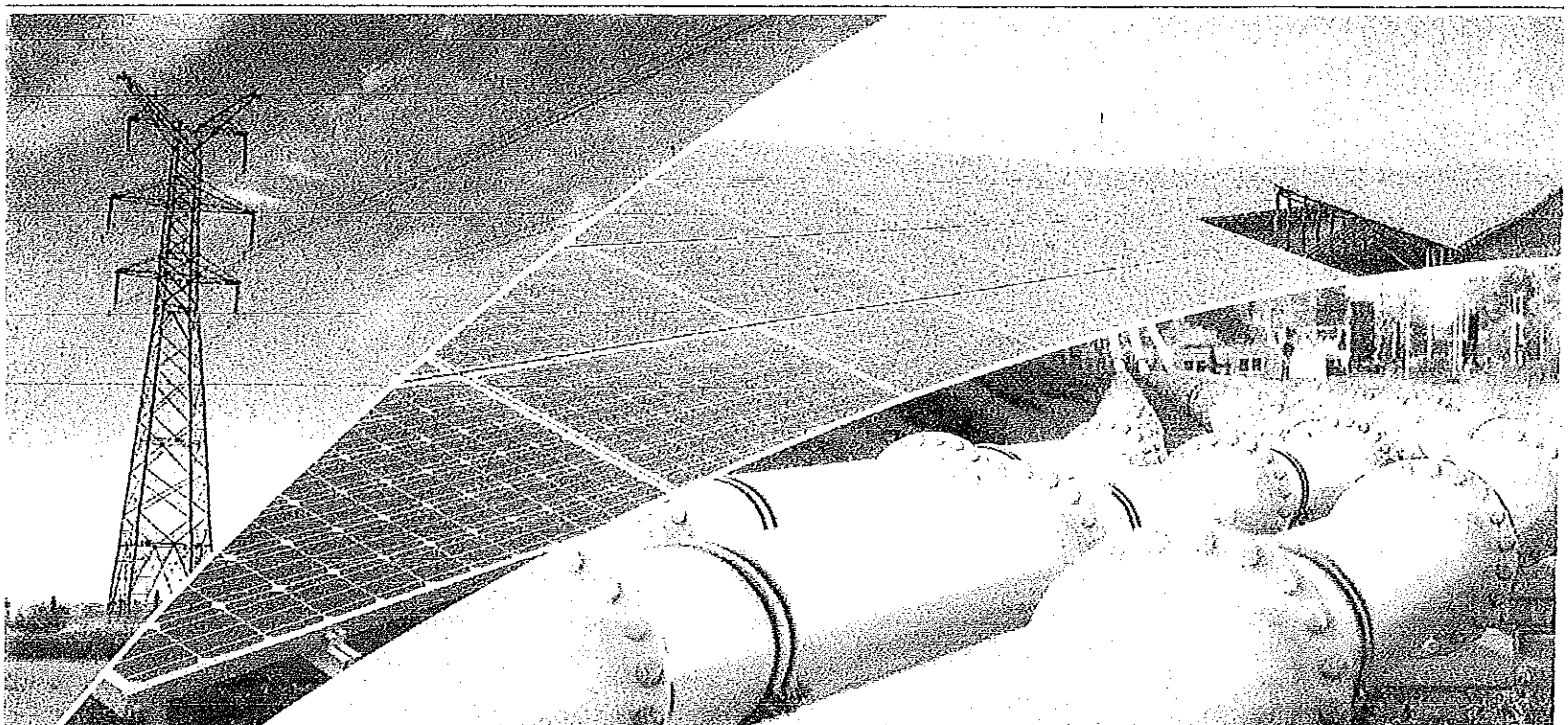
Footnote 15 & DAB-5 (P.40)

DOE/EIA-0383(2016) | August 2016

Annual Energy Outlook 2016

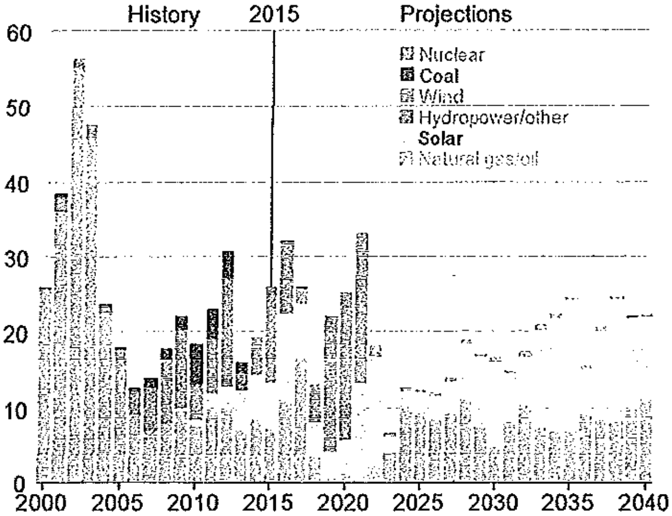
with projections to 2040



U.S. Energy Information
Administration

Renewables and natural gas lead capacity additions through 2040 in the Reference case

