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International Energy Outlook 2013

Independent Statistics & Analysis
U.S. Energy Information Administration

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With Projections to 2040

July 2013

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Preface

The *International Energy Outlook 2013 (IEO2013)* presents an assessment by the U.S. Energy Information Administration (EIA) of the outlook for international energy markets through 2040. U.S. projections appearing in *IEO2013* are consistent with those published in EIA's *Annual Energy Outlook 2013 (AEO2013)* in April 2013. *IEO2013* is provided as a service to energy managers and analysts, both in government and in the private sector. The projections are used by international agencies, federal and state governments, trade associations, and other planners and decisionmakers. They are published pursuant to the Department of Energy Organization Act of 1977 (Public Law 95-91), Section 205(c).

The *IEO2013* energy consumption projections are divided according to Organization for Economic Cooperation and Development members (OECD)[1] and non-members (non-OECD). OECD members are divided into three basic country groupings: OECD Americas (United States, Canada, and Mexico/Chile), OECD Europe, and OECD Asia (Japan, South Korea, and Australia/New Zealand). Non-OECD countries are divided into five separate regional subgroups: non-OECD Europe and Eurasia (which includes Russia); non-OECD Asia (which includes China and India); Middle East; Africa; and Central and South America (which includes Brazil). In some instances, the *IEO2013* energy production models have different regional aggregations to reflect important production sources (for example, Middle East OPEC is a key region in the projections for liquids production). Complete regional definitions are listed in Appendix M.

IEO2013 focuses exclusively on marketed energy. Non-marketed energy sources, which continue to play an important role in some developing countries, are not included in the estimates. The *IEO2013* projections are based on U.S. and foreign government laws in effect on September 1, 2012. The potential impacts of pending or proposed legislation, regulations, and standards are not reflected in the projections, nor are the impacts of legislation for which the implementing mechanisms have not yet been announced.

The report begins with a review of world trends in energy demand and the major macroeconomic assumptions used in deriving the *IEO2013* projections, along with the major sources of uncertainty in the projections. For the first time, projections extend through 2040. In addition to the Reference case projections, High Economic Growth and Low Economic Growth cases were developed to consider the effects of higher and lower growth paths for economic activity than are assumed in the Reference case. *IEO2013* also includes a High Oil Price case and, alternatively, a Low Oil Price case. The resulting projections—and the uncertainty associated with international energy projections in general—are discussed in Chapter 1, "World energy demand and economic outlook."

Projections for energy consumption and production by fuel—petroleum and other liquid fuels, natural gas, and coal—are presented in Chapters 2, 3, and 4, along with reviews of the current status of each fuel on a worldwide basis. Chapter 5 discusses the projections for world electricity markets—including nuclear power, hydropower, and other marketed renewable energy resources—and presents projections of world installed generating capacity. New to this year's outlook, Chapter 6 presents a discussion of energy used in the buildings sector (residential and commercial). Chapter 7 provides a discussion of industrial sector energy use. Chapter 8 includes a detailed look at the world's transportation energy use. Finally, Chapter 9 discusses the outlook for global energy-related carbon dioxide emissions.

Objectives of the *IEO2013* projections

The projections in *IEO2013* are not statements of what will happen, but what might happen given the specific assumptions and methodologies used for any particular scenario. The Reference case projection is a business-as-usual trend estimate, given known technology and technological and demographic trends. EIA explores the impacts of alternative assumptions in other scenarios with different macroeconomic growth rates and world oil prices. The *IEO2013* cases generally assume that current laws and regulations are maintained throughout the projections. Thus, the projections provide policy-neutral baselines that can be used to analyze international energy markets.

While energy markets are complex, energy models are simplified representations of energy production and consumption, regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development. Behavioral characteristics are indicative of real-world tendencies, rather than representations of specific outcomes.

Energy market projections are subject to much uncertainty. Many of the events that shape energy markets are random and cannot be anticipated. In addition, future developments in technologies, demographics, and resources cannot be foreseen with certainty. Key uncertainties in the *IEO2013* projections are addressed through alternative cases.

