitt	Dept Of Energy

Overview AEO2019 Electric Sector Working Group: 1st teleconference

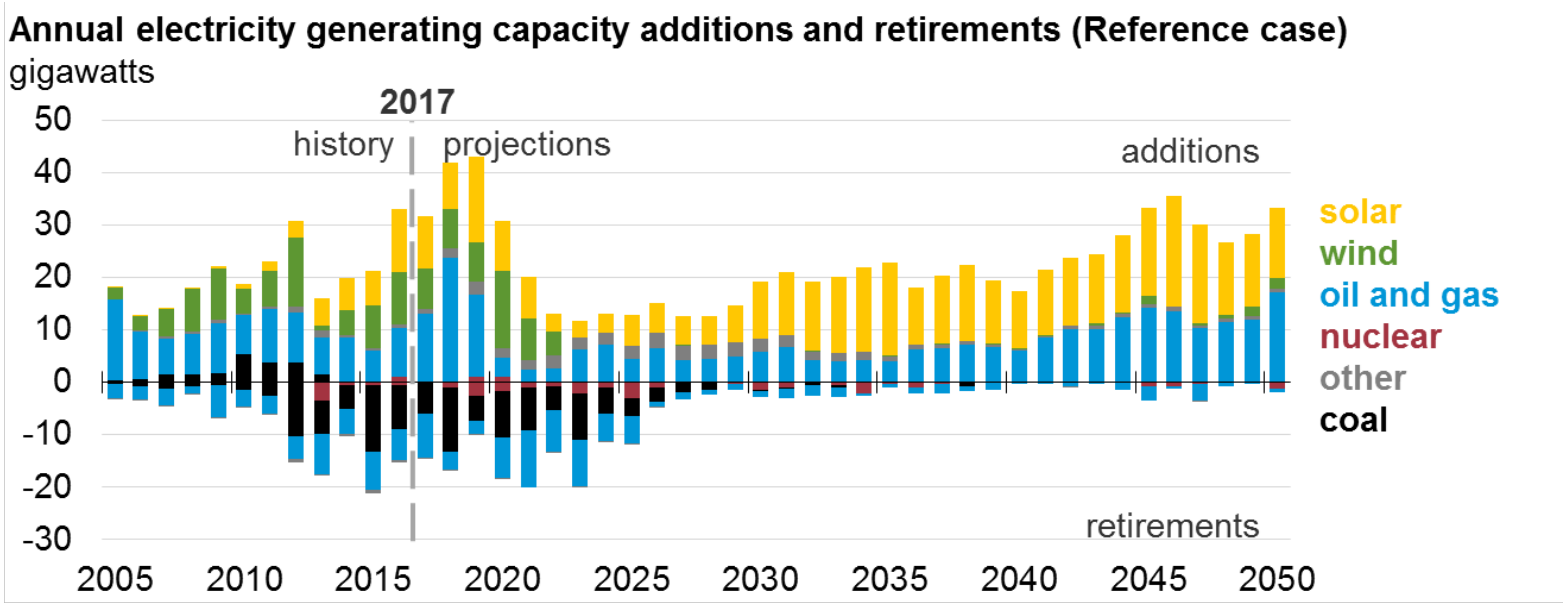
- Review of AEO2018 Results: solicit comments/responses
- Pending AEO2019 modeling- enhancements to NEMS EMM
- Analytic agenda for longer term EMM enhancements
- AEO2019 release schedule

The projected mix of electricity generation technologies varies widely across cases as differences in fuel prices result in significant substitution