Figure MT-30. Additions to electricity generation capacity by fuel in the Reference case, 2000–2040 (gigawatts)



In the AEO2016 Reference case, two developments significantly improve the prospects for renewable capacity: extension of favorable federal tax treatment for renewable generators, and continued dramatic reductions in the capital cost of solar photovoltaic (PV) systems. In the Reference case, cumulative additions to U.S. generating capacity from 2016-40 total 483 gigawatts (GW) for all technologies, including 302 GW of renewable technology additions (63% of the total), both power-sector and end-use generators (Figure MT-30). Renewable generation capacity additions consist primarily of wind (73 GW) and solar (221 GW) technologies, including 77 GW of solar PV installations in the end-use sectors.

The increase in renewable capacity additions helps offset the retirement of 100 GW of coal-fired capacity as a result of environmental legislation, including implementation of the Clean Power Plan. Relatively low natural gas prices from 2016-40 also lead to a significant increase in natural gas-fired capacity, with 175 GW of gas-fired capacity additions accounting for 36% of the total increase. Total renewable capacity additions average 16 GW/year through 2024. From 2025-40, renewable capacity additions slow to 10 GW/year, as electricity demand growth slows. Virtually all capacity additions after 2025 in the Reference case are solar PV and natural gas, which account for 53% and 43% of total additions, respectively, over the 2025-40 period. Among fossil fuel generating technologies, natural gas-fired combined-cycle plants remain the least-cost option for new capacity additions, and they generally are more efficient to operate than existing steam plants fueled with natural gas, oil, or coal.

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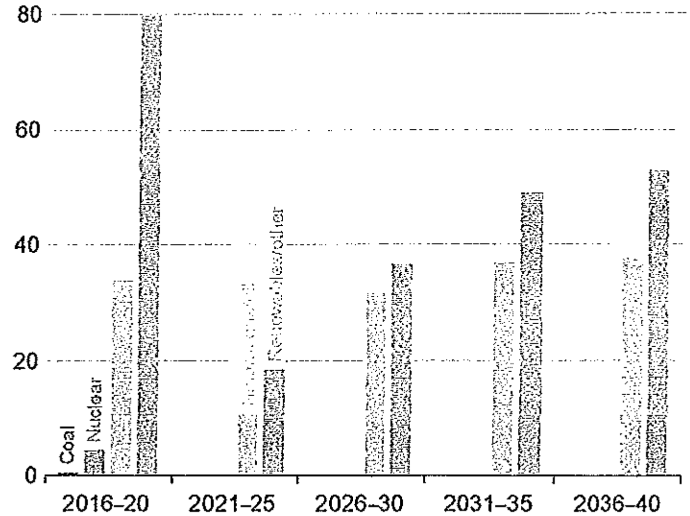
In the No CPP case, most new electricity generation capacity uses natural gas and renewables

Figure MT-31. Cumulative additions to electricity generation capacity by fuel in the No CPP case by period (gigawatts)



In the No CPP case, additions to electricity generation capacity—including those in the end-use sectors—total 392 gigawatts (GW) from 2016-40 (Figure MT-31). Capacity additions in the near term replace retiring coal-fired plants, which are the result of low natural gas prices and implementation of the Mercury Air Toxic Standards. Coal-fired capacity declines from 284 GW in 2015 to 215 GW in 2040, with much of that capacity retired by 2025. A total of 60 GW of coal-fired capacity is retired from 2016-25 in the No CPP case, including both announced retirements and those projected on the basis of market factors. Total capacity additions average 16 GW/year from 2016-40, with 97 GW of renewable capacity additions from 2016-25 and 44 GW of natural gas additions over the same period.

