AEO2014 Early Release Overview

Executive summary

Projections in the *Annual Energy Outlook 2014 (AEO2014)* Reference case focus on the factors that shape U.S. energy markets through 2040, under the assumption that current laws and regulations remain generally unchanged throughout the projection period. The early release provides a basis for the examination and discussion of energy market trends and serves as a starting point for analysis of potential changes in U.S. energy policies, rules, or regulations or possible technology breakthroughs. Readers are encouraged to review the full range of cases that will be presented when the complete *AEO2014* is released in 2014, exploring key uncertainties in the Reference case.

Major highlights of the *AEO2014* Reference case include:

Growing domestic production of natural gas and crude oil continues to reshape the U.S. energy economy, with crude oil production approaching the historical high achieved in 1970 of 9.6 million barrels per day

Ongoing improvements in advanced technologies for crude oil and natural gas production continue to lift domestic supply and reshape the U.S. energy economy. Domestic production of crude oil (including lease condensate) increases sharply in the *AEO2014* Reference case, with annual growth averaging 0.8 million barrels per day (MMbbl/d) through 2016, when it totals 9.5 MMbbl/d (Figure 1). While domestic crude oil production is expected to level off and then slowly decline after 2020 in the Reference case, natural gas production grows steadily, with a 56% increase between 2012 and 2040, when production reaches 37.6 trillion cubic feet (Tcf).The full *AEO2014* will include cases that represent alternative oil and natural gas resource and technology assumptions.

Low natural gas prices boost natural gas-intensive industries

Industrial shipments grow at a 3.0% annual rate over the first 10 years of the projection and then slow to 1.6% annual growth for the rest of the projection. Bulk chemicals and metals-based durables account for much of the increased growth in industrial shipments in *AEO2014*. Industrial shipments of bulk chemicals, which benefit from an increased supply of natural gas liquids, grow by 3.4% per year from 2012 to 2025 in *AEO2014*, as compared with 1.9% in the *Annual Energy Outlook 2013 (AEO2013)* Reference case. The projection assumes growing competition from abroad that flattens output growth in energy-intensive industries after 2030.

The higher level of industrial shipments leads to more natural gas consumption (including lease and plant fuel) in the U.S. industrial sector, increasing from 8.7 quadrillion British thermal units (Btu) in 2012 to 10.6 quadrillion Btu in 2025 in *AEO2014*, compared to 9.8 quadrillion Btu in 2025 in *AEO2013*.

Light-duty vehicle energy use declines sharply, reflecting slow growth in vehicle miles traveled and accelerated improvement in vehicle efficiency

AEO2014 includes a new, detailed demographic profile of driving behavior by age and gender as well as new lower population growth rates based on updated U.S. Census Bureau projections. As a result, annual increases in vehicle miles traveled (VMT) for light-duty vehicles (LDVs) in the *AEO2014* Reference case average 0.9% from 2012 to 2040, compared to 1.2% per year in *AEO2013* over the same period. The rising fuel economy of LDVs more than offsets the modest growth in VMT, and LDV energy consumption declines in the *AEO2014* Reference case from 16.0 quadrillion Btu in 2012 to 12.1 quadrillion Btu in 2040, as compared with the *AEO2013* total of 13.0 quadrillion Btu in 2040 (Figure 2). The full *AEO2014* will include an Issues in Focus discussion of VMT projections that addresses the implications of alternative VMT scenarios.

Figure 1. U.S. petroleum and other liquid fuels supply by source, 1970-2040 (million barrels per day)
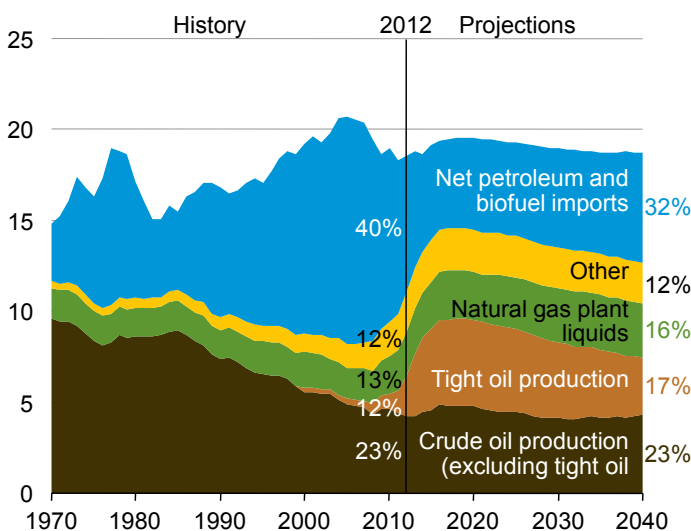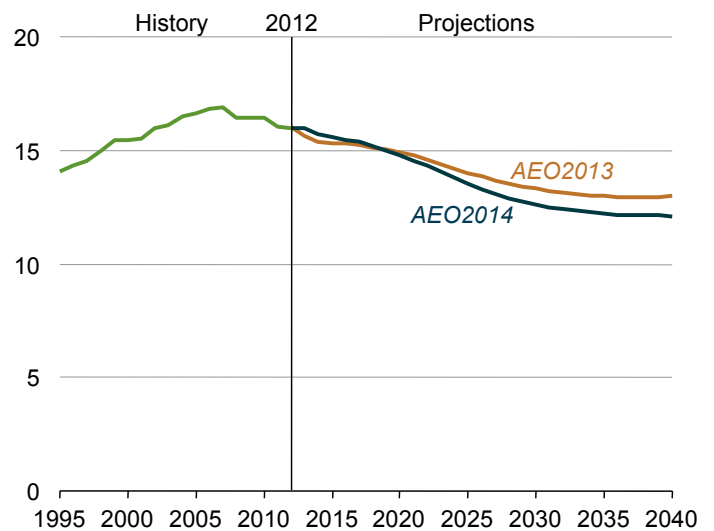

Figure 2. Energy consumption by light-duty vehicles in the United States, *AEO2013* and *AEO2014*, 1995-2040 (quadrillion Btu)

Natural gas overtakes coal to provide the largest share of U.S. electric power generation

Projected low prices for natural gas make it a very attractive fuel for new generating capacity. In some areas, natural gas-fired generation replaces generation formerly supplied by coal and nuclear plants. In 2040, natural gas accounts for 35% of total electricity generation, while coal accounts for 32% (Figure 3). Generation from renewable fuels, unlike coal and nuclear power, is higher in the *AEO2014* Reference case than in *AEO2013*. Electric power generation with renewables is bolstered by legislation enacted at the beginning of 2013 extending tax credits for various renewable technologies; which was passed after the *AEO2013* Reference case had been completed, but was considered in an alternative case in *AEO2013*. The full *AEO2014* will include a variety of cases addressing the implications of alternative market conditions and policies for the electricity generation mix.

Higher natural gas production also supports increases in exports of both pipeline and liquefied natural gas

In addition to increases in domestic consumption in the industrial and electric power sectors, U.S. exports of natural gas also increase in the *AEO2014* Reference case (Figure 4). U.S. exports of liquefied natural gas (LNG) increase to 3.5 Tcf in 2029 and remain at that level through 2040. Pipeline exports of U.S. natural gas to Mexico grow by 6% per year, from 0.6 Tcf in 2012 to 3.1 Tcf in 2040, and pipeline exports to Canada grow by 1.2% per year, from 1.0 Tcf in 2012 to 1.4 Tcf in 2040. Over the same period, U.S. pipeline imports from Canada fall by 30%, from 3.0 Tcf in 2012 to 2.1 Tcf in 2040, as more U.S. demand is met by domestic production. Projected exports are sensitive to assumptions regarding conditions in U.S. and global natural gas markets. The full *AEO2014* will include cases that illustrate the sensitivity of projected natural gas exports to alternative resource, economic, and price scenarios.

With strong growth in domestic crude oil and natural gas production, U.S. use of imported fuels falls sharply

In the *AEO2014* Reference case, U.S. domestic energy production increases from 79.1 quadrillion Btu in 2012 to 102.1 quadrillion Btu in 2040, and net use of imported energy sources, which was 30% in 2005, falls from 16% of total consumption in 2012 to 4% in 2040. In the *AEO2013* Reference case, domestic energy production reached a total of 98.5 quadrillion Btu, and energy imports is projected to decline as a percentage of consumption to 9% in 2040. The larger increase in domestic energy production in *AEO2014* is primarily a result of higher projections of production of natural gas and biomass/other renewables. Crude oil production (including lease condensate) increases from 13.9 quadrillion Btu in 2012 to a peak of 20.5 quadrillion Btu in 2019 before dropping to 16.0 quadrillion Btu in 2040.

With domestic crude oil production rising to 9.5 MMbbl/d in 2016, the import share of U.S. petroleum and other liquids supply falls to about 25%. Domestic production begins to decline after 2019, and the import share of total petroleum and other liquids supply grows to 32% in 2040, still lower than the 2040 level of 37% in the *AEO2013* Reference case. The alternative cases in the full *AEO2014* will illustrate how different assumptions about resources, markets, and policies can dramatically impact projections of import dependence.

Improved efficiency of energy use in the residential and transportation sectors and a shift away from carbon-intensive fuels for electricity generation keep U.S. energy-related carbon dioxide emissions below their 2005 level through 2040

In the *AEO2014* Reference case, total U.S. energy-related emissions of carbon dioxide (CO_2) remain below the 2005 level in every year through 2040. Projected emissions in 2020 and 2040 are, respectively, about 9% and 7% below the 2005 level.

In *AEO2014*, CO_2 emissions associated with U.S. industrial activity (including CO_2 emissions associated with the generation of electricity used in the industrial sector) begin to surpass emissions from the transportation sector in the middle of the next

Figure 3. Electricity generation from natural gas and coal, 2005-2040 (billion kilowatthours)
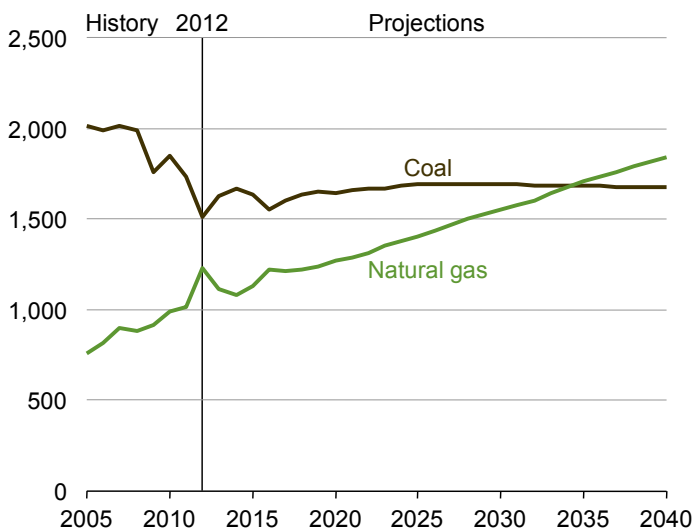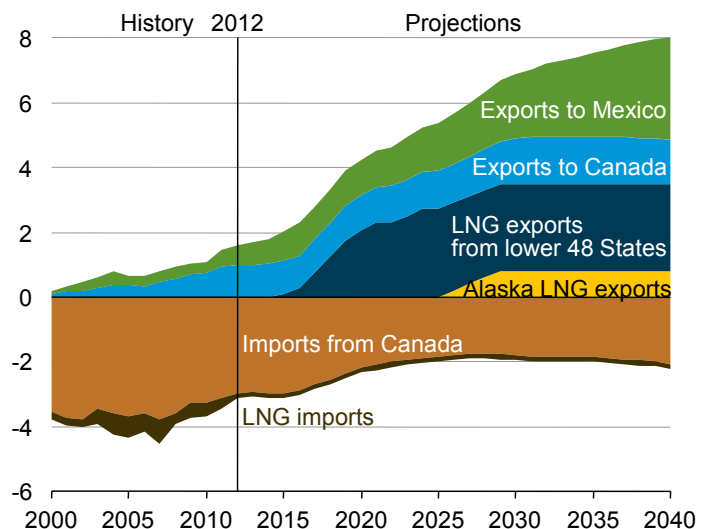

Figure 4. U.S. natural gas imports and exports, 2000-40 (trillion cubic feet)

decade for the first time since the late 1990s. In the transportation sector, as a result of new fuel economy standards, biofuel mandates, and shifts in consumer behavior, emissions from transportation sector use of petroleum and other liquids generally decline or remain stable from 2012 through 2040. Emissions from energy use in the commercial sector increase more rapidly than in the residential sector, and in 2040 emissions from these two sectors are about equal. In the electric power sector, CO_2 emissions from coal combustion decline after 2029 as more power plants are fueled by lower-carbon fuels, including natural gas and renewables. However, the lower level of CO_2 emissions in the electric power sector because of the reduced role for coal is partially offset by less projected generation from nuclear power. Generation from nuclear power in *AEO2014* is 10% below levels in *AEO2013* in 2040 as a result of increased nuclear plant retirements.

