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Annual Energy Outlook 2020: Case Descriptions

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Overview

Factors such as economic growth, future oil prices, the ultimate size of domestic energy resources, and technological change are often uncertain. To illustrate some of these uncertainties, EIA runs side cases to show how the model responds to changes in key input variables compared with the Reference case. The various cases covered in the *Annual Energy Outlook 2020* (AEO2020) are described in this document. AEO2020 has seven core cases:

- Reference
- High Economic Growth
- Low Economic Growth
- High Oil Price
- Low Oil Price
- High Oil and Gas Supply
- Low Oil and Gas Supply

EIA also introduces two new cases to capture uncertainty around the cost of electricity generated from renewable sources:

- High Renewables Cost
- Low Renewables Cost

Table 5 provides the formal case names, scenario names, and date keys. Results for all AEO2020 cases are available on the AEO table browser.

Because AEO2020 is a full edition of the AEO, EIA ran additional cases to support *Issues in Focus* analyses, which will be released later this year. The topics of these analyses are

- Alternative policies—cases analyzing renewable portfolio standards, the Affordable Clean Energy Rule, possible carbon allowance fees, and the amount paid for electricity generated by end users and sold to the grid
- Global natural gas demand

Macroeconomic growth cases

The Low Economic Growth and High Economic Growth cases were developed to reflect the uncertainty in projections of economic growth. These cases show the effects of alternative growth assumptions that are higher than and lower than the Reference case energy market projections. In the economic growth cases, population and nonfarm labor productivity growth assumptions are altered, yielding changes in the growth of nonfarm employment, real disposable income, and real gross domestic product (GDP), among other macroeconomic effects. Table 1 shows average annual growth rates of these model parameters in the Reference case and in the macroeconomic side cases.

Table 1. Macroeconomic growth rates in the AEO2020 Low Economic Growth, Reference, and High Economic Growth cases

Compound annual growth rate, 2019–2050	Low Economic Growth case	Reference case	High Economic Growth case
Population	0.4%	0.5%	0.7%
Nonfarm labor productivity	1.2%	1.5%	1.9%
Nonfarm employment (labor force)	0.3%	0.5%	0.8%
Real disposable income per capita	1.4%	1.6%	1.8%
Real gross domestic product	1.4%	1.9%	2.4%

Oil price cases

Different expectations about long-term future oil prices can significantly affect the energy system. The AEO considers three oil price cases (Reference, Low Oil Price, and High Oil Price) to assess the impacts of alternative views on the future course of oil prices. The benchmark world crude oil price in the AEO is based on historical spot prices for North Sea Brent crude oil, which is an international standard for light, sweet crude oil prices. Data tables also include West Texas Intermediate (WTI) prices—a critical reference point for the value of crude oil production in the U.S. Midcontinent—as well as the refiner's acquisition cost for imported crude oil.

The Reference case Brent spot price path is based on an increasing trend projection for both global oil supply and demand, with crude oil prices rising steadily across the projection period. Global petroleum and other liquids consumption increases steadily throughout the Reference case, in part because of an increase in the number of vehicles across the world—which is offset somewhat by improvements in light-duty vehicle (LDV) and heavy-duty vehicle (HDV) fuel economy in developing countries and increased natural gas consumption for transportation in most regions. Economic growth is steady during the projection period. The industrial sector also uses some substitutes for liquid fuels.

The Low and High Oil Price cases encompass a wide range of potential price paths, illustrating potential variation in global demand for and supply of petroleum and other liquid fuels. The Low Oil Price case assumes conditions under which foreign (global, excluding the United States) liquids demand is lower and supply is higher than in the Reference case, and the High Oil Price case assumes the opposite. Note that assumptions about U.S. supply and demand remain the same across the cases, and U.S. liquids production and consumption respond only to changes in prices.

In the Low Oil Price case, relatively low foreign demand occurs as a result of several assumptions:

- Economic growth that is relatively slow compared with historical trends, especially in the countries outside of the Organization for Economic Cooperation and Development (OECD)
- Reduced consumption in developed countries as a result of adopting more efficient technologies, extending Corporate Average Fuel Economy (CAFE) standards, lowering travel demand, and increasing consumption natural gas or electricity
- Efficiency improvements in nonmanufacturing industries in the non-OECD countries
- Industrial fuel switching from liquids to natural gas feedstocks for methanol and ammonia production

The Low Oil Price case also assumes higher supply than in the Reference case, as producers face lower costs of production for both crude oil and other liquids production technologies. With lower demand and higher supply, prices remain lower in the Low Oil Price case than in the Reference case throughout the projection period, but the impacts on global quantities produced and consumed are muted because the demand and supply effects somewhat offset each other at equilibrium.

