Independent Statistics and Analysis
U.S. Energy Information Administration

# Annual Energy Outlook 2025

April 2025

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# Introduction

The *Annual Energy Outlook* 2025 (AEO2025) explores potential long-term energy trends in the United States. AEO2025 is published in accordance with Section 205c of the Department of Energy Organization Act of 1977 (Public Law 95-91), which requires the Administrator of the U.S. Energy Information Administration (EIA) to prepare an annual report that contains trends and projections of energy consumption and supply. These projections are used by federal, state, and local governments; industry; trade associations; and other planners and decisionmakers in the public and private sectors.

We prepared the AEO by using the National Energy Modeling System (NEMS) to project a set of scenarios that, taken together, represent a range of outcomes for the U.S. energy system. AEO2025 represents the culmination of a year-long effort that enabled major upgrades to NEMS.

Our policy assumptions are central to understanding our AEO2025 projections. In most of the cases we model, we only consider laws and regulations implemented as of December 2024. As is the case every time we prepare an AEO, a cutoff date is necessary to enable us to conclude our modeling and integrate the final results for publication. Therefore, legislation, regulations, executive actions, and court rulings after that date are not included. We are releasing the model results without a lengthy market analysis this year.

The U.S. energy system underwent major changes in the first quarter of the 21st century as oil and natural gas production surged, renewables were deployed more widely, and energy consumption patterns changed. AEO2025 can help stakeholders examine the ways in which the system could further change through 2050.

Energy markets are complex. Energy models are simplified representations of energy production and consumption, laws and regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development. These results are not predictions of what will happen. Instead, AEO2025 results represent modeled projections of what could happen given certain assumptions and methodologies.

Consistent with our historical practices and statutory mission, we do not independently propose or advocate future legislative and regulatory changes, although at times we do analyze scenarios based on existing policy proposals. Our assumptions documents provide additional details on the assumptions we included in AEO2025, and an overview of the laws and regulations included in AEO2025 is available on the AEO website.

AEO2025's projections reflect business-as-usual trends, given known technological and demographic trends and current laws and regulations, and so provides a policy-neutral Reference case and an accompanying set of core side cases that can be used to analyze policy initiatives. For some readers, this approach may be unsatisfying because policy rarely remains static for long periods. But the purpose of basing projections on laws and regulations as of December 2024 is to provide a comparison point for further analysis; without such a reference point, critical information about incremental changes to energy system outcomes based on new assumptions is lost.

Because policies can have meaningful impacts on the energy sector, we have also included two alternative policy cases this year to help stakeholders to examine the effects of regulations implemented since our last AEO. When compared with the Reference case, one case allows stakeholders to examine the effects of recent regulations on power plants and the other recent regulations targeting vehicle fuel economy and emissions.

# Modeled Cases

Outcomes concerning future technology, demographics, and resources cannot be known with any degree of certainty. We address many key uncertainties in our projections through alternative cases. In AEO2025, we ran 11 cases to model a range of assumptions. In addition to the two alternative policy cases we examined this year, we also include eight core side cases, which we have presented in prior releases of the AEO. A detailed explanation of each case is available on the website, and a brief description is in the following sections.

## AEO2025 Reference case

Our Reference case assesses how the U.S. energy markets could operate under laws and regulations current as of December 2024 and under historically observed technological growth assumptions.

## Alternative Electricity case

Our Alternative Electricity case assumes the Clean Air Act (CAA) Section 111 rule implemented by the Environmental Protection Agency (EPA) in April 2024 to regulate carbon dioxide emissions from new gas-fired combustion turbines and existing coal, oil, and gas-fired steam generating units is not in place, and the affected generators are able to operate under rules existing prior to April 2024. In this case, existing coal-fired plants continue operating without requiring modifications to reduce emissions, and generation from new natural gas-fired combined cycle units isn't constrained based on whether the plant has installed carbon capture equipment.

## Alternative Transportation case

Our Alternative Transportation case assumes the National Highway Traffic Safety Administration's Corporate Average Fuel Economy standards and EPA's vehicle tailpipe emission standards for model years 2027–2032 are not in place. The case also assumes the California Air Resources Board's zero-emission vehicle sale mandates for trucks issued since our last published AEO are not in place. Rules affecting fuel economy and tailpipe emissions that were issued for model years 2026 and earlier remain in place. In this case, introduction of new electric vehicle (EV) models and building of EV charging infrastructure are based on growth in EV sales and registrations rather than on announced public and private sector plans. In addition, manufacturer reshoring of EV and battery supply chains, including growth in eligibility for credits under the Inflation Reduction Act, is slower than in the Reference case.

## High and Low Oil Price cases

In the High Oil Price case, the price of Brent crude oil increases to $157 per barrel (b) in 2050, compared with $91/b in the Reference case and $48/b in the Low Oil Price case.

### High and Low Oil and Gas Supply cases

The High Oil and Gas Supply case assumes ultimate recovery for new tight oil, tight gas, or shale gas wells are 50% higher than in the Reference case. The case also assumes 50% higher undiscovered resources in Alaska and offshore fields. Technological improvement is assumed to be 50% faster. The Low Oil and Gas Supply case assumes the converse.

### High and Low Zero-Carbon Technology Cost cases

The Low Zero-Carbon Technology Cost case assumes faster cost declines for electricity-generating technologies that produce zero emissions as construction and manufacturing experience grows, resulting in 40% lower costs than in the Reference case in 2050. The High Zero-Carbon Technology Cost case, conversely, assumes no additional cost reductions from learning with additional deployment of these electricity generating technologies.

### High and Low Economic Growth cases

The High Economic Growth case assumes the compound annual growth rate for U.S. GDP is 2.1% through 2050, and the Low Economic Growth case assumes a 1.2% rate. By contrast, the Reference case assumes the U.S. GDP annual growth rate is 1.8% over the projection period.

## Major Changes for AEO2025

In 2024 we made significant updates to NEMS, and an overview of the changes can be found in our assumptions documents and in the module-specific fact sheets. Briefly, the model that underpins our outlook now includes three new modules:

- The Hydrogen Market Module, which represents hydrogen production and pricing, including the impacts of policy, storage, and logistics
- The Carbon Capture, Allocation, Transportation, and Sequestration Module, which allocates projected supply of captured $CO_2$ across the energy system either for enhanced oil recovery or storage
- The Hydrocarbon Supply Module, which improves the representation of upstream oil and natural gas resources, replacing the legacy NEMS Oil and Gas Supply Module

In addition to the new modules, we have extensively enhanced many existing modules to better reflect market dynamics and emerging technologies. We will provide additional details in the AEO2025 model documentation in the coming months.

We have rewritten and modernized significant portions of the NEMS code base. The source code associated with NEMS is now available via GitHub under an open-source license.

In addition to changes to NEMS, we also updated the way we calculate primary energy consumption of electricity generation from noncombustible renewable energy sources such as solar, wind, hydroelectric, and geothermal. We now calculate consumption of noncombustible renewable energy for electricity generation using the *captured energy approach*, which applies a constant conversion factor of 3,412 British thermal units per kilowatthour (Btu/kWh), using the heat content of electricity. This approach is a

change from our previous  methodology, called the *fossil fuel equivalency approach*, and is consistent with the methodology now used for all EIA products and reports.

The captured energy approach is more consistent with international energy statistics standards than the fossil fuel equivalency approach.