

# *Annual Energy Outlook 2023 (AEO2023)*

## *Working Group for Electricity, Coal, and Renewables Analysis: Model Development and Current Status*



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*For*

*EIA Joint Working Group for Electricity, Coal, and Renewables  
September 8, 2022*

*By*

*Office of Long-Term Modeling – Electricity, Coal, and Renewables Modeling*

# Overview of working group

- Review of *Annual Energy Outlook 2022 (AEO2022)* results
- Current efforts for *Annual Energy Outlook 2023 (AEO2023)*
- Baseline model development with respect to the Inflation Reduction Act of 2022 (IRA)
- Review of additional current laws and regulations
- Long-term modeling plans

# Review of AEO2022 results

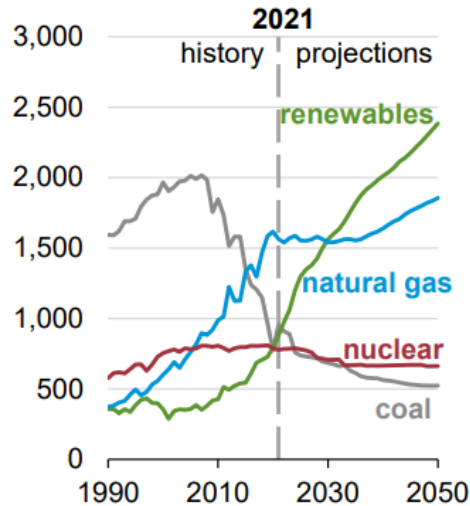


# Generation mix – AEO2022

## U.S. electricity generation, AEO2022 oil and gas supply cases

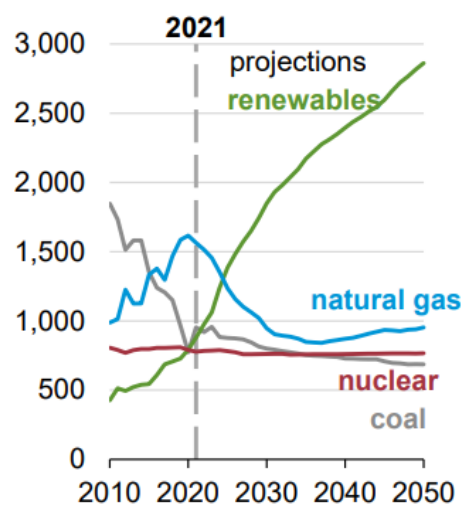
### Reference case

billion kilowatthours



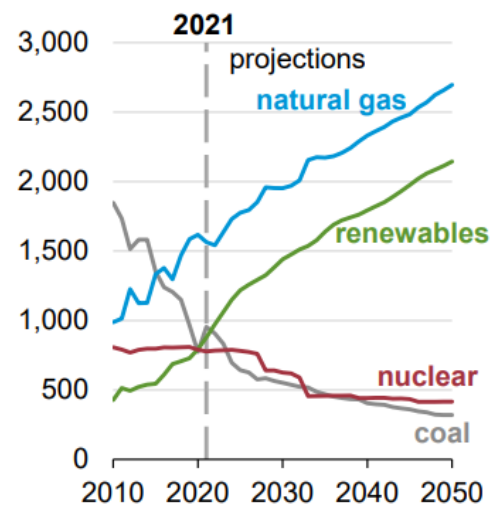
### Low Oil and Gas Supply case

billion kilowatthours



### High Oil and Gas Supply case

billion kilowatthours



Note: Renewables category includes electricity generation from wind, solar, hydroelectric, geothermal, wood, and other biomass sources.