EIA has endeavored to make these projections as objective, reliable, and useful as possible. They should, however, serve as an adjunct to, not a substitute for, a complete and focused analysis of public policy initiatives.

[1]OECD includes all members of the organization as of September 1, 2012, throughout all time series included in this report. Israel became a member in 2010 and is reported in OECD Europe for statistical reporting purposes.

Appendix A contains summary tables for the *IEO2013* Reference case projections of world energy consumption, GDP, energy consumption by fuel, carbon dioxide emissions, and regional population growth. Summary tables of projections for the High and Low Economic Growth cases are provided in Appendixes B and C, respectively, and projections for the High and Low Oil Price cases are provided in Appendixes D and E, respectively. Reference case projections of delivered energy consumption by end-use sector and region are presented in Appendix F. Appendix G contains summary tables of projections for world petroleum and other liquids production in all cases. Appendix H contains summary tables of Reference case projections for installed electric power capacity by fuel and regional electricity generation. Appendix I contains summary tables for projections of world natural gas production in all cases. Appendix J includes a set of tables for each of the four Kaya Identity components. In Appendix K, a set of comparisons of projections from the International Energy Agency's *World Energy Outlook 2012* with the *IEO2013* projections is presented. Comparisons of the *IEO2013* and *IEO2011* projections are also presented in Appendix K. Appendix L describes the models used to generate the *IEO2013* projections, and Appendix M defines the regional designations included in the report.

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Highlights

The *International Energy Outlook 2013 (IEO2013)* projects that world energy consumption will grow by 56 percent between 2010 and 2040. Total world energy use rises from 524 quadrillion British thermal units (Btu) in 2010 to 630 quadrillion Btu in 2020 and to 820 quadrillion Btu in 2040 (Figure 1). Much of the growth in energy consumption occurs in countries outside the Organization for Economic Cooperation and Development (OECD),[2] known as non-OECD, where demand is driven by strong, long-term economic growth. Energy use in non-OECD countries increases by 90 percent; in OECD countries, the increase is 17 percent. The *IEO2013* Reference case does not incorporate prospective legislation or policies that might affect energy markets.

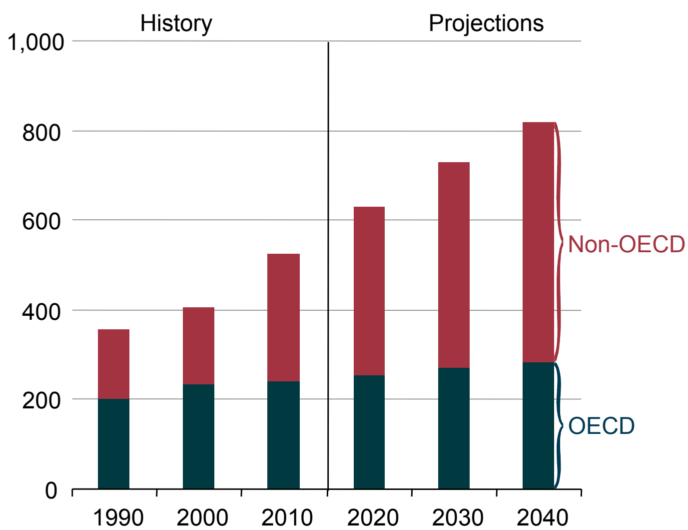
Renewable energy and nuclear power are the world's fastest-growing energy sources, each increasing by 2.5 percent per year. However, fossil fuels continue to supply almost 80 percent of world energy use through 2040. Natural gas is the fastest-growing fossil fuel in the outlook. Global natural gas consumption increases by 1.7 percent per year. Increasing supplies of tight gas, shale gas, and coalbed methane support growth in projected worldwide natural gas use. Coal use grows faster than petroleum and other liquid fuel use until after 2030, mostly because of increases in China's consumption of coal and tepid growth in liquids demand attributed to slow growth in the OECD regions and high sustained oil prices.

