

# *Annual Energy Outlook 2020:*

## *Preliminary Results for Electricity, Coal, Nuclear, and Renewables*



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*For*

*Joint Session – AEO2020 Working Groups*

*September 11, 2019*

*By*

*Office of Electricity, Coal, Nuclear, and Renewables Analysis*

# Welcome to AEO2020 preliminary results working group

- We will be confirming attendance: **please state your name and affiliation at log-in.**
- We are conducting the meeting under Chatham House Rules.
- Slides and notes of the meeting will be made available to the public within a few weeks

# Key developments for AEO2020 in electric sector modeling

## Across all sectors

- Updated capital costs and performance characteristics for new generating units for all technologies
- Redefined regions to better align with ISO/RTO markets

## Electricity/Nuclear

- Region Greenhouse Gas Initiative (RGGI)
- New Source Performance Standards (NSPS)
- Affordable Clean Energy Rule

## Renewables

- Renewable Portfolio Updates for: the District of Columbia, Ohio, Maine, Maryland, Nevada, New Mexico, New York, and Washington
- State offshore wind mandates

## Coal

- Updated base year from 2017 to 2018

# AEO2020 cases

- Reference Case
- Core side cases
  - High/Low Oil Price
  - High/Low Economic Growth
  - High/Low Oil and Gas Resource and Technology
  - High/Low Renewables Cost Case \*\*\*NEW\*\*\*

# AEO2020 Joint Updates:

## *Capital Cost Updates and Regional Redefinition*

# Updated capital costs for new generating units – fossil/nuclear in dollars per kilowatt (\$/kW)

Technology	AEO2020 Capital cost (2019 \$/kW)	AEO2019 Capital cost (2019 \$/kW)	Approx. % change
Combined cycle 2x2x1 (GE 7HA.02)	\$958	\$808	15.7%
Combined cycle 1x1x1, single shaft (H Class)	\$1,084	\$1,016	6.3%
Combined cycle 1x1x1, single shaft, w/ 90% carbon capture	\$2,481	\$2,235	9.9%
Combustion turbines – simple cycle (2 x LM6000)	\$1,175	\$1,144	2.6%
Combustion turbines – simple cycle (1 x GE 7FA)	\$713	\$703	1.4%
Advanced nuclear (brownfield)	\$6,041	\$6,138	-1.6%
Nuclear small modular reactor (SMR)	\$6,190	NA	
Internal combustion engine	\$1,810	\$1,395	22.9%
650 MW net ultra-supercritical coal 30% carbon capture	\$4,558	\$5,259	-15.4%
650 MW net ultra-supercritical coal 90% carbon capture	\$5,876	\$5,815	1.0%
650 MW net ultra-supercritical coal w/o carbon capture – greenfield	\$3,676	NA	

Previous report, completed for [AEO2016](#), is available on EIA.gov. EIA completes cost updates for each AEO for wind and solar. You can find the report for [AEO2019](#) on EIA.gov.

# Updated capital costs for new generating units – renewables in dollars per kilowatt (\$/kW)

Technology	AEO2020 capital cost (2019\$/kW)	AEO2019 capital cost (2019\$/kW)	Approx. % change
Onshore wind – large plant footprint: Great Plains region	\$1,265	\$1,652	-30.6%
Onshore wind – small plant footprint: Coastal region	\$1,677	NA	
Fixed-bottom offshore wind: monopile foundations	\$4,375	\$6,656	-52.1%
Solar PV w/single axis tracking	\$1,313	\$2,004	-52.6%
Solar PV w/single axis tracking + battery storage 150 MW AC solar; 50MW / 200 MWh storage	\$1,755	NA	
Concentrated solar power tower	\$7,221	\$4,365	39.5%
Battery storage system 50 MW 200 MWh	\$1389/kW net \$347/kWh	\$1,603	-15.4%
Battery storage system 50 MW 100 MWh	\$845/kW net \$423/kWh	NA	
Internal combustion engine – landfill gas	\$1,563	NA	
50-MW biomass plant	\$4,097	\$3,967	3.2%
Hydroelectric power plant	\$5,316	\$2,999	43.6%

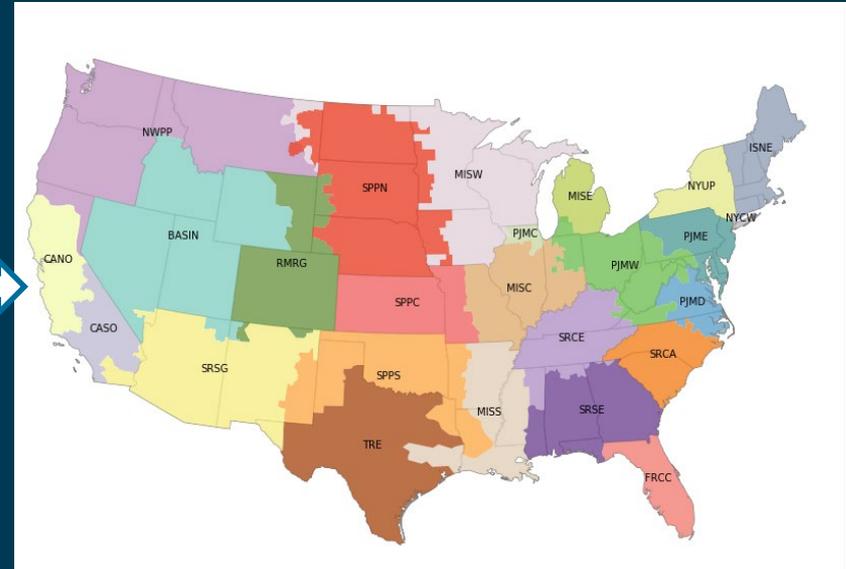
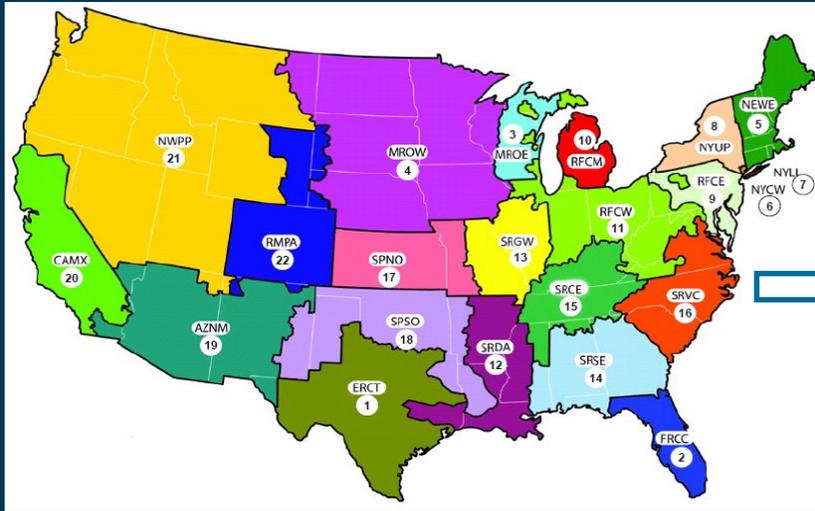
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\* Denotes new technology from previous studies