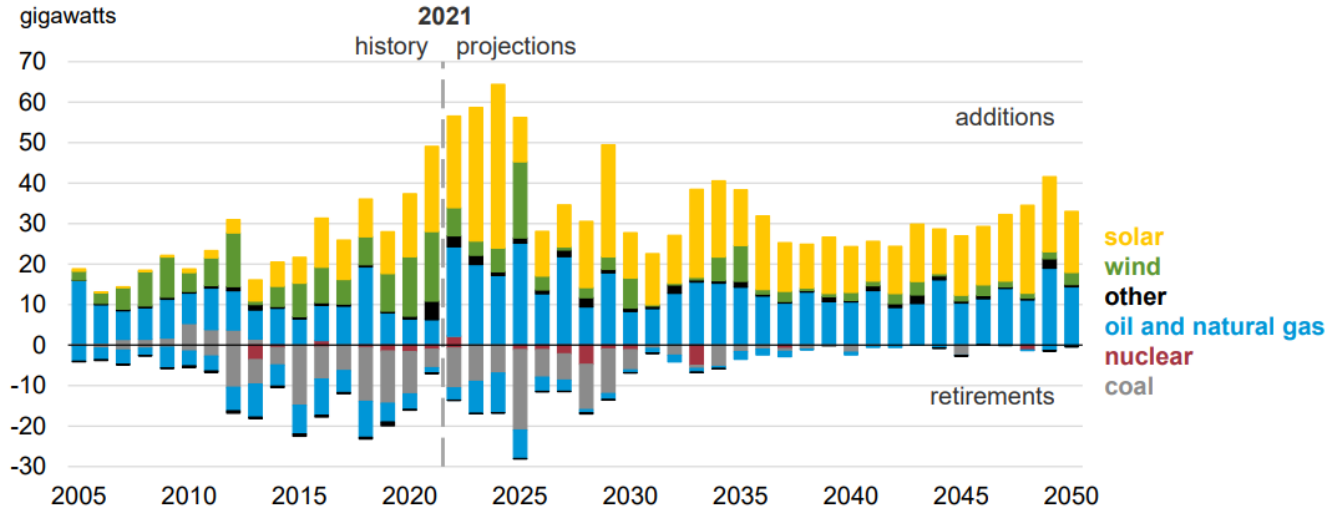
Source: U.S. Energy Information Administration, Annual Energy Outlook 2022

# Capacity additions – AEO2022



## U.S. retiring and new generating capacity

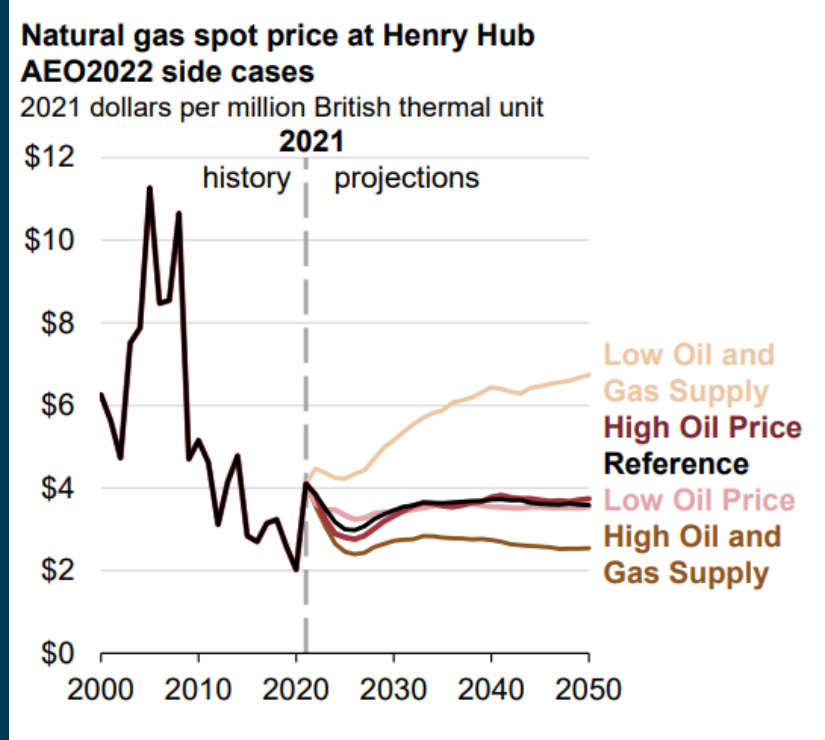
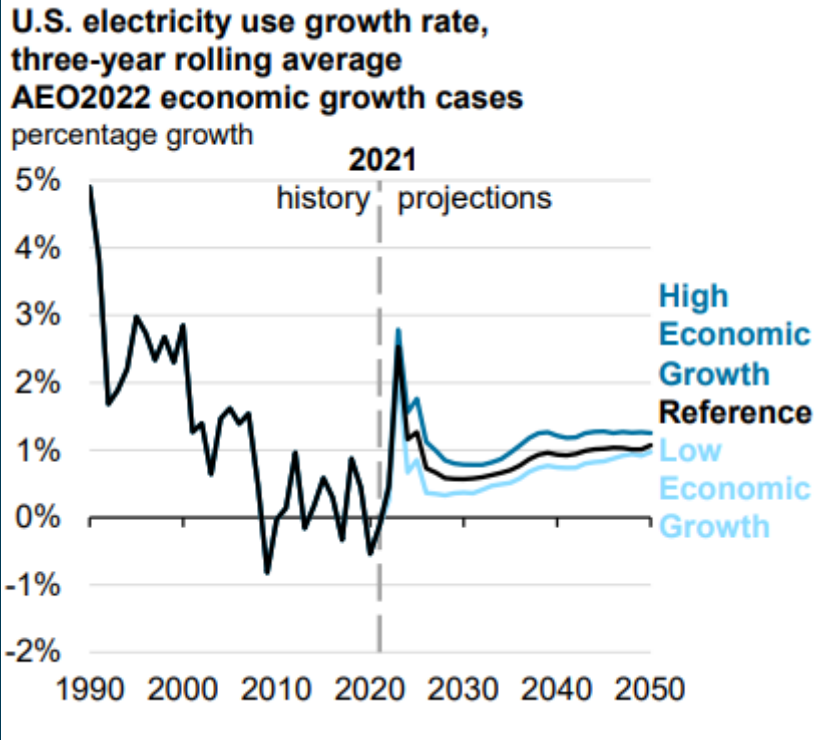
Annual electricity generating capacity additions and retirements  
AEO2022 Reference case