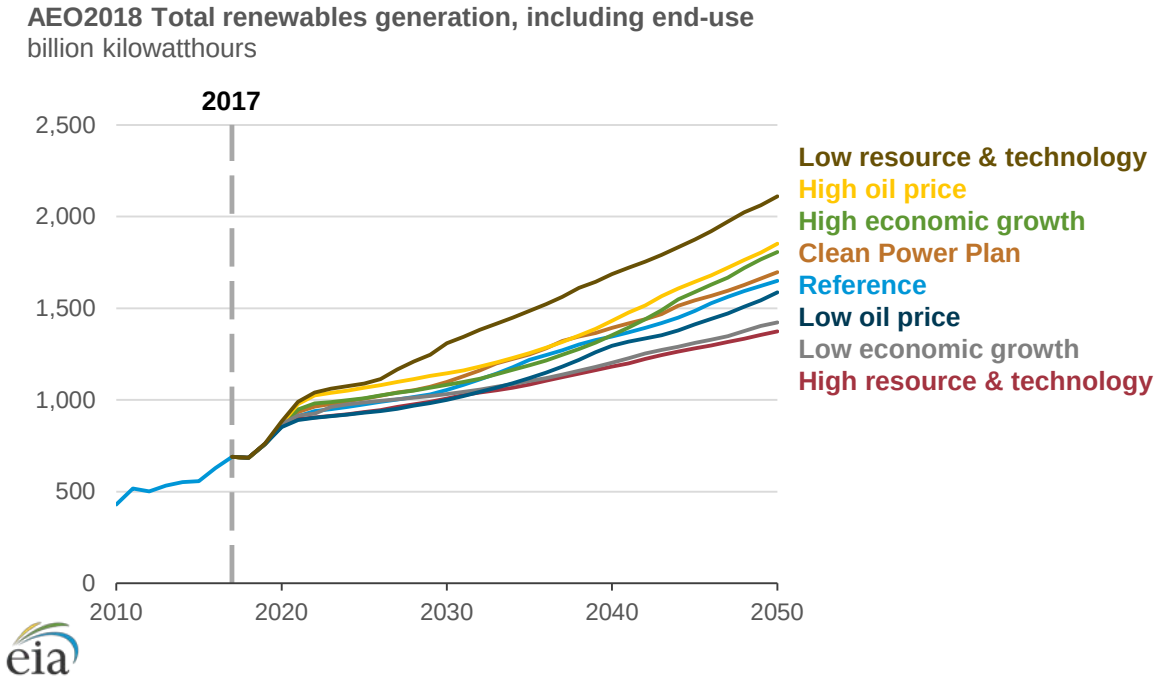
Source: ref2018.1213a, highrt.1213a, lowrt.1213a

Renewables and natural gas comprise most of the capacity additions throughout the projection period in AEO2018 Reference Case



Source: ref2018.1213a

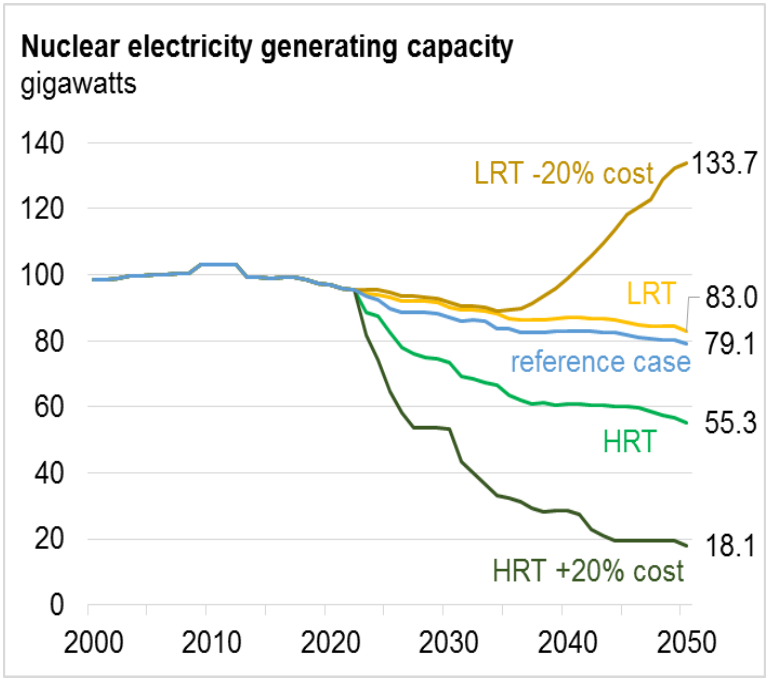
Increasing cost competitiveness of renewables leads to growth in generation even with projection for low electricity demand and low natural gas prices



Source: ref2018.1213a, highmacro.1213a, highrt.1213a, lowprice.1213a, ref_cpp.1213a, highprice.1220a, lowmacro.1213a, lowrt.1213a