Projected growth in real gross domestic product is slightly slower than in AEO2013, but projected per capita GDP and disposable income are higher than in AEO2013 because of a reduced projection for U.S. population growth

Annual growth of real gross domestic product (GDP) from 2012 to 2040 averages 2.4% in the *AEO2014* Reference case, slightly below the *AEO2013* Reference case growth rate over the same period. However, industrial output growth is higher in *AEO2014*, averaging 2.1% per year from 2012 to 2040. Industries that supply equipment for increased natural gas production, as well as industries benefitting from lower natural gas prices, account for much of the higher growth in manufacturing. On a per capita basis, projected annual growth rates for real GDP and disposable income in *AEO2014*, both averaging 1.7% per year, are above the comparable rates in *AEO2013*, reflecting lower projected population growth rate estimates (0.7% in *AEO2014* compared to 0.9% in *AEO2013*) for the 2012-40 period provided by the U.S. Census Bureau.

Introduction

In preparing the *AEO2014* Reference case, the U.S. Energy Information Administration (EIA) evaluated a wide range of trends and issues that could have major implications for U.S. energy markets. This overview presents the *AEO2014* Reference case and compares it with the *AEO2013* Reference case released in April 2013 (see Table 1 on pages 17-18). Because of the uncertainties inherent in any energy market projection, the Reference case results should not be viewed in isolation. Readers are encouraged to review the alternative cases when the complete *AEO2014* publication is released, to gain perspective on how variations in key assumptions can lead to different outlooks for energy markets.

To provide a basis against which alternative cases and policies can be compared, the *AEO2014* Reference case generally assumes that current laws and regulations affecting the energy sector remain unchanged throughout the projection (including the implication that laws that include sunset dates do, in fact, expire at the time of those sunset dates). This assumption clarifies the relationship of the Reference case to other *AEO2014* cases and enables policy analysis with less uncertainty regarding unstated legal or regulatory assumptions.

As in past editions, the complete *AEO2014* will include additional cases, many of which reflect the effects of extending a variety of current energy programs beyond their current expiration dates and the permanent retention of a broad set of programs that currently are subject to sunset provisions. In addition to the alternative cases prepared for *AEO2014*, EIA has examined proposed policies at the request of Congress over the past few years. Reports describing the results of those analyses are available on EIA's website.[1]

Key updates made for the *AEO2014* Reference case include the following:

Macroeconomic

- Revised U.S. Census Bureau population projections.[2] The population projection for 2040 in the *AEO2014* Reference case is almost 6% below the 2040 projection used for the *AEO2013* Reference case. Most of the revision in overall population growth results from a lower projection for net international migration, with younger age groups showing the largest differences from the earlier projection. The slower rate of population growth leads to less labor force growth, which contributes to slower GDP growth.

Residential, commercial, and industrial

- Revised base year residential equipment stocks and energy consumption for space heating, space cooling, and water heating, based on data from EIA's 2009 Residential Energy Consumption Survey (RECS), the most recent data available.[3] Estimates of appliance stocks and energy consumption for several miscellaneous electric loads also were updated, based on a report by Navigant Consulting Inc., to better reflect recent changes and trends in the residential sector.[4]

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[1]See "Congressional & Other Requests," http://www.eia.gov/analysis/reports.cfm?t=138.
[2]The new population projections were released on December 12, 2012. See U.S. Department of Commerce, "U.S. Census Bureau Projections Show a Slower Growing, Older, More Diverse Nation a Half Century from Now" (Washington, DC: December 12, 2012), http://www.census.gov/newsroom/releases/archives/population/cb12-243.html.
[3]U.S. Energy Information Administration, "Residential Energy Consumption Survey (RECS): 2009 RECS Survey Data, Public Use Microdata File (Washington, DC: January 2013), http://www.eia.gov/consumption/residential/data/2009/index.cfm?view=microdata.
[4]Navigant Consulting, Inc., *Analysis and Representation of Miscellaneous Electric Loads in the National Energy Modeling System (NEMS)* (Washington, DC: May 2013), prepared for the U.S. Department of Energy, U.S. Energy Information Administration.

- Updated and expanded representation of miscellaneous electric loads in the commercial sector, as well as personal computers and data center servers, based on the Navigant report, reflecting recent and expected trends in electronics use.[5]

- Updated costs and improved representation of residential lighting applications, including wider representation of light emitting diode (LED) lighting and outdoor lighting, based on the 2009 RECS and two U.S. Department of Energy (DOE) reports.[6, 7]

- Revised handling of the regional efficiency standard for residential furnaces, based on an ongoing legal appeal of the standard. The regional standard scheduled to take effect in 2013 is not included in *AEO2014* because of a court challenge and proposed settlement that would vacate the standard in question and require DOE to develop new residential furnace standards.

- Revised commercial capacity factors governing annual usage of major end-use equipment, based on an EIA-contracted analysis.

- Updated manufacturing sector data to reflect the 2010 Manufacturing Energy Consumption Survey (MECS).[8]

- Revised outlook for industrial production to reflect the effects of increased shale gas production and lower natural gas prices, resulting in faster growth for industrial production and energy consumption. The industries primarily affected include energy-intensive bulk chemicals and primary metals, both of which provide products used by the mining and other downstream industries such as fabricated metals and machinery. The bulk chemicals industry is also a major user of natural gas and, increasingly, hydrocarbon gas liquid (HGL) feedstocks.[9]

- Expanded process flow models for the cement and lime industry and the aluminum industry, allowing technologies based on energy efficiency to be incorporated, as well as enhancement of the cement model to include renewable fuels.

Transportation

- Implemented a new approach to VMT projections for LDVs, based on an analysis of VMT by age cohorts and the aging of the driving population over the course of the projection, which resulted in a significantly lower level of VMT growth after 2018 compared with *AEO2013*. On balance, demographic trends (such as an aging population and decreasing rates of licensing and travel among younger age groups) combine with employment and income factors to produce a 30% increase in VMT from 2012 to 2040 in *AEO2014* compared with 41% growth in *AEO2013*.

- Added LNG as a potential fuel choice for freight rail locomotives and domestic marine vessels, resulting in significant penetration of natural gas as a fuel for freight rail (35% of freight rail energy consumption in 2040) but relatively minor penetration in domestic marine vessels (2% of domestic marine energy consumption in 2040).

- Adopted a new approach for estimating freight travel demand by region and commodity for heavy-duty vehicles (HDVs), rail, and domestic marine vessels, as well as updated fuel efficiencies for freight rail and domestic marine vessels.

- Updated handling of flex-fuel vehicle (FFV) fuel shares to better reflect consumer preferences and industry response. FFVs are necessary to meet the renewable fuels standard (RFS), but the phase-out of corporate average fuel economy (CAFE) credits for their sale, as well as limited demand from consumers, reduces their market penetration.

- Revised attributes for battery electric vehicles—including (1) product availability, (2) electric drive fuel efficiency, and (3) non-battery system costs by vehicle size class, battery size, and added battery cost per kilowatthour based on vehicle power-to-energy ratio for vehicle type—applied to hybrid electric, plug-in hybrid electric, and all-electric vehicles.

Oil and natural gas production and product markets

- Revised network pricing assumptions based on benchmarking of regional natural gas hub prices to historical spot natural gas prices, basing flow decisions on spot prices, setting variable tariffs based on historical spot natural gas price differentials, and estimating the price of natural gas to the electric power sector off a netback from the regional hub prices.[10]

[5]Navigant Consulting, Inc., *Analysis and Representation of Miscellaneous Electric Loads in the National Energy Modeling System (NEMS)* (Washington, DC: May 2013), prepared for the U.S. Department of Energy, U.S. Energy Information Administration.

[6]U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates* (Washington, DC: December 2012), http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf.

[7]U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *2010 U.S. Lighting Market Characterization* (Washington, DC: January 2012), http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.

[8]U.S. Energy Information Administration, "Manufacturing Energy Consumption Survey (MECS): 2010 MECS Survey Data" (Washington, DC: March 19, 2013), http://www.eia.gov/consumption/manufacturing/data/2010/.

[9]Growing production of wet natural gas and lighter crude oil has focused attention on natural gas liquids (NGL). EIA has developed and adopted a neutral term—"hydrocarbon gas liquid" (HGL)—to equate the supply (natural gas plant liquids [NGPL] + liquefied refinery gases [LRG]) and market (NGL + refinery olefins) terms. For example, liquefied petroleum gas (LPG) is currently defined by EIA as ethane, propane, normal butane, and isobutane and their olefins (ethylene, propylene, butylene, and isobutylene). This definition is inconsistent with definitions used by other federal agencies, international organizations, and trade groups, in that it implies that all the products are in a liquid state (ethane typically is not) and are used in the same way (higher-value olefins are used differently). Part of the HGL implementation redefines LPG to include only propane, butane, and isobutane and to exclude ethane and refinery olefins. The tables included in *AEO2014* have been relabeled to conform to this newly adopted definition.

[10]Estimating natural gas prices to the electricity generation sector based on hub prices, rather than the citygate prices as was done in prior years, is a better reflection of current market conditions, in which many large natural gas consumers are outside the citygate.

- Allowed secondary flows of natural gas out of the Middle Atlantic region to change dynamically in the model based on relative prices, which enables a larger volume of natural gas from the Middle Atlantic's Marcellus formation to supply neighboring regions.

- Developed the estimated ultimate recovery of tight oil and shale gas on the basis of county-level data.[11]

- Updated oil and gas supply module that explicitly reports technically recoverable resources of liquids in natural gas, enabling estimation of dry and wet natural gas.