Source: Form EIA-860M, Monthly Update to the Annual Electric Generator Report, August 2021

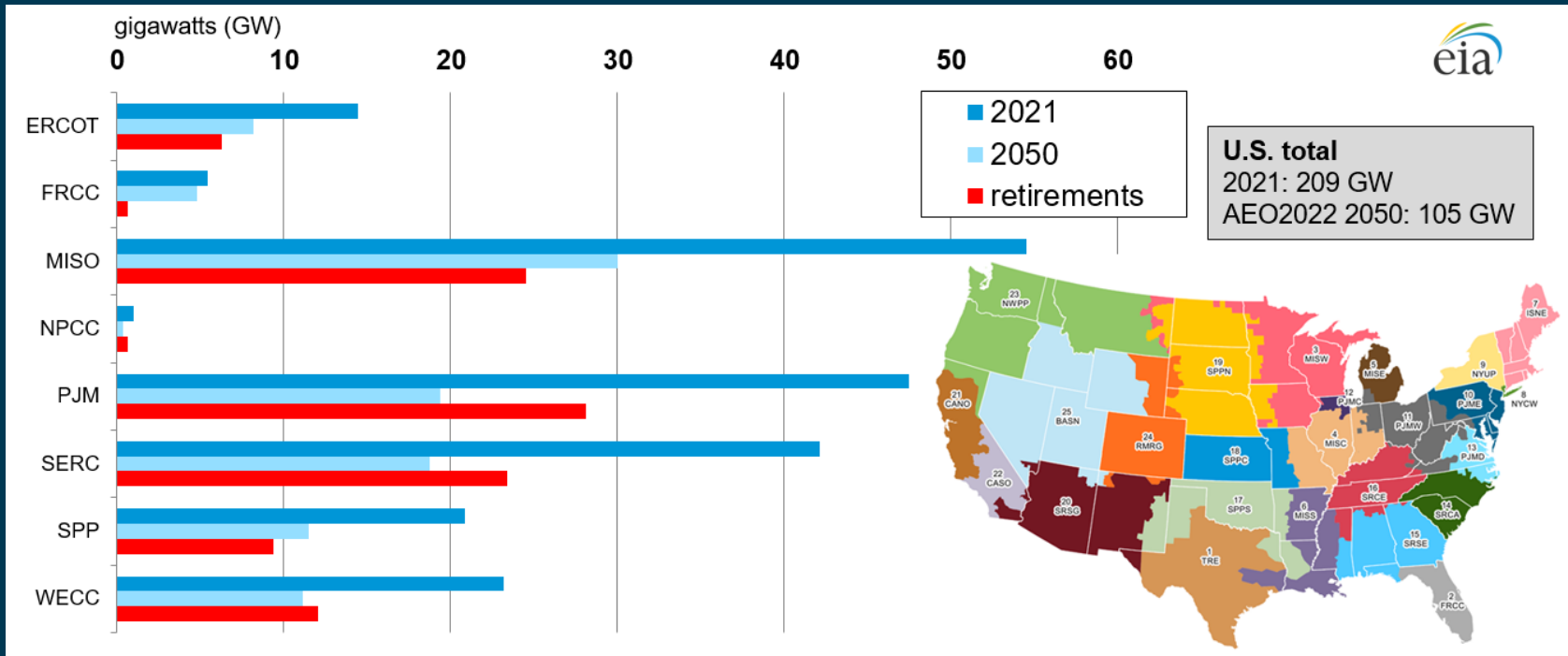
Source: U.S. Energy Information Administration, Annual Energy Outlook 2022

