THE IMPACT ON GREEN ENERGY STOCK

Course: Impact of COVID-19 to financial markets

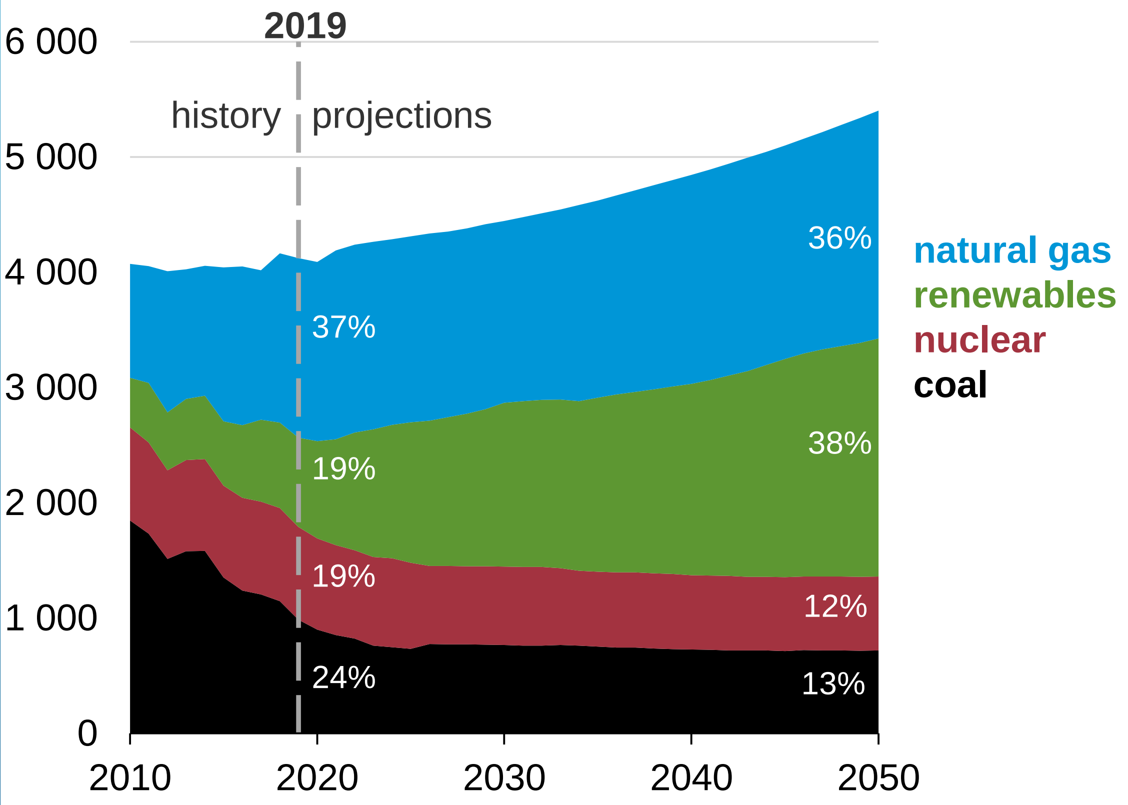
Professor Nabijon Holov

ELECTRICITY

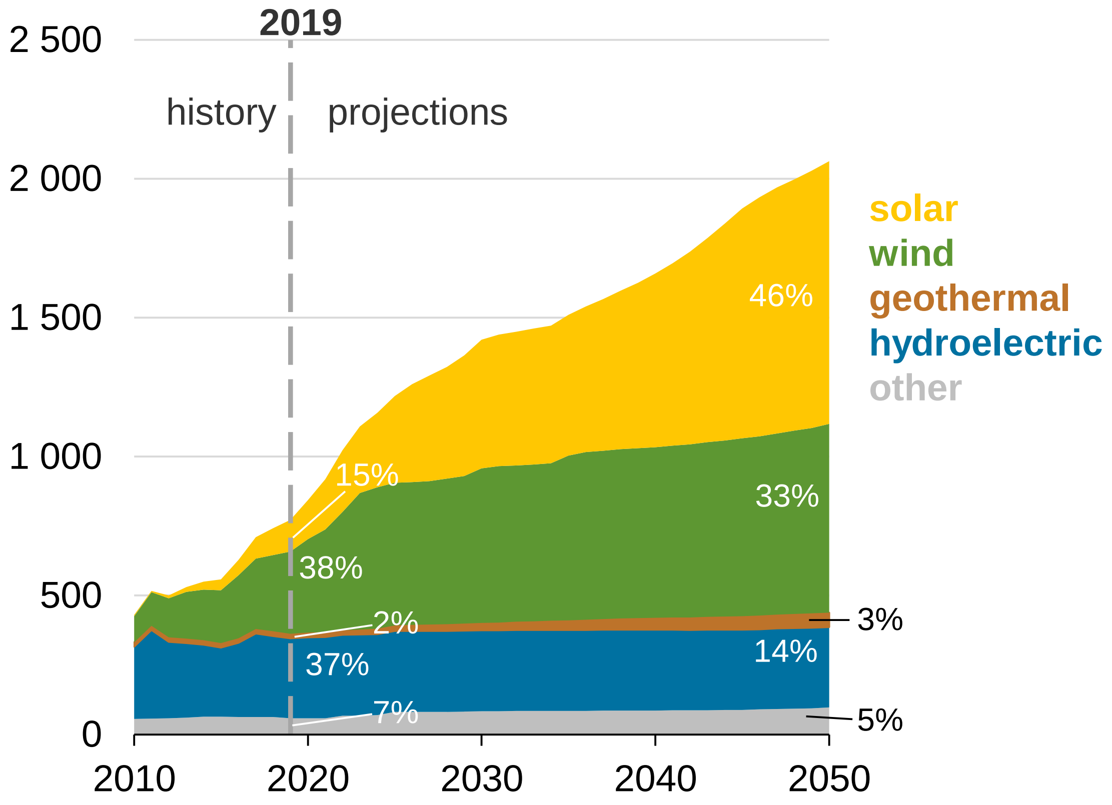
As electricity demand grows modestly, the primary drivers for new capacity in the AEO2020 Reference case are retirements of older, less-efficient fossil fuel units; the near-term availability of renewable energy tax credits; and the continued decline in the capital cost of renewables, especially solar photovoltaic. Low natural gas prices and favorable costs for renewables result in natural gas and renewables as the primary sources of new generation capacity through 2050. The future generation mix is sensitive to the price of natural gas and growth in electricity demand.

ELECTRICITY GENERATION FROM NATURAL GAS AND RENEWABLES INCREASES AS A RESULT OF LOWER NATURAL GAS PRICES AND DECLINING COSTS OF SOLAR AND WIND RENEWABLE CAPACITY, MAKING THESE FUELS INCREASINGLY COMPETITIVE

Electricity generation from selected fuels (AEO2020 Reference case)
billion kilowatthours

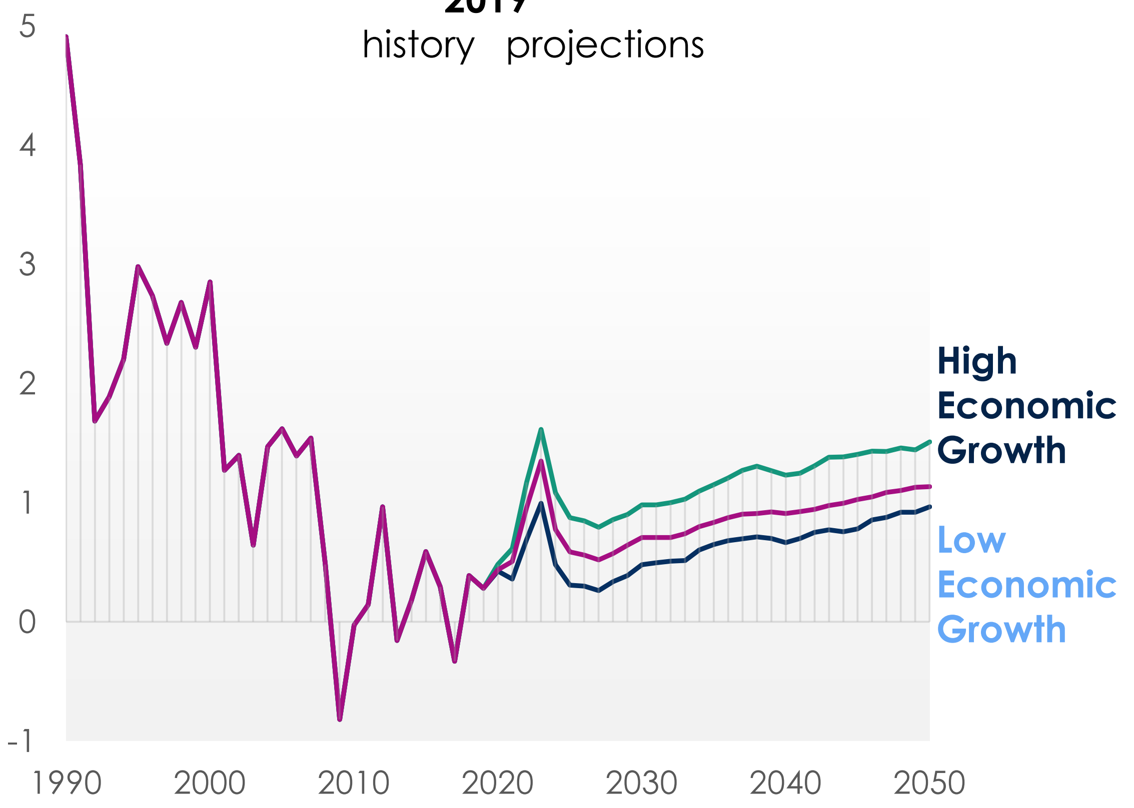


Renewable electricity generation, including end use (AEO2020 Reference case)
billion kilowatthours

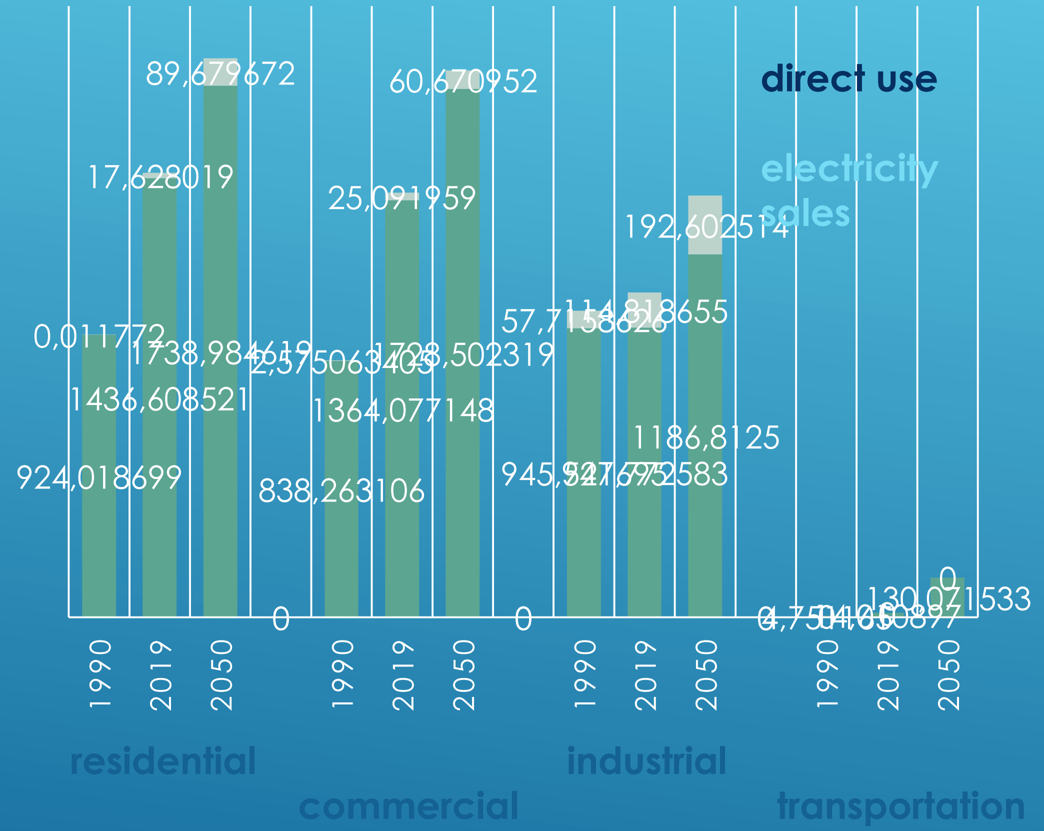


ELECTRICITY DEMAND GROWS SLOWLY THROUGH 2050 IN THE AEO2020 REFERENCE CASE—

AEO2020 Electricity use growth rate
percentage growth (three-year rolling average)



Electricity use by end-use sector (AEO2020 Reference case)
billion kilowatthours



—WITH INCREASES OCCURRING ACROSS ALL END-USE SECTORS

- Although near-term electricity demand may fluctuate as a result of year-to-year changes in weather, trends in long-term demand tend to be driven by economic growth offset by increases in energy efficiency. The annual growth in electricity demand averages about 1% throughout the projection period (2019-2050) in the AEO2020 Reference case.