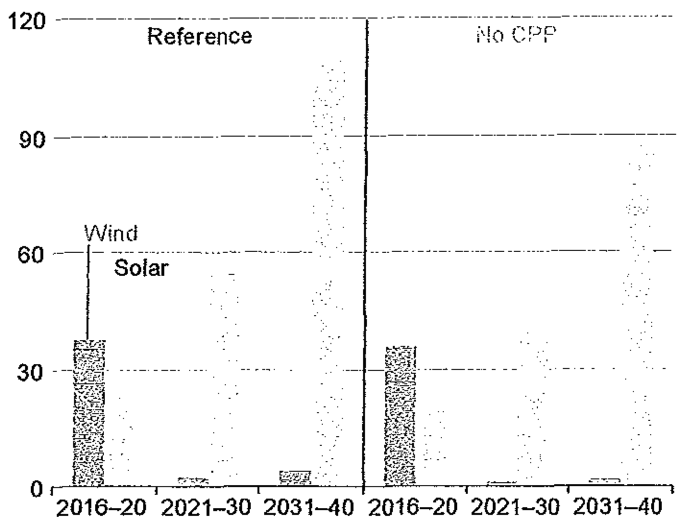
Renewable additions in the No CPP case benefit from the extension of the federal tax credit in the near term and from declining costs in the long term. Renewable additions total 236 GW from 2016-40, primarily solar (178 GW) and wind (52 GW). The solar capacity additions include 74 GW of rooftop and other distributed solar generation installations in the end-use sectors. Most of the wind capacity is added before 2025 to take advantage of the production tax credit, which is available only to projects beginning substantive development before 2020. Solar capacity is added steadily through 2040, as it becomes more cost-competitive as a result of declining capital cost and the investment tax credit. The tax credit phases down from 30% in 2016 to 10% in 2022 and then remains at that level for utility and commercially operated solar projects but ends for residential solar projects.

In the No CPP case, natural gas accounts for 38% (150 GW) of cumulative capacity additions from 2016-40. The relatively steady growth of natural gas capacity, which helps to maintain

MW), and Diablo Canyon Units 1 and 2 (2,240 MW). These reecent announcements represent an additional incremental reduction of 2.6 gigawatts of retirements not reflected in the Reference case. The Reference case addresses near-term accelerated nuclear retirements but assumes that subsequent license renewals will allow for long-term operation up to 80 years. Future AEOs will discuss the ability of nuclear power stations to achieve long-term operation beyond 60 years.

Renewable capacity additions are dominated by solar photovoltaics

Figure MT-36. Wind and solar electricity generation capacity additions in all sectors by energy source in two cases, 2016–20, 2021–30, and 2031–40 (gigawatts)



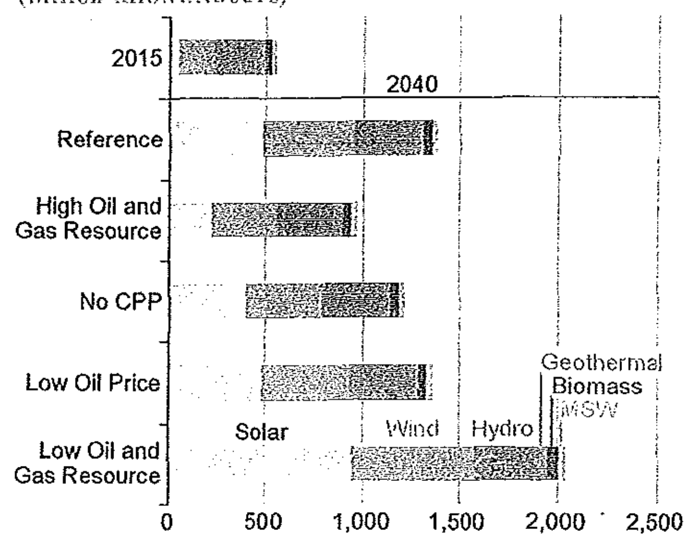
In the AEO2016 Reference case, total wind and solar electricity generation capacity grows by 5%/year from 2016-40, adding more than 294 gigawatts (GW) to provide 80% of total renewables capacity in 2040 (Figure MT-36). In the No CPP case, which assumes that the Clean Power Plan (CPP) is not implemented, wind and solar capacity together increase by more than 4%/year, adding almost 230 GW of generating capacity over the 2016-40 period. Wind and solar capacity increases by 10%/year from 2016-20 and then slows to 3%/year from 2021-40 in both the Reference and No CPP cases.