# Demand growth and natural gas prices – AEO2022



Source: U.S. Energy Information Administration, Annual Energy Outlook 2022

# Net summer coal-fired generating capacity in the electric power sector declines disproportionately by region in the AEO2022 Reference case

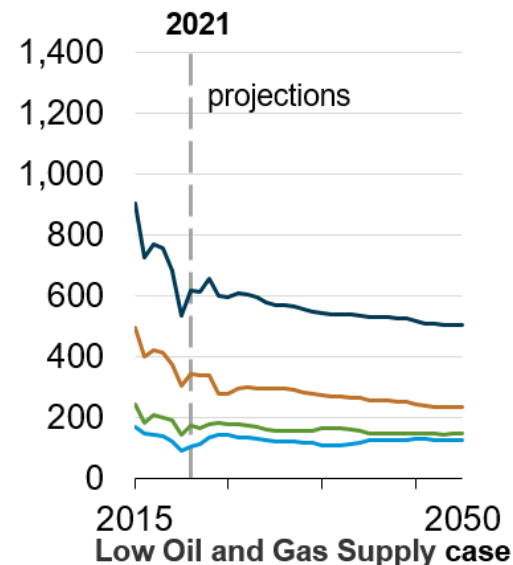
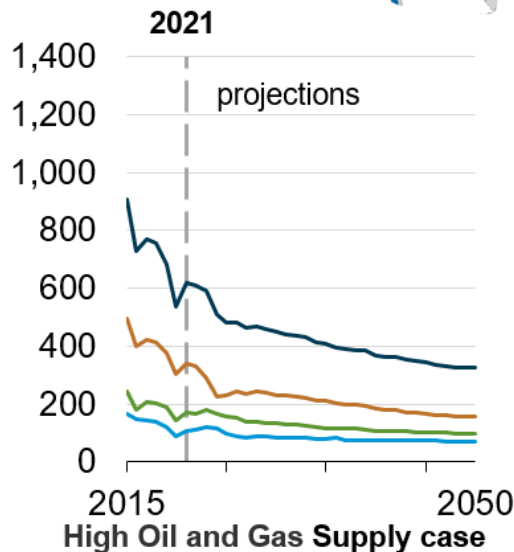
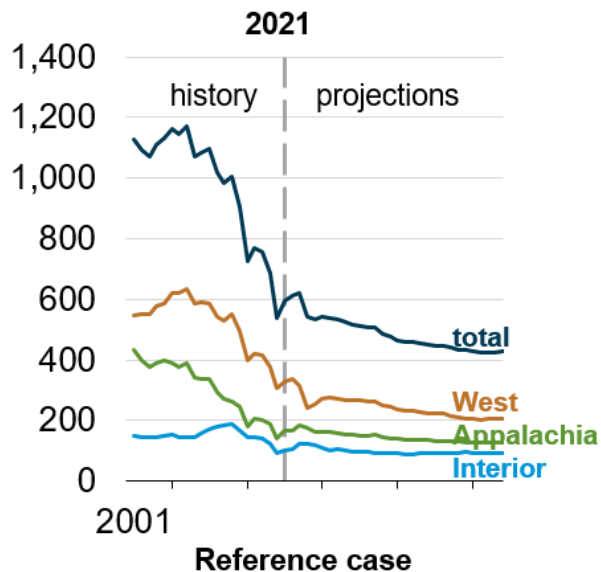