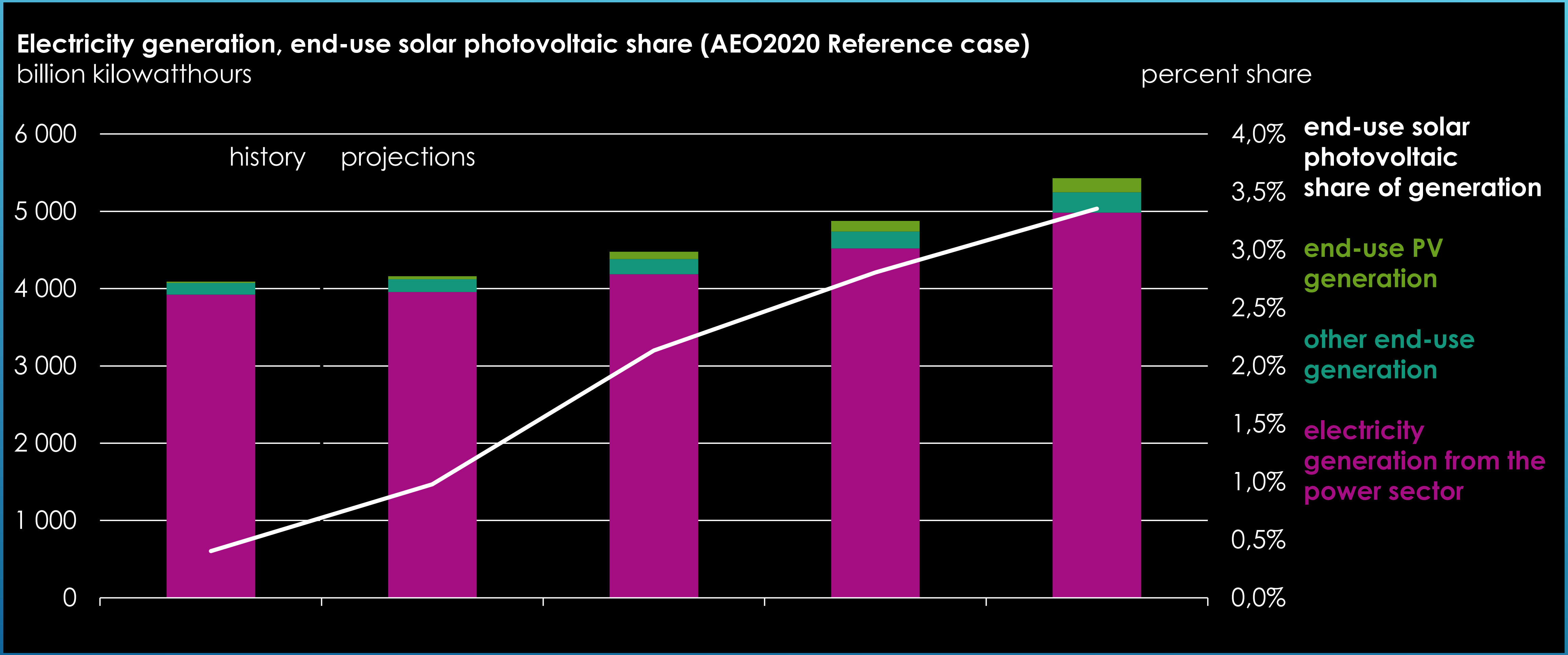
- Historically, although the economy has continued to grow, growth rates for electricity demand have slowed as new, efficient devices and production processes that require less electricity have replaced older, less-efficient appliances, heating, ventilation, cooling units, and capital equipment.

- Average electricity growth rates in the AEO2020 High Economic Growth and Low Economic Growth cases vary the most from the Reference case. Electricity use in the High Economic Growth case grows 0.3 percentage points faster on average, and electricity use in the Low Economic Growth case grows 0.2 percentage points slower.

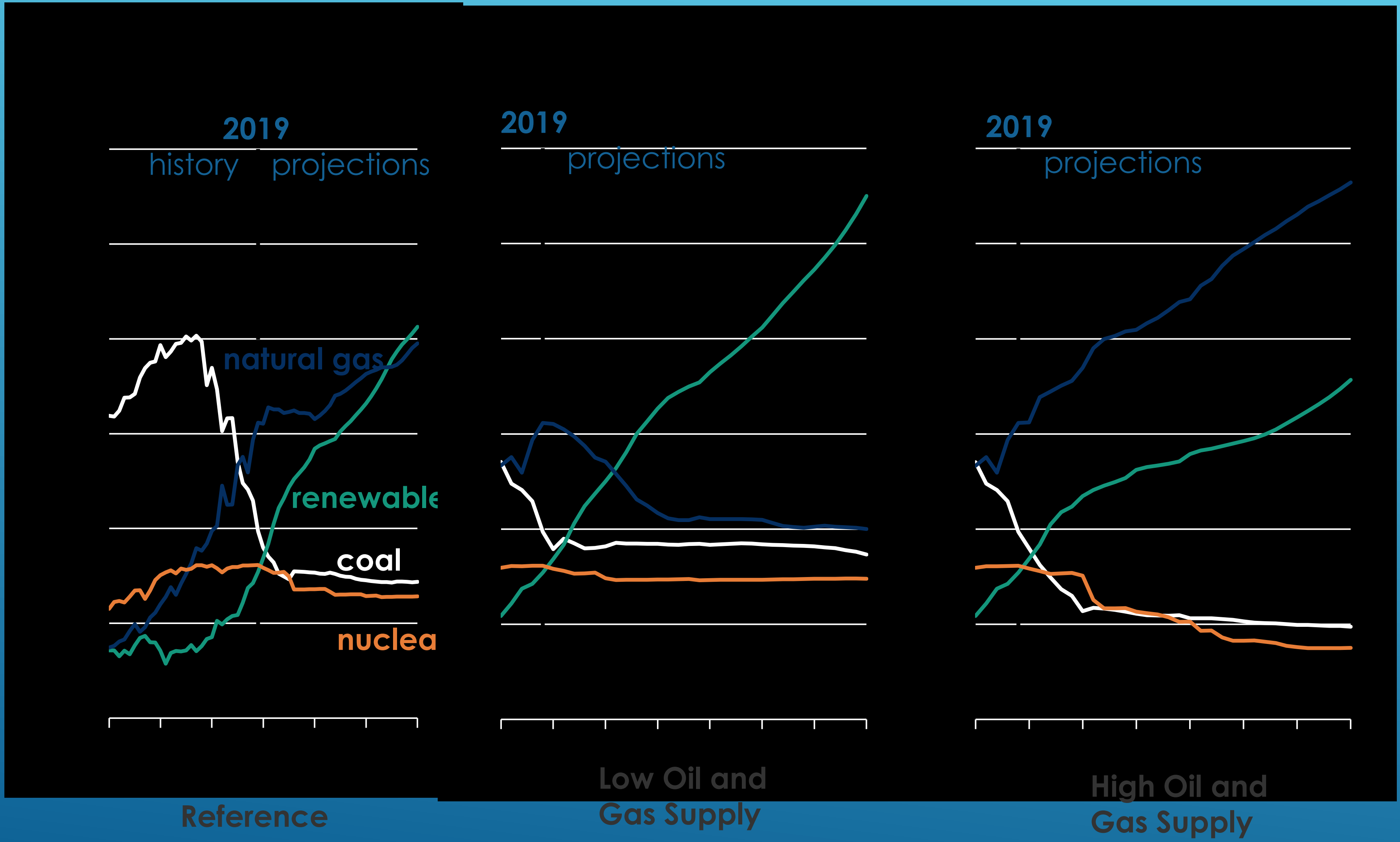
- The growth in projected electricity sales during the projection period would be higher if not for significant growth in generation from rooftop photovoltaic (PV) systems, primarily on residential and commercial buildings, and combined-heat-and-power systems in industrial and some commercial applications. By 2050, end-use solar photovoltaic accounts for 4% of U.S. generation in the AEO2020 Reference case.

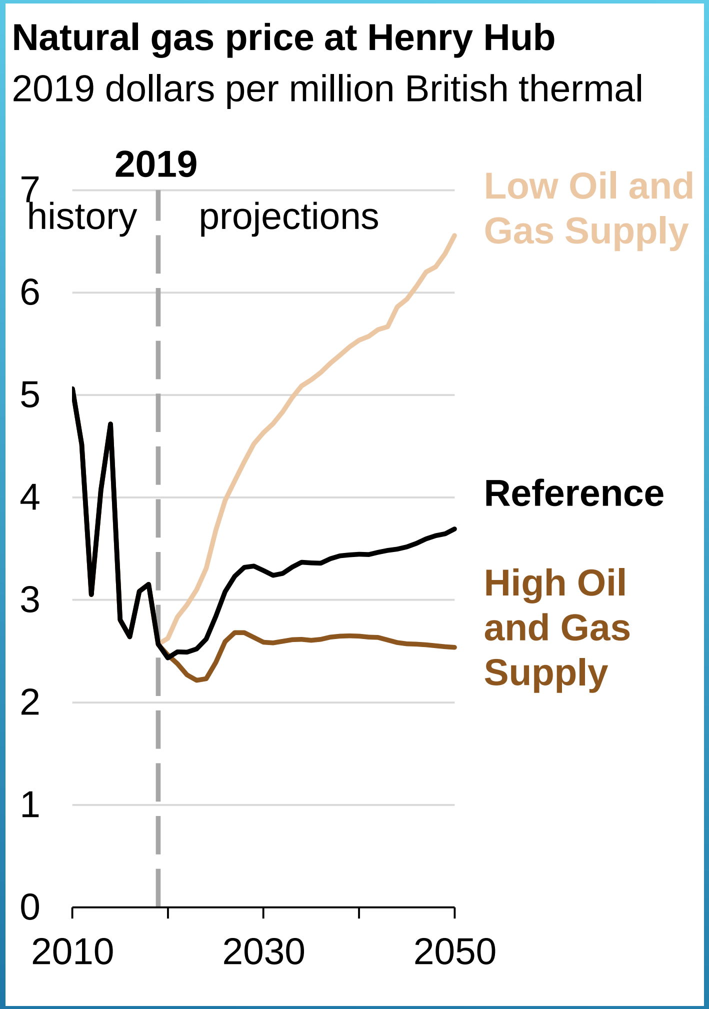
- Electric power demand from the transportation sector is a very small percentage of economy-wide demand because electric vehicles (EVs) still represent a developing market. Given the lack of market evidence to date that would indicate a significant increase in U.S. consumer preference for EVs, EIA's AEO2020 projections reflect the dependence of the EV market on regulatory policies. Both vehicle sales and utilization (miles driven) would need to increase substantially for EVs to raise electric power demand growth rates by more than a fraction of a percentage per year.

AN INCREASING SHARE OF TOTAL ELECTRICITY DEMAND IS MET WITH CUSTOMER-OWNED GENERATION, INCLUDING ROOFTOP SOLAR PHOTOVOLTAIC



DECLINING COSTS FOR NEW WIND AND SOLAR PROJECTS SUPPORT THE GROWING RENEWABLES SHARE OF THE GENERATION MIX ACROSS A WIDE RANGE OF ASSUMPTIONS—





—ALTHOUGH THE RESULTS ARE SENSITIVE TO NATURAL GAS RESOURCE AND PRICE ASSUMPTIONS

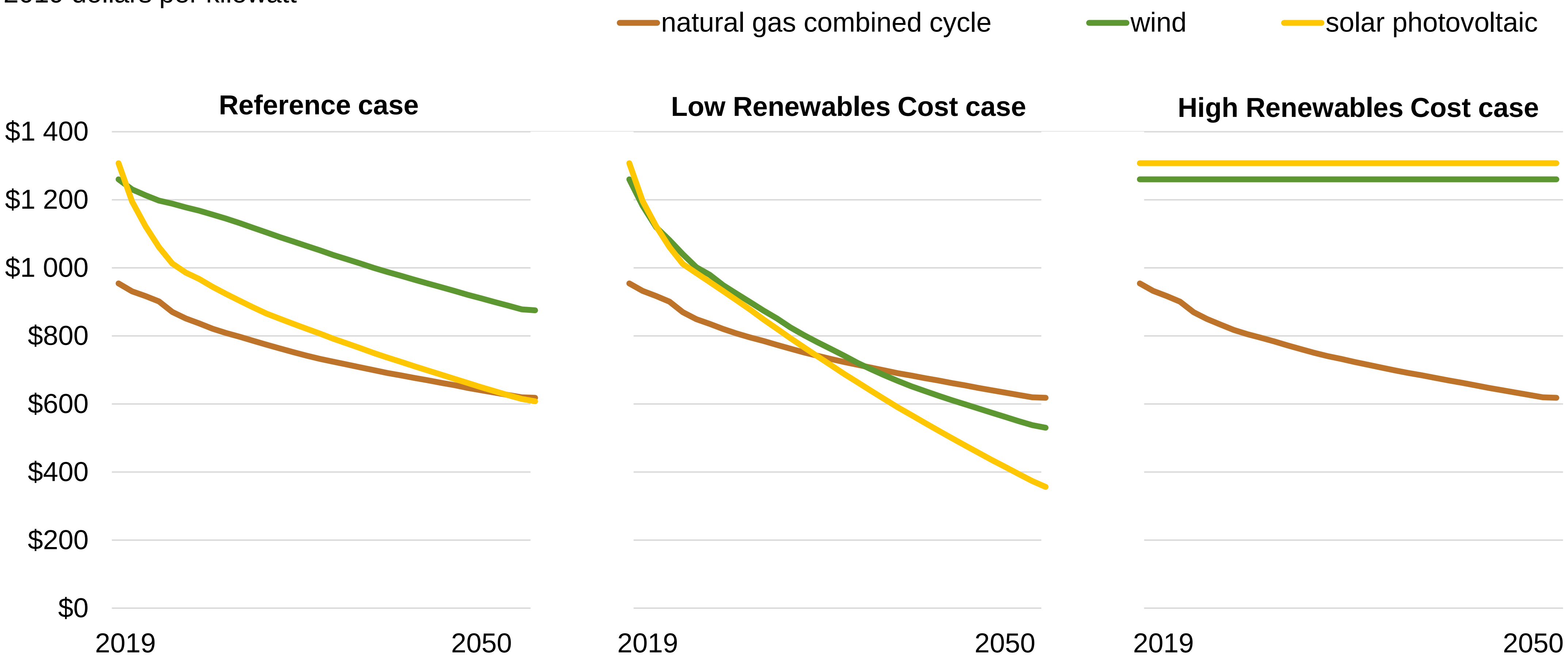
- Because of declining capital costs and higher renewable portfolio standards (RPS) targets in some states, AEO2020 projects that the relatively sharp growth in renewables seen during the past 10 years will continue through the projection period. Total renewable generation exceeds natural gas-fired generation after 2045 in the AEO2020 Reference case. Renewable generation grows faster than overall electricity demand.