- Improved representation of the dynamics of U.S. gasoline and diesel exports versus U.S. demand, through adoption of endogenous modeling.[12]

- Added representation of the U.S. crude oil distribution system (pipelines, marine, and rail), to allow crude oil imports to go to logical import regions for transport to refineries, which enables crude imports and domestic production to move among refining regions and keeps imports of Canadian crude oil from flowing directly to U.S. Gulf refiners.[13]

- Revised production outlook for nonpetroleum other liquids—gas-to-liquids, coal-to-liquids (CTL), biomass-to-liquids, and pyrolysis[14]—with lower production levels than in *AEO2013*, as more recent experience with these emerging technologies indicates higher costs than previously assumed.[15]

- Revised representation of CO_2-enhanced oil recovery (EOR) that better integrates the electricity, oil and gas supply, and refining modules.[16]

Electric power sector

- Revised approach to reserve margins, which are set by region on the basis of North American Electric Reliability Corporation/ Independent System Operator requirements,[17] and capacity payments, which are calculated as a combination of levelized costs for combustion turbines and the marginal value of capacity in the electricity model.

- Revised handling of spinning reserves, with the required levels set explicitly depending on the mix of generating technologies used to meet peak demand by region, to allow better representation of capacity requirements and costs in regions or cases with high penetration of intermittent loads.

- Revised assumptions concerning the potential for unannounced retirement of nuclear capacity in several regions to better reflect the impact of rising operating costs and low electricity prices. Announced nuclear retirements are already incorporated as planned.

- Updated handling of Mercury and Air Toxics Standards (MATS)[18] covering the electric power sector to reflect potential upgrades of electrostatic precipitators, requirements for plants with dry scrubbers to employ fabric filters, and revised costs for retrofits of dry sorbent injection and fabric filters.

- Updated treatment of the production tax credit (PTC) for eligible renewable electricity generation technologies—consistent with the American Taxpayer Relief Act of 2012 (ATRA) passed in January 2013[19]—including revision of PTC expiration dates for each PTC-eligible technology to reflect the concept of projects being declared "under construction" as opposed to being placed "in service" and extension of the expiration date of the PTC for wind generation projects by one year.

Economic growth

Macroeconomic projections in the *Annual Energy Outlook (AEO)* are trend projections, with no major shocks assumed and with potential growth determined by the economy's supply capability. Growth in aggregate supply depends on increases in the labor force, growth of capital stocks, and improvements in productivity. Long-term demand growth depends on labor force growth,

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[11]After accounting for infrastructure constraints and general development patterns, oil and natural gas resources in "sweet spots" are developed earlier than lower quality resources, based on net present value.

[12]High U.S. crude oil production and low fuel costs have given U.S. refiners a competitive advantage over foreign refiners, as evidenced by high U.S. refinery utilization and increasing U.S. exports of gasoline and diesel fuel.

[13]Oil imports from Canada now are required to go to Petroleum Administration for Defense District (PADD) 2 (Midwest: North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio, Kentucky, and Tennessee); PADD 4 (Rocky Mountain: Montana, Idaho, Wyoming, Utah, and Colorado); and PADD 5 (West Coast: Washington, Oregon, Nevada, California, Arizona, Alaska, and Hawaii) for redistribution through the crude oil distribution infrastructure.

[14]Pyrolysis is defined as the thermal decomposition of biomass at high temperatures (greater than 400°F, or 200°C) in the absence of air.

[15]EIA undertook detailed assessments of these technologies in order to characterize key parameters considered in the model, such as capital cost, contingency factors, construction time, first year of operation, plant life, plant production capacity, efficiency, and feedstock and other operating costs.

[16]When considering CO_2 EOR, the oil and gas supply module assesses a location and the availability and price of CO_2 from power plants and CTL facilities. The electric power plants now consider the market size and prices for CO_2 captured. The refining module assesses a location and the availability and price of CO_2 from CTL facilities. The power sector now assesses opportunities for plants equipped with carbon capture and storage, as the CO_2 produced at these facilities can be used for EOR operations. This enables the model to solve dynamically for the capture of CO_2 and the production of oil from anthropogenic CO_2 EOR.

[17]North American Electric Reliability Corporation, *2013 Summer Reliability Assessment* (Atlanta, GA: May 2013), http://www.nerc.com/pa/RAPA/ra/ Reliability%20Assessments%20DL/2013SRA_Final.pdf.

[18]U.S. Environmental Protection Agency, "Mercury and Air Toxics Standards (MATS)," http://www.epa.gov/mats.

[19]U.S. House of Representatives, 112th Congress, Public Law 112-240, "American Taxpayer Relief Act of 2012," Sections 401-412 (Washington, DC: January 2, 2013), http://www.gpo.gov/fdsys/pkg/PLAW-112publ240/pdf/PLAW-112publ240.pdf.

income growth, and population growth. *AEO2014* uses the U.S. Census Bureau's December 2012 middle population projection. The U.S. Census Bureau revised its population projections primarily to reflect lower assumptions regarding international net migration.

In *AEO2014*, U.S. population is expected to grow at an annual rate of 0.7% from 2012 to 2040, or 0.2 percentage points lower than the 0.9% average annual population growth rate in *AEO2013*. As shown in Figure 5, most of the change from *AEO2013* to *AEO2014* is in the younger age cohorts. Real GDP, labor force, and productivity in *AEO2014* grow by average annual rates of 2.4%, 0.6%, and 1.8%, respectively, from 2012 to 2040.

Total industrial production growth (which includes manufacturing, construction, agriculture, and mining) in *AEO2014* is higher than projected in *AEO2013*, primarily as a result of more rapid growth in manufacturing output, with most of the difference accounted for by machinery, transportation equipment, fabricated metals, and bulk chemicals. Those industries, in addition to being trade-sensitive, supply equipment or raw materials used in oil and gas production or otherwise benefit from lower natural gas prices. In 2040, the manufacturing share of total gross output is 18% in *AEO2014*, compared with 16% in *AEO2013*.

Energy prices

Crude oil

Oil prices are influenced by several factors, including some that have mainly short-term impacts. Other factors, such as expectations about future world demand for petroleum and other liquids and production decisions by the Organization of the Petroleum Exporting Countries (OPEC), can affect prices over the longer term. Supply and demand in the world oil market are balanced through responses to price movements, with considerable complexity in the evolution of underlying supply and demand expectations. For petroleum and other liquids, the key determinants of long-term supply and prices can be summarized in four broad categories: the economics of non-OPEC supply; OPEC investment and production decisions; the economics of other liquids supply; and world demand for petroleum and other liquids.

Key assumptions driving global crude oil markets in the *AEO2014* Reference case over the projection period include: average economic growth of 1.9% per year for major U.S. trading partners[20] and average economic growth of 4.0% per year for other U.S. trading partners. Growth in petroleum and other liquids use occurs almost exclusively outside the Organization for Economic Cooperation and Development (OECD) member countries, with 1.8% average annual growth in petroleum and other liquids consumption by non-OECD countries, including significantly higher average annual consumption growth in both China and India.

Petroleum and other liquids production in *AEO2014* from non-OPEC countries, particularly the United States, increases to levels above those in *AEO2013*. As a result, the OPEC market share declines to less than 40% in the near term before starting to rise again after 2016. The Brent crude oil spot price decreases from $112 per barrel (bbl) in 2012 to $92/bbl in 2017 in the Reference case (in 2012 dollars), then increases to $141/bbl in 2040 (or about $235/bbl in nominal dollars) as growing demand leads to the development of more costly resources (Figure 6). However, those resources are not as costly to develop as projected in *AEO2013*.

Figure 5. Comparisons of population growth by projection period and age cohort in the *AEO2014* and *AEO2013* Reference cases (*AEO2014* growth minus *AEO2013* growth)
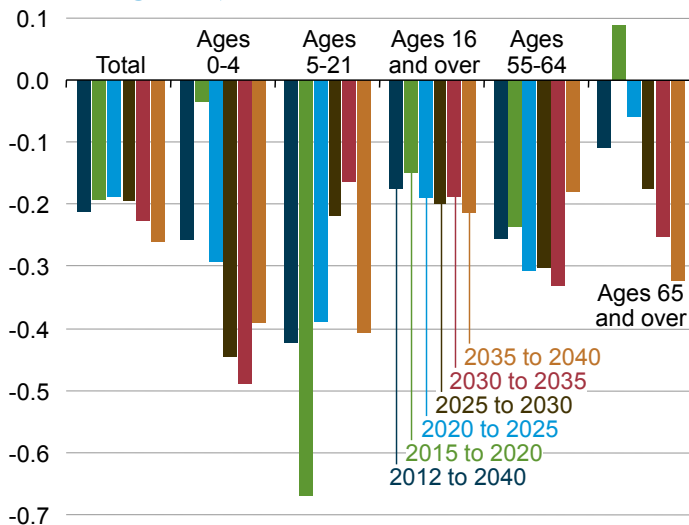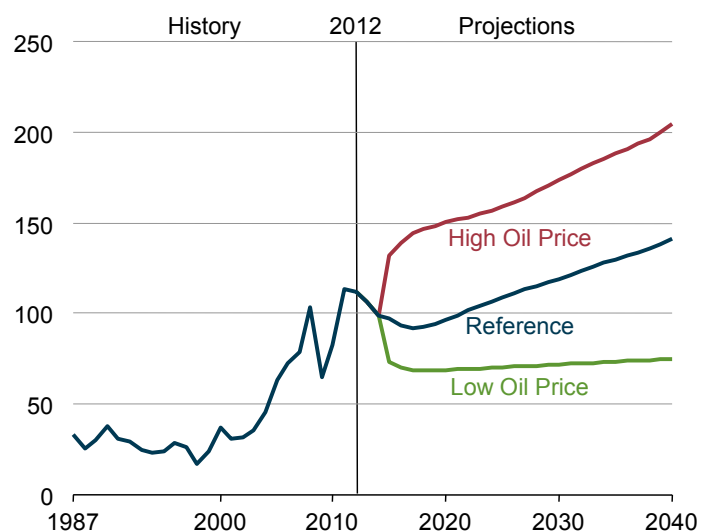
Figure 6. Average annual Brent spot crude oil prices in three cases, 1987-2040 (2012 dollars per barrel)

[20]Major trading partners include Australia, Canada, Switzerland, United Kingdom, Japan, Sweden, and the Eurozone.

Petroleum and other liquids products

With lower crude oil prices and lower gasoline demand projected in the *AEO2014* Reference case, the real end-use price of motor gasoline in the United States declines to $3.03 per gallon (2012 dollars) in 2017, then rises to $3.90 per gallon in 2040 (compared to $4.40 per gallon in 2040 in *AEO2013*). The end-use price of diesel fuel in the transportation sector follows a similar pattern, dropping to $3.50 per gallon in 2017 and then rising to $4.73 per gallon in 2040 (compared to $5.03 per gallon in *AEO2013*). Although both gasoline and diesel prices dip modestly in the early years of the projection period, they increase steadily thereafter. The diesel share of total domestic petroleum and other liquids production rises, and the gasoline share falls, mostly as a result of the greenhouse gas (GHG) and CAFE standards for LDVs beginning in model year 2017. Increasing demand for diesel puts pressure on refiners to increase diesel yields and results in a rising difference between diesel prices and gasoline prices from 2017 to 2025.

Legislated targets for cellulosic fuels use mandated by the Energy Independence and Security Act of 2007 (EISA2007) are not attained, as the U.S. Environmental Protection Agency (EPA)[21] continues to make use of the flexibility provided in the statute to adjust those requirements.