Source: U.S. Energy Information Administration, Annual Energy Outlook 2022

# Coal production decreases throughout as a result of retiring coal-fired electric generating capacity



**AEO2022 coal production by region**  
million short tons



Source: U.S. Energy Information Administration, Annual Energy Outlook 2022



# Current efforts for AEO2023



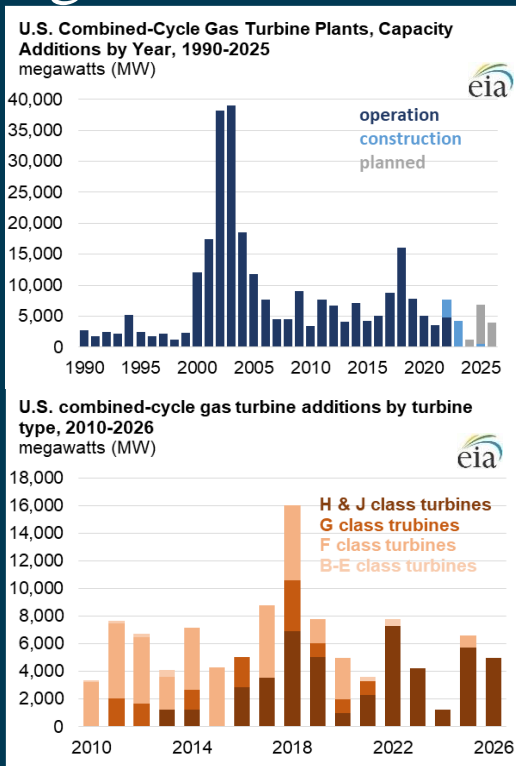
# Current model development efforts

- Cost-of-capital adder of 3% to natural gas combined-cycle
- Improvements to photovoltaic-battery (PV-battery) hybrid representation including dispatch and capacity credits
- Improvements to the market-sharing algorithm
- Adjustments to technology-learning levels

# Capital cost adder for natural gas combined-cycle

- Since AEO2009, we have added 3 percentage points to the weighted average cost of capital for coal plants with less than 90% carbon capture.
- This was intended to capture observed market behavior reflecting reluctance to finance coal plants.
- Recent evidence suggests a similar dynamic is at play in the market affecting CC and possibly CT plants.
- ECRM is extending the 3 percentage point adder to CC investments in the power sector.

# Evidence that developers are turning away from combined-cycle gas turbines

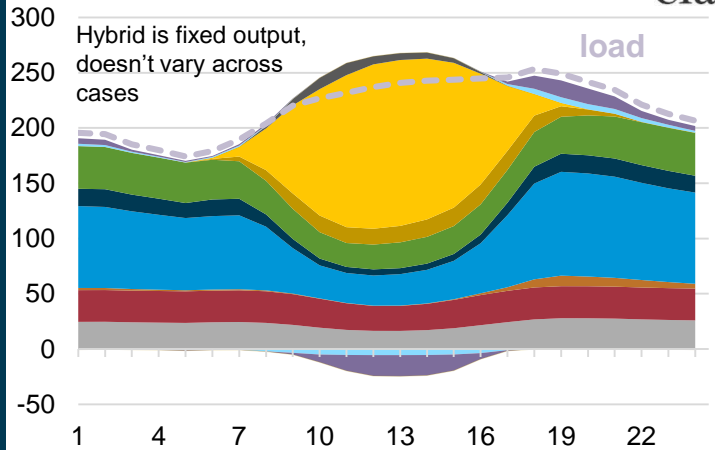


Source: EIA 860 and subject matter expert analysis

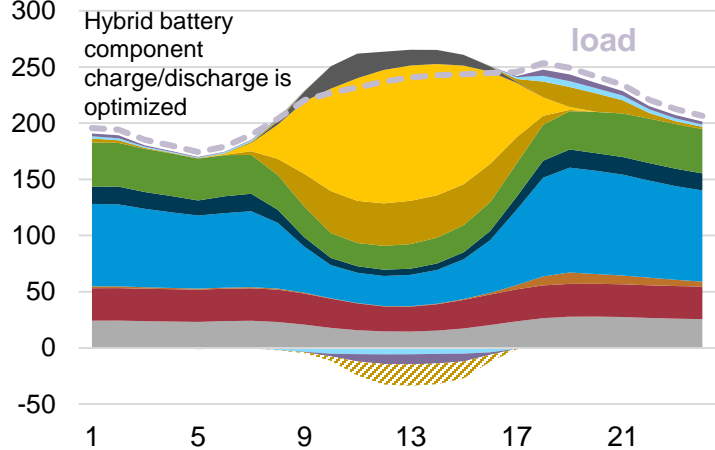
- Combined-cycle gas turbine (CCGT) generating fleet rated at close to 280,000-MW by start of 2022
- About 12,500-MW of new CCGT capacity under construction for opening in 2022 – 2024
- Another 11,600-MW of CCGT capacity in planning stages through 2026, but has not begun construction
- Number of new projects much lower after 2023, and essentially goes to zero by 2027
- About half of existing CCGT fleet is 20-years old having opened during 2000-2005 period
- Increasing number of states have zero-carbon generation targets

# Dispatchable PV-battery hybrid

Hourly U.S. electricity generation and load by fuel for reference case before dispatch PV hybrid, 2050  
Billion kilowatthours