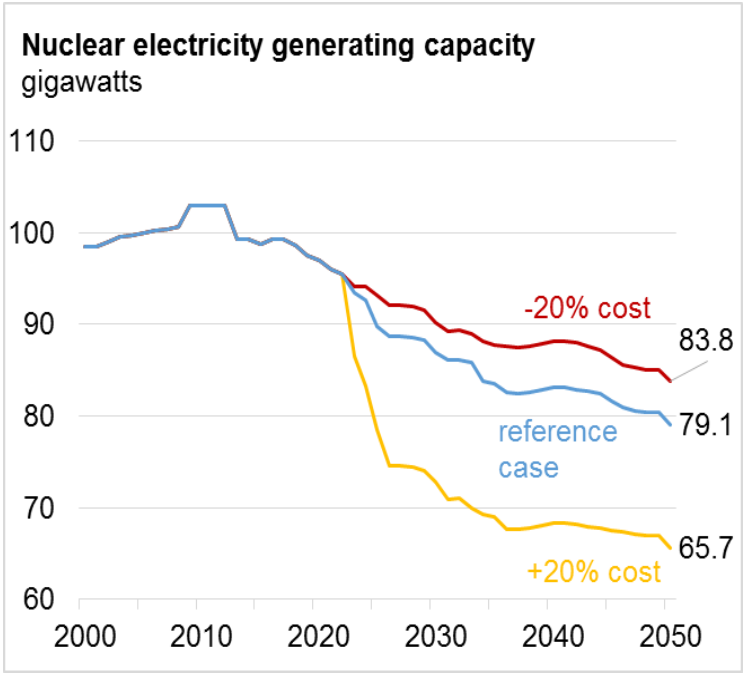
Natural gas prices have a significant impact on nuclear capacity

- High natural gas prices (LRT) leads to only 4 GW fewer retirements relative to the Reference case in 2050
  - While low natural gas prices (HRT) result in roughly 24 GW of additional retirements
- Increasing nuclear operating and new construction costs 20% with low natural gas prices (HRT +20% case) leads to an *additional* 37 GW of retirements in 2050
  - Decreasing nuclear operating costs by 20% in conjunction with high natural gas prices (LRT -20% cost) leads to new nuclear builds beginning in 2035