# AEO2020 Regional Mapping Redefinition

Previous Electricity Market Module (EMM) regional mapping (22 regions)

New Electricity Markets Module (EMM) regional mapping (25 regions)



## Summary of Regional Changes

- PJM split into East/West/Dominion/ComEd
- Expanded MISO split into four pricing zones
- Expanded SPP split into three zones
- SERC reduced to three regions

- CA split into North/South regions
- WECC split into six regions
- Unchanged: ISO-NE, FL, TX

# AEO2020 Electricity/Nuclear Updates

# AEO2020 Legislative/Regulatory Updates

- Affordable Clean Energy (ACE) Rule
- Revised New Source Performance Standard for greenhouse gases from electric generating units
- New Jersey rejoins Regional Greenhouse Gas Initiative (RGGI)
  - NJ RGGI budget: 30% reduction by 2030 from 2020 18 million tons baseline
- Section 45-Q tax treatment for carbon capture and storage CCS
- State support for financially-stressed nuclear plants
  - Ohio: subsidy for Davis-Besse/Perry nuclear units

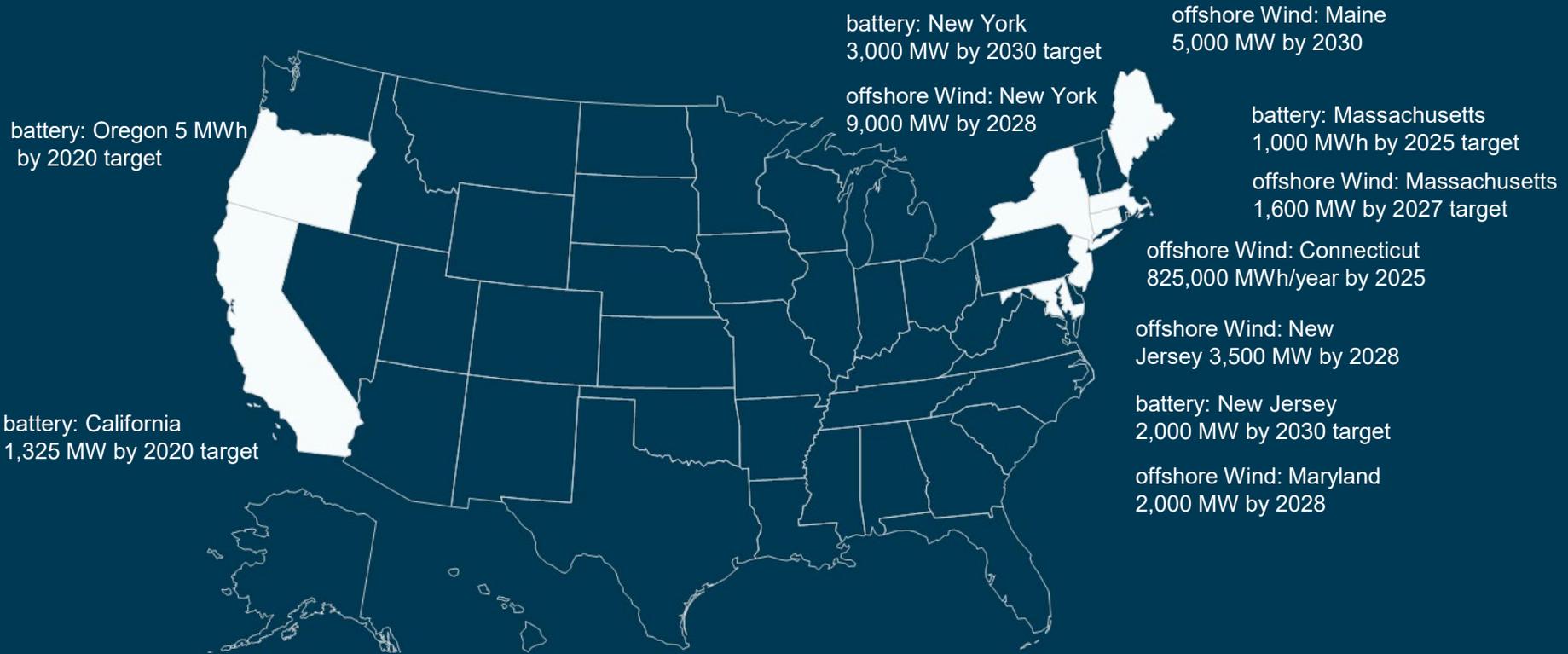
# AEO2020 Renewables Updates

# AEO2020 includes Renewable Portfolio Standard (RPS) updates to seven states and DC

State	Old policy	New policy
Washington DC	50% renewables by 2032	100% renewables by 2032
New Mexico	20% renewables by 2020	100% carbon-free by 2045
Washington	15% renewables by 2024	100% carbon-neutral by 2045
Nevada	50% renewables by 2030	100% clean energy by 2050
Maryland	22.5% renewables by 2024	50% renewables by 2030
New York	50% renewables by 2030	70% renewables by 2030 100% clean power by 2040
Maine	40% renewables by 2030	80% renewables by 2030 100% renewables by 2050
Ohio*	12.5% renewables by 2030	8.5% renewables by 2030