Hourly U.S. electricity generation and load by fuel for reference case after dispatch PV hybrid, 2050  
Billion kilowatthours



- curtailment
- battery storage
- pumped storage
- solar
- solar hybrid
- wind
- hydroelectric
- natural gas combined-cycle
- natural gas and oil
- peakers
- nuclear
- coal
- solar hybrid charging (hatched)

Source: ref2023\_final\081722a

# Updates to the market-sharing algorithm

- Market sharing allows for a more nuanced representation of capacity expansion beyond the *winner-take-all* tendency of optimizing algorithms
  - Technologies that are *close* to the economically optimal solution are awarded some market share
- Although we have used this approach for many years, the old approach could allow undesirable substitutions
  - For example, allowing non-renewables to substitute for a renewable being built to satisfy an renewable portfolio standard constraint or an intermittent substituting for capacity primarily serving reliability markets
- The new approach allows us to limit technology substitution to those cases that make both policy and technical sense

# Maximum capital cost learning

- The Electricity Market Model (EMM) has long-implemented endogenous learning-by-doing to reflect the tendency of capital costs to decline with increasing market share
- We had previously limited cost declines to be 50% of initial capital cost for new technologies
- Market experience, such as cost declines in PV over the past decade, have shown this to be unnecessarily constraining
- We will remove this limit to better capture observed cost decline potential for emerging technologies

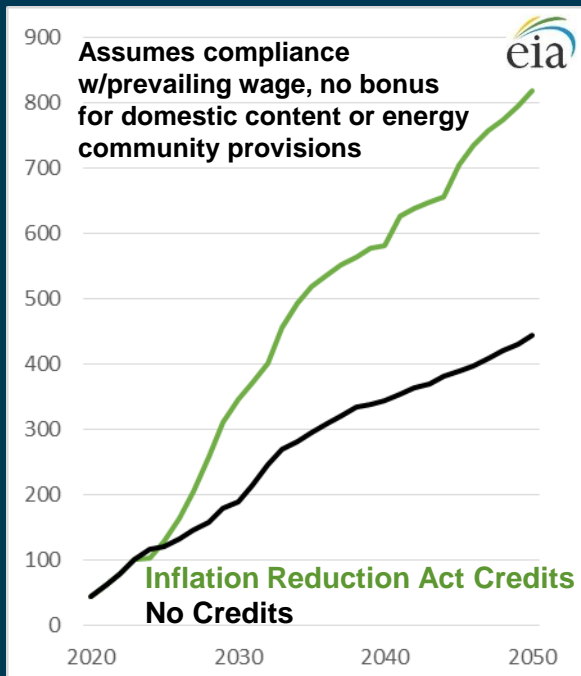
# Inflation Reduction Act of 2022

- Tax credit provisions
  - Production Tax Credit (PTC)/Investment Tax Credit (ITC) extension for all zero-emission technologies
  - ITC for standalone storage
  - PTC for existing conventional nuclear generators
  - PTC/ITC for advanced nuclear generators
  - Carbon capture and sequestration (CCS) tax credit
  - Investigating prevailing wage and domestic manufacturing credit
- Credit for advanced manufacturing as it relates to capital cost impacts
- Credit extension beyond 2032
- Possible side cases