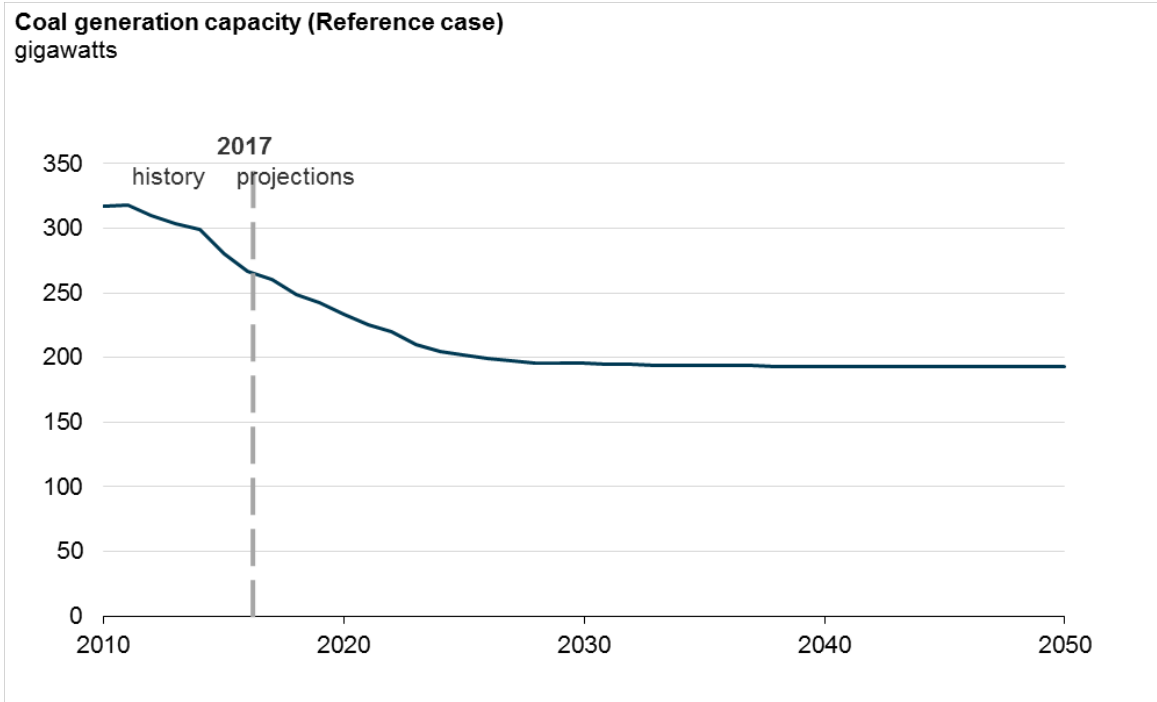


Significant changes in costs (20%) lead to modest changes in nuclear investment decision under most likely conditions

- Under the reference case assumptions, nuclear power declines through 2050 from 99.3 GWe to 79.1 GWe
  - Nuclear industry cost reduction goal of 30%
  - Nuclear generation capacity declines through 2050 for all cases, including reducing operating cost by 20%
  - Reducing operating costs 20% reduces retirements by less than 4 GW, relative to the Reference case
  - Operating cost increases accelerate and increase retirements
  - Illustrates that only about 4% of the fleet capacity are sensitive to cost reductions, while 13% are sensitive to cost increases (in terms of early retirement)

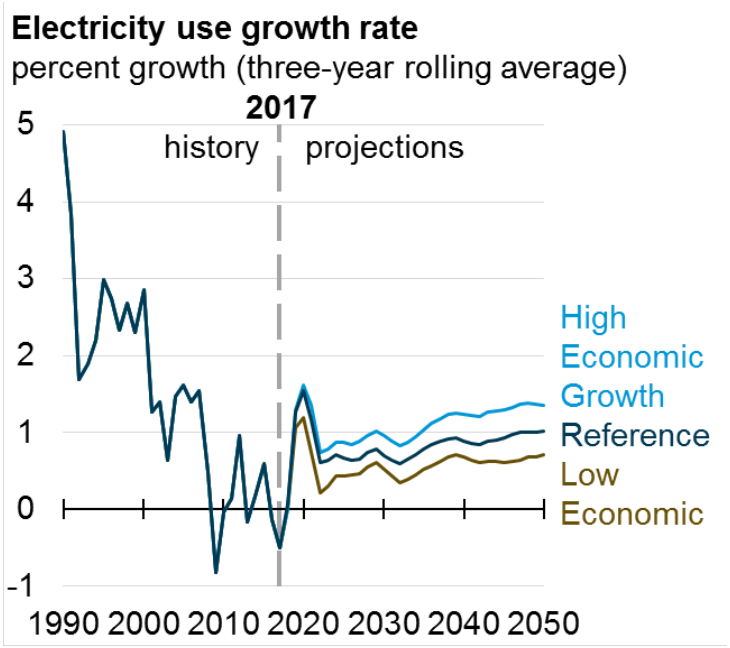


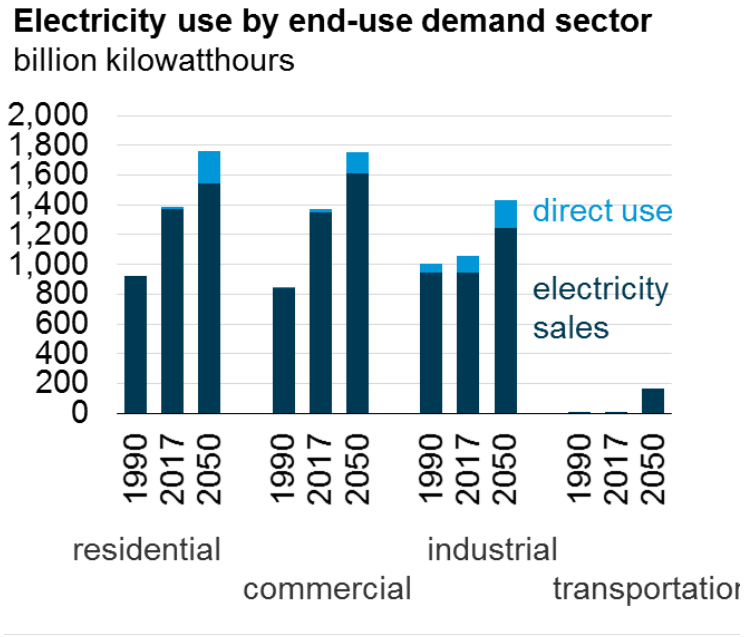
In AEO2018 Reference Case coal and nuclear capacity continue to retire as they are displaced by natural gas and renewables