The industrial sector continues to account for the largest share of delivered energy consumption; the world industrial sector still consumes over half of global delivered energy in 2040. Given current policies and regulations limiting fossil fuel use, worldwide energy-related carbon dioxide emissions rise from about 31 billion metric tons in 2010 to 36 billion metric tons in 2020 and then to 45 billion metric tons in 2040, a 46-percent increase.

World economic background

The world is still recovering from the effects of the 2008-2009 global recession.[3] As these effects continue to be felt, many unresolved economic issues add to the uncertainty associated with this year's long-term assessment of world energy markets. Currently, there is wide variation in the economic performance of different countries and regions around the world. Among the more mature OECD regions, the pace of growth varies but generally is slow in comparison with the emerging economies of the non-OECD regions. In the United States and Europe, short- and long-term debt issues remain largely unresolved and are key sources of uncertainty for future growth. Economic recovery in the United States has been weaker than the recoveries from past recessions, although expansion is continuing. In contrast, many European countries fell back into recession in 2012, and the region's economic performance has continued to lag. Japan, whose economy had been sluggish before the devastating earthquake in March 2011, is recovering from its third recession in 3 years. Questions about the timing and extent of a return to operation for Japan's nuclear power generators compound the uncertainty surrounding its energy outlook.

Figure 1. World energy consumption, 1990-2040 (quadrillion Btu)



In contrast to the OECD nations, developing non-OECD economies, particularly in non-OECD Asia, have led the global recovery from the 2008-2009 recession. China and India have been among the world's fastest growing economies for the past two decades. From 1990 to 2010, China's economy grew by an average of 10.4 percent per year and India's by 6.4 percent per year. Although economic growth in the two countries remained strong through the global recession, both slowed in 2012 to rates much lower than analysts had predicted at the start of the year. In 2012, real GDP in China increased by 7.2 percent, its lowest annual growth rate in 20 years. India's real GDP growth slowed to 5.5 percent in 2012.

The world's real gross domestic product (GDP, expressed in purchasing power parity terms) rises by an average of 3.6

[2]OECD member countries as of September 1, 2012, are the United States, Canada, Mexico, Austria, Belgium, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, Japan, South Korea, Australia, and New Zealand. For statistical reporting purposes, Israel is included in OECD Europe.

[3]The International Monetary Fund (*World Energy Outlook 2008*, October 2008, p. 43) defines a global recession to be when the world's annual gross domestic product (GDP)—on a purchasing power parity basis—increases by less than 3.0 percent. According to Oxford Economics, world GDP grew by 2.7 percent in 2008, -1.1 percent in 2009, and 4.9 percent in 2010. However, the National Bureau of Economic Research declared that the U.S. recession began in December 2007 and ended in June 2009.

percent per year from 2010 to 2040. The fastest rates of growth are projected for the emerging, non-OECD regions, where combined GDP increases by 4.7 percent per year. In the OECD regions, GDP grows at a much slower rate of 2.1 percent per year over the projection, owing to more mature economies and slow or declining population growth trends. The strong growth in non-OECD GDP drives the fast-paced growth in future energy consumption projected for these nations.

In addition to concerns about the pace of world economic growth, other events have added further uncertainty to this year's energy outlook. Political unrest in several North African and Middle Eastern nations has persisted, most notably in Syria, but elsewhere as well. A number of the countries that experienced political transition as a result of the Arab Spring revolutions, including Egypt, Tunisia, and Yemen, have struggled to establish stability. In addition, the sanctions imposed on Iran as a result of its nuclear program have dampened the country's growth outlook. Unrest in the Middle East has been one reason that oil prices have been in the range of $90 to $130 per barrel[4] well into 2013. The Brent crude oil spot price averaged $112 per barrel in 2012, and EIA's July 2013 *Short-Term Energy Outlook* projects averages of $105 per barrel in 2013 and $100 per barrel in 2014. With prices expected to increase in the long term, the world oil price in real 2011 dollars reaches $106 per barrel in 2020 and $163 per barrel in 2040 in the *IEO2013* Reference case.