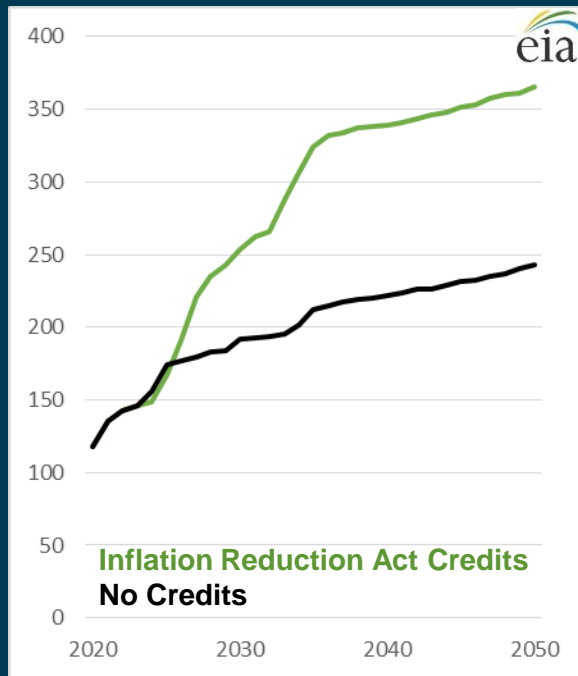


# Preliminary IRA impacts – renewables (incomplete model specification)

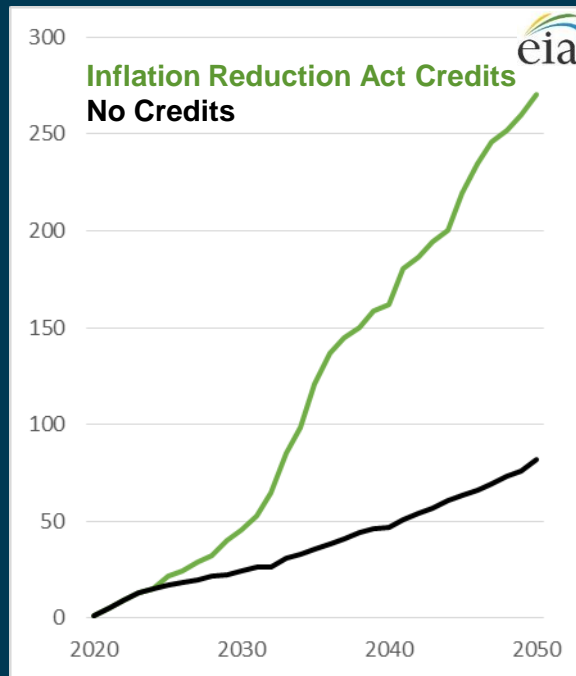
Solar capacity  
gigawatts (GW)



Wind capacity  
gigawatts (GW)



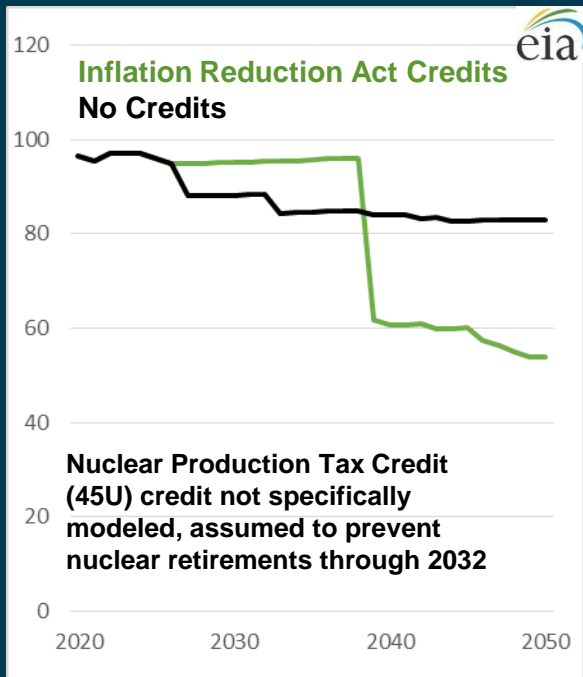
Storage capacity  
gigawatts (GW)



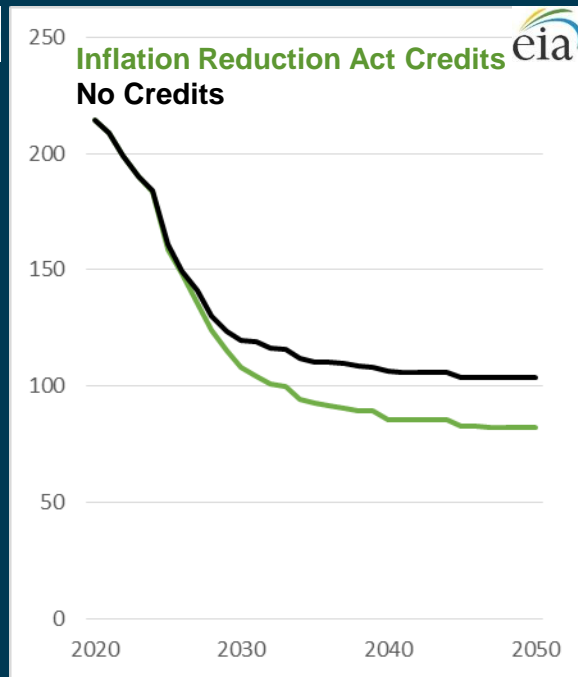
Source: Inflation Reduction Act - newcred/d082422a No Inflation Reduction Act - ef2023\d082922b