\* Denotes RPS reduction

# State level mandates for battery storage and offshore wind



# AEO2020 Coal Updates

# AEO2020 coal updates

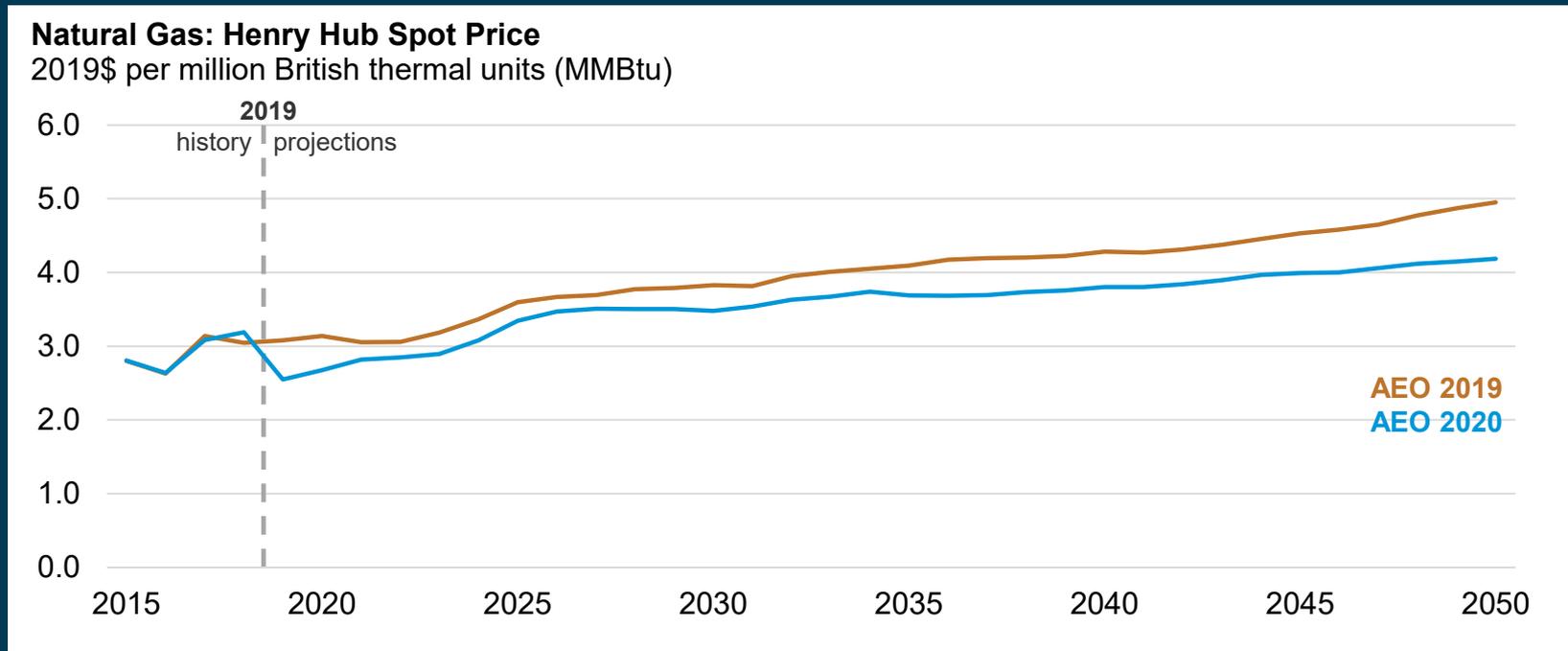
- Completed base year data updates for coal transportation rates, coal supply curve inputs, and coal contracts (still ongoing)
- Implemented revised seaborne coal freight rate methodology
- Updated U.S. coal export volume constraints for each coal export category and region

# Preliminary Results

# Summary of preliminary results

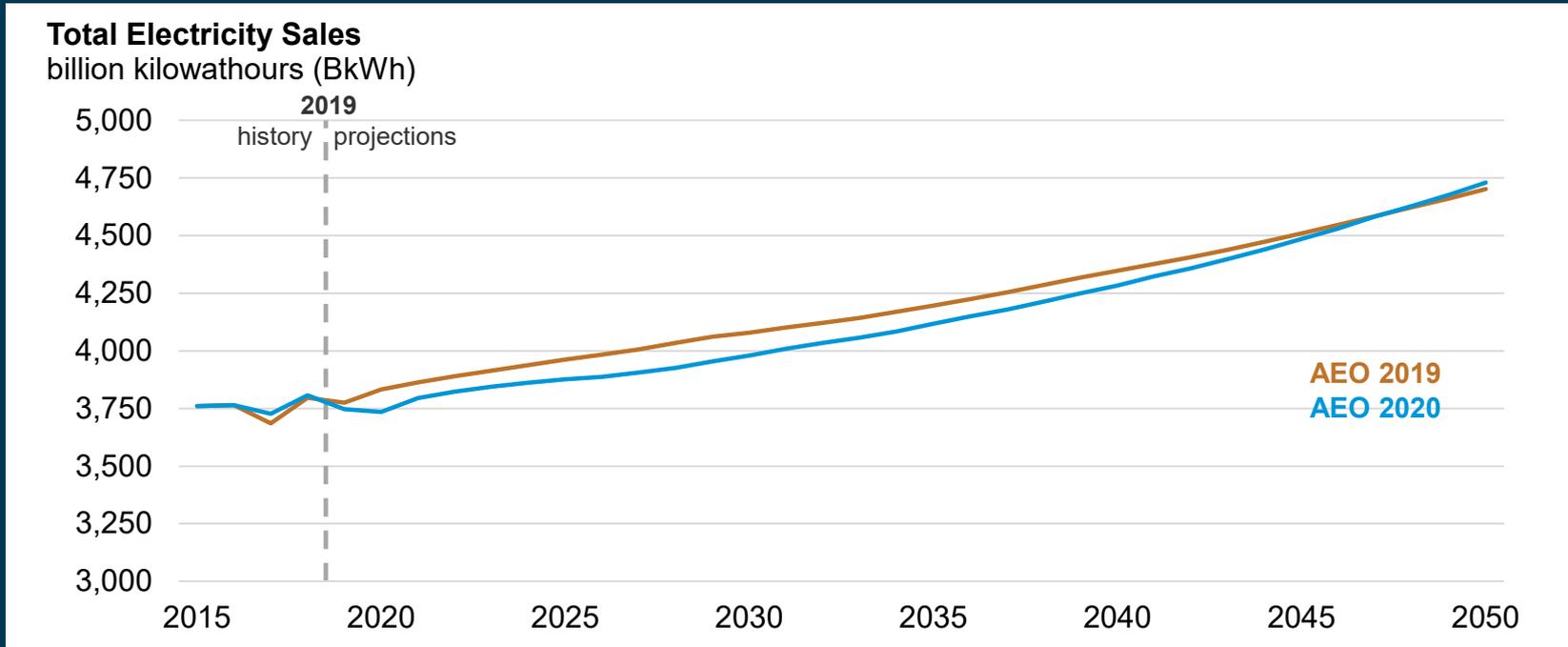
- Although we have a few model inputs and structures left to finalize, early results suggest a substantial shift across generating resources
- Lower PV and wind costs could significantly increase growth rates compared with previous AEO's. Are we adequately capturing supply curve or other market constraints?
- Coal retirements are slow and then coal-fired generation stabilizes in response to rising natural gas prices; is this consistent with current trends?
- Pace of nuclear retirements quickens as energy and capacity revenues decline. How sensitive will these plants be to economic turbulence?
- Natural gas is squeezed in the middle of growing renewables and coal stabilization. Are we really on the cusp of “peak gas”?