Natural gas

The Henry Hub spot price for natural gas in the *AEO2014* Reference case is higher than projected in *AEO2013* through 2037, with price increases in the near term driven by faster growth of consumption in the industrial and electric power sectors and, later, growing demand for export at LNG facilities. A sustained increase in production follows, leading to slower price growth over the rest of the projection period.

The Henry Hub spot natural gas price in *AEO2014* reaches $4.80 per million Btu (MMBtu) (2012 dollars) in 2018, which is 77 cents/ MMBtu higher than in *AEO2013*. The stronger near-term price growth is followed by a lagged increase in supply from producers, eventually causing prices to settle at $4.38/MMBtu in 2020, which is still notably higher than in *AEO2013*.

After 2020, increases in natural gas spot prices are driven by continued but slower growth in U.S. demand and net exports. The Henry Hub spot natural gas price rises to $7.65/MMBtu in 2040, an increase of $3.28 from 2020 but 4% below the 2040 price projection in *AEO2013*. In *AEO2014*, production grows to 37.5 Tcf in 2040, compared with 33.1 Tcf in *AEO2013*. A price increase starting in 2033 is far less pronounced than was projected in *AEO2013*, in part because the growth in net exports from the United States slows significantly.

Regional spot price projections throughout the United States follow the same general pattern as the Henry Hub spot price. However, the average Lower 48 spot price generally increases at a slightly slower rate than the Henry Hub spot price, because regional production growth outside those areas that serve the Henry Hub is projected to be somewhat faster than the growth in production that serves the Henry Hub.

Coal

The average minemouth price of coal increases by 1.4% per year in the *AEO2014* Reference case, from $1.98/MMBtu in 2012 to $2.96/MMBtu in 2040 (2012 dollars). The upward trend of coal prices primarily reflects an expectation that cost savings from technological improvements in coal mining will be outweighed by increases in production costs associated with moving into reserves that are more costly to mine. The upward trend in the minemouth price of coal in the *AEO2014* Reference case is similar to the trend in the *AEO2013* Reference case, but the average price through the projection period in *AEO2014* is generally lower, primarily reflecting a lower price outlook for coking coal.

Relative to minemouth prices, the average delivered price of coal to all sectors (excluding exports) increases at a slightly slower pace of 1.0% per year, from $2.60/MMBtu in 2012 to $3.43/MMBtu in 2040. The slower growth rate primarily reflects modest growth in average coal transportation rates, which increase by 0.2% per year in *AEO2014*—from $0.83/MMBtu in 2012 to $0.89/ MMBtu in 2040—as a result of gradually increasing fuel costs and changes over time in the pattern of coal distribution.

U.S. coal exports, which have surged in recent years from 50 million short tons in 2005 to a record 126 million short tons (MMst) in 2012, have become an increasingly important source of revenue for both U.S. coal producers and coal transportation companies (primarily railroads and barge companies). In 2012, coal export revenues totaled about $15 billion, representing about 25% of all U.S. coal revenues, despite the fact that coal exports in 2012 represented only 12% of total U.S. production (short tons). In the *AEO2014* Reference case, U.S. coal export prices increase by 1.2% per year, to $6.40/MMBtu in 2040.

Electricity

Following the decline of natural gas prices since 2008, real average delivered prices for electricity have dropped consistently (although more gradually) since 2009, to 9.8 cents per kilowatthour (kWh) in 2012. Retail electricity prices are influenced by fuel prices, and particularly by natural gas prices. However, the relationship between retail electricity prices and natural gas prices is complex, and many factors influence the degree to which, and the timeframe over which, they are linked. Those factors include the share of natural gas generation in a region, the level of costs associated with the electricity transmission and distribution systems,

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[21]U.S. Environmental Protection Agency, "2014 Standards for the Renewable Fuel Standard Program: Proposed Rule," 40 CFR Part 80 [EPA-HQ-OAR-2013-0479; FRL-9900-90-OAR], RIN 2060-AR76, *Federal Register,* Vol. 78, No. 230 (Washington, DC: November 29, 2013), pp. 71732-71784, http://www.gpo.gov/fdsys/pkg/FR-2013-11-29/pdf/2013-28155.pdf.

the mix of competitive versus cost-of-service pricing, and the number of customers who purchase power directly from wholesale power markets. As a result, it can take time for changes in fuel prices to affect electricity prices, and the impacts can vary from region to region.

In the *AEO2014* Reference case, electricity prices are higher throughout the projection than they were in the *AEO2013* Reference case. Natural gas prices for electricity generators are higher than those in *AEO2013* in the first few years but fairly similar in the long term. Reliance on natural gas-fired generation remains strong, as a result of additional near-term retirements of coal-fired and nuclear capacity, and natural gas prices continue to influence electricity prices. In the long term, both natural gas prices and electricity prices rise. Electricity prices, which in 2030 are 10.4 cents/kWh (2012 dollars) in the *AEO2014* Reference case, compared with 9.9 cents/kWh in the *AEO2013* Reference case, continue rising to 11.1 cents/kWh in 2040 in *AEO2014*, compared with 11.0 cents/kWh in the *AEO2013* Reference case.

The *AEO2014* Reference case includes an updated calculation of electricity prices in competitive regions that better represents payments required to maintain reserve capacity, contributing to higher projected electricity prices relative to *AEO2013*. In addition, the updated regional reserve margin requirements in *AEO2014* generally are higher and thus more costly than those in *AEO2013*.

## Delivered energy consumption by sector[22]

Transportation

Delivered energy consumption in the transportation sector declines from 26.7 quadrillion Btu in 2012 to 25.5 quadrillion Btu in 2040 in the *AEO2014* Reference case (Figure 7) because of a significant decline in energy consumption by LDVs that more than offsets growth in energy consumption for other modes. The decline in transportation sector delivered energy consumption is markedly different from the historical trend of 1% average annual growth in transportation energy consumption from 1975 to 2012.[23] Transportation energy consumption is considerably lower in *AEO2014* than projected in the *AEO2013* Reference case (27.1 quadrillion Btu in 2040) with energy consumption by nearly all transportation modes reduced in *AEO2014* as a result of lower macroeconomic indicators, higher energy efficiency, changing demographics, and a revised calculation of VMT.

LDV energy consumption declines in the *AEO2014* Reference case from 16.0 quadrillion Btu in 2012 to 12.1 quadrillion Btu in 2040, compared with 13.0 quadrillion Btu in 2040 in the *AEO2013* Reference case. GHG emission standards and CAFE standards increase new LDV fuel economy through model year 2025 and beyond, with more fuel-efficient new vehicles gradually replacing older vehicles on the road and raising the fuel efficiency of the LDV stock by an average of 2.0% per year, from 21.5 miles per gallon (mpg) in 2012 to 37.2 mpg in 2040. The higher fuel economy of LDVs more than offsets increases in VMT that average 0.9% per year from 2012 to 2040, a reduction from the *AEO2013* projection that reflects changes in driving behavior related to changing demographics. The average fuel economy of the vehicle stock is higher, and travel by LDVs is lower in *AEO2014* than projected in *AEO2013*. The large decline in LDV energy consumption in *AEO2014* shrinks the LDV modal share of total transportation energy consumption from 60% in 2012 to 47% in 2040.

LDVs powered by motor gasoline remain the dominant vehicle type in the *AEO2014* Reference case, retaining a 78% share of new LDV sales in 2040, down from their 82% share in 2012. The fuel economy of LDVs powered by motor gasoline continues to increase, and advanced technology fuel efficiency subsystems are added, such as micro hybridization, which is installed on 42% of new motor gasoline LDVs in 2040. The numbers of LDVs powered by fuels other than gasoline, such as diesel, electricity, or E85, or equipped with hybrid drive trains, such as plug-in hybrid or gasoline hybrid electric, increase modestly from 18% of new sales in 2012 to 22% in 2040. Ethanol FFVs account for 11% of overall vehicle sales in 2040, followed by hybrid electric vehicles (excluding micro hybrids) at 5% of new sales in 2040, up from 3% in 2012, diesel vehicles at 4% in 2040, up from 2% in 2012, and plug-in hybrid vehicles and electric vehicles at about 1% each, both up from negligible shares in 2012. New vehicle sales shares are generally similar in *AEO2014* and *AEO2013* but with moderate variation. In *AEO2013*, the new vehicle sales share of motor gasoline vehicles was 80% in 2040 (with 36% of those vehicles including micro hybridization), followed by 7% for ethanol FFVs, 6% for hybrid electric, 3% for diesel, 2% for plug-in hybrids, and 1% for electric vehicles. The differences from *AEO2013* to *AEO2014* result from different fuel prices,

Figure 7. Delivered energy consumption by sector, 1980-2040 (quadrillion Btu)
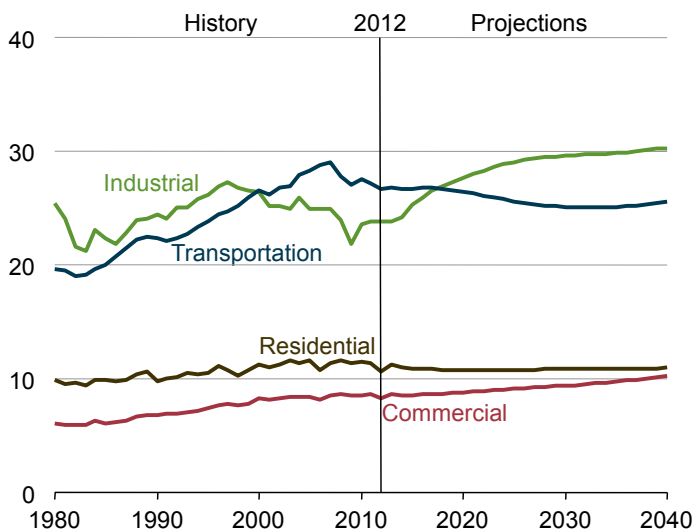
[22]The amount of energy delivered to the sector; no adjustment is made for the fuels consumed to produce electricity or district sources.

[23]S.C. Davis, S.W. Diegel, and R.G. Boundy, *Transportation Energy Data Book*, ORNL-6989 (Edition 32 of ORNL-5198) (Oak Ridge, TN: July 2013), Chapter 2, Table 2.1, "U.S. Consumption of Total Energy by End-Use Sector, 1973-2012."

updated manufacturer product offerings, changing technology attributes, and an updated view of consumer perceptions of infrastructure availability for E85 vehicles.

Delivered energy demand for HDVs in *AEO2014* increases from 5.3 quadrillion Btu in 2012 to 7.5 quadrillion Btu in 2040, similar to the 2040 level of 7.6 quadrillion Btu in *AEO2013,* and represents the largest growth among all transportation modes. Growth in industrial output in *AEO2014* leads to solid growth in HDV VMT, averaging 1.9% per year from 2012 to 2040. HDV energy demand is tempered somewhat by an average 0.5% annual increase in fuel economy from 2012 to 2040 as a result of GHG emission and fuel efficiency standards for medium- and heavy-duty vehicles and engines. Competitive natural gas prices significantly increase the demand for LNG and compressed natural gas in *AEO2014*, from an insignificant share in 2012 to 8% of HDV energy consumption in 2040, which is less than the 13% share projected in *AEO2013* because of the lower prices of competing fuels in *AEO2014*. The rapid growth of energy consumption by HDVs in *AEO2014* increases their modal share of total transportation energy consumption from 20% in 2012 to 29% in 2040.