# Preliminary IRA Impacts – nuclear, coal, natural gas (incomplete model specification)

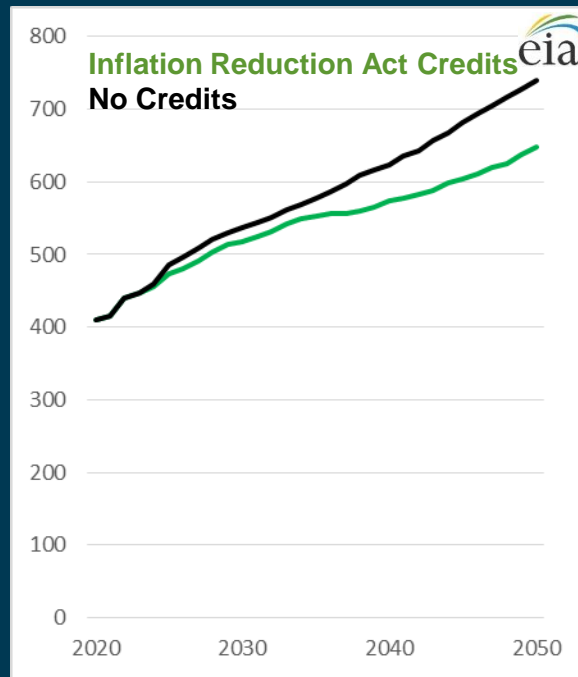
Nuclear capacity  
gigawatts (GW)



Coal capacity  
gigawatts (GW)



Natural gas capacity  
gigawatts (GW)



Source: Inflation Reduction Act - newcred/d082422a No Inflation Reduction Act - ef2023\d082922b

# Other legislative and regulation updates

- Updates to clean energy standards
  - Updated Clean Energy Standards for five states (Illinois, Maryland, North Carolina, Nebraska, Rhode Island)
  - Included executive orders for clean energy not previously included (Colorado, Connecticut, Louisiana, Massachusetts, Michigan, New Jersey, Wisconsin)
  - Moving forward we are considering a broader approach to Clean Energy Standards (CES) and carbon reduction goals
- Updates to state mandates for offshore wind and battery storage

# Long-term modeling plans

# Potential topics to address in future AEOs

- New coal regionalization
- Incorporate insight from high-resolution production-cost modeling to inform long-term modeling
- Hydrogen modeling both within the power sector and across the broader economy
- Load shape and price feedback to accommodate changes to demand

# Contact information for EIA Electricity, Coal, and Renewables Modeling Team

- Chris Namovicz, Team Leader [Chris.Namovicz@eia.gov](mailto:Chris.Namovicz@eia.gov) (202) 586-7120
- Laura Martin [Laura.Martin@eia.gov](mailto:Laura.Martin@eia.gov) (202) 586-1494
- Augustine Kwon [Augustine.Kwon@eia.gov](mailto:Augustine.Kwon@eia.gov) (202) 586-3645
- David Fritsch [David.Fritsch@eia.gov](mailto:David.Fritsch@eia.gov) (202) 287-6538
- Kien Chau [Kien.Chau@eia.gov](mailto:Kien.Chau@eia.gov) (202) 586-4280
- Manussawee Sukunta [Manussawee.Sukunta@eia.gov](mailto:Manussawee.Sukunta@eia.gov) (202) 586-0279
- Richard Bowers [Richard.Bowers@eia.gov](mailto:Richard.Bowers@eia.gov) (202) 586-8586
- Vikram Linga [Vikram.Linga@eia.gov](mailto:Vikram.Linga@eia.gov) (202) 586-9224
- Kenneth Dubin [Kenneth.Dubin@eia.gov](mailto:Kenneth.Dubin@eia.gov) (202) 586-0477
- Ed Thomas [Edward.Thomas@eia.gov](mailto:Edward.Thomas@eia.gov) (202) 586-3704
- Singfoong Cheah [Singfoong.Cheah@eia.gov](mailto:Singfoong.Cheah@eia.gov) (202) 586-0465
- Nina Vincent [Nina.Vincent@eia.gov](mailto:Nina.Vincent@eia.gov) (202) 586-8501

## For more information

U.S. Energy Information Administration homepage | [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)

Monthly Energy Review | [www.eia.gov/mer](http://www.eia.gov/mer)

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

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

Coal Data Browser | [www.eia.gov/coal/data/browser](http://www.eia.gov/coal/data/browser)

U.S. Energy Mapping System | [www.eia.gov/state/maps.php?v=Coal](http://www.eia.gov/state/maps.php?v=Coal)

International Energy Portal | [www.eia.gov/beta/international/?src=home-b1](http://www.eia.gov/beta/international/?src=home-b1)