# Lower natural gas price path in AEO2020



Source: ref2019..111619a, ref2020.0906d

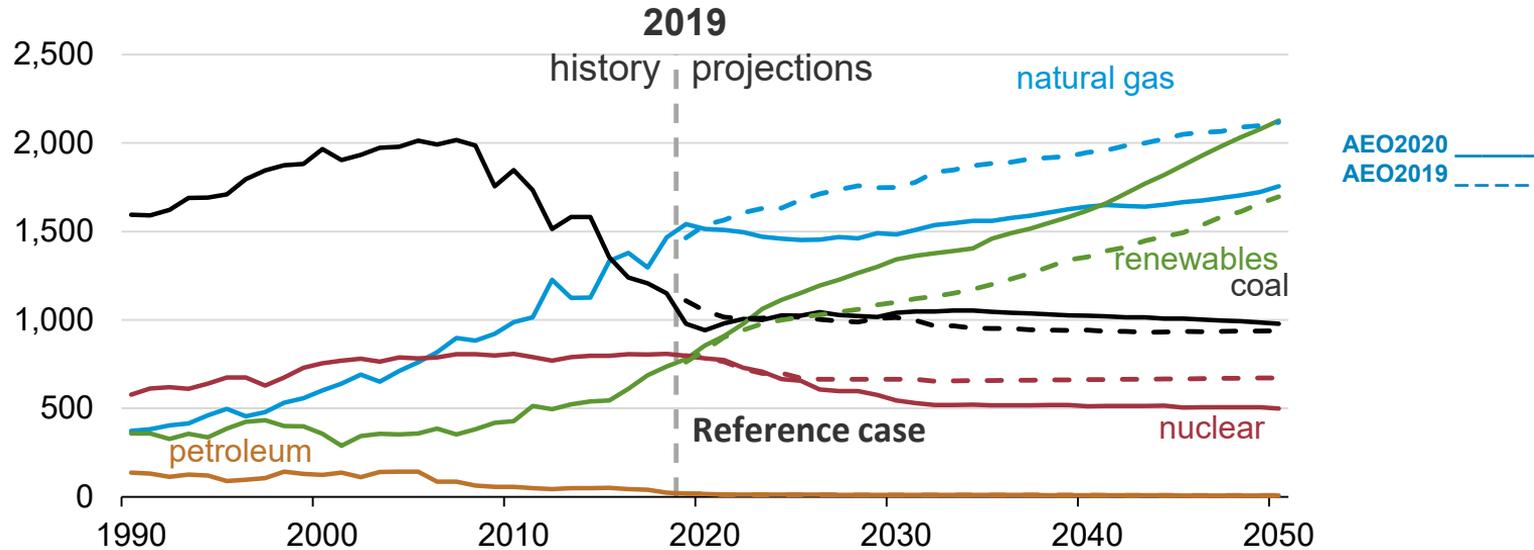
# Electricity sales change



Source: ref2019..111619a, ref2020.0906d

# Generation mix

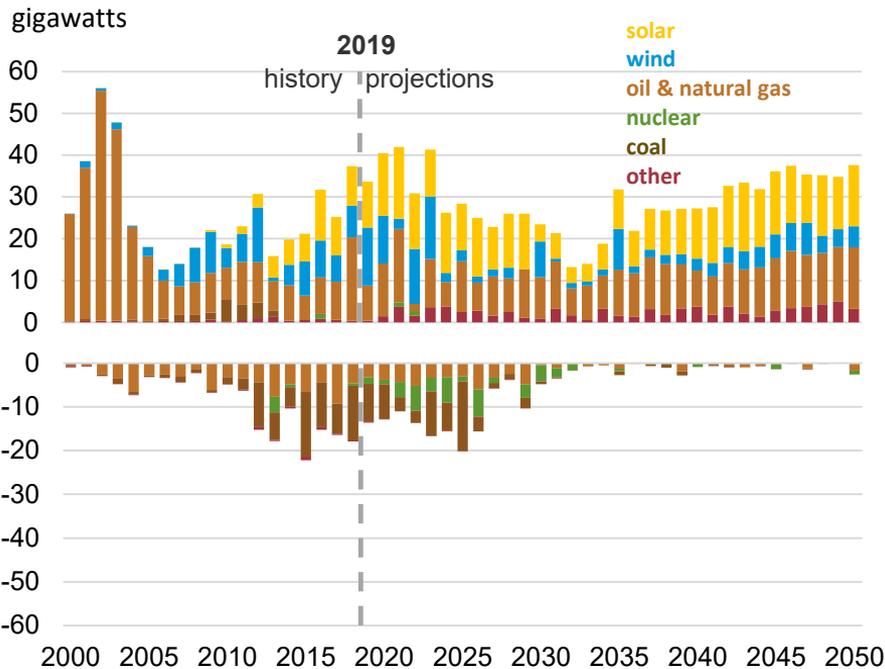
**Electricity generation from selected fuels**  
billion kilowatthours