Solar power provides the largest increase in renewable capacity, from 25 GW in 2015 to more than 246 GW in 2040 in the Reference case and more than 202 GW in the No CPP case. The increases in wind capacity are much smaller, at 73 GW in the Reference case and less than 52 GW in the No CPP case from 2016-40. Solar installations have benefitted from significant reductions in technology costs in recent years, while wind capacity is hampered by the need to access wind sites farther from existing transmission lines or with less favorable development characteristics. Wind capacity additions are particularly slow between 2030-40, at slightly more than 4 GW in the Reference case and 2 GW in the No CPP case. With slow growth in wind capacity additions and continued fast growth in solar additions, solar capacity surpasses wind capacity in 2032 in the Reference case and in 2033 in the No CPP case.

Renewable capacity growth is supported by a variety of federal and state policies. The recent five-year extension of production tax credits and investment tax credits supports the growth of new renewable capacity through 2022. The CPP policy takes effect in 2022, providing additional incentives for renewable capacity additions to meet CO2 emissions targets from 2022-29. Although the targets remain flat after the interim period, additions of renewable capacity continue in order to meet CO2 emissions targets while satisfying demand for new generation.

Renewable electricity generation sensitive to government policies and natural gas prices

Figure MT-37. Renewable electricity generation by fuel type in all sectors in five cases, 2015 and 2040 (billion kilowatthours)



Total renewable electricity generation increases in the Reference case by more than 150%, from 546 billion kilowatthours (kWh) in 2015 to 1,374 billion kWh in 2040 (Figure MT-37). The total varies in the alternative cases with different price, resource, and policy assumptions, ranging from a 76% increase in the High Oil and Gas Resource and Technology case to a 271% increase in the Low Oil and Gas Resource and Technology case. Generation from wind and solar resources represents the largest share of the increase in renewable generation. In the Reference case, solar generation increases by an average of 11%/year, from 38 billion kWh in 2015 to 477 billion kWh in 2040, and wind generation increases by an average of 4%/year, from 190 billion kWh in 2015 to 473 billion kWh in 2040. Solar power provides about 35% of total renewable electricity generation in 2040 in the Reference case, up from 7% in 2015.

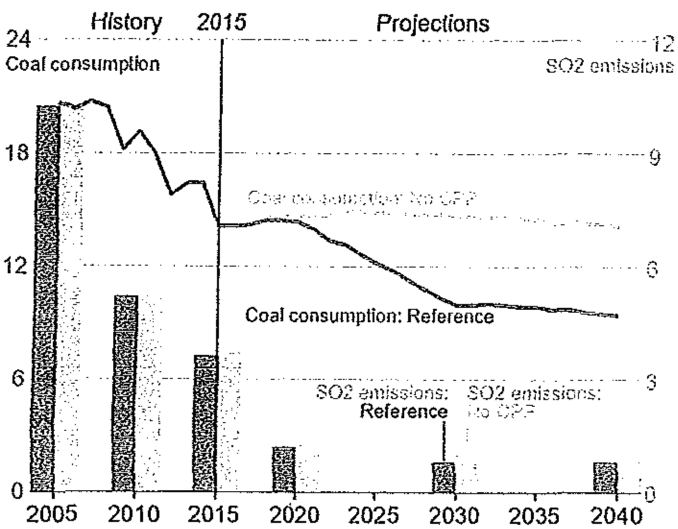
In the Low Oil and Gas Resource and Technology case, which has the highest natural gas prices among all the AEO2016 cases, renewable generation increases to 2,030 billion kWh in 2040, with approximately 46% of the total coming from solar generation, 31% from wind, and 15% from hydropower. Because natural gas often is the marginal fuel in determining wholesale electricity prices, higher natural gas prices tend to make renewable generation more competitive. Solar generation, which is available during the day to meet peak demand and can

LCOE = levelized cost of electricity -
LACE = levelized avoided cost of electricity

In comparisons of two new plants using different technologies, LCOE may not account for differences in the grid services each is providing. For example, nuclear plants and natural gas combined-cycle plants both provide baseload services to the grid and thus have similar LACE values, even if their LCOE values differ. By 2040, the LACE range for most technologies is expected to shift upward, indicating the increasing value of new generation to the grid as demand for new sources grows. Wind plants have increased generation during the night (when the demand for and value of electricity typically are low) and thus provide a limited contribution to system reliability reserves. Solar PV plants produce most of their energy during the middle of the day, when higher demand increases the value of electricity. Consequently, in 2040, the upper bound of LACE for solar PV generation, at 55.7-80.3 dollars/megawatthour (MWh), is higher than the upper bound of LACE for wind (50.6-65.3 dollars/MWh). In 2022, the lower bound of LCOE without tax credits for solar PV generation (not shown) is generally much higher than the lower bound for generation with tax credits, although available tax credits close the gap in some regions. In 2040, the LCOE and LACE ranges for solar PV are overlapping, even without the 10% investment tax credit that, under current law, would be available for solar PV in 2040.