Energy demand for aircraft grows in the *AEO2014* Reference case from 2.5 quadrillion Btu in 2012 to 2.7 quadrillion Btu in 2040, which is less than the *AEO2013* projection of 2.9 quadrillion Btu in 2040. Personal air travel (billion seat-miles) grows by an average of 0.7% per year in *AEO2014*, but improved fuel efficiency (by an average of 0.5% per year) reduces the effect on energy consumption. The difference between *AEO2014* and *AEO2013* stems from lower demand for personal air travel in *AEO2014* as a result of lower economic growth. The aircraft share of total transportation energy consumption in *AEO2014* increases from 9% in 2012 to 11% in 2040.

Energy consumption by marine vessels increases from 0.9 quadrillion Btu in 2012 to 1.0 quadrillion Btu in 2040 in *AEO2014*, reflecting the impacts of increased foreign trade on international shipping and higher incomes on recreational boating. Pipeline energy use rises modestly, from 0.7 quadrillion Btu in 2012 to 0.8 quadrillion Btu in 2040, as increasing volumes of natural gas are produced but closer to end-use markets. Rail energy consumption remains nearly flat at 0.5 quadrillion Btu from 2012 to 2040 in *AEO2014*, as a result of a plateau in coal shipments and increases in fuel efficiency, which offset growth in rail transportation of other industrial commodities.

Other energy use in the transportation sector, which includes both lubricants and military energy use, increases from 0.8 quadrillion Btu in 2012 to 0.9 quadrillion Btu in 2040. Marine, pipeline, other transportation, and rail energy use all are relatively minor pieces of the overall transportation energy consumption picture in *AEO2014*, each accounting for less energy demand than in the *AEO2013* projections, as a result of lower economic growth in the *AEO2014* Reference case.

Industrial

Approximately one-third of total U.S. delivered energy in 2012, 23.6 quadrillion Btu, was consumed in the industrial sector, which includes manufacturing, agriculture, construction, and mining. In the *AEO2014* Reference case, total industrial delivered energy consumption grows to 30.2 quadrillion Btu in 2040—1.5 quadrillion Btu, or 5%, higher than the *AEO2013* Reference case projection. The industrial sector becomes the largest energy consuming sector by 2018 and remains so for the rest of the projection period.

The growth rate for total industrial energy consumption in the *AEO2014* Reference case is greater than in *AEO2013* as a result of lower natural gas prices, which boost industrial production, and greater availability of natural gas liquids (NGL).[24] The industry that consumes the most energy is bulk chemicals, where total energy consumption grows from 5.5 quadrillion Btu in 2012 to 7.0 quadrillion Btu in 2040. In the *AEO2014* Reference case, energy consumption by the bulk chemicals industry in 2040 is 1.2 quadrillion Btu higher than projected in *AEO2013*.

Total manufacturing shipments in the *AEO2014* Reference case also increase more rapidly than in the *AEO2013* Reference case, from $4.5 trillion in 2012 to $8.4 trillion in 2040, or 87%. The growth rate for shipments in energy-intensive manufacturing is one-half the rate for non-energy-intensive manufacturing, reflecting the continuing shift toward less energy-intensive manufacturing, such as transportation equipment, computers, and other durable metal goods. The rate of growth in all manufacturing industries is higher from 2012 to 2025 than after 2025, as a result of increased international competition in the later years of the projection.

Shipments in the energy-intensive industries—refining, food, paper, bulk chemicals, glass, cement and lime, iron and steel, and aluminum—grow from $1.6 trillion in 2012 to $2.3 trillion in 2040 in the *AEO2014* Reference case, an annual rate of growth of 1.3%, compared to 1.0% in the *AEO2013* Reference case. The rate of increase in *AEO2014* is much faster from 2012 to 2025 (2.0% per year) than from 2025 to 2040 (0.7% per year). Shipments of bulk chemicals, iron and steel, and aluminum peak in the late 2020s and decline thereafter, as export growth slows. Total energy consumption in the energy-intensive industries increases by 0.7% per year from 2012 to 2040, with almost all the growth occurring in the 2012-25 period.

Energy use for heat and power in the energy-intensive industries grows from 11.5 quadrillion Btu in 2012 to 13.1 quadrillion Btu in 2040, averaging 0.9% per year from 2012 to 2025 and 0.1% per year from 2025 to 2040. With energy intensity declining in the energy-intensive industries, largely because of improvements in efficiency, the growth of energy use for heat and power is slower than the growth of shipments. In the bulk chemicals and petroleum refining industries, demand for feedstocks—which include HGL,[25] petroleum (usually naphtha), and natural gas—grows by 1.3% per year on average, from 3.5 quadrillion Btu in 2012 to 5.0

[24]Natural gas liquids include ethane, propane, normal butane, isobutane, and pentanes plus.
[25]HGL includes NGL, ethane, propane, normal butane, isobutane, natural gasoline (pentanes plus), and olefins.

quadrillion Btu in 2040, with average increases of 2.9% per year from 2012 to 2025 followed by a decline from 2025 to 2040 averaging 0.1% per year.

Only the bulk chemical industry uses liquid feedstocks (HGL and petrochemical feedstocks), which are used to produce organic chemicals, inorganic chemicals, resins, synthetic rubber, and fibers. With demand for bulk chemicals higher in the *AEO2014* Reference case than in *AEO2013*, consumption of liquid feedstocks also is higher in *AEO2014*. HGL feedstocks and petrochemical feedstocks (naphtha and heavier inputs) often can be interchanged to some degree, depending on price and the product slate. In the *AEO2014* Reference case, HGL feedstock consumption totals 2.2 quadrillion Btu in 2012, 2.9 quadrillion Btu in 2025, and 2.7 quadrilion Btu in 2040; and petrochemical feedstock use totals 0.8 quadrillion Btu in 2012, 1.5 quadrillion Btu in 2025, and 1.6 quadrillion Btu in 2040.

Shipments from the nonenergy-intensive manufacturing sector increase by 2.7% per year from $2.9 trillion in 2012 to $6.1 trillion in 2040 in the *AEO2014* Reference case, with growth rates of 3.2% per year from 2012 to 2025 and 2.3% per year after 2025. Energy consumption for nonenergy-intensive manufacturing grows from 3.6 quadrillion Btu in 2012 to 4.9 quadrillion Btu in 2040, averaging 1.0% per year—the same rate as in the *AEO2013* Reference case. In parallel with the growth of shipments, energy consumption in the nonenergy-intensive manufacturing sector grows more rapidly from 2012 to 2025 (1.3% per year) than from 2025 to 2040 (0.8% per year).

In the nonmanufacturing industries—agriculture, construction, and mining—shipments grow by 1.6% per year from 2012 to 2040 in the *AEO2014* Reference case, slightly less than the annual growth rate of 1.8% in the *AEO2013* Reference case over the same period. Growth in the *AEO2014* Reference case averages 2.8% per year from 2012 to 2025 and slows to 0.7% per year after 2025. Energy consumption by nonmanufacturing industries grows by 1.2% per year, from 4.8 quadrillion Btu in 2012 to 6.8 quadrillion Btu in 2040. While energy intensity declines somewhat in the agriculture and construction industries, it increases in the mining industry as exploration activities move over time to less desirable—and more energy-intensive—resources.

Residential

Residential delivered energy consumption remains roughly constant in the *AEO2014* Reference case from 2012 to 2040. However, consumption levels are lower than those in *AEO2013* for most fuels. In addition to lower population growth projections, the lower consumption levels in the *AEO2014* Reference case are explained in part by incorporation of the 2009 RECS data, which include characteristic information such as the mix of building types in each region of the country, equipment stocks, and appliance saturation levels, as well as energy consumption estimates for three major end uses—space heating, space cooling, and water heating. In addition, weather-related demand elasticities for heating and cooling also have been updated to better align *AEO* projections with those in EIA's *Short-Term Energy Outlook.*

The *AEO2014* Reference case removes the 2013 federal efficiency standard for condensing gas furnaces, based on challenges to the DOE rulemaking, first by an association of natural gas utilities and later by equipment distributors. Although natural gas use tends to be lower when the standard is included, consumption in the *AEO2014* Reference case (without the standard) is lower than in *AEO2013* (with the standard) through most of the projection period, largely because of changes in the end-use allocations from the 2009 RECS.

An EIA-contracted report[26] provides updated estimates of the installed stock and consumption of several miscellaneous electric loads, including televisions, computers, and related equipment. This update generally resulted in lower electricity consumption for these appliances than was projected in the *AEO2013* Reference case.

For *AEO2014*, outdoor lighting was added to the residential model as a separate application. In addition, cost and performance attributes for most residential lighting types were updated on the basis of EIA-contracted technology reports[27] and market studies from DOE.[28] Lower costs and wider availability of LEDs result in lower energy consumption after 2020 in *AEO2014* relative to *AEO2013*.

Commercial

Commercial sector delivered energy consumption grows from 8.3 quadrillion Btu in 2012 to 10.2 quadrillion Btu in 2040 in the *AEO2014* Reference case, similar to the *AEO2013* Reference case despite slower growth in the near term. Commercial electricity consumption increases by 0.8% per year from 2012 to 2040 in *AEO2014*, lower than the 1.0% average annual growth in commercial floorspace, in part because projected demand for cooling and lighting is lower than in *AEO2013*. Also, more rapid reductions in energy use for personal computers than previously estimated, largely because of a shift to more efficient portable devices, result in a projected 5.6% annual decline in electricity demand for commercial PC equipment in the *AEO2014* Reference case. Following

[26]Navigant Consulting, Inc., *Analysis and Representation of Miscellaneous Electric Loads in NEMS* (Washington, DC, May 2013), prepared for the U.S. Department of Energy, U.S. Energy Information Administration.

[27]U.S. Energy Information Administration, "Updated Buildings Sector Appliance and Equipment Costs and Efficiency" (Washington, DC: August 7, 2013), http://www.eia.gov/analysis/studies/buildings/equipcosts/.

[28]U.S. Department of Energy, Energy Efficiency & Renewable Energy, *Residential Lighting End-Use Consumption Study: Estimation Framework and Initial Estimates* (Washington, DC: December 2012), http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_residential-lighting-study.pdf, and *2010 U.S. Lighting Market Characterization* (Washington, DC: January 2012), http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf.

slower-than-expected adoption of new data centers as a result of the recent recession, installations of new data center servers increase more in *AEO2014* than in *AEO2013*.

Growth of natural gas consumption in the commercial sector averages roughly 0.7% per year from 2012 to 2040, similar to the *AEO2013* Reference case.