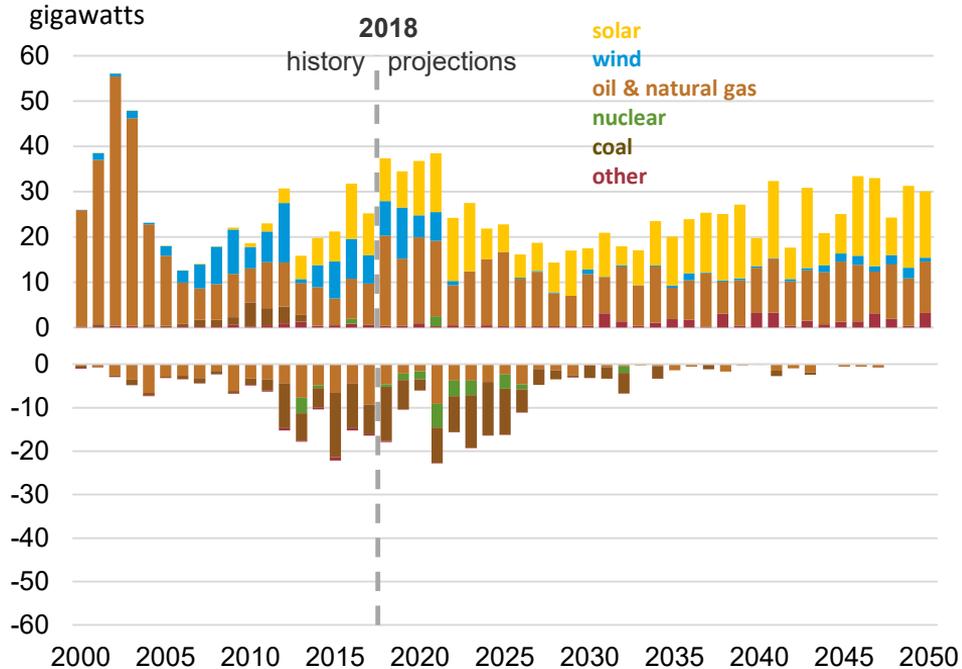
Source: ref2019..111619a, ref2020.0906d

# Capacity additions/retirements by fuel type 2000-2050

Electricity generating capacity additions/retirements AEO2020



Electricity generating capacity additions/retirements, AEO2019

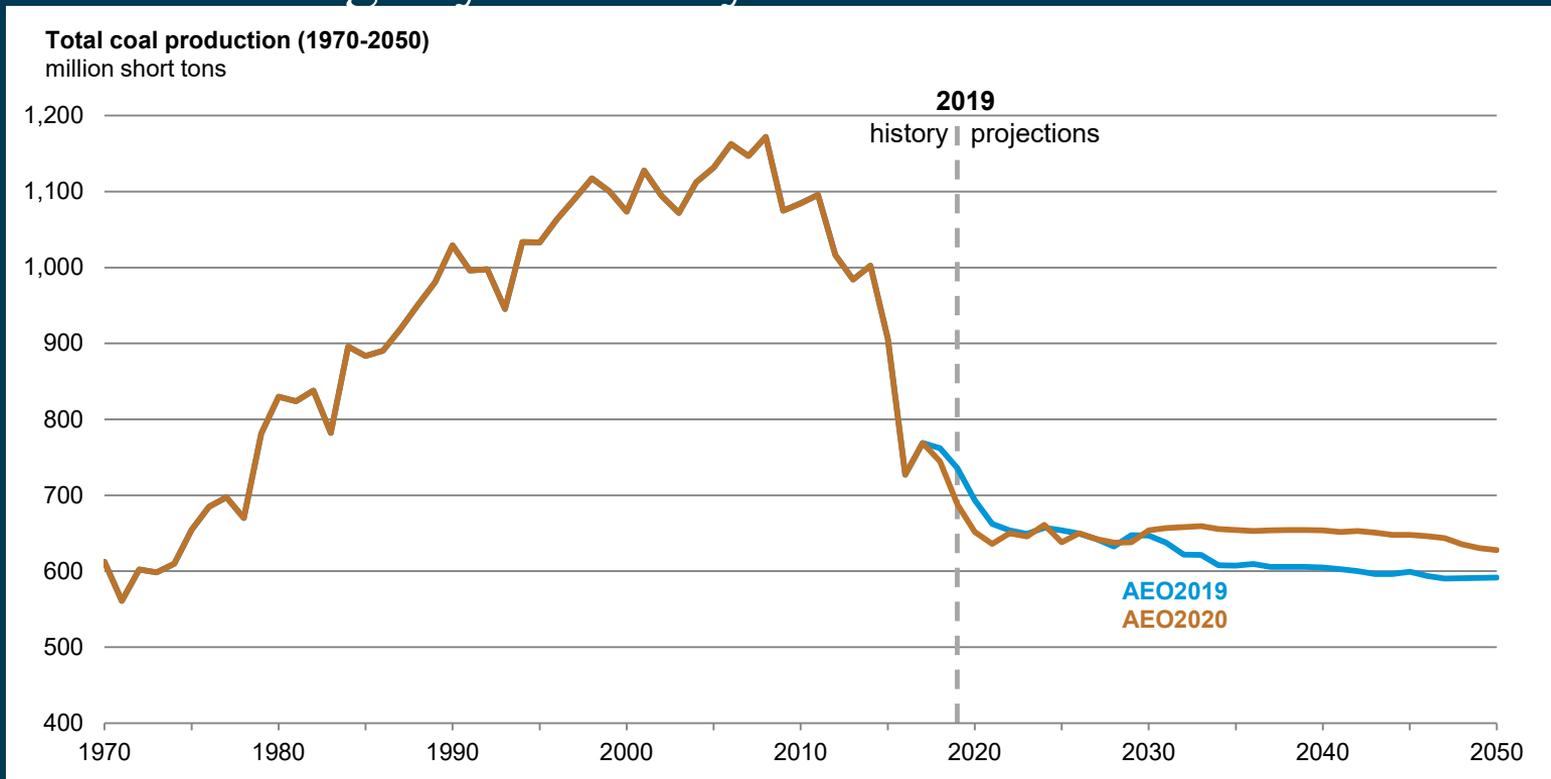


# Review of preliminary results

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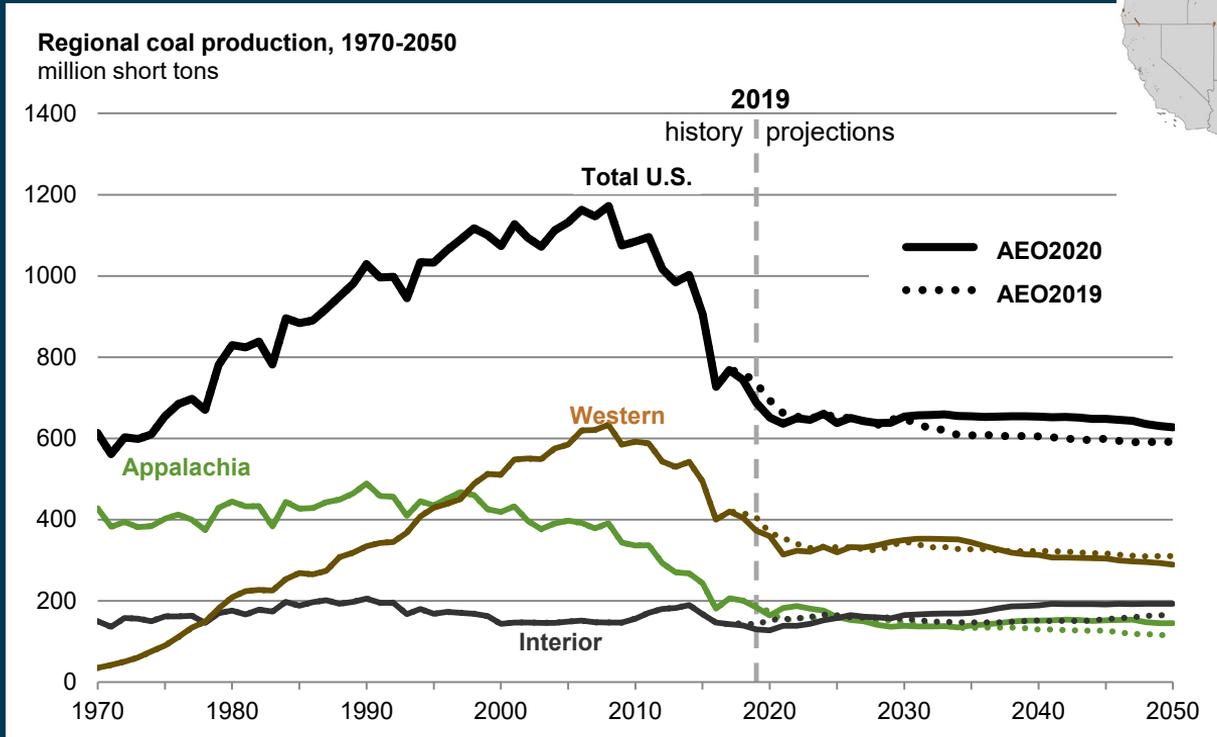
# Coal Production and Exports