In the High Oil Price case, these assumptions are largely reversed. Liquid fuel demand is higher as a result of higher economic growth, particularly in non-OECD countries, than in the Reference case. In

non-OECD countries, consumers demand greater personal mobility and consume more goods. Fewer efficiency gains occur in the industrial sector, while growing demand for fuel in the non-manufacturing sector continues to be fulfilled with liquid fuels. Liquids supply decreases as a result of a lack of global investment in the oil sector, which eventually leads to higher production from non-Organization of the Petroleum Exporting Countries (OPEC) producers relative to the Reference case. Higher prices stimulate increased production of more costly resources, including tight/shale oil and bitumen, and also lead to significant increases in production of renewable liquid fuels, gas-to-liquids, and coal-to-liquids compared with the Reference case.

Table 2 shows assumptions of the Brent crude oil benchmark price in the most recent historical year and in the first and last years of the projection period for both oil price cases and the Reference case.

Table 2. AEO2020 Brent oil prices in selected years in both oil price cases and the Reference case (2019 dollars per barrel)

2019 dollars per barrel	2019	2020	2050
High Oil Price case		$87.61	$183.11
Reference case	$63.37	$58.51	$104.98
Low Oil Price case		$38.01	$46.28

Oil and gas supply cases

Estimates of technically recoverable tight/shale oil and natural gas resources are particularly uncertain and change over time as new information is gained through drilling, production, and technology experimentation. During the past decade, as more tight/shale oil formations have gone into production, estimates of technically recoverable tight/shale oil and natural gas resources have generally increased. However, these increases in technically recoverable resources (TRR) are based on many assumptions that might not apply over the long term or over the entire tight/shale formation. For example, some resource estimates may assume that crude oil and natural gas production rates achieved in one portion of the formation represent the entire formation, even though neighboring well production rates can vary greatly. In addition, the tight/shale formation can differ significantly across the petroleum basin with respect to depth, thickness, porosity, carbon content, pore pressure, clay content, thermal maturity, and water content. Technological improvements and innovations may also result in the development of crude oil and natural gas resources that have not been identified yet, and therefore they are not included in the Reference case.

The sensitivity of the AEO projections to changes in assumptions regarding domestic crude oil and natural gas resources and technological progress is examined in two side cases. These side cases are included to provide a framework to examine the effects of higher and lower domestic supply on energy demand, imports, and prices. Assumptions associated with these cases are described below.

In the Low Oil and Gas Supply case (formerly known as the Low Oil and Gas Resource and Technology case), the estimated ultimate recovery per well is assumed to be 50% lower than in the Reference case for

- Tight oil
- Tight gas
- Shale gas in the United States
- Undiscovered resources in Alaska
- Offshore Lower 48 states

Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% lower than in the Reference case. These assumptions increase the per-unit cost of crude oil and natural gas development in the United States.

In the High Oil and Gas Supply case (formerly known as the High Oil and Gas Resource and Technology case), the estimated ultimate recovery per well is assumed to be 50% higher than in the Reference case for

- Tight oil
- Tight gas
- Shale gas in the United States
- Undiscovered resources in Alaska
- Offshore Lower 48 states

Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% higher than in the Reference case. In addition, tight oil and shale gas resources are added to reflect new prospects or the expansion of known prospects. Crude oil pipeline and export capacity in the Liquid Fuels Markets Module (LFMM) is assumed to increase in the projection period to accommodate higher levels of domestic oil production.

Table 3. AEO2020 unproved technically recoverable resource assumptions at the start of 2018

Case	Oil (billion barrels)	Natural gas (trillion cubic feet)
High Oil and Gas Supply case	483	3,554
Reference case	302	2,390
Low Oil and Gas Supply case	172	1,351

Renewables cost cases

For AEO2020, EIA introduces two new cases to address uncertainty of future costs of renewable power generation technologies: one assuming renewables costs that are higher than those in the Reference case and another assuming renewables costs that are lower.

In the High Renewables Cost case, the overnight capital cost is held constant at the 2019 level throughout the projection period for all renewable technologies, including conventional hydropower, in the electric power sector and for small wind and solar technologies in the end-use sectors.

In the Low Renewables Cost case, overnight capital costs, operating and maintenance (O&M) costs, and fuel prices, where applicable, are assumed to decline more rapidly than in the Reference case, reaching levels 40% lower than their Reference case equivalents by 2050 for all renewable generation technologies (wind, solar, conventional hydropower, biomass, geothermal, and municipal solid waste), including in end-use applications. Other assumptions within the National Energy Modeling System (NEMS) are unchanged from the Reference case. Similarly, solar photovoltaics (PV) and small wind equipment, installation, and fixed O&M costs in the end-use sectors are 40% lower than those in the Reference case by 2050.

Alternative policy cases

The AEO Reference case generally assumes that existing laws and regulations remain as enacted throughout the projection period, including sunset dates or other specific changes over time that are written into the laws or regulations. Therefore, the Reference case serves as a starting point for analysis of possible changes in legislation or regulations. The cases in this section analyze the effects of recently enacted legislation and assumed future changes to laws and regulations that have a history of being extended beyond their legislated sunset dates or that call for periodic updates beyond current standard levels. EIA plans to publish an *Issues in Focus* article later in 2020 that discusses these projections and will provide a complete description of these cases.