- Although coal-fired and nuclear generation decline through the mid-2020's as a result of retirements, generation from these sources stabilizes over the longer term as the more economically viable plants remain in service. At projected Reference case prices, natural gas-fired generation is the marginal fuel source to fulfill incremental demand and increases in the later projection years, averaging 0.8% growth per year through 2050.

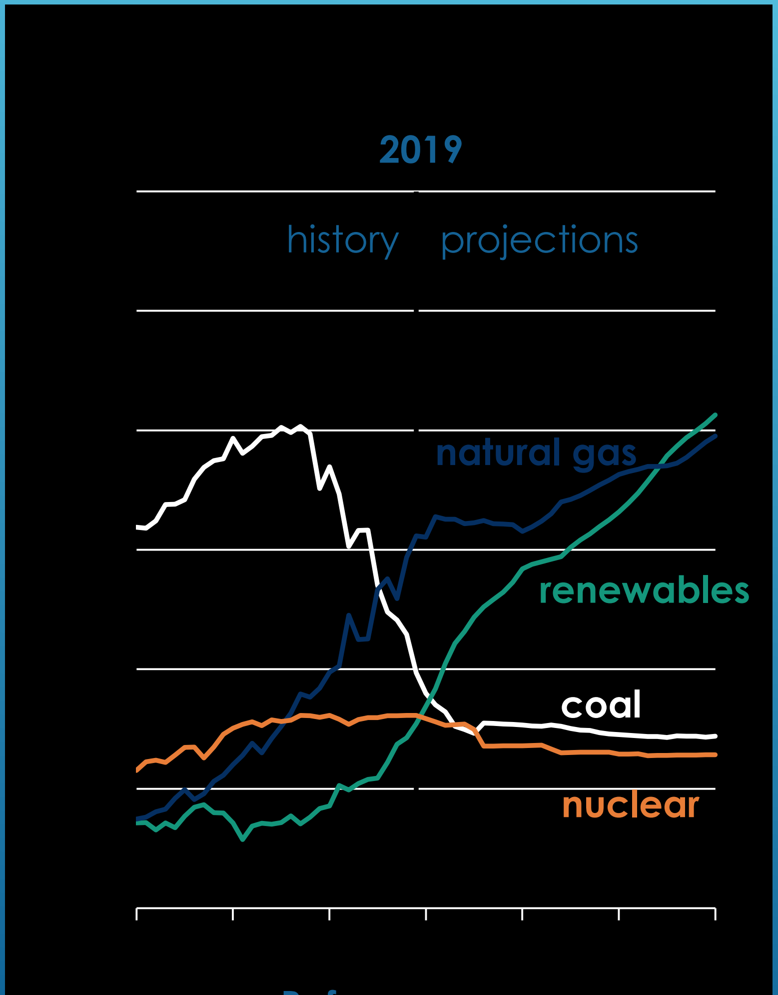
- As a result of projected lower natural gas prices in the High Oil and Gas Supply case, natural gas-fired generation increases 1.9% per year through the projection period, reaching a 51% share of the generation mix by 2050. In contrast, under the projected higher natural gas prices in the Low Oil and Gas Supply case, natural gas-fired generation declines 1.4% per year through 2050, reaching a 19% share of the generation mix by 2050.

THE HIGH RENEWABLES COST AND LOW RENEWABLES COST CASES ASSUME DIFFERENT RATES OF COST REDUCTION FOR RENEWABLE TECHNOLOGIES COMPARED WITH THE REFERENCE CASE; NON-RENEWABLES ASSUME THE SAME RATES

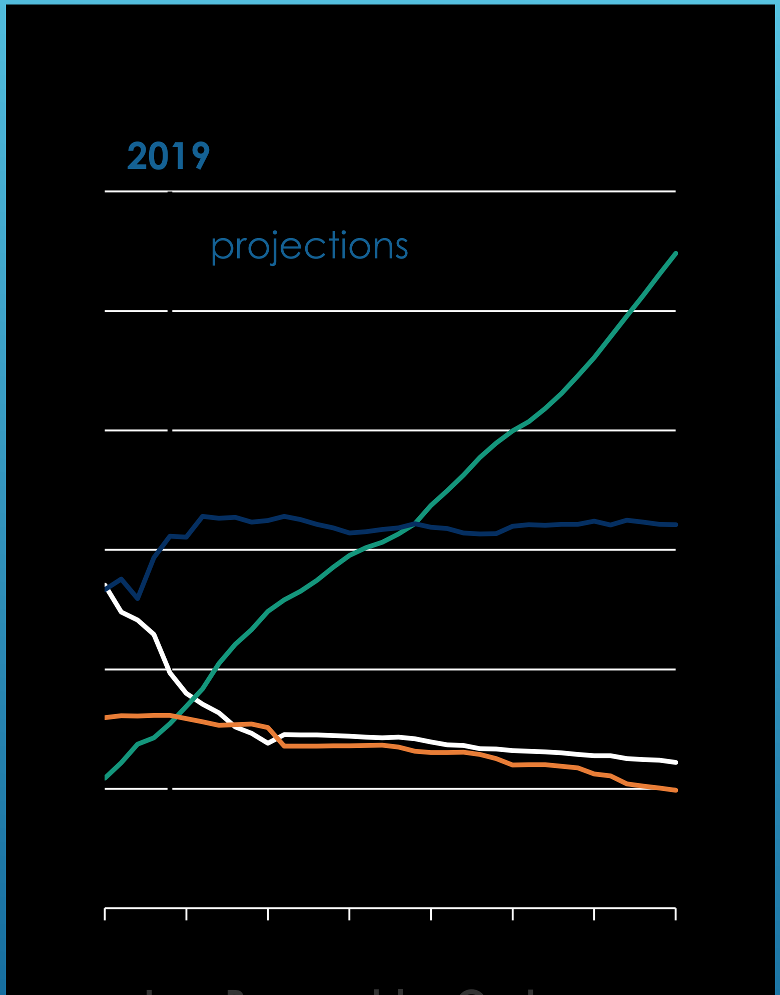
AEO2020 overnight installed cost by technology
2019 dollars per kilowatt



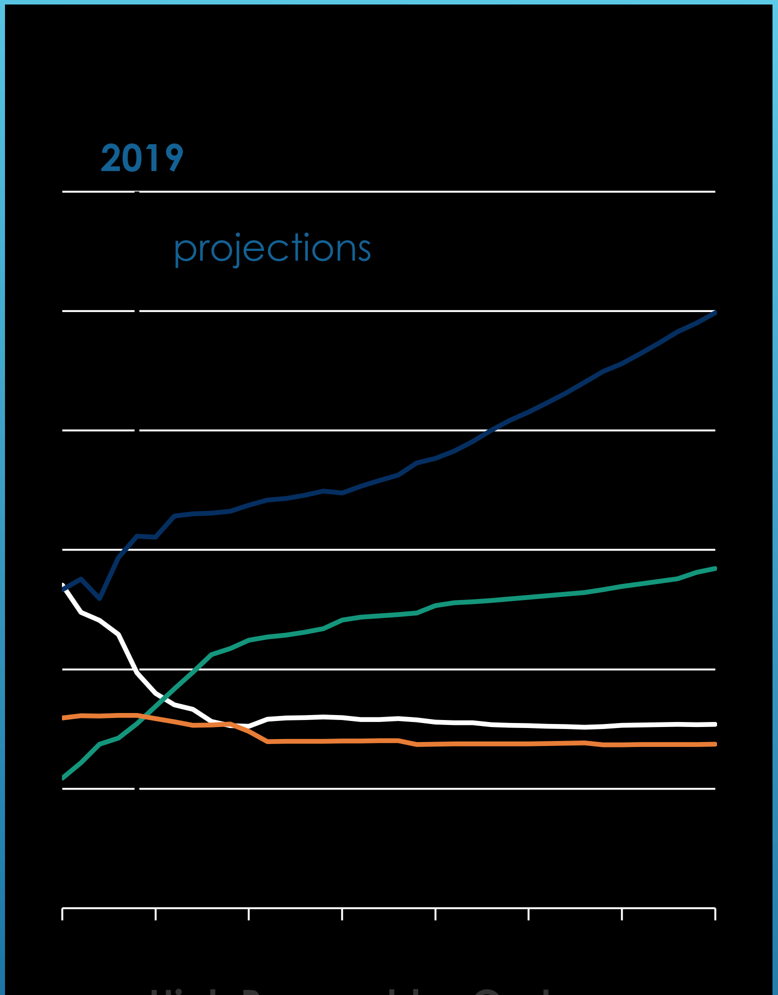
CHANGES IN COST ASSUMPTIONS FOR NEW WIND AND SOLAR PROJECTS RESULT IN SIGNIFICANTLY DIFFERENT PROJECTED FUEL MIXES FOR ELECTRICITY GENERATION