With Clean Power Plan, power plant coal use and sulfur dioxide emissions decline in the Reference case

Figure MT-40. Coal consumption (quadrillion Btu) and sulfur dioxide emissions (million short tons) in the Reference and No CPP cases, 2005–40



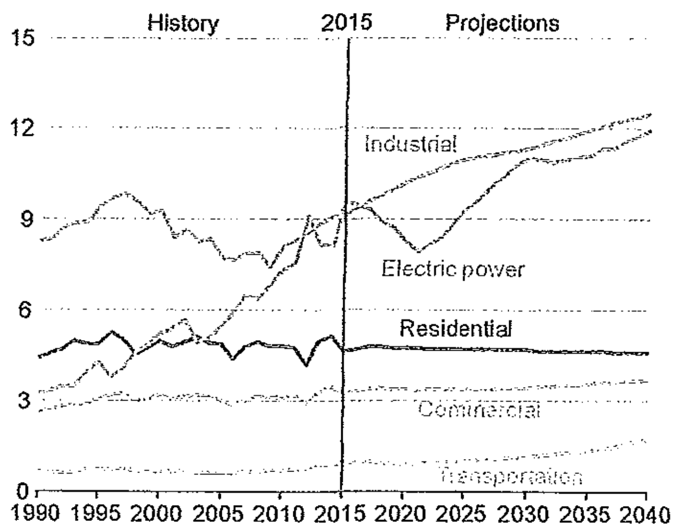
Sulfur dioxide (SO2) emissions from electricity generation have declined with reduced coal use. In 2016, SO2 emissions are expected to fall by nearly two-thirds from 2015 levels with the lapse of extended deadlines for compliance with the Mercury and Air Toxics Standards (MATS) for almost all generating units in April 2016. The MATS rule requires that any coal-fired power plant in operation after the deadline must be retrofitted to control mercury and acid gases with either dry sorbent injection or flue-gas desulfurization (scrubbing) equipment, which also removes 70%-90% of SO2 emissions. Although the Cross-State Air Pollution Rule (CSAPR) is still in effect and covers SO2 emissions from these units, the more stringent reduction requirements under MATS render CSAPR irrelevant.

For some generators, the prospect of meeting MATS compliance requirements is uneconomical, based on cost recovery with likely lower operating rates for retrofitted coal units in a market driven by lower natural gas prices. Even in the No CPP case, a cumulative total of 40 gigawatts (GW) of coal-fired capacity is retired by 2016 and 57 GW by 2020. Utility sector coal use increases slightly from 2016-20 with increased utilization, but SO2 emissions are largely unchanged as a result of high levels of SO2 removal with newly installed retrofits and remain at about the same level through 2040.

In the AEO2016 Reference case, which includes the requirement for power plants in each state to lower CO2 emissions beginning in 2022, retirements continue to a cumulative total of 92 GW in 2030 and to nearly 100 GW in 2040. As a result, utility coal consumption in the Reference Case falls by approximately 35%, from 14.3 quadrillion Btu in 2020 to 9.4 quadrillion Btu in 2040 (Figure MT-40). SO2 emissions also fall by about one-third, from 1.2 million tons in 2020 to 0.8 million tons in 2040.

Electric power sector accounts for 35% of U.S. natural gas consumption in 2040

Figure MT-41. Natural gas consumption by sector in the Reference case, 1990–2040 (trillion cubic feet)



Total U.S. natural gas consumption grows from 27.5 trillion cubic feet (Tcf) in 2015 to 34.4 Tcf in 2040 in the AEO2016 Reference case (Figure MT-41). Consumption of natural gas for electric power generation increases by 2.4 Tcf, accounting for 34% of the total increase. Natural gas consumption was at a record high in 2015, which resulted primarily from low natural gas prices and the retirement of coal-fired capacity. In the Reference case, natural gas use for electricity generation declines from 2015-21 as a result of rising natural gas prices and increasing use of renewable fuels. With implementation of the Clean Power Plan starting in 2022, as well as the reduction