Source: ref2018.1213a

After decades of slowing growth, electricity consumption is expected to grow steadily through 2050 in AEO2018





Source: ref2018.1213a, highmacro.1213a, lowmacro.1213a

AEO2019–Current laws & regulation

- Federal
  - Taxes: 2017 Tax Reform legislation/ 45Q tax credit for CCS
  - Solar panel tariffs
  - No Clean Power Plan vs. Revised Clean Power Plan (if available) versions
- State
  - Illinois: Future Energy Jobs bill/New York: Clean Energy Standard legislation
  - Additional state subsidy programs (NJ)
  - Revised RPS
- Regional CO2 programs: AB 398 (California)/ RGGI states

Pending AEO2019 modeling- enhancements to NEMS EMM

- Impact of 2017 tax reform legislation on electric sector
- Updating methods for projected changes in generation costs (S&L study)
- Treatment of generation-at-risk
- Considering ways to represent of impact of generation diversity
- Changes in modeling renewables/coal/nuclear generation

Federal tax: impact of tax reform on electric sector/other tax law changes

- Tax Cuts and Jobs Act of 2017
  - reviewing broad, macro feedbacks on electricity demand, as well as
  - changes to investment economics from the change in marginal tax rates and the temporary provisions for immediate expensing
- Section 45Q tax credit for Carbon Capture and Storage
  - Reviewing possible impact on cost treatment in EMM
  - revised (from $20) to $50 per metric ton for secure geologic storage
  - revised (from $10) to $35 per metric ton for EOR, EGR, or utilization

Updating methods for projecting changes in generation costs *(Sargent & Lundy study- forthcoming)*

Variables Affecting Annual Changes in Real Spending per kW

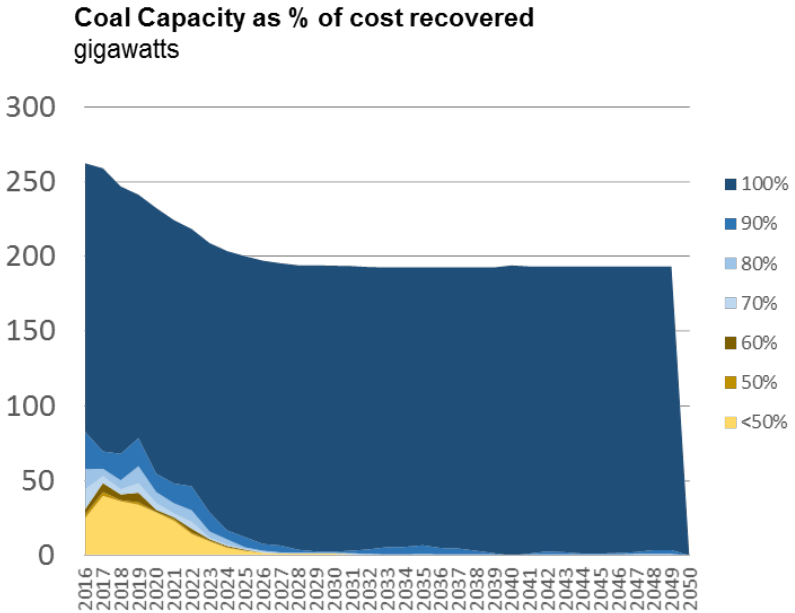
Generating Capacity	Capital Expenditures	O&M Spending
Coal Steam	Age (for units with FGD)	-
Gas/Oil Steam	Capacity	-
Gas/Oil Combined-Cycle	Operating Hours	-
Gas/Oil Combustion Turbines	Starts	-
Conventional Hydropower	-	Age
Pumped Storage – Hydraulic Turbine Reversible	-	-
Solar Thermal – Central Tower	-	-
Solar Photovoltaic – Single-Axis Tracking	-	-
Geothermal	-	-
Wind	Capacity	Age

Key Issues Addressed in Study

- Are there predictable patterns of spending associated with aging/ plant life extension?
- What other variables are critical determinants of spending patterns?
- Is regulatory status a significant factor in spending?
- Is there sufficient historical data on non-hydro renewable generation to determine impacts of aging?