Reference case

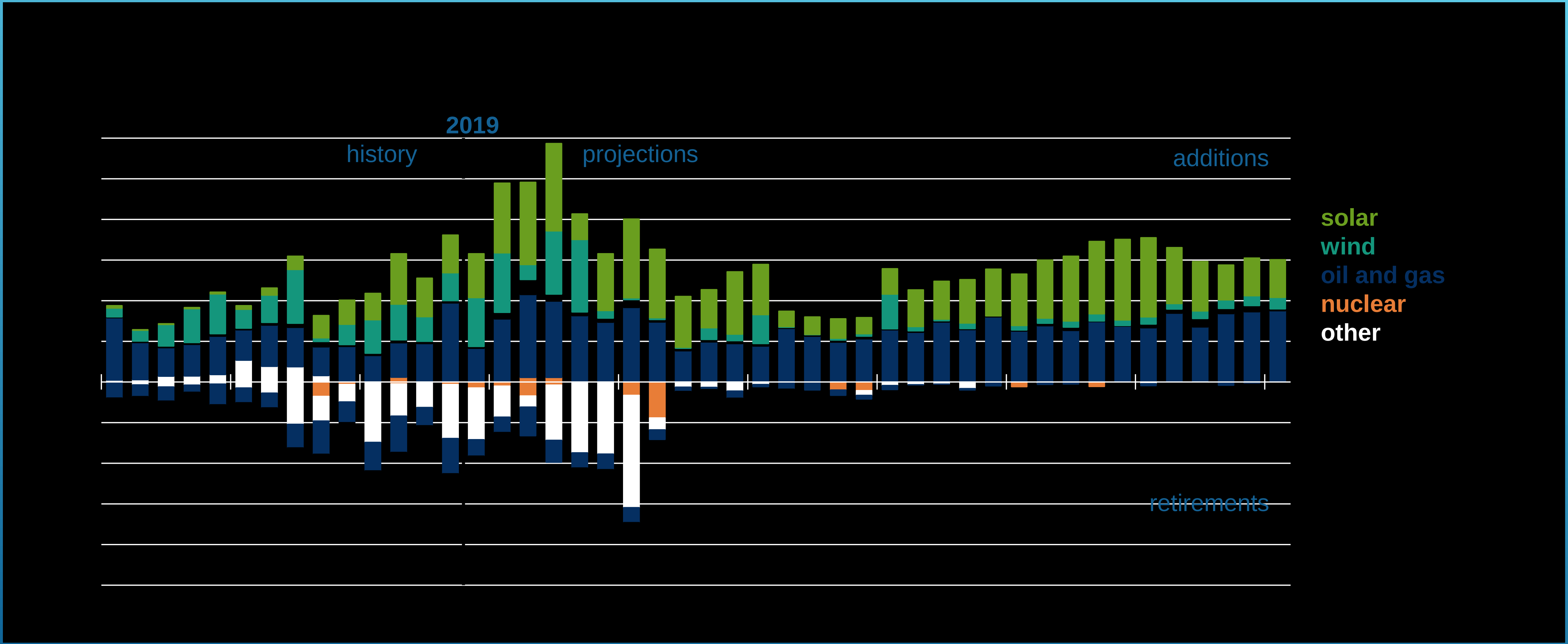


Low Renewables Cost case



High Renewables Cost case

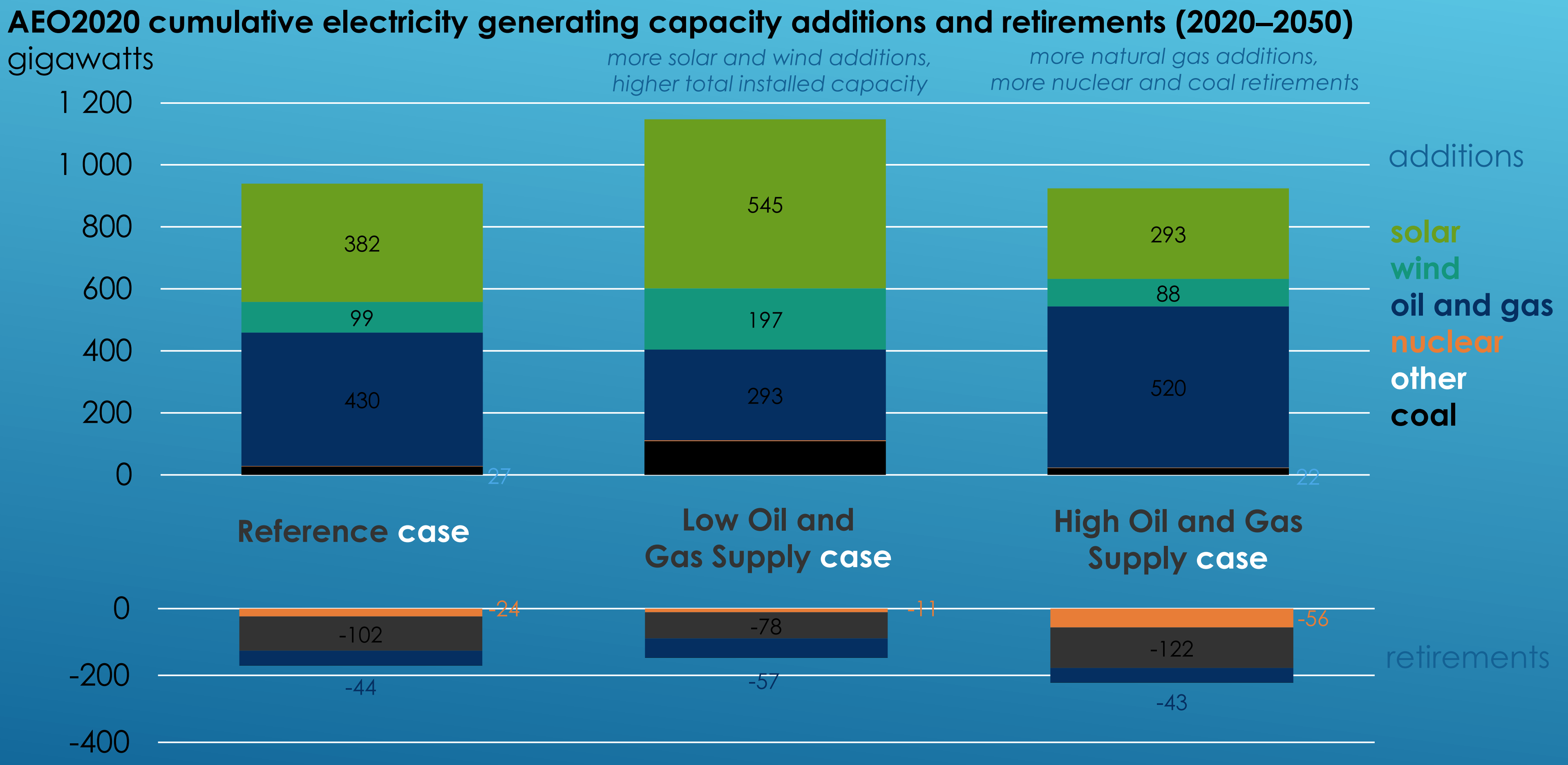
EXPECTED REQUIREMENTS FOR NEW GENERATING CAPACITY WILL BE MET BY RENEWABLES AND NATURAL GAS IN THE AEO2020 REFERENCE CASE—



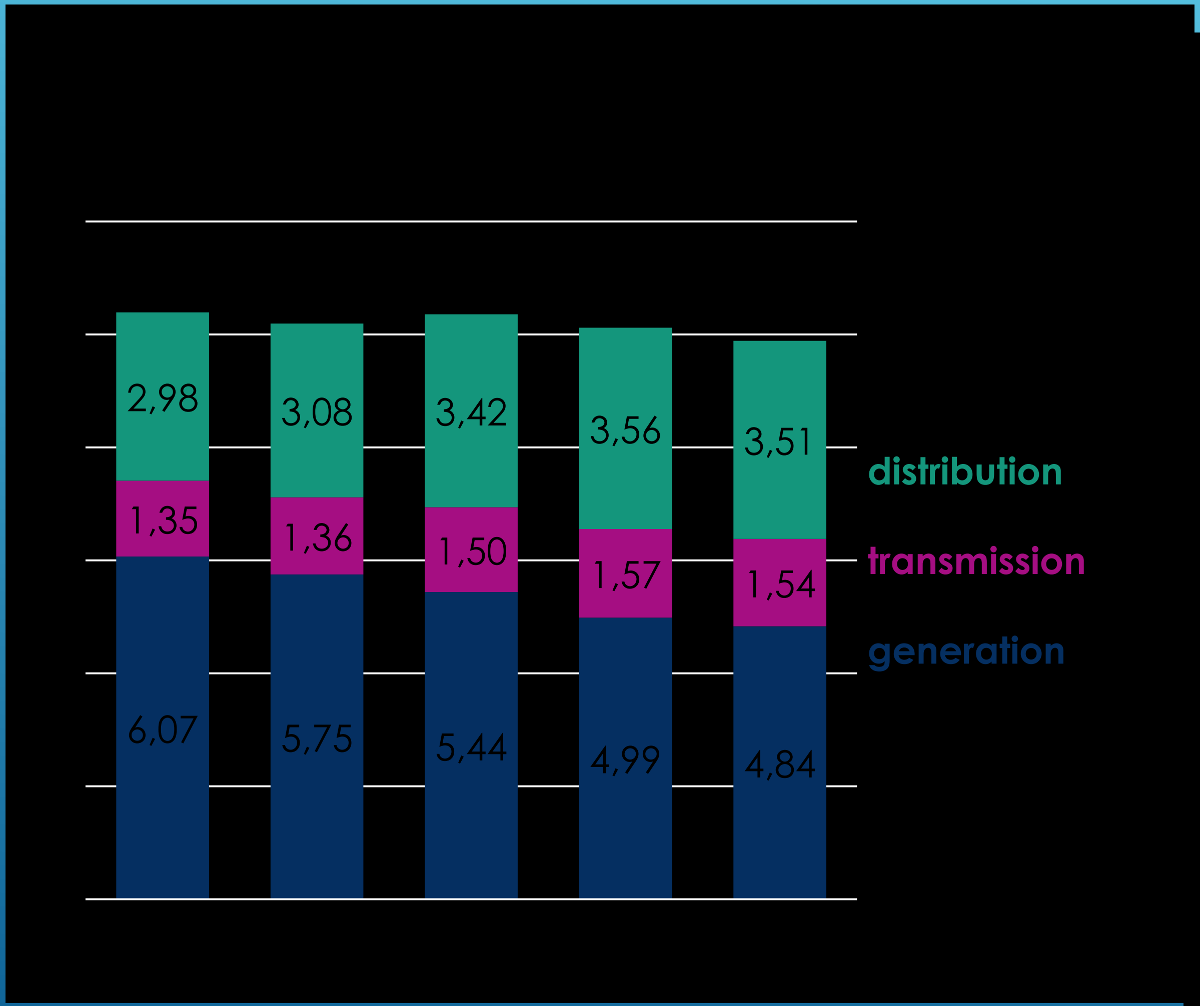
—AS A RESULT OF COMPETITIVE NATURAL GAS PRICES AND DECLINING COSTS FOR RENEWABLES

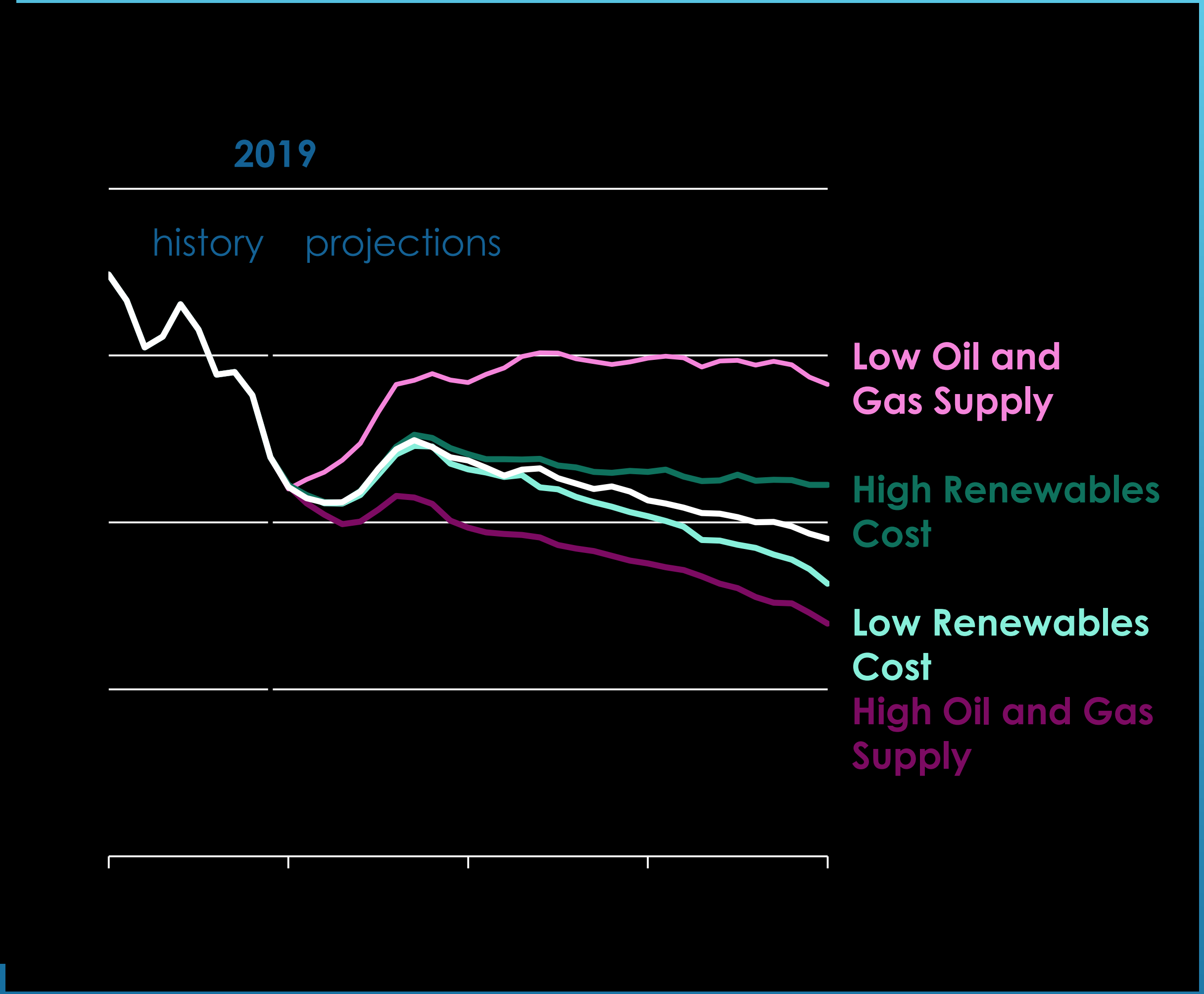
- In the AEO2020 Reference case, the United States adds 117 gigawatts (GW) of new wind and solar capacity between 2020 and 2023, which is the result of tax credits, increasing RPS targets, and declining capital costs.
- New wind capacity additions continue at much lower levels after production tax credits expire in the early 2020s, but the growth in solar capacity continues through 2050 for both the utility-scale and small-scale applications because the cost of solar PV declines throughout the projection period.
- Natural gas-fired combined-cycle generation capacity is also added steadily throughout the projection period to meet rising demand.
- Most of the electric generation capacity retirements assumed in the AEO2020 Reference case occur by 2025. Although the final schedule will depend upon state-level implementation plans, in AEO2020 EIA assumes that coal-fired plants must either invest in heat rate improvement technologies by 2025 or retire to comply with the Affordable Clean Energy (ACE) rule. Heat rate improvement technologies increase the efficiency of power plants. The remaining coal plants are more efficient and continue to operate throughout the projection period. Low natural gas prices in the early years also contribute to the retirements of coal-fired and nuclear plants because both coal and nuclear generators are less profitable in these years.