# Total coal production is down slightly in the short-term, but increases slightly in later years



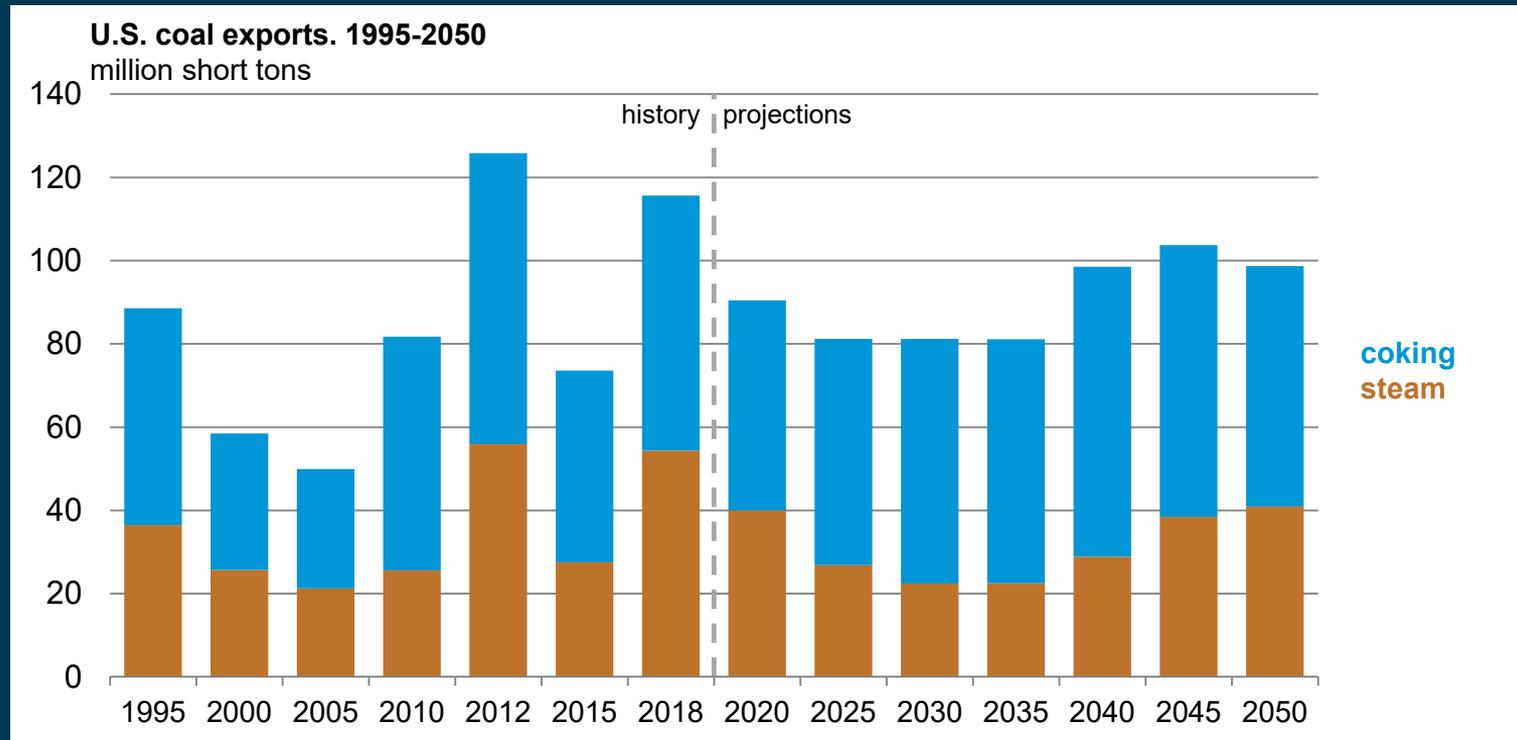
Source: ref2019..111619a, ref2020.0906d \*2018 - 2020 data are estimated per the STEO projections

# Coal production by region, 1970-2050



Source: ref2019..111619a, ref2020.0906d \*2018 - 2020 data are estimated per the STEO projections

# U.S. coal exports are expected to recover only gradually through 2050



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# Additional Areas of Consideration

# Long-term modeling considerations beyond AEO2020

- Include economic retirement options for renewable technologies
- Update to capacity factor assumptions for wind and solar, including capacity factor improvement and performance degradation
- Include a solar plus storage technology option
- Continue development of a dynamic regional structure to EMM

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U.S. Energy Information Administration home page | [www.eia.gov](http://www.eia.gov)

Annual Energy Outlook | [www.eia.gov/aeo](http://www.eia.gov/aeo)

Short-Term Energy Outlook | [www.eia.gov/steo](http://www.eia.gov/steo)

International Energy Outlook | [www.eia.gov/ieo](http://www.eia.gov/ieo)

Today in Energy | [www.eia.gov/todayinenergy](http://www.eia.gov/todayinenergy)

State Energy Profiles | [www.eia.gov/state](http://www.eia.gov/state)