Energy consumption by primary fuel

Total primary energy consumption grows by 12% in the *AEO2014* Reference case, from 95 quadrillion Btu in 2012 to 106 quadrillion Btu in 2040—1.3 quadrillion Btu less than in *AEO2013* (Figure 8). The fossil fuel share of energy consumption falls from 82% in 2012 to 80% in 2040, as consumption of petroleum-based liquid fuels declines, largely as a result of slower growth in VMT and increased vehicle efficiency.
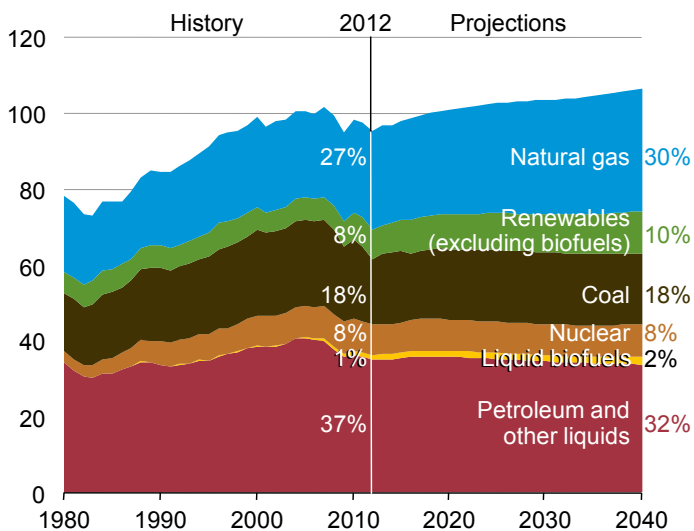
Total U.S. consumption of petroleum and other liquids, which was 35.9 quadrillion Btu (18.5 MMbbl/d) in 2012, increases to 36.9 quadrillion Btu (19.5 MMbbl/d) in 2018, then declines to 35.4 quadrillion Btu (18.7 MMbbl/d) in 2034 and remains at that level through 2040. Total consumption of domestically produced biofuels increases slightly through 2022 and then remains relatively flat. Production of cellulosic biofuels is currently well under 1% of the EISA2007 targets.[29] With the PTC for cellulosic biofuels scheduled to expire at the end of 2013, production of cellulosic biofuels remains below the EISA2007 target through the projection period. Within the transportation sector, which dominates demand for petroleum and other liquids, there is a shift from motor gasoline (losing more than 10% of its share of total transportation petroleum and other liquids demand over the projection) to distillate (gaining slightly less than 10% of the total). The increased use of compressed natural gas and LNG in vehicles also offsets about 3% of petroleum and other liquids consumption in the transportation sector in 2040.

Domestic natural gas consumption in the *AEO2014* Reference case rises from 25.6 Tcf in 2012 to 31.6 Tcf in 2040 (about 2.1 Tcf higher than in the *AEO2013* Reference case). The largest share of the growth is for electricity generation. Demand for natural gas in the electric power sector increases from 9.3 Tcf in 2012 to 11.2 Tcf in 2040, with a portion of the growth attributable to the retirement of 50 gigawatts of coal-fired capacity by 2021. Natural gas consumption in the industrial sector is also higher in *AEO2014* than was projected in *AEO2013*, as a result of the rejuvenation of the industrial sector as it benefits from surging shale gas production that is accompanied by slower growth of natural gas prices. Industries such as bulk chemicals, which use natural gas as a feedstock, are more strongly affected than others. In the residential sector, natural gas consumption declines throughout the projection.

Total coal consumption increases from 17.3 quadrillion Btu (891 MMst) in 2012 to 18.7 quadrillion Btu (979 MMst) in 2040 in the *AEO2014* Reference case. Coal consumption, mostly for electric power generation, falls off in 2016, the first year of the MATS. After 2016, coal-fired electricity generation increases slowly over the next 10 years as the remaining coal-fired capacity is used more intensively, but little capacity is added. Coal consumption in the electric power sector in 2040 is 17.3 quadrillion Btu (909 MMst) in the *AEO2014* Reference case. This level is about 1.4 quadrillion Btu (75 MMst) lower than in the *AEO2013* Reference case. No coal is consumed for CTL technology in the *AEO2014* Reference case.

With the implementation of the federal RFS for transportation fuels and state renewable portfolio standards for electricity generation, consumption of marketed renewable fuels grows by 1.4% per year in the *AEO2014* Reference case. Marketed renewable energy includes wood, municipal waste, other biomass, and hydroelectricity in the end-use sectors; hydroelectricity, geothermal, municipal solid waste, biomass, solar, and wind power in the electric power sector; and ethanol for gasoline blending and biomass-based diesel in the transportation sector, of which 1.5 quadrillion Btu is included with petroleum and other liquid fuels consumption in 2040. Excluding hydroelectricity, renewable energy consumption in the electric power sector grows from 1.9 quadrillion Btu in 2012 to 4.5 quadrillion Btu in 2040, with biomass accounting for 27% of the growth and wind 39%. Generation of electricity from solar photovoltaic energy shows the fastest growth, starting from a small base and accounting for 7.5% of total electricity generation from all nonhydropower renewable energy sources in 2040.

Figure 8. U.S. primary energy consumption by fuel, 1980-2040 (quadrillion Btu)

Energy intensity

From 1992 to 2012, energy use per dollar of GDP declined on average by 1.9% per year, in large part because of shifts within the economy from manufactured goods to the service sectors,

[29]Based on 2010, 2011, 2012, and 2013 evaluations of the volumes of cellulosic biofuels available, EPA substantially reduced the cellulosic biofuels obligation under the RFS for those years, with the 2013 obligation set at 6 million ethanol-equivalent gallons, less than 1% of the legislated target of 1 billion gallons.

which use relatively less energy per dollar of GDP. The dollar-value increase in the service sectors (in constant dollar terms) was almost 12 times the corresponding increase for the industrial sector over the same period. As a result, the share of total shipments accounted for by the industrial sector fell from 30% in 1992 to 22% in 2012 (including a slight increase from 2009 to 2012). In the *AEO2014* Reference case, the industrial share of total shipments increases to 24% in 2016, after which it declines again, at a very slow rate, to 23% in 2040. Energy use per 2005 dollar of GDP declines by 43% from 2012 to 2040 in *AEO2014* as the result of a continued shift from manufacturing to services (and, even within manufacturing, to less-energy-intensive manufacturing industries), rising energy prices, and the adoption of policies that promote energy efficiency.

U.S. energy use per capita was fairly constant from 1990 to 2007 but began to fall after 2007. In the *AEO2014* Reference case, energy use per capita continues to decline as a result of improvements in energy efficiency (e.g., new appliance and CAFE standards) and changes in the ways energy is used in the U.S. economy. Total U.S. population increases by 21% from 2012 to 2040, but energy use grows by only 12%, with energy use per capita declining by 8% from 2012 to 2040 (Figure 9).

CO_2 emissions per 2005 dollar of GDP have historically tracked closely with energy use per dollar of GDP. In the *AEO2014* Reference case, however, with lower-carbon fuels accounting for a growing share of total energy use, CO_2 emissions per dollar of GDP decline more rapidly than energy use per dollar of GDP, to 56% below their 2005 level in 2040 (or by 2.3% per year).

Energy production and imports

Net imports of energy decline both in absolute terms and as a share of total U.S. energy consumption in the *AEO2014* Reference case (Figure 10). The decline in energy imports reflects increased domestic production of petroleum and natural gas, along with demand reductions resulting from rising energy prices and gradual improvement in vehicle efficiency. At the same time, natural gas exports increase (as domestic supplies increase and it becomes attractive to liquefy the natural gas for export), along with exports of motor gasoline (as demand declines and refiners are left with more than they can sell domestically) and exports of crude oil (as lighter domestic crude oil is swapped for the heavier crudes more commonly run in modern refineries). The net import share of total U.S. energy consumption is 4% in 2040, compared with 16% in 2012 and about 30% in 2005.

Petroleum and other liquids

U.S. production of crude oil (including lease condensate) in the *AEO2014* Reference case increases from 6.5 MMbbl/d in 2012 to 9.6 MMbbl/d in 2019, 22% higher than in *AEO2013* (Figure 11). Despite a decline after 2019, U.S. crude oil production remains at or above about 7.5 MMbbl/d through 2040. Higher production volumes result mainly from increased onshore oil production, predominantly from tight (very-low-permeability) formations. Offshore crude oil

Figure 9. Energy use per capita, energy use per dollar of GDP, and emissions per dollar of GDP, 1980-2040 (index, 2005=1)

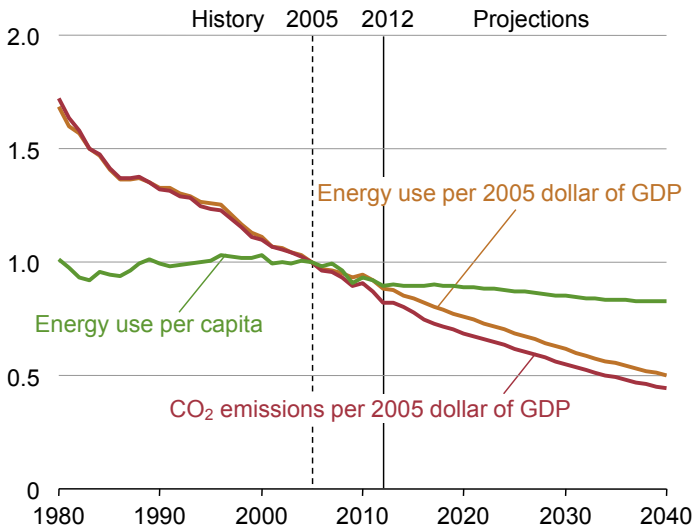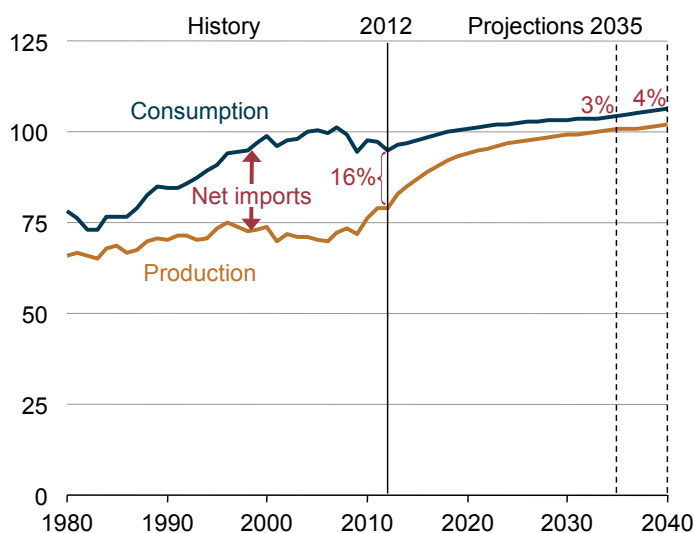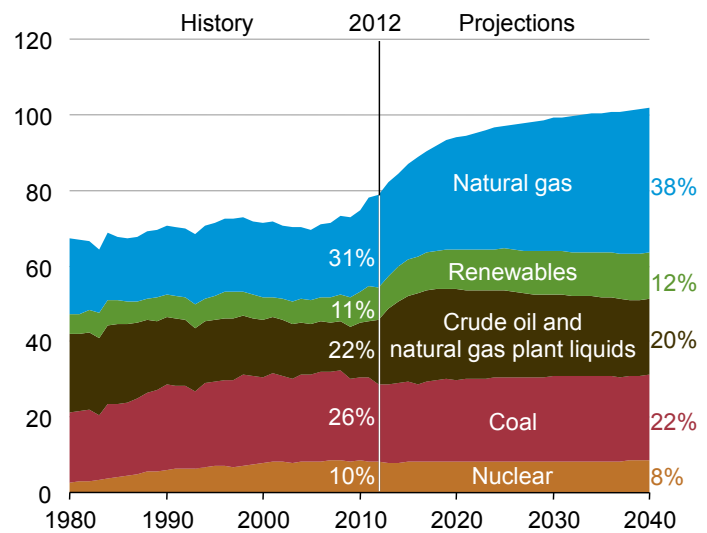**Figure 10. Total energy production and consumption, 1980-2040 (quadrillion Btu)**

Figure 11. U.S. energy production by fuel, 1980-2040 (quadrillion Btu)

provides a steady supply of domestic crude oil production, ranging between 1.6 and 2.0 MMbbl/d from 2015 through 2040, as the pace of development activity quickens and new, large development projects, predominantly in the deepwater and ultra-deepwater portions of the Gulf of Mexico, are brought into production.