AEO2020'S LONG-TERM TRENDS IN ELECTRICITY GENERATION ARE DOMINATED BY SOLAR AND NATURAL GAS-FIRED CAPACITY ADDITIONS; COAL, NUCLEAR, AND LESS EFFICIENT NATURAL GAS GENERATORS CONTRIBUTE TO CAPACITY RETIREMENTS



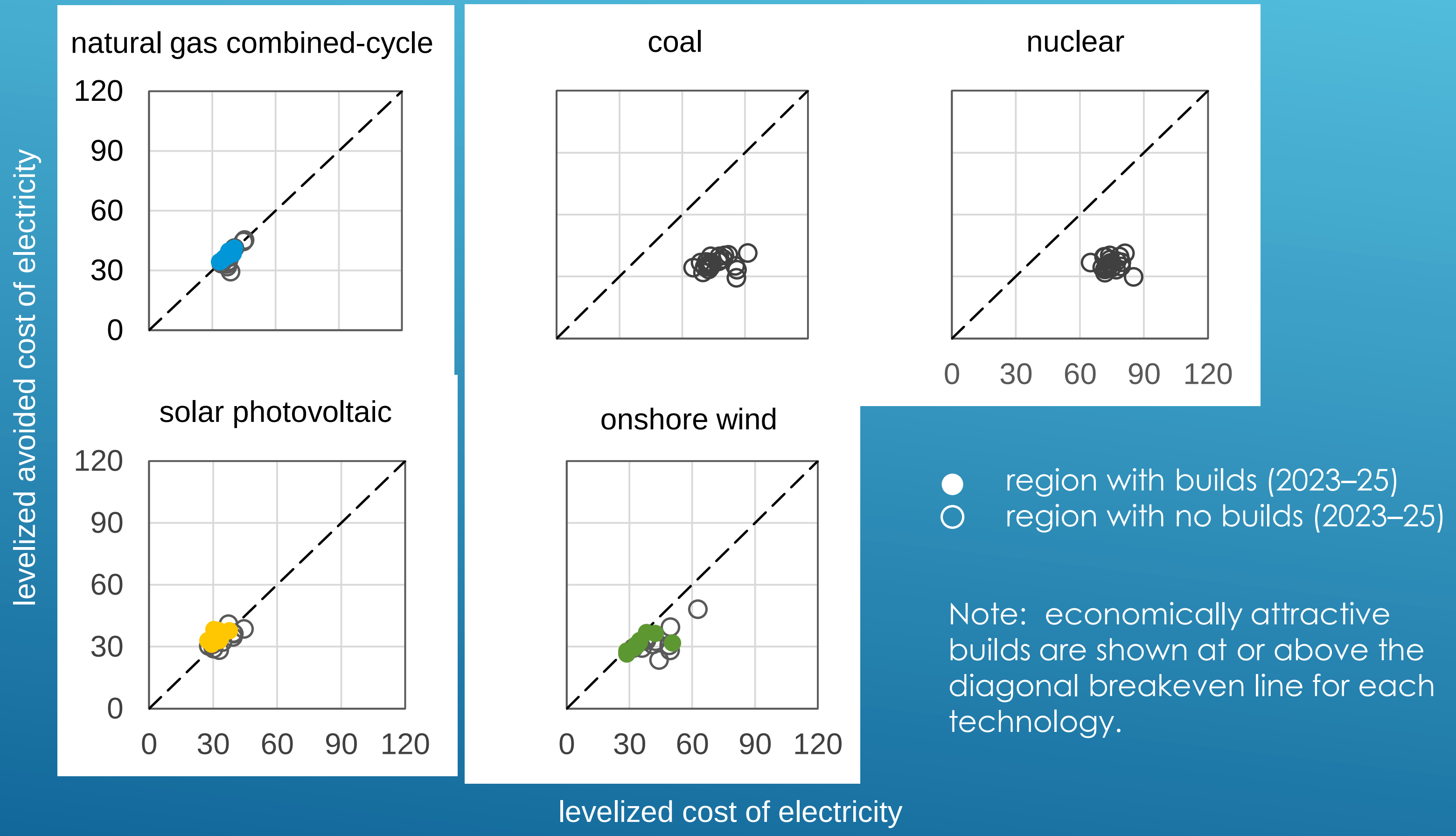
AEO2020 REFERENCE CASE ELECTRICITY PRICES FALL SLIGHTLY; DECLINING GENERATION COSTS ARE OFFSET BY RISING TRANSMISSION AND DISTRIBUTION COSTS





IN THE AEO2020 REFERENCE CASE, COMBINED-CYCLE AND SOLAR PHOTOVOLTAIC ARE THE MOST ECONOMICALLY COMPETITIVE GENERATING TECHNOLOGIES—

AEO2020 levelized cost of electricity and levelized avoided cost of electricity by technology and region, 2025
2019 dollars per megawatthour



Note: economically attractive builds are shown at or above the diagonal breakeven line for each technology.

—WHEN CONSIDERING THE OVERALL COST TO BUILD AND OPERATE AND THE VALUE OF THE PLANT TO THE GRID

- The levelized cost of electricity (LCOE) reflects the cost to build and operate a power plant per unit of generation, annualized over a cost recovery period. When compared with the levelized avoided cost of electricity (LACE), or expected average revenue realized by that plant, we can estimate the economic competitiveness for that generating technology.

- The solid, colored circles on the figure indicate that projects tend to be built in regions where revenue (LACE) exceeds costs (LCOE). In the AEO2020 Reference case, expected revenues from electric generation for both natural gas-fired combined-cycle and solar photovoltaic with single axis tracking are generally greater than or equal to projected costs across the most electricity market regions in 2025. Correspondingly, these two technologies show the greatest projected growth through the middle of the 2030s.

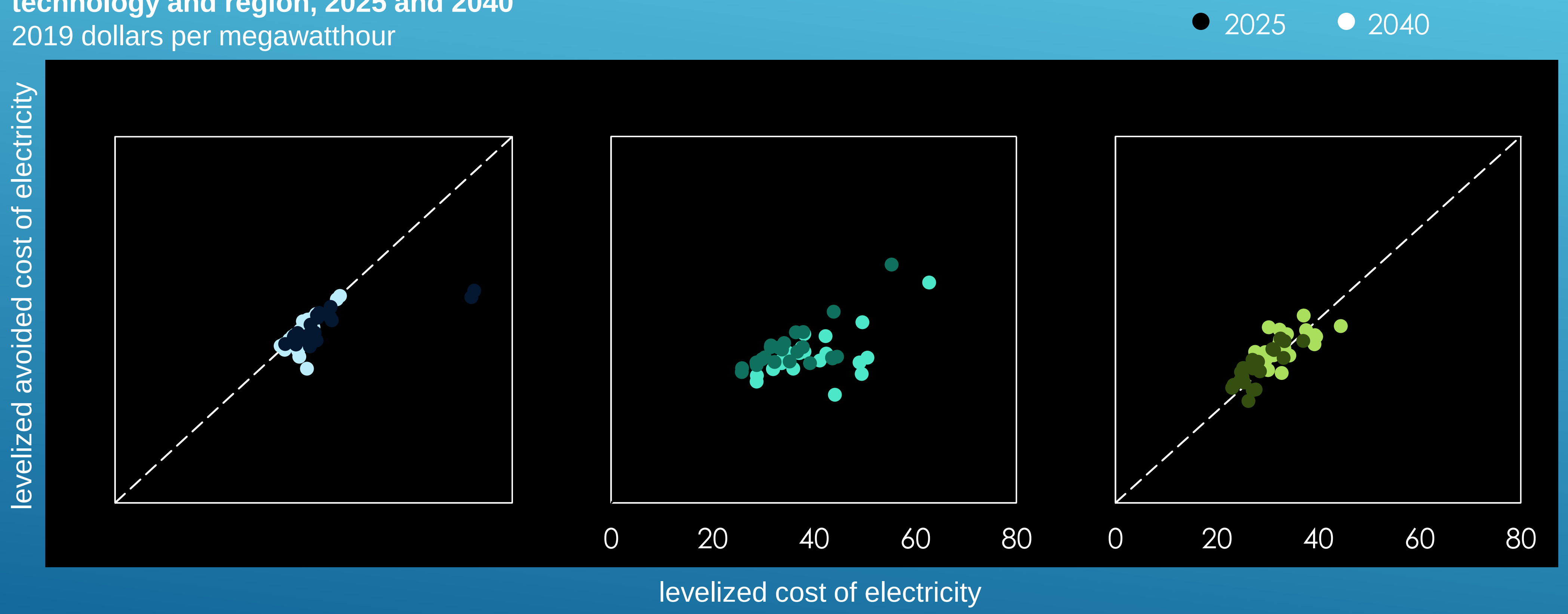
- The value of wind approaches its cost in nearly half of the regions. These regions see new wind capacity builds in the AEO2020 Reference case, primarily in advance of the phase-out of the production tax credit (PTC), through the early part of the next decade.

- LACE accounts for both the variation in daily and seasonal electricity demand in the region where a new project is under consideration and the characteristics of the existing generation fleet where the new capacity will be added. The prospective new generation resource is compared with the mix of new and existing generation and capacity that it would displace. For example, a wind resource that would primarily displace existing natural gas-fired generation will usually have a different value than one that would displace existing coal-fired generation.

ONSHORE WIND WILL BECOME MORE COMPETITIVE OVER TIME, WHILE NATURAL GAS-FIRED COMBINED-CYCLE AND SOLAR PHOTOVOLTAIC MAINTAIN THEIR CURRENT COMPETITIVE POSITIONS—

AEO2020 Reference case levelized cost of electricity (LCOE) and levelized avoided cost of electricity (LACE) by technology and region, 2025 and 2040

2019 dollars per megawatthour



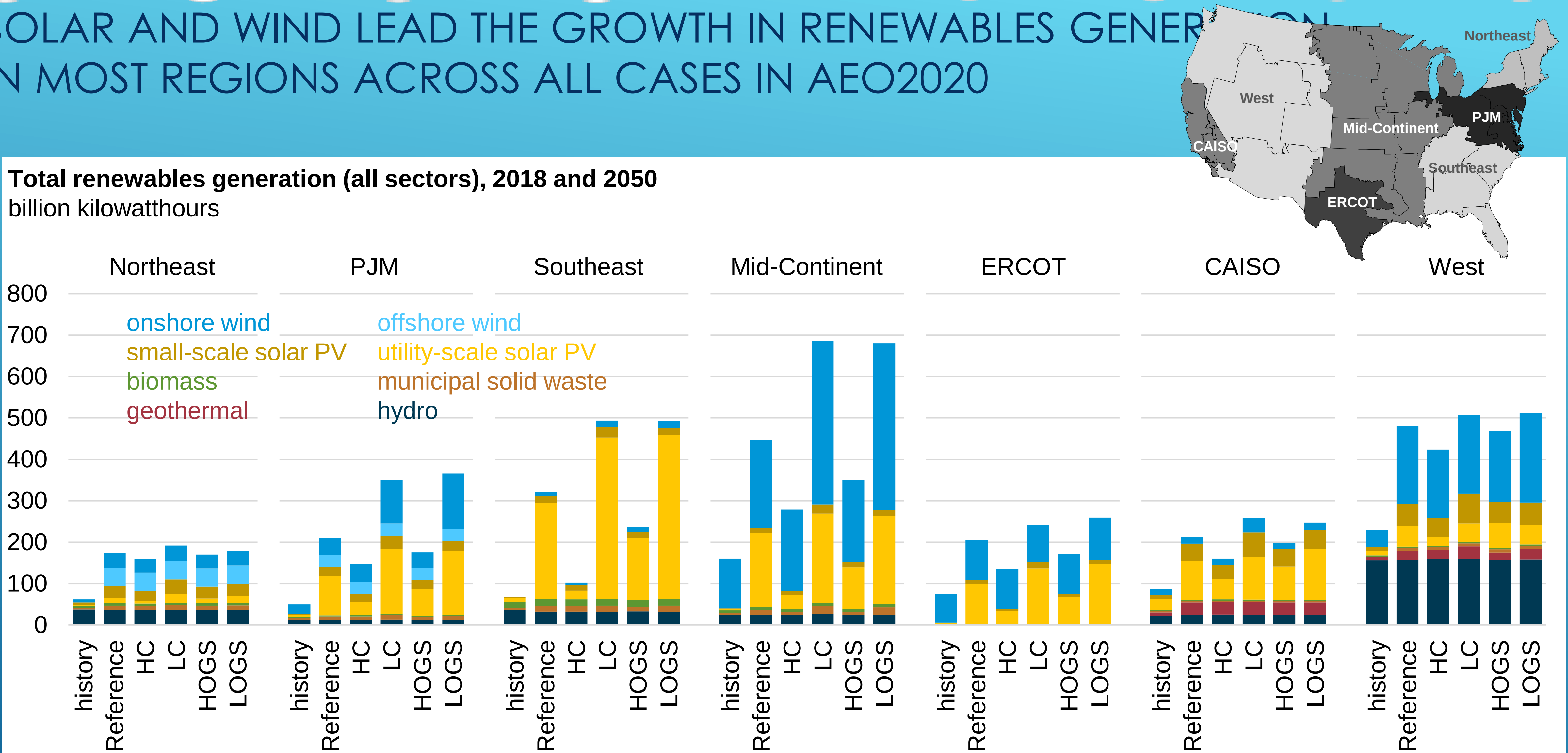
—AS LCOE DECLINES THROUGH LEARNING-INDUCED COST REDUCTIONS AND LACE INCREASES WITH RISING DEMAND AND NATURAL GAS PRICES

- Changes in AEO2020 electricity generation costs over time reflect a number of factors, sometimes working in different directions. For both solar photovoltaic (PV) and onshore wind, LCOE increases in the near term with the phase-out and expiration of the investment tax credit (ITC) and PTC, respectively. However, LCOE eventually declines over time because technological improvements tend to reduce LCOE through lower capital cost or improved performance (as measured by heat rate for natural gas combined-cycle plants or capacity factor for onshore wind or solar PV plants), partly offsetting the loss of the tax credits.

- Natural gas-fired combined-cycle plants with online years of 2025 and 2040 in the AEO2020 projection have similar LCOE because the technology has reached market maturity, judging from the build patterns throughout the projection years across all regions. The two outliers in the 2040 LCOE projection are attributed to the increase in variable operations and in maintenance costs for plants in California as a result of the state's phase-out of fossil fuel-fired generation starting in 2030.

- Solar may show strong daily generation patterns within any given region; therefore, AEO2020 LACE for solar PV declines over time as the market becomes saturated with generation from resources with similar hourly generation patterns. LACE for onshore wind is generally lower than other technologies because most of the generation at these plants occurs at night or during fall and spring seasons when the demand for and the value of electricity is typically lower. Solar PV plants produce most of their energy during the middle of the day when higher demand increases the value of electricity, resulting in higher LACE.