Evaluating alternative measures of generation at-risk: share of cost recovery

AEO2018 Reference Case- Coal Generators



Key issues under consideration

- How does varying current NEMS-EMM treatment (3+ unprofitable periods) influence projected retirements?
- How does use of energy only vs. inclusion of capacity payments influence retirements?
- Is there a generally-accepted industry definition of generation-at-risk?

Alternative generation at-risk criteria

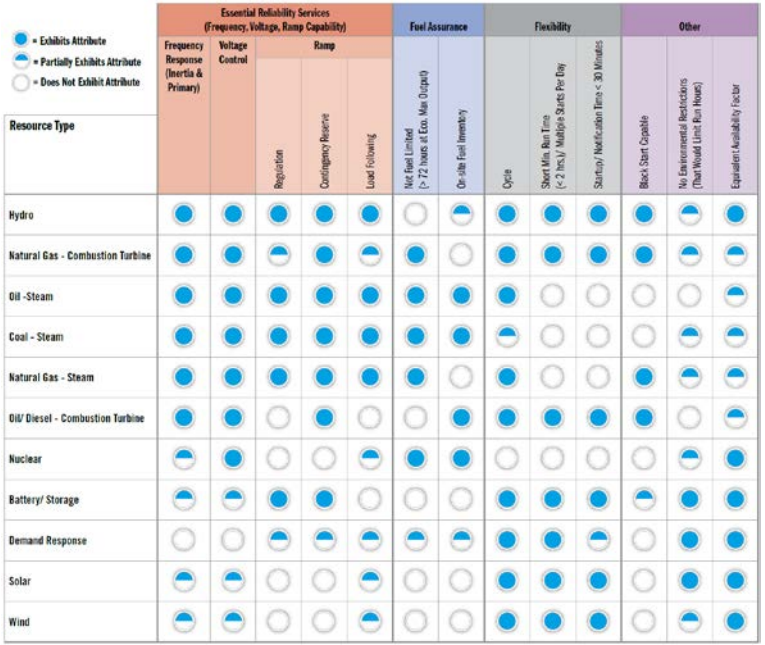
- **PJM Coal** *(2011)*
  - Physical Screen[1]: Older than 40 years old; less than 400 MW are “most at risk”
  - Economic Screen: “At risk” level measured by costs relative to replacement capacity costs Net Cost of New Entry (Net CONE
- **PJM Nuclear and Coal** *(2017)*
  - More stringent criteria[2]: units that have not recovered 100% avoidable costs from total market (energy, ancillary and capacity market) revenues
  - Relaxed criteria
    - Coal: units that have recovered <90% of total market revenues
    - Nuclear: units that have not recovered 100% of avoidable costs based on forward price

[1]Coal Capacity at Risk for Retirement in PJM: Potential Impacts of the Finalized EPA Cross State Air Pollution Rule and Proposed National Emissions Standards for Hazardous Air Pollutants

[2]2017 State of the Market Report for PJM: Volume 2: Detailed Analysis

Evaluating alternative means of representing impact of generation diversity

PJM rating of generation types by reliability attributes



● = Exhibits Attribute
◓ = Partially Exhibits Attribute
○ = Does Not Exhibit Attribute

Resource Type	Essential Reliability Services (Frequency, Voltage, Ramp Capability)					Fuel Assurance		Flexibility			Other		
	Frequency Response (Inertia & Primary)	Voltage Control	Ramp			Not Fuel Limited (> 72 hours at Eco. Max Output)	On-site Fuel Inventory	Cycle	Short Min. Run Time (< 2 hrs.) / Multiple Starts Per Day	Start-up / Notification Time < 30 Minutes	Black Start Capable	No Environmental Restrictions (That Would Limit Run Hours)	Equivalent Availability Factor
			Regulation	Contingency Reserve	Load Following								
Hydro	●	●	●	●	●	○	◓	●	●	●	●	◓	●
Natural Gas - Combustion Turbine	●	●	◓	●	◓	●	○	●	●	●	●	◓	◓
Oil -Steam	●	●	●	●	●	●	●	●	○	○	○	○	◓
Coal - Steam	●	●	●	●	●	●	●	◓	○	○	○	◓	◓
Natural Gas - Steam	●	●	●	●	●	●	○	●	○	○	●	◓	◓
Oil/ Diesel - Combustion Turbine	●	●	○	●	○	○	●	●	●	●	●	○	◓
Nuclear	◓	●	○	○	◓	●	●	○	○	○	○	◓	●
Battery/ Storage	◓	◓	●	●	○	○	○	●	●	●	◓	●	●
Demand Response	○	○	◓	◓	◓	◓	◓	●	●	◓	○	●	●
Solar	◓	◓	○	○	◓	○	○	●	●	●	○	●	●
Wind	◓	◓	○	○	◓	○	○	●	●	●	○	◓	●