# Supplemental Slides

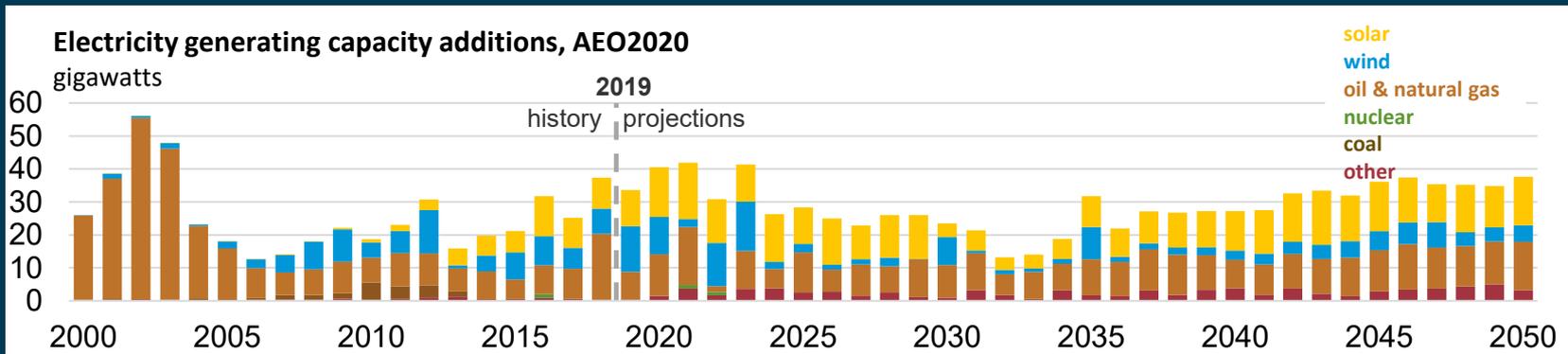
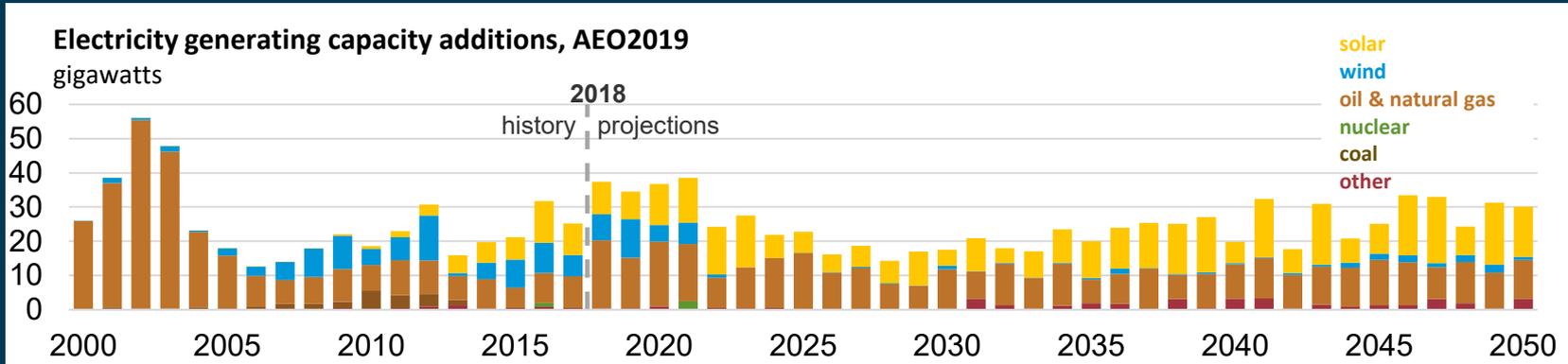
# Updated operation and maintenance (O&M) costs – fossil/nuclear in dollars per megawatthour (\$/MWh)

Technology	AEO2019 fixed O&M (2019\$/MWh)	AEO2020 fixed O&M (2019\$/MWh)	% change	AEO2019 variable O&M (2019\$/MWh)	AEO2020 variable O&M (2019\$/MWh)	% change
Combined cycle 2x2x1	\$14.10	\$11.53	18.2%	\$1.87	\$3.67	-96.5%
Combined cycle 1x1x1, single shaft	\$12.20	\$10.49	14.1%	\$2.55	\$2.10	17.8%
Combined cycle 1x1x1, single shaft, w/ 90% carbon capture	\$27.60	\$35.05	-27.0%	\$5.84	\$7.47	-27.9%
Combustion turbines – simple cycle	\$16.30	\$18.35	-12.6%	\$4.70	\$3.67	21.8%
Combustion turbines – simple cycle	\$7.00	\$7.14	-1.9%	\$4.50	\$11.40	-153.4%
Advanced nuclear (brownfield)	\$121.64	\$105.17	13.5%	\$2.37	\$2.41	-1.8%
Internal combustion engine	\$35.16	\$7.24	79.4%	\$5.69	\$6.14	-7.9%
650 MW net ultra-supercritical coal 30% carbon capture	\$54.29	\$73.42	-35.2%	\$7.08	\$7.44	-5.1%
650 MW net ultra-supercritical coal 90% carbon capture	\$59.54	-	-	\$10.97	-	-

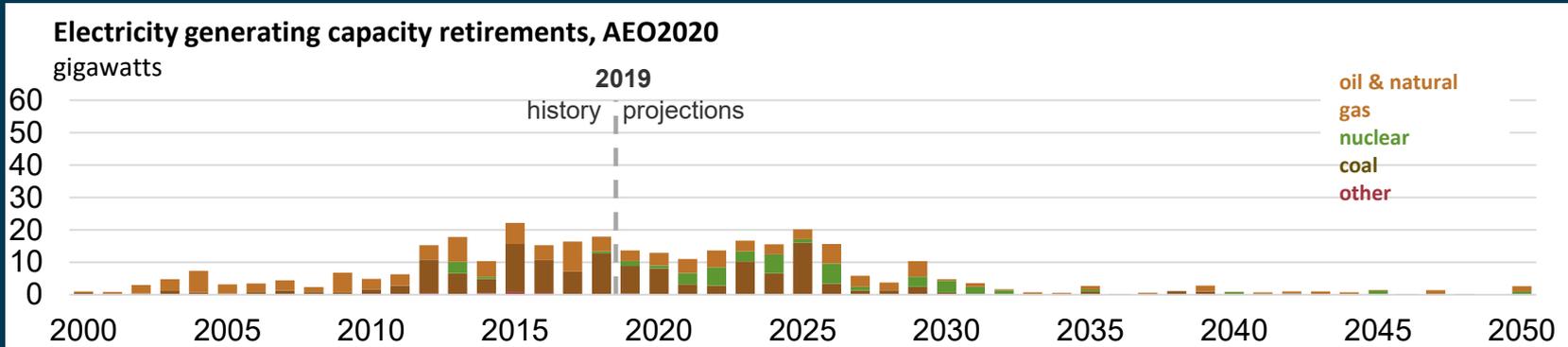
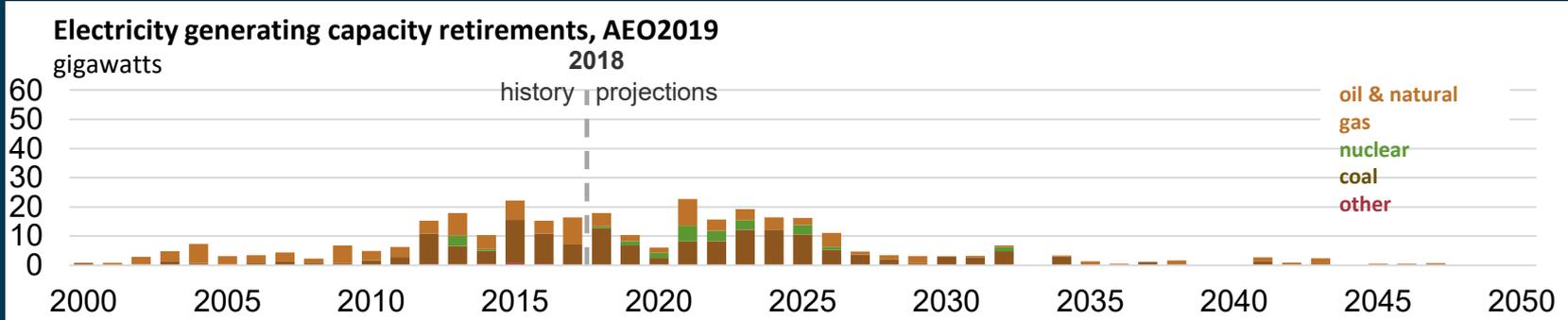
# Updated operation and maintenance (O&M) costs – renewables in dollars per megawatthour (\$/MWh)

