



Independent Statistics & Analysis
U.S. Energy Information
Administration

Annual Energy Outlook 2021: Case Descriptions

February 2021



This report was prepared by the U.S. Energy Information Administration (EIA), the statistical and analytical agency within the U.S. Department of Energy. By law, EIA's data, analyses, and forecasts are independent of approval by any other officer or employee of the U.S. Government. The views in this report therefore should not be construed as representing those of the U.S. Department of Energy or other federal agencies.

Table of Contents

Overview 1

Summary of AEO2021 cases 2

Macroeconomic growth cases 3

Oil price cases 4

Oil and gas supply cases..... 6

Renewables cost cases..... 8

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 2021* (AEO2021) are described in this document. AEO2021 has nine 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
- High Renewables Cost
- Low Renewables Cost

Table 1 provides the formal case names, scenario names, and date keys. Results for all AEO2021 cases are available in the [AEO table browser](#).

Summary of AEO2021 cases

Table 1. Summary of AEO2021 cases (released February 3, 2021)

Case name	Scenario name	Datekey
Reference	ref2021	d113020a
Low Economic Growth	lowmacro	d113020a
High Economic Growth	highmacro	d113020a
Low Oil Price	lowprice	d113020a
High Oil Price	highprice	d113020a
Low Oil and Gas Supply	lowogs	d113020a
High Oil and Gas Supply	highogs	d120120a
Low Renewables Cost	lorencst	d113020a
High Renewables Cost	hirencst	d113020a

Macroeconomic growth cases

The Low Economic Growth case and High Economic Growth case were developed to reflect the uncertainty in projections of economic growth. These cases show the effects of alternative economic 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 2 shows the average annual growth rates of these model parameters in the Reference case and in the macroeconomic side cases.

Table 2. Macroeconomic growth rates in the AEO2021 Low Economic Growth, Reference, and High Economic Growth cases

Compound annual growth rate, 2020–2050	Low Economic Growth case	Reference case	High Economic Growth case
Population	0.4%	0.5%	0.8%
Nonfarm labor productivity	1.1%	1.6%	2.1%
Nonfarm employment	0.6%	0.9%	1.0%
Real disposable income per capita	0.9%	1.3%	1.3%
Real gross domestic product	1.6%	2.1%	2.6%

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 Brent spot price path in the Reference case is based on a projection that both global oil supply and demand will increase in the projection period and that crude oil prices will also rise steadily across the projection period. Global petroleum and other liquid fuels consumption increases steadily throughout the Reference case, in part because of an increase in the number of vehicles globally—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) liquid fuels 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. liquid fuels 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 of natural gas or electricity
- Efficiency improvements in nonmanufacturing industries in the non-OECD countries
- Industrial fuel switching from liquid fuels 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 liquid fuels 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 nonmanufacturing sector continues to be fulfilled with liquid fuels. Liquid fuels supply decreases as a result of a lack of global investment in the oil sector, which eventually leads to higher production in countries outside of the Organization of the Petroleum Exporting Countries (OPEC) relative to the Reference case. Higher prices stimulate increased production of more costly resources, including tight/shale oil and bitumen, and they also lead to significant increases in production of renewable liquid fuels, gas-to-liquids, and coal-to-liquids compared with the Reference case.

Table 3 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 3. AEO2021 Brent oil prices in selected years in both oil price cases and the Reference case (2020 dollars per barrel)

2020 dollars per barrel	2020	2021	2050
High Oil Price case		\$76.03	\$173.26
Reference case	\$41.19	\$46.58	\$94.97
Low Oil Price case		\$29.90	\$47,56

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 in the long term or for 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 developing crude oil and natural gas resources that have not been identified yet, and therefore, they are not included in the Reference case.

Two AEO side cases examine the AEO projections' sensitivity to changes in assumptions regarding domestic crude oil and natural gas resources and technological progress (Table 4). 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.

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, and shale gas in the Lower 48 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, and shale gas in the Lower 48 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 Market Module (LFMM) is assumed to increase in the projection period to accommodate higher levels of domestic oil production.

Table 4. AEO2021 unproved technically recoverable resource assumptions at the start of 2019

Case	Oil (billion barrels)	Natural gas (trillion cubic feet)
High Oil and Gas Supply case	460	3,543
Reference case	304	2,392
Low Oil and Gas Supply case	171	1,326

Renewables cost cases

To address the uncertainty in the future costs of renewable power generation technologies, AEO2021 provides two cases: 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 2020 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 (in other words, wind, solar, conventional hydropower, biomass, geothermal, and municipal solid waste) in the power sector. 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. Other assumptions within the National Energy Modeling System (NEMS) are unchanged from the Reference case.