The faster growth of tight oil production through 2020 in the *AEO2014* Reference case results in higher domestic crude oil production than in *AEO2013* throughout the projection. The pace of oil-directed drilling in the near term is much stronger than in *AEO2013*, as producers locate and target the sweet spots of plays currently under development and find additional tight formations that can be developed with the latest technologies. In the *AEO2014* Reference case, tight oil production increases from 2.3 MMbbl/d in 2012 (35% of total U.S. crude oil production) to 4.8 MMbbl/d in 2021 (51% of the total). As in *AEO2013*, tight oil production declines in *AEO2014* after 2021, as more development moves into less-productive areas.

U.S. use of imported petroleum and other liquid fuels continues to decline in *AEO2014* mainly as a result of increased domestic oil production. Imported petroleum and other liquid fuels as a share of total U.S. use reached 60% in 2005 before dipping below 50% in 2010 and falling further to 40% in 2012. The import share continues to decline to 25% in 2016 and then rises to about 32% in 2040 in the *AEO2014* reference case, as domestic production of tight oil begins to decline in 2022 (Figure 12).

Natural gas

Cumulative production of dry natural gas from 2012 to 2040 in the *AEO2014* Reference case is about 11% higher than in *AEO2013*, primarily reflecting continued growth in shale gas production resulting from the dual application of horizontal drilling and hydraulic fracturing. Another contributing factor is ongoing drilling in shale and other plays with high concentrations of NGL and crude oil, which in energy-equivalent terms have a higher value than dry natural gas. Cumulative production levels for tight gas and onshore associated-dissolved gas from oil formations exceed those in *AEO2013* through 2040 by 9% and 36%, respectively, making material contributions to the overall increase in production. Natural gas prices above $6/MMBtu toward the end of the projection period encourage drilling in less-productive but still-profitable areas in tight oil, shale oil, and natural gas formations. Lower 48 offshore natural gas production fluctuates between 1.7 Tcf and 2.9 Tcf per year, similar to the pattern in *AEO2013*. The multiyear decline in offshore natural gas production was reversed in 2012, with 15 new deepwater projects coming on line during the year.

In the *AEO2014* Reference case, the United States becomes a net exporter of LNG in 2016, and it becomes an overall net exporter of natural gas in 2018, two years earlier than in *AEO2013*. U.S. exports of LNG from new liquefaction capacity are expected to surpass 2 Tcf by 2020 and increase to 3.5 Tcf in 2029. Net pipeline imports from Canada fall steadily until 2033, and then increase through 2040. Net pipeline exports to Mexico grow by more than 400% in the Reference case, with additional pipeline infrastructure added to enable the Mexican market to receive more pipeline natural gas from the United States.

U.S. cumulative net LNG exports from 2012 to 2040 are up by 160% in *AEO2014* compared with *AEO2013*, supported by increased use of LNG in markets outside America, strong domestic production, and low U.S. natural gas prices relative to other global markets.
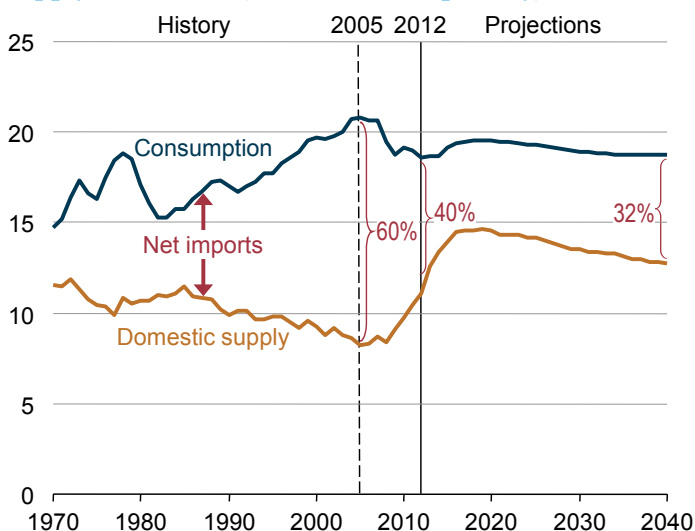
Coal

Total U.S. coal production grows at an average rate of 0.3% per year in the *AEO2014* Reference case, from 20.6 quadrillion Btu (1,016 MMst) in 2012 to 22.6 quadrillion Btu (1,121 MMst) in 2040. U.S. electricity generation accounted for 91% of total U.S. coal consumption (in Btu) in 2012. Coal production declined by more than 7% in 2012, from 1,096 MMst in 2011, mostly in response to gas-on-coal competition. In the Reference case, production recovers to 1,062 MMst by 2015, in response to a rise in natural gas prices along with a moderate increase in electricity demand. A wave of coal-fired generating capacity retirements in response to MATS requirements coincides with a secondary drop in coal production to 1,022 MMst in 2016. Total production then increases gradually to 1,127 MMst in 2030 before stabilizing as a result of limits on achievable long-term capacity utilization rates for available coal units compared to *AEO2013*.

Coal production from the Eastern Interior region in the *AEO2014* Reference case increases at a faster rate than projected in *AEO2013*, because of an improved productivity outlook, with 2020 production 27 MMst (18%) higher and 2040 production 58 MMst (34%) higher than projected in *AEO2013*. Lower overall coal consumption and improved competitiveness of coal produced in the Eastern Interior region compared to *AEO2013* lead to lower outlooks for Northern Appalachian and Powder River Basin coal production, as well as an accelerated decline in Central Appalachian production in *AEO2014*. As a result of changes to CTL cost assumptions, no CTL coal consumption or related production is projected in

Figure 12. U.S. petroleum and other liquid fuels supply, 1970-2040 (million barrels per day)

AEO2014, compared with 0.3 quadrillion Btu in 2040 in *AEO2013*. Expectations for total U.S. coal exports in *AEO2014* are generally similar to those in *AEO2013*, with an increase from 126 MMst in 2012 to 161 MMst by 2040.

Electricity generation

Total electricity consumption in the *AEO2014* Reference case, including both purchases from electric power producers and on-site generation, grows from 3,826 billion kWh in 2012 to 4,954 billion kWh in 2040, an average annual rate of 0.9% that is about the same as in the *AEO2013* Reference case. While growth in electricity consumption is similar overall, growth in the industrial sector is much stronger than in *AEO2013*, while growth in the residential sector is weaker.

The combination of slow growth in electricity demand, competitively priced natural gas, programs encouraging renewable fuel use, and the implementation of environmental rules dampens future coal use. The *AEO2014* Reference case continues to assume implementation of the Clean Air Interstate Rule (CAIR)[30] as a result of an August 2012 federal court move to vacate the Cross-State Air Pollution Rule.[31] In addition, *AEO2014* continues to assume the implementation of MATS in 2016. Once MATS is in place, sulfur dioxide levels are reduced to well below the levels required by CAIR, and mercury emissions drop to 6.1 tons in 2016 from 30.8 tons in 2011 when the rule was finalized.

Coal-fired power generation over the next few years is slightly higher in *AEO2014* than in the *AEO2013* Reference case because of higher natural gas prices during that period, as well as pending nuclear retirements that necessitate additional baseload generation. After 2020, generation from coal flattens out and remains lower than projected in *AEO2013*, because more coal-fired capacity is retired and fewer new coal plants are built (Figure 13).

Coal-fired electricity generation has traditionally been the largest component of electricity generation, representing 37% of total generation in 2012. By 2035, however, natural gas generation is projected to surpass coal generation. Coal and natural gas each represent 34% of total generation in 2035, but by 2040 the coal share drops to 32%, and the natural gas share increases to 35%. Market concerns about GHG emissions continue to dampen the expansion of coal-fired capacity in the *AEO2014* Reference case, even with the assumption of current laws and policies. Low fuel prices for new natural gas-fired plants also affect the relative economics of coal-fired capacity, as does the continued rise in construction costs for new coal-fired power plants. As retirements far outpace new additions, total coal-fired generating capacity falls from 310 gigawatts (GW) in 2012 to 262 GW in 2040 in the *AEO2014* Reference case. As with all projections, projected generation shares are highly sensitive to both fuel prices and changes in policies and regulations. Alternative cases in the full *AEO2014* will quantify these sensitivities.
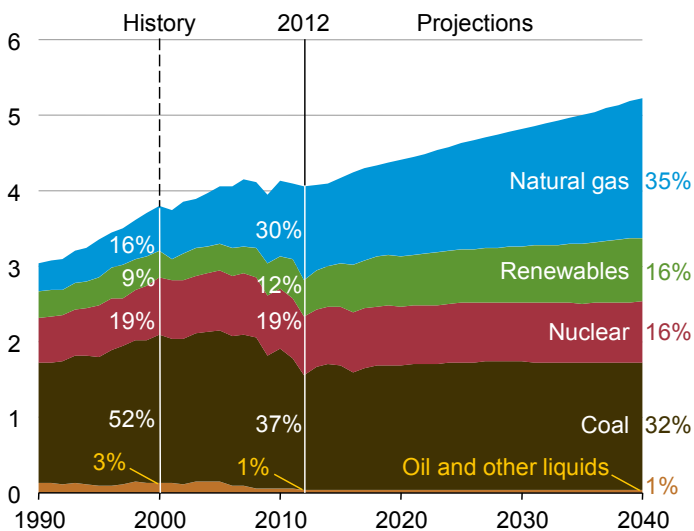
In the first few years of the projection, electricity generation using natural gas is slightly lower in the *AEO2014* Reference case than in the *AEO2013* Reference case because of higher natural gas prices in *AEO2014*. By 2017, however, natural gas-fired generation is higher in *AEO2014* than in the *AEO2013* Reference case, and the difference continues to grow. Additional retirements of coal and nuclear plants result in the need for new capacity, and new natural gas-fired plants are much cheaper to build than coal, nuclear, or renewable plants. In 2020, natural gas-fired generation in *AEO2014* is 7% higher than in *AEO2013*, and in 2040 it is 16% higher.

Electricity generation from nuclear power plants grows by 5% in the *AEO2014* Reference case, from 769 billion kWh in 2012 to 811 billion kWh in 2040, accounting for about 16% of total generation in 2040 (compared with 19% in 2012). Nuclear generating capacity decreases from 102 GW in 2012 to 98 GW in 2020 as new construction (5.5 GW) and uprates at existing plants (0.7 GW) are more than offset by retirements in several regions where existing nuclear units are facing challenging economic conditions. After 2025, a small amount of new nuclear capacity comes on line as natural gas prices rise. In 2040, overall nuclear capacity is back up to 102 GW. *AEO2014* incorporates updated information from EIA data collections regarding planned nuclear plant construction and capacity uprates at existing units.

Figure 13. Electricity generation by fuel, 1990-2040 (trillion kilowatthours)

Increased generation with renewable energy, excluding hydropower, accounts for 28% of the overall growth in electricity generation from 2012 to 2040 in the *AEO2014* Reference case. Generation from renewable resources grows in response to federal tax credits, state-level policies, and federal requirements to use more biomass-based transportation fuels, some of which can produce electricity as a byproduct of their production processes. In the final decade of the projection, however, renewable generation growth is driven by increasing cost competiveness with other nonrenewable technologies.