Technology	AEO2020 Fixed O&M (2019\$/MWh)	AEO2019 Fixed O&M (2019\$/MWh)	% Change	AEO2020 Variable O&M (2019\$/MWh)	AEO2019 Variable O&M (2019\$/MWh)	% Change
Onshore wind – large plant footprint: Great Plains region	\$25.33	\$49.29	-94.6%	\$0.00	\$0.00	
Fixed-bottom offshore wind: monopile foundations	\$110.00	\$81.44	26%	\$0.00	\$0.00	
Solar PV w/single axis tracking	\$31.27	\$22.86	26.9%	\$0.00	\$0.00	
Concentrated solar power tower	\$85.39	\$74.15	13.1%	\$0.00	\$0.00	
Battery storage system	\$24.80	\$36.97	-49.1%	\$0.00	\$7.39	
50-MW biomass plant	\$125.72	\$116.45	7.4%	\$4.83	\$5.80	-20.08%
Hydroelectric power plant	\$29.86	\$41.59	-39.3%	\$0.00	\$0.00	
Geothermal	\$128.54	\$433.04	-236.9%	\$1.16	\$9.64	-731%
Fuel cell	\$30.78	\$46.56	-51.3%	\$0.59	0	

# Capacity additions by fuel type 2000-2050

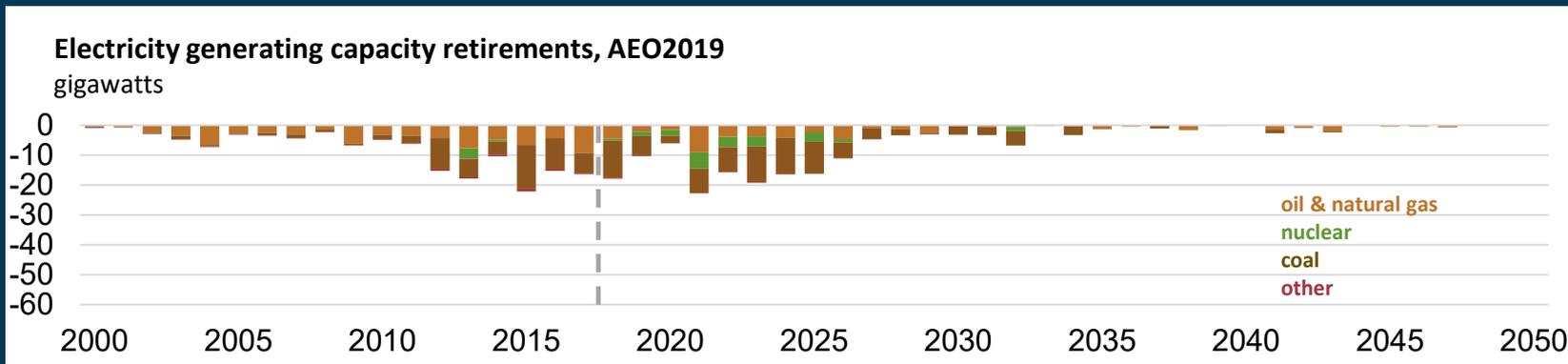
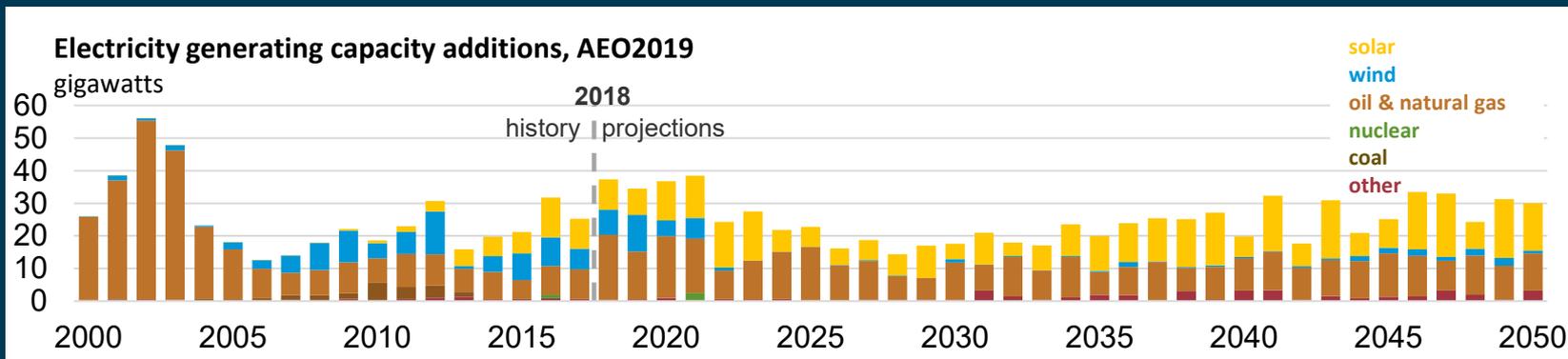


# Capacity retirements by fuel type 2000-2050



# Capacity additions/retirements by fuel type 2000-2050

## AE02019



# Capacity additions/retirements by fuel type 2000-2050

## AEO2020