SOLAR AND WIND LEAD THE GROWTH IN RENEWABLES GENERATION IN MOST REGIONS ACROSS ALL CASES IN AEO2020



Note: HC = High Renewables Cost, LC = Low Renewables Cost, HOGS = High Oil and Gas Supply, LOGS = Low Oil and Gas Supply, PV= photovoltaic

—BUT ITS PENETRATION RATE DIFFERS BY REGIONAL RESOURCE AND GENERATION MIX

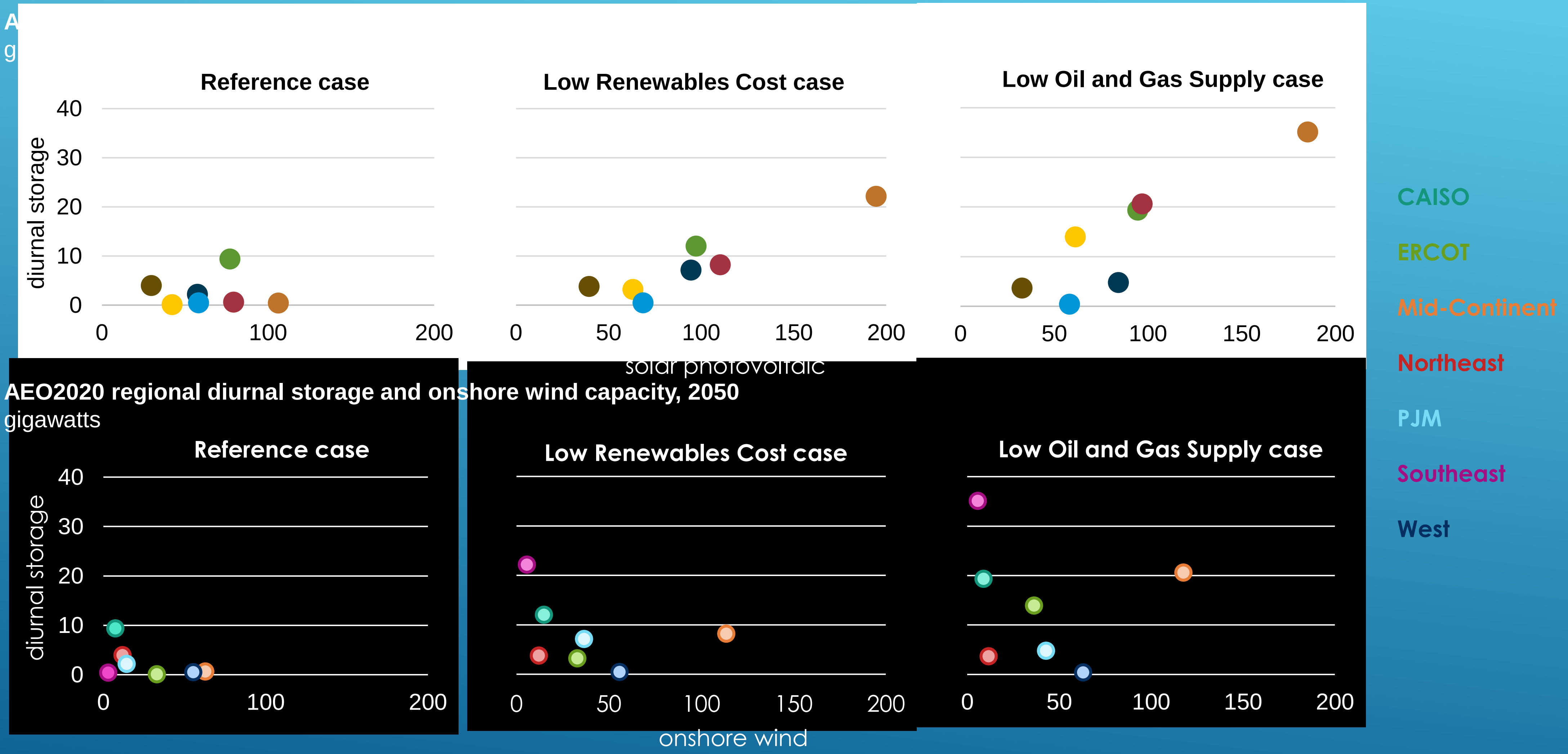
- The AEO2020 projects that generation from renewable sources will rise from 18% of total generation in 2018 to 38% by 2050 in the Reference case. Solar photovoltaic (PV) contributes the most to the growth in renewable generation, increasing from 13% of total renewable generation in 2018 to 46% by 2050. Although onshore wind generation more than doubles during the projection period, its share of renewable generation declines slightly from 37% to 29% between 2018 and 2050.

- Solar PV generation grows the most in Southeast and Mid-Continent regions in nearly all cases. On average, these two regions have higher-than-average delivered U.S. natural gas prices, making natural gas generation a more expensive option to replace retired coal or nuclear generation. Because solar PV generates mostly during daytime hours, it can readily substitute natural gas generation during periods of higher demand. Regions with existing wind capacity continue to install new wind capacity between 2018 and 2050.

- When natural gas prices are higher, as in the Low Oil and Gas Supply case, onshore wind becomes the incremental generation source in the Mid-Continent region, where wind resources are abundant. Wind generation for the region is 189 billion kilowatthours (BkWh) higher (89% increase) in 2050 than in the Reference case, and all-sector solar PV generation is 37 BkWh higher (20% increase).

- The Northeast, ERCOT (Electric Reliability Council of Texas), CAISO (California Independent System Operator), and West regions have relatively small variations in results across the alternative cases. The small variations are most likely a result of the regions' current small shares of existing coal generation capacity that may need to be replaced over the projection period. The share of renewables is also comparatively large in these regions.

Growth in utility-scale battery storage in AEO2020 follows growth in solar in most regions in high renewable penetration scenarios—



—BUT DOES NOT BENEFIT FROM WIND GROWTH, WHICH HAS MORE UNPREDICTABLE GENERATION PATTERNS

- The AEO2020 Reference case projects that the United States will have 17 GW of battery storage capacity in 2050. Storage capacity takes advantage of times when an oversupply of electricity occurs, which generally happens in areas that have a high penetration of non-dispatchable renewable resources such as wind and solar. Limitations in the time a battery can store electricity make batteries more suitable for solar, which has more predictable generation patterns than wind.

- The large number of combustion turbine (CT) additions in the West and Mid-Continent regions correspond the large number of wind additions in these regions. Because wind energy is less predictable and fluctuates in intensity for long periods, current limitations in the length of time a battery can store or generate power make batteries an inadequate backup for wind power. Therefore, CTs, which have no duration limit as long as natural gas fuel is available, fill the gap. CTs in the West region are also supported by its large hydropower resources.

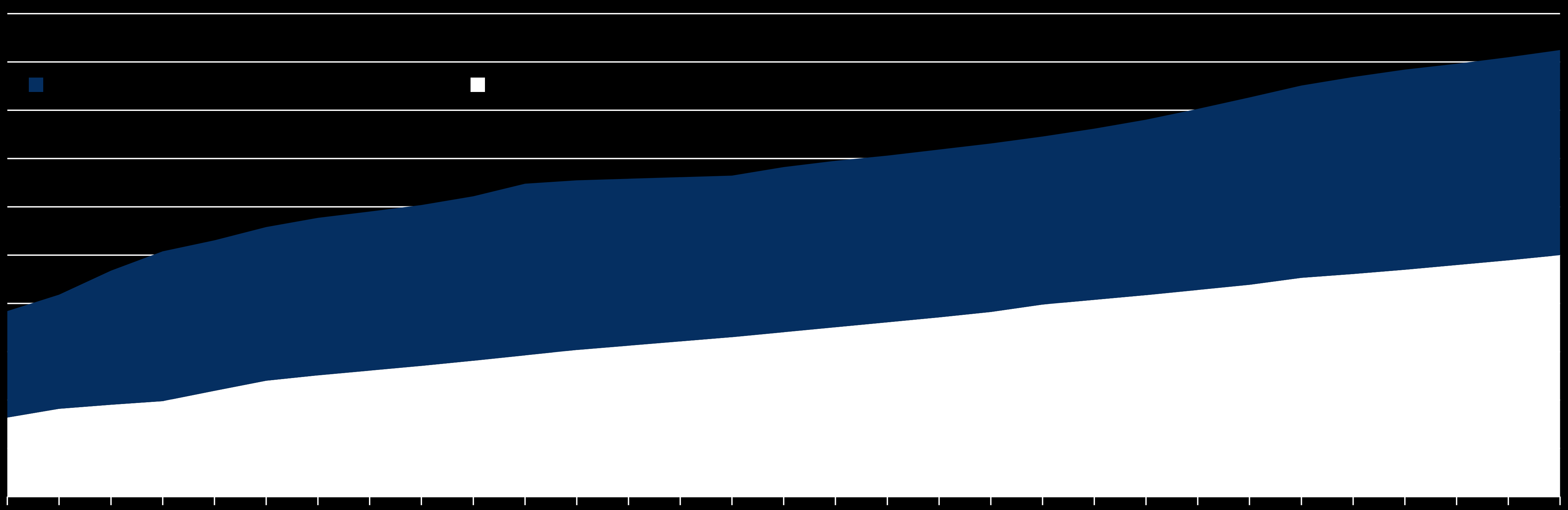
- Storage growth is stronger in AEO2020 scenarios that have a high penetration of renewables, such as the Low Renewables Cost and Low Oil and Gas Supply cases. The Low Renewables Cost case projects 57 GW of storage by 2050, and the Low Oil and Gas Supply case projects 98 GW of storage by 2050.

- In both the Low Renewables Cost and Low Oil and Gas Supply cases, the Southeast and California regions see high amounts of solar capacity in 2050, minimal amounts of wind capacity, and concurrently large amounts of battery storage. The Northeast, the West, and the PJM regions have relatively low solar capacity and lower storage capacity.

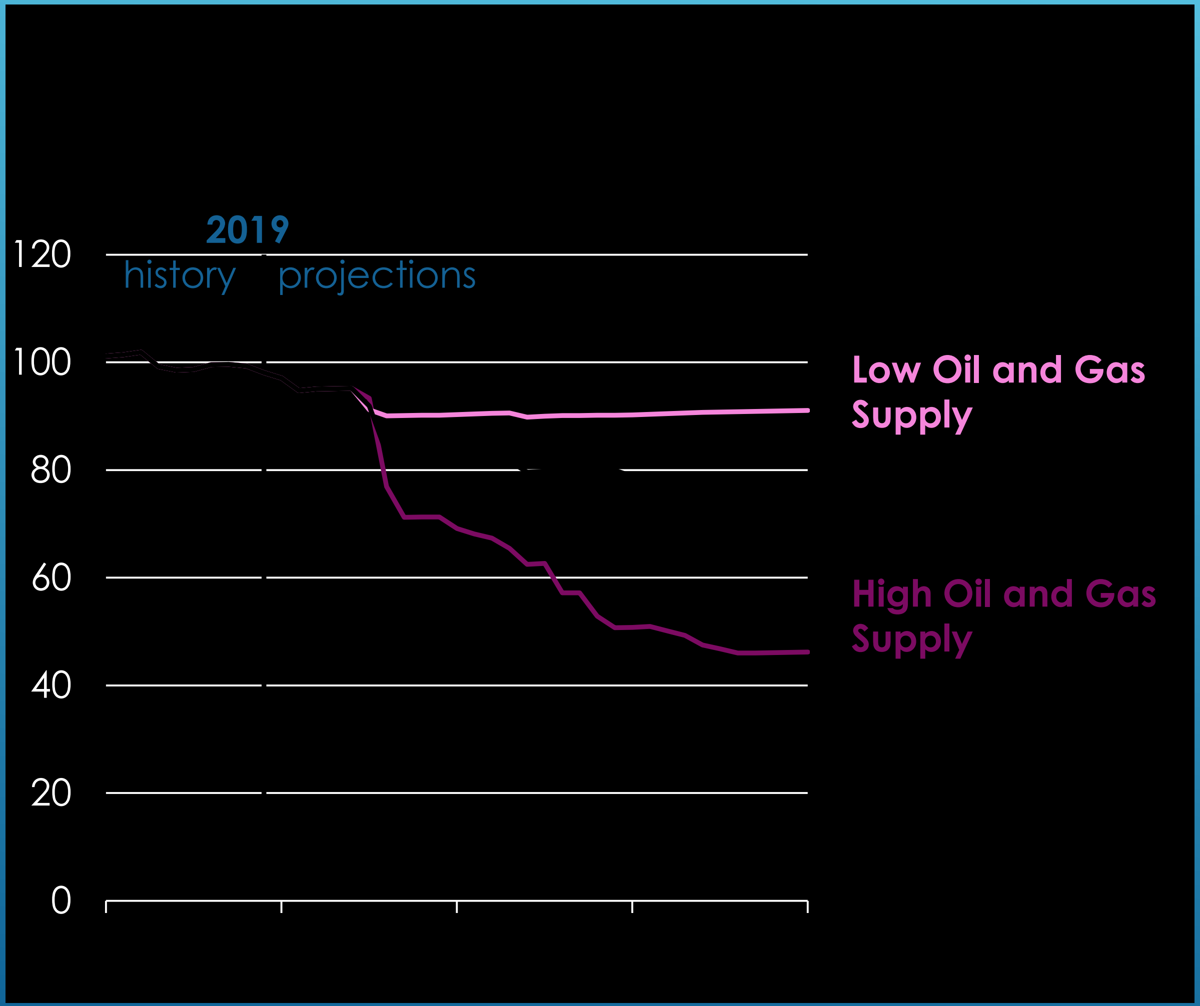
EVEN WITH RECENT INCREASES IN SEVERAL STATES' RENEWABLE PORTFOLIO STANDARDS, RENEWABLE GENERATION THAT EXCEEDS REQUIREMENTS ALLOWS FOR FULL COMPLIANCE IN THE AEO2020 REFERENCE CASE BY 2050