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[30]U.S. Environmental Protection Agency, "Clean Air Interstate Rule (CAIR)" (Washington, DC: December 19, 2012), http://www.epa.gov/cair/.
[31]U.S. Environmental Protection Agency, "Fact Sheet: The Cross-State Air Pollution Rule: Reducing the Interstate Transport of Fine Particulate Matter and Ozone" (Washington, DC: July 2011), http://www.epa.gov/airtransport/pdfs/CSAPRFactsheet.pdf.

Compared to the *AEO2013* Reference case, renewable generation is higher throughout most of the projection period, particularly in the near term, because of the inclusion of the energy provisions of the ATRA. This law, among other things, extends several tax credits for utility-scale renewables and redefines the qualification criteria, resulting in more construction of wind-powered generating capacity in the near term.

Reported renewable capacity already under construction has increased in recent years and is represented in *AEO2014*. Growth in renewable generation is supported by many state requirements, as well as regulations on CO_2 emissions in California. The share of U.S. electricity generation coming from renewable fuels (including conventional hydropower) grows from 12% in 2012 to 16% in 2040 in the *AEO2014* Reference case, even with federal subsidies for renewable generation assumed to expire as enacted. Extensions of such subsidies could have a large impact on renewable generation. The long-run projections for renewable capacity are also sensitive to natural gas prices and the relative costs of alternative generation sources.

Energy-related CO_2 emissions

In the *AEO2014* Reference case, total U.S. energy-related CO_2 emissions in 2040 equal 5,599 million metric tons, 92 million metric tons (1.6%) lower than in *AEO2013*. However, the carbon intensity of the economy in 2040 is slightly (0.6%) higher in *AEO2014* as compared with *AEO2013*. Projected energy-related CO_2 emissions in 2020 and 2040 are, respectively, about 9% and 7% below the 2005 level, compared to 9% and 5% below the 2005 level in *AEO2013*.

The lower GDP projection in *AEO2014* is partly the result of a lower population growth rate, and GDP per capita in 2040 is almost 4% higher in *AEO2014* than in *AEO2013*. Energy use per capita and energy-related CO_2 emissions per capita are higher in *AEO2014* than in *AEO2013* (about 5% in 2040). Also, higher levels of energy consumption and CO_2 emissions per dollar of GDP in *AEO2014* occur with a sectoral shift in the share of energy consumption from the residential, commercial, and transportation sectors toward the industrial sector, which generally is more energy- and carbon-intensive than other sectors of the economy. Over the projection period from 2012 to 2040, industrial emissions grow at an average annual rate of 0.6% in *AEO2014*, and industrial energy-related CO_2 emissions in 2040 are 133 million metric tons higher in *AEO2014* than in *AEO2013*.

When examining the electric power sector, excluding combined heat and power, there are offsetting factors in comparing *AEO2014* and *AEO2013*. Coal use for generation is 7.9% lower in 2040 (141 billion kWh) in *AEO2014* compared to *AEO2013* as a result of increased retirements of coal capacity and replacement with natural gas and renewables. However, nuclear generation, which has no CO_2 emissions, is also 10.1% (91 billion kWh) lower in 2040 in *AEO2014* compared to *AEO2013* because of more nuclear retirements in *AEO2014*. This offsets the CO_2 reduction achieved by switching from coal to natural gas and renewables. In total, the carbon intensity of the electric power sector is lower in *AEO2014* as generation declines by 0.2% (9 billion kWh), but emissions are 1.9% lower in 2040.

List of Acronyms

AEO	*Annual Energy Outlook*	LDV	Light-duty vehicle
AEO2013	*Annual Energy Outlook 2013*	LED	Light emitting diode
AEO2014	*Annual Energy Outlook 2014*	LNG	Liquefied natural gas
ATRA	American Taxpayer Relief Act of 2012	LPG	Liquefied petroleum gases
bbl	Barrels	LRG	Liquefied refinery gases
Btu	British thermal units	MATS	Mercury and Air Toxics Standards
CAFE	Corporate average fuel economy	MECS	Manufacturing Energy Consumption Survey
CAIR	Clean Air Interstate Rule	MMbbl/d	Million barrels per day
CO_2	Carbon dioxide	MMBtu	Million Btu
CTL	Coal-to-liquids	MMst	Million short tons
DOE	U.S. Department of Energy	NEMS	National Energy Modeling System
E85	Motor fuel containing up to 85% ethanol	NGL	Natural gas liquids
EIA	U.S. Energy Information Administration	NGPL	Natural gas plant liquids
EISA2007	Energy Independence and Security Act of 2007	OECD	Organization for Economic Cooperation and Development
EOR	Enhanced oil recovery		
EPA	U.S. Environmental Protection Agency	OPEC	Organization of the Petroleum Exporting Countries
FFV	Flexible fuel vehicle		
GDP	Gross domestic product	PADD	Petroleum Administration for Defense District
GHG	Greenhouse gas	PTC	Production tax credit
GW	Gigawatts	RECS	Residential Energy Consumption Survey
HDV	Heavy-duty vehicle	RFS	Renewable fuel standard
HGL	Hydrocarbon gas liquid	Tcf	Trillion cubic feet
kWh	Kilowatthour	VMT	Vehicle-miles traveled

Table 1. Comparison of projections in the *AEO2014* and *AEO2013* Reference cases, 2011-2040

Energy and economic factors	2011	2012	2025 AEO2014	2025 AEO2013	2040 AEO2014	2040 AEO2013
Primary energy production (quadrillion Btu)						
Crude oil and natural gas plant liquids	15.31	17.08	23.03	18.70	19.99	17.01
Dry natural gas	23.04	24.59	32.57	29.22	38.37	33.87
Coal	22.22	20.60	22.36	22.54	22.61	23.54
Nuclear/Uranium	8.26	8.05	8.15	9.54	8.49	9.44
Hydropower	3.11	2.67	2.84	2.86	2.90	2.92
Biomass	3.90	3.78	5.08	5.27	5.61	6.96
Other renewable energy	1.70	1.97	3.09	2.32	3.89	3.84
Other	0.80	0.41	0.24	0.85	0.24	0.89
Total	**78.35**	**79.15**	**97.36**	**91.29**	**102.09**	**98.46**
Net imports (quadrillion Btu)						
Petroleum and other liquid fuels[a]	18.78	16.55	11.41	15.89	13.65	15.99
Natural gas (- indicates exports)	2.03	1.58	-3.41	-1.56	-5.81	-3.55
Coal/other (- indicates exports)	-2.32	-2.86	-3.16	-3.02	-3.69	-2.95
Total	**18.49**	**15.26**	**4.85**	**11.31**	**4.15**	**9.49**
Energy consumption by fuel (quadrillion Btu)						
Petroleum and other liquid fuels[a]	36.56	35.87	36.28	36.87	35.35	36.07
Natural gas	24.91	26.20	28.97	27.28	32.32	29.83
Coal	19.62	17.34	19.03	19.35	18.75	20.35
Nuclear/Uranium	8.26	8.05	8.15	9.54	8.49	9.44
Hydropower	3.11	2.67	2.84	2.86	2.90	2.92
Biomass	2.60	2.53	3.74	3.82	4.26	4.91
Other renewable energy	1.70	1.97	3.09	2.32	3.89	3.84
Other	0.35	0.39	0.35	0.30	0.35	0.29
Total	**97.11**	**95.02**	**102.45**	**102.34**	**106.31**	**107.64**
Energy consumption by sector, including losses in electricity generation (quadrillion Btu)[b]						
Residential	21.39	20.10	20.58	21.08	21.48	23.08
Commercial	18.05	17.61	18.77	19.04	20.88	21.13
Industrial	30.46	30.54	37.43	35.46	38.33	36.16
Transportation	27.21	26.77	25.67	26.75	25.62	27.27
Total	**97.11**	**95.02**	**102.45**	**102.34**	**106.31**	**107.64**
Petroleum and other liquid fuels (million barrels per day)						
Domestic crude oil production	5.66	6.49	9.00	6.79	7.48	6.13
Other domestic production	4.71	4.60	5.14	5.63	5.22	5.83
Net imports	8.57	7.50	5.12	7.08	6.02	7.00
Consumption	18.92	18.49	19.27	19.50	18.73	18.95
Natural gas (trillion cubic feet)						
Dry gas production + supplemental gas	22.61	24.12	31.93	28.65	37.61	33.21
Net imports (- indicates exports)	1.96	1.51	-3.41	-1.58	-5.80	-3.55
Consumption	24.38	25.64	28.35	26.87	31.63	29.54

Table 1. Comparison of projections in the *AEO2014* and *AEO2013* Reference cases, 2011-2040 (continued)

Energy and economic factors	2011	2012	2025 AEO2014	2025 AEO2013	2040 AEO2014	2040 AEO2013
Coal (million short tons)						
Production and waste coal	1,109	1,027	1,128	1,134	1,139	1,195
Net exports	96	118	135	124	160	123
Consumption	1,003	891	993	1,010	979	1,071
Prices (2012 dollars)						
Brent spot crude oil (dollars per barrel)	113.24	111.65	108.99	119.45	141.46	165.57
West Texas Intermediate spot crude oil (dollars per barrel)	96.55	94.12	106.99	117.41	139.46	163.54
Natural gas at Henry Hub (dollars per million Btu)	4.07	2.75	5.23	4.96	7.65	7.97
Domestic coal at minemouth (dollars per short ton)	41.74	39.94	49.67	52.94	59.16	62.37
Average electricity price (cents per kilowatthour)	10.1	9.8	10.1	9.7	11.1	11.0
Economic indicators						
Real gross domestic product (billion 2005 dollars)	13,299	13,593	18,769	18,985	26,670	27,277
GDP chain-type price index (2005 = 1.000)	1.134	1.154	1.421	1.429	1.913	1.871
Real disposable personal income (billion 2005 dollars)	10,150	10,304	14,162	14,259	19,724	19,785
Value of industrial shipments (billion 2005 dollars)	5,926	6,147	8,778	8,548	10,994	10,616
Primary energy intensity (thousand Btu per 2005 dollar of GDP)	7.30	6.99	5.46	5.39	3.99	3.95
Population (millions)	312.3	314.6	347.0	356.5	380.5	404.4
Energy-related carbon dioxide emissions (million metric tons)	5,498	5,290	5,526	5,501	5,599	5,691

[a]Includes petroleum-derived fuels and non-petroleum-derived fuels, such as ethanol and biodiesel, and coal-based synthetic liquids. Petroleum coke, which is a solid, is included. Also included are natural gas plant liquids and crude oil consumed as a fuel.
[b]Electric power sector consumption is distributed to the end-use sectors.

Notes: Quantities reported in quadrillion Btu are derived from historical volumes and assumed thermal conversion factors. Other production includes liquid hydrogen, methanol, and some inputs to refineries. Net imports of petroleum include crude oil, petroleum products, unfinished oils, alcohols, ethers, and blending components. Other net imports include coal coke and electricity. Both coal consumption and coal production include waste coal consumed in the electric power and industrial sectors.

Sources: AEO2014 National Energy Modeling System, run REF2014.D102413A; and AEO2013 National Energy Modeling System, run REF2013. D102312A.