No Affordable Clean Energy Rule case

The AEO2020 Reference case includes the No Affordable Clean Energy (ACE) Rule, which the U.S. Environmental Protection Agency issued in June 2019 to establish guidelines for states developing plans to limit carbon dioxide emissions at their coal-fired power plants. AEO2020 reflects this program in its projections by requiring all coal plants with the potential to improve plant heat rates to undertake these projects or retire by 2025. As a sensitivity case, the No ACE Rule case assumes that the existing ACE rule is not implemented and that all coal-fired power plants continue to operate at their current efficiency levels if economic to do so.

Carbon-Free Generation Standard case

The Carbon-Free Generation Standard case assumes that all 50 states achieve at least 50% of electricity sales by 2050 using a suite of generation technologies that emit little to no net carbon dioxide, including

- Nuclear
- Existing large scale and new hydropower
- Fossil-fuel generation with carbon capture and sequestration
- Geothermal
- Biomass
- Municipal solid waste
- Solar PV
- Solar thermal
- Onshore wind
- Offshore wind

States that currently have a renewable portfolio standard (RPS), clean energy standard (CES), or similar policy designed to reach at least that level of carbon-free generation maintain their existing targets with no change. Other states with such policies continue until the terminal target year and then switch to a path that achieves the 50% generation standard by 2050. Finally, states that do not currently have any such policy, including states that had a terminal target year before 2020, are assumed to adopt a 50% generation by 2050 standard using the suite of generation technologies specified above.

Utility rate structure cases

In the Reference case, residential end users who sell electricity to the grid are compensated at the retail electricity rate. The utility rate structure cases assume all net distributed solar PV generation (excluding generation consumed onsite) are compensated at the wholesale or marginal price of electricity. The primary Utility Rate Structure case will use Reference case assumptions, except for the change to compensation for residential solar PV generation. Other sensitivity cases will apply the change in compensation for residential solar PV generation to various core side cases covered in AEO2020.

Carbon fee case

The three carbon fee cases assume economy-wide implementation of a carbon allowance fee starting in 2021 and increasing at 5% (real) per year. Emissions revenues are distributed back to consumers via lump-sum payments, keeping government deficit neutral. Table 4 shows the allowance fees in the first year of the program and in the last projection year.

Table 4. Economy-wide carbon dioxide emissions prices in the AEO2020 carbon fee side cases (2019 dollars per metric ton of carbon dioxide)

Case	2021	2050
$15 Carbon Fee case	$15.00	$61.74
$25 Carbon Fee case	$25.00	$102.90
$35 Carbon Fee case	$35.00	$144.06

Global natural gas demand cases

Analyses prepared for the *International Energy Outlook 2019* (IEO2019) identified long-term uncertainty in the global supply and demand for natural gas. The projections in the AEO2020 Reference case for exports of liquefied natural gas (LNG) depend on IEO2019's projections of

- Demand for natural gas in OECD Europe and in Asia
- Natural gas production in Asia
- Global supply of flexible LNG (defined as the LNG volumes that do not have a destination clause and can be delivered to any demand market)

Because U.S. natural gas production growth is largely supported by increased natural gas exports, EIA developed sensitivity cases for AEO2020 to create a range of levels of U.S. LNG exports to understand the effects they may have on U.S. natural gas markets.

EIA constructed the high and low global LNG side cases by varying three assumptions:

- Natural gas demand in Asia (Japan, South Korea, India, China, and non-OECD Asia)
- Natural gas production in Asia
- Global flexible LNG supply

EIA will provide a complete discussion of these side cases and their construction with the publication of the *Issues in Focus* article discussing these projections.

Summary of AEO2020 cases

Table 5a. Summary of AEO2020 cases (released January 29, 2020)

Case name	Scenario name	Datekey
Reference	ref2020	d112119a
Low Economic Growth	Lowmacro	d112619a
High Economic Growth	Highmacro	d112619a
Low Oil Price	lowprice	d112619a
High Oil Price	highprice	d112619a
Low Oil and Gas Supply	lowogs	d112619a
High Oil and Gas Supply	highogs	d112619a
Low Renewables Cost	lorencst	d120119a
High Renewables Cost	hirencst	d112619a

Table 6b. Summary of AEO2020 cases (to be released later in 2020)

Case name	Release date
No Affordable Clean Energy Rule	March 5, 2020
Renewable Portfolio Standard Extension	March 5, 2020
$15 Carbon Dioxide Allowance Fee	March 5, 2020
$25 Carbon Dioxide Allowance Fee	March 5, 2020
$35 Carbon Dioxide Allowance Fee	March 5, 2020
Utility Rate Structure	March 5, 2020
High Global LNG Demand	Later in 2020
Low Global LNG Demand	Later in 2020