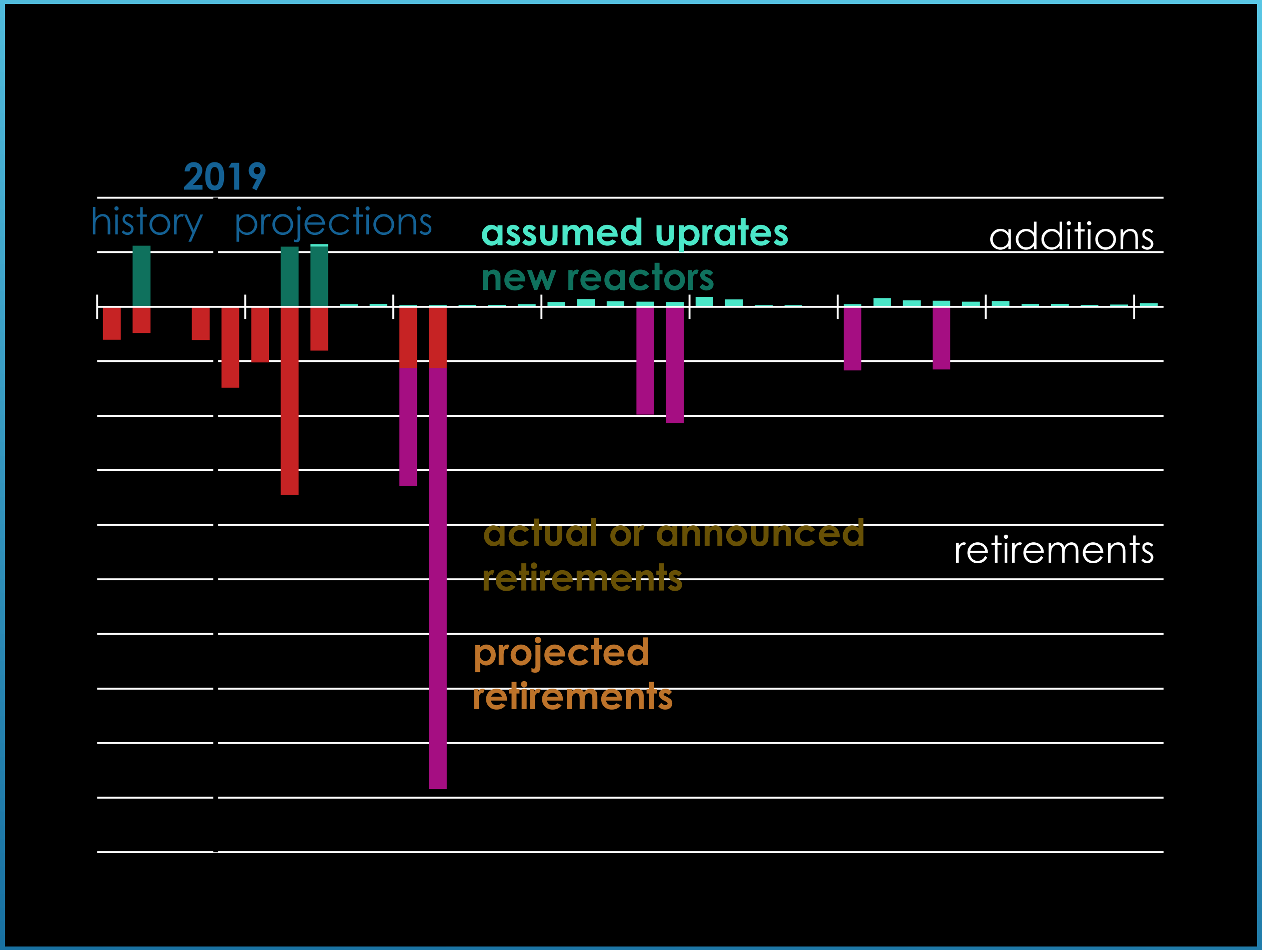
AEO2020 Reference case

projected total generation from compliant technologies, –



LOWER NATURAL GAS PRICES THROUGHOUT THE AEO2020 PROJECTION PERIOD ACCELERATE NUCLEAR CAPACITY RETIREMENTS—





—AS A RESULT OF DECLINING REVENUE IN COMPETITIVE WHOLESALE POWER MARKETS

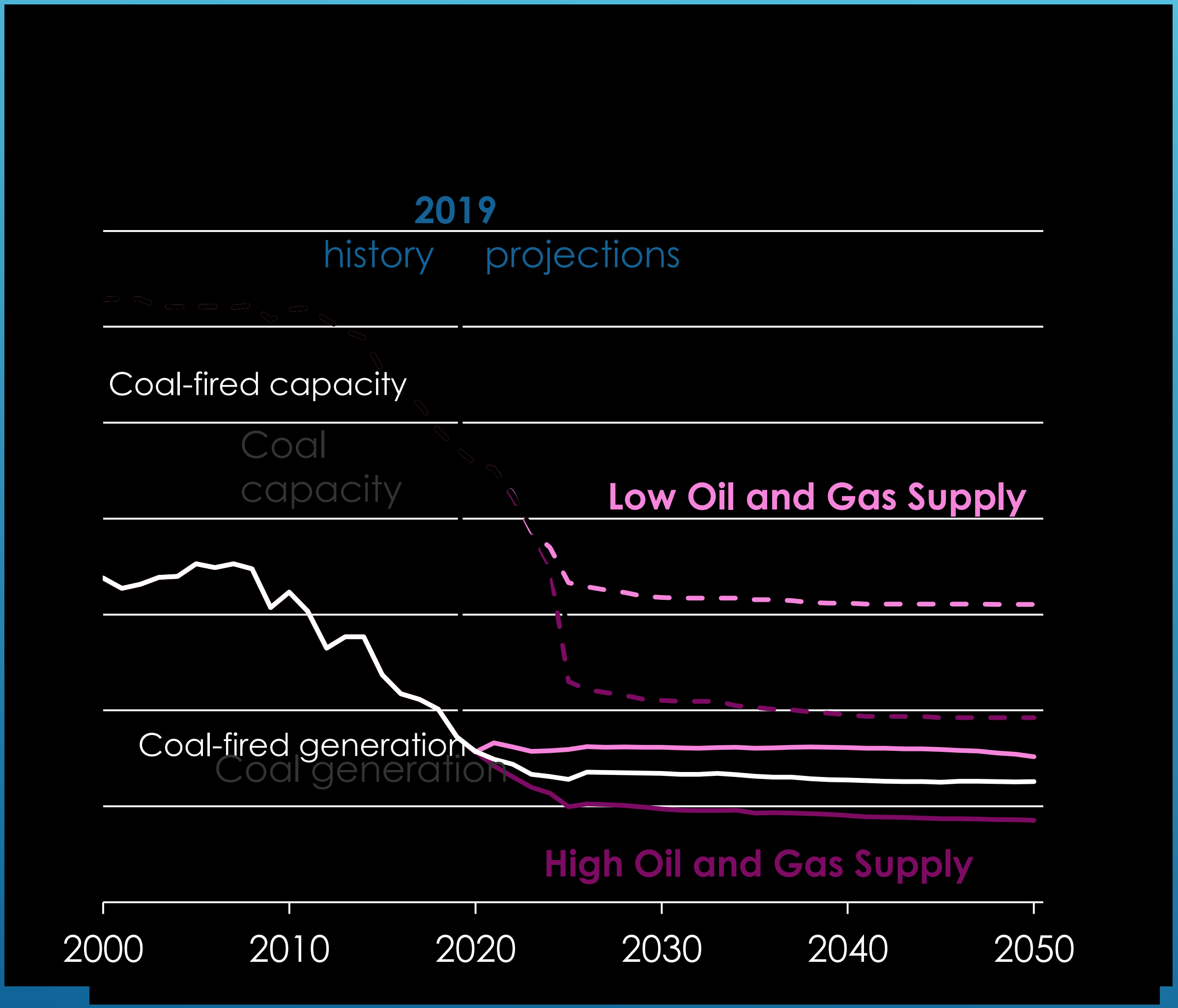
- The AEO2020 Reference case projects a 19% decline in nuclear electric generating capacity from 98 GW in 2019 to 79 GW in 2050. No new plant additions occur beyond 2022, and existing plants have 2 GW of uprates starting in 2022.

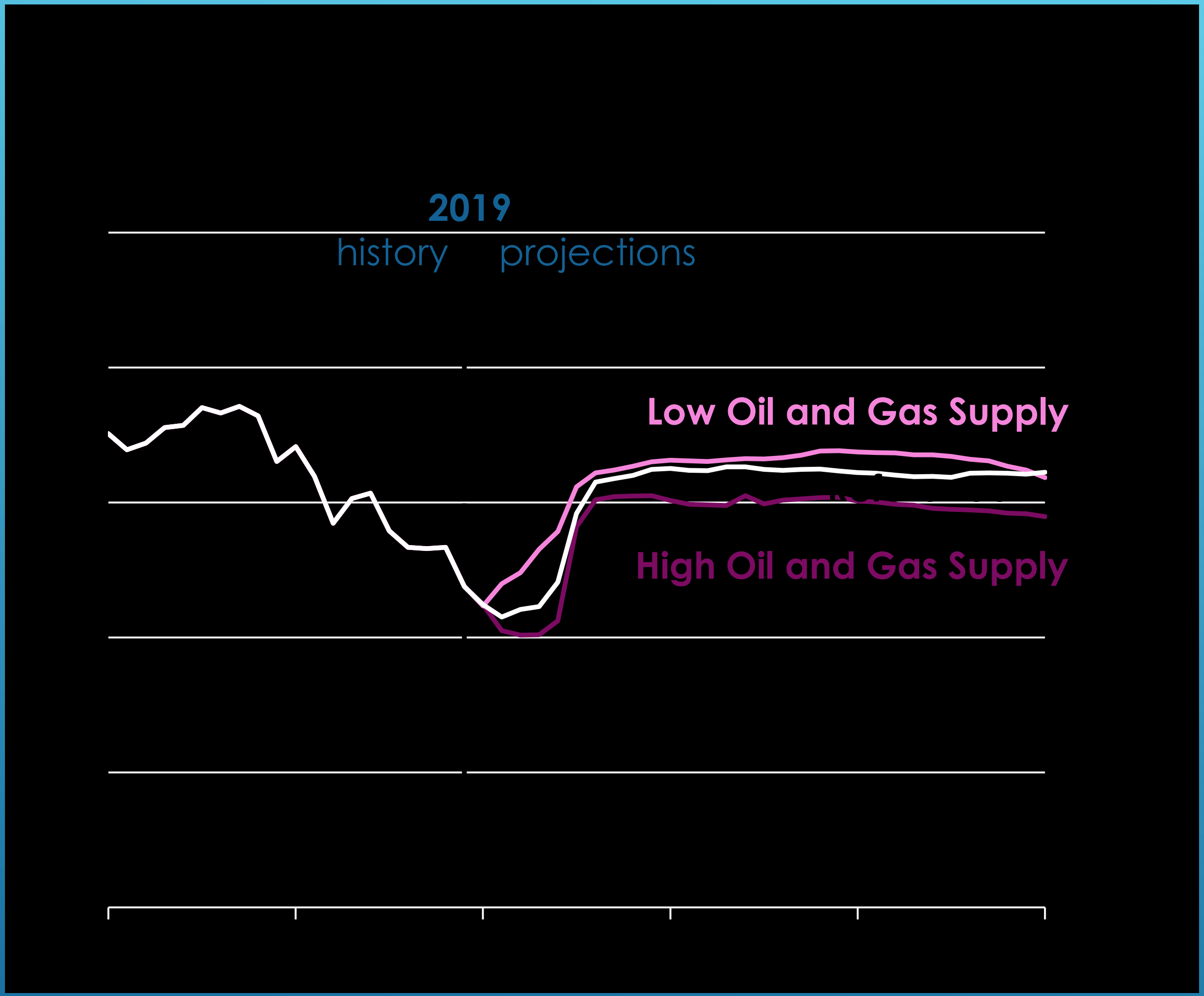
- Projected nuclear retirements are driven by declining revenues that result from low growth in electricity load and from increasing competition from low-cost natural gas and declining-cost renewables. Smaller, single-reactor nuclear plants with higher average operating costs are most affected, particularly those plants operating in regions with deregulated wholesale power markets and in states without a zero emission credit policy.

- Lower natural gas prices in the High Oil and Gas Supply case lead to lower wholesale power market revenues for nuclear power plant operators, accelerating an additional 32 GW of nuclear capacity retirements by 2050 compared with the Reference case.

- Higher natural gas prices in the Low Oil and Gas Supply case help increase profitability for nuclear power plant operators, resulting in 13 GW fewer retirements through 2050 compared with the Reference case.