Source:
http://www.pjm.com/~/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx pg. 16

Key issues under consideration

- What other attributes ought to be considered? Which could be eliminated, or represented differently?
- How do these reliability attributes contribute to grid resilience?
- Should these attributes be weighted equally, or are some more critical than others?
- What is the best way to represent these factors in the model?

Other electric power sector updates for AEO2019

- **Renewables- Completed or Likely Completed for AEO2019**
  - Integrate a new renewables/energy storage mini-dispatch model (REStore)
  - Model weighted-average capacity value algorithm for solar/wind
  - Update renewable-related input assumptions for the spinning reserves requirement
- **Renewables-Possible Model Updates for AEO2019**
  - Include second solar/wind technology to capture performance/cost tradeoffs
  - Change the solar thermal technology profiles to one with storage
  - Assess retail price structure impacts of distributed PV
- **Coal/Nuclear-Possible Model Updates for AEO2019**
  - Re-evaluate CT/CC costs
  - Nuclear risk assessment
  - Reconsider nuclear uprate potential

Analytic agenda for longer term EMM enhancements

- Regional redefinition
- T&D spending projections
- Plant-life-extension costs/retirements
- Relationship between capital and O&M costs and generator performance for existing units
- New technologies
- Changing policies- revised regulations
- Update capital cost estimates for new generating technologies and performance

Cost data for new technologies are periodically reviewed

Current technologies modeled in EMM and vintage of cost input

AEO2018	AEO2017	AEO2016	Earlier vintage	Available (not modeled)
Battery storage	Coal with 90% CCS	Coal with 30% CCS	Gas CC with 90% CCS	Coal without CCS
Hydroelectric (partial update for non-powered dams: source ORNL)		Gas combined cycle (conv and adv)	Fuel Cells	Internal combustion engine
Solar PV – fixed tilt (source LBNL)		Gas combustion turbine (conv and adv)	Hydro (new sites, upgrades of existing dams: source INEEL)	Solar PV - alternative size installations
		Nuclear - AP1000	Biomass	Onshore wind – low wind speed
		Solar PV - tracking	Geothermal (source NREL)	
		Onshore Wind	MSW	
			Solar thermal	
			Offshore wind	

Unless noted otherwise, costs are from the EIA contractor capital cost studies available online. If baseline costs were not updated in a particular cycle, they were adjusted to reflect learning.

AEO2019 Outlook Schedule

- Model development: Jun-Oct 2018
- 2nd Working Group Session: Jul-Aug 2018
- Expected AEO release: Jan 2019

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Supplemental Slides

Generation at-risk criteria

- **PJM Coal[1] (2011)**
  - Physical Screen: Older than 40 years old; less than 400 MW are “most at risk”
    - Less efficient\run less frequently
    - Lower CF leads to decline in revenues
    - No economies of scale for retrofit costs
  - Economic Screen: “At risk” level measured by costs relative to replacement capacity costs
    - Capacity requiring capital expenditures (CAPEX) needed for plant to keep running, with costs greater than the Net Cost of New Entry (Net CONE), are “most at risk”
    - Capacity requiring CAPEX between 0.5 Net Cone and Net Cone are “at some risk”
    - Capacity requiring CAPEX less than 0.5 Net Cone “not at risk”

- **PJM Nuclear and Coal[2] (2017)**
  - More stringent criteria: units that have not recovered 100% avoidable costs from total market (energy, ancillary and capacity market) revenues
  - Relaxed criteria
    - Coal: units that have recovered <90% of total market revenues
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