COAL-FIRED GENERATING CAPACITY RETIRES AT A FASTER PACE THAN TOTAL GENERATION IN THE AEO2020 REFERENCE CASE—





AS CAPACITY FACTORS INCREASE FOR THE MORE EFFICIENT COAL-FIRED UNITS THAT REMAIN IN SERVICE

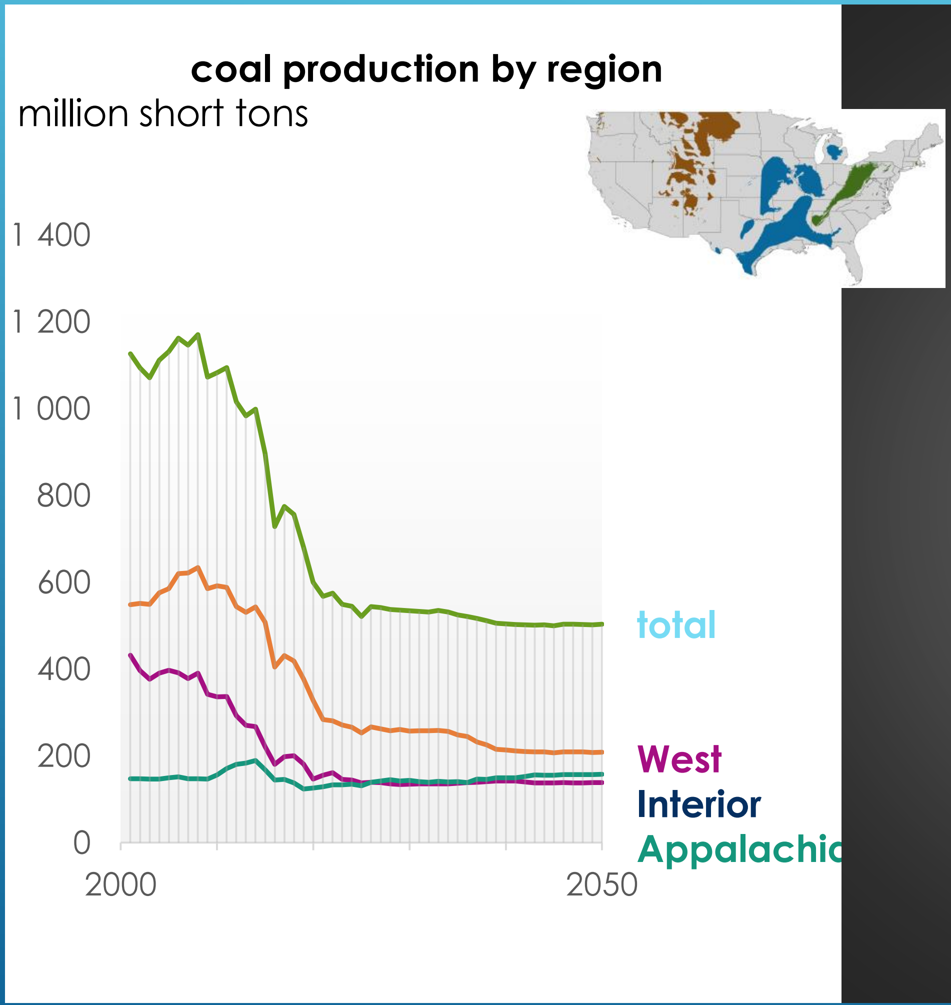
- In addition to decreases as a result of competitively priced natural gas and increasing renewables generation, coal-fired generating capacity decreases by 109 GW (or 46%) between 2019 and 2025 to comply with the Affordable Clean Energy (ACE) rule before leveling off near 127 GW in the AEO2020 Reference case by 2050.

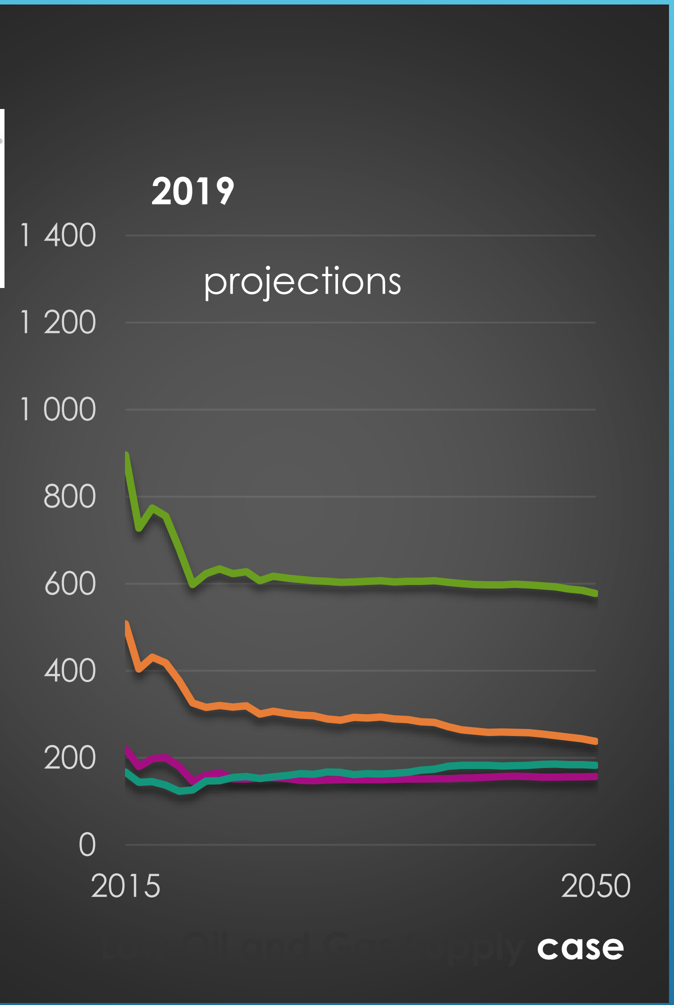
- Average capacity factors for coal-fired generating units improve over time as less-efficient units are retired, as heat rates in the remaining coal fleet improve to comply with the ACE rule, and as natural gas prices increase

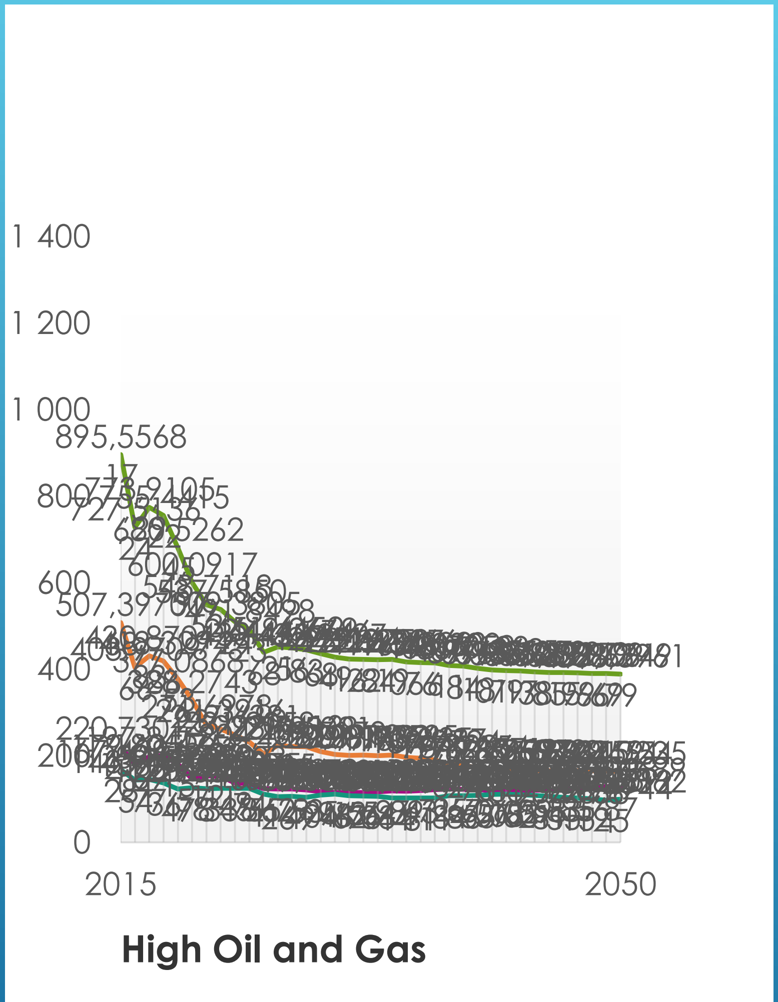
- Between 2019 and 2025, coal-fired generation decreases by 26% in the Reference case while natural gas prices increase. By 2030, the utilization rate of the remaining coal-fired capacity returns to 65%, which is slightly less than in the early 2000s. In the High Oil and Gas Supply case, coal-fired generation decreases by 42% between 2019 and 2025, and lower natural gas prices limit the utilization rate of the coal fleet to about 60% in 2030.

- Higher natural gas prices in the Low Oil and Gas Supply case slow the pace of coal power plant retirements by about 23 GW through 2025 compared with the Reference case. The Low Oil and Gas Supply case has 155 GW of coal-fired capacity still in service in 2050. Conversely, lower natural gas prices in the High Oil and Gas Supply case increase coal-fired power plant retirements by 28 GW in 2025, and 96 GW of remaining coal-fired capacity remains by 2050.

COAL PRODUCTION DECREASES THROUGH 2025 DUE TO RETIRING COAL-FIRED ELECTRIC GENERATING CAPACITY, BUT FEDERAL RULE COMPLIANCE AND HIGHER NATURAL GAS PRICES LEAD TO COAL PRODUCTION LEVELING OFF AFTERWARDS

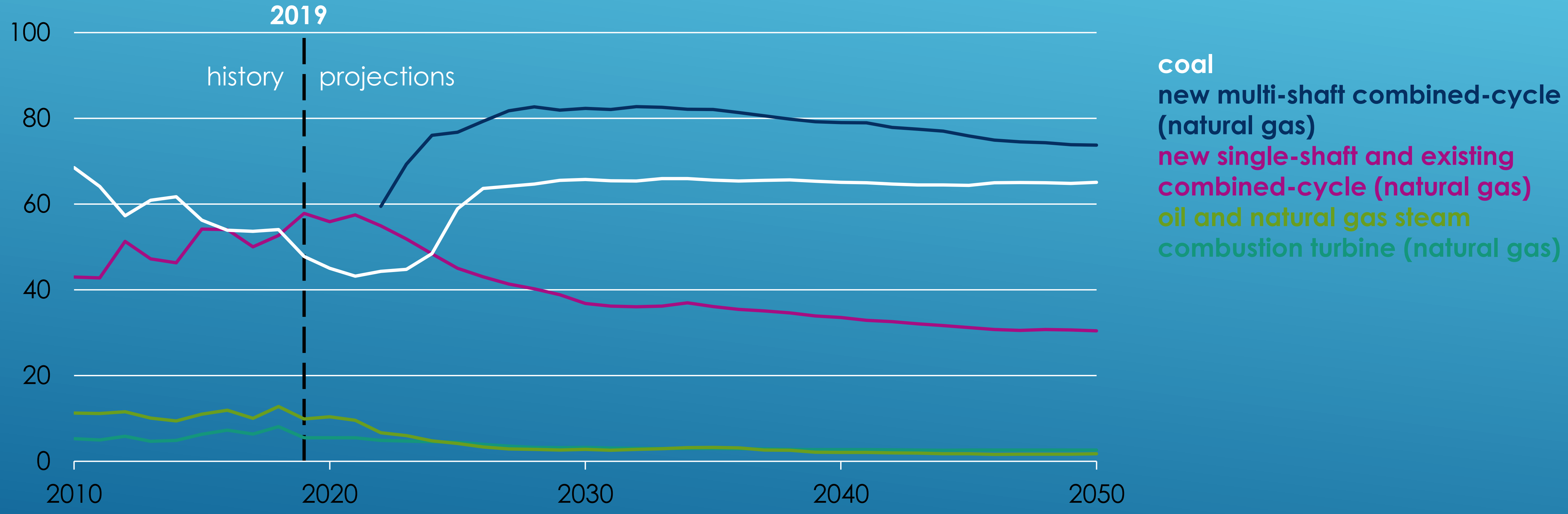






LOWER OPERATING COSTS AND HIGHER EFFICIENCIES RESULT IN ADVANCED NATURAL GAS-FIRED COMBINED-CYCLE CAPACITY FACTORS OF 80% BY 2030 IN THE AEO2020 REFERENCE CASE—

Capacity factor for fossil-fired plants (AEO2020 Reference case)
percent



—BUT THEN DECLINE OVER TIME AS NATURAL GAS PRICES INCREASE AND RENEWABLE GENERATION GROWS

- Lower natural gas prices and reduced capital costs for new natural gas-fired combined-cycle generating units change fossil fuel electric generation use during the next decade in the AEO2020 Reference Case. Beginning in 2022—the first year of availability—new, multi-shaft (2 x 2 x 1 configuration) combined-cycle natural gas-fired units have the highest projected capacity factors of all technologies, averaging 81% between 2025 and 2035. The currently most common combined-cycle units, with their lower efficiency, and the new single-shaft (1 x 1 x 1 configuration) combined-cycle units decline in utilization as a group, from 56% in 2020 to 36% by 2035.

- After 2035, capacity factors for both combined-cycle technologies decline gradually, in part because large increases in intermittent generation through 2050 alter the dispatch patterns and requirements for fossil fuel-fired generation.

- The utilization rate of coal plants has fallen significantly in recent years as declining natural gas prices have led to a shift in economics between existing coal-fired and natural gas-fired combined-cycle generators. In 2019, the average capacity factor of the U.S. coal-fired fleet was 48% compared with an average natural gas-fired combined-cycle capacity factor of 58%. The low capacity factor for coal plants reflects a certain amount of idled inefficient capacity, which the Reference case projects will retire by 2025 as a result of the ACE rule. After 2025, the installed coal-fired capacity level is much lower because only the most efficient plants remain online. As a result, the average capacity factor for the fleet recovers quickly and stabilizes at about 65%.

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