High sustained oil prices can affect consumer demand for liquid fuels, encouraging the use of less energy or alternative forms of energy, but also encouraging more efficient use of energy. Energy efficiency improvements are anticipated in every end-use sector, with global liquids intensity—liquid fuels consumed per dollar of GDP—declining (improving) by 2.6 percent per year from 2010 to 2040. However, some of the greatest potential for altering the growth path of energy use is in the transportation sector. The U.S. transportation sector provides a good example of this potential to change future liquids consumption. More stringent U.S. vehicle fuel economy standards offset growth in transportation activity, resulting in a decline in the country's use of petroleum and other liquids over the projection. Improving vehicle fuel economy standards will likely be adopted throughout most of the world, helping to moderate future growth in liquids consumption.

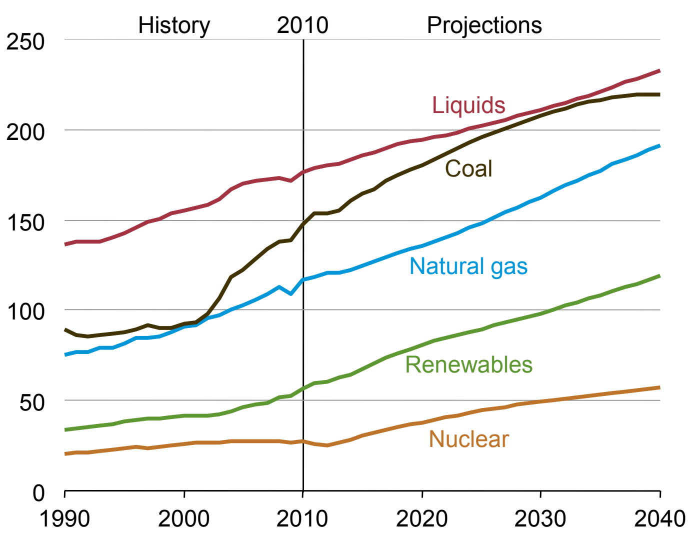
World energy markets by fuel type

In the long term, the *IEO2013* Reference case projects increased world consumption of marketed energy from all fuel sources through 2040 (Figure 2). Fossil fuels are expected to continue supplying much of the energy used worldwide. Although liquid fuels—mostly petroleum-based—remain the largest source of energy, the liquids share of world marketed energy consumption falls from 34 percent in 2010 to 28 percent in 2040, as projected high world oil prices lead many energy users to switch away from liquid fuels when feasible. The fastest growing sources of world energy in the Reference case are renewables and nuclear power. In the Reference case, the renewables share of total energy use rises from 11 percent in 2010 to 15 percent in 2040, and the nuclear share grows from 5 percent to 7 percent.

Liquid fuels

World use of petroleum and other liquid fuels[5] grows from 87 million barrels per day in 2010 to 97 million barrels per day in 2020 and 115 million barrels per day in 2040. In the Reference case, all the growth in liquids use is in the transportation and industrial sectors. In the transportation sector, in particular, liquid fuels continue to provide most of the energy consumed. Although advances in nonliquids-based transportation technologies are anticipated, they are not enough to offset the rising demand for transportation services worldwide. Despite rising fuel prices, use of liquids for transportation increases by an average of 1.1 percent per year, or 38 percent overall, from 2010 to 2040. The transportation sector accounts for 63 percent of the total increase in liquid fuel use from 2010 to 2040, and the remainder is attributed to the industrial sector, where the chemicals industry continues to consume large quantities of petroleum throughout the projection. The use of liquids declines in the other end-use sectors and for electric power generation.

Figure 2. World energy consumption by fuel type, 1990-2040 (quadrillion Btu)



To satisfy the increase in world liquids demand in the Reference case, liquids production increases by 28.3 million barrels per day from 2010 to 2040, including the production of both petroleum (crude oil and lease condensate, natural gas plant liquids [NGPL], bitumen, extra-heavy oil, and

[4]Nominal dollars per barrel of Brent crude oil.

[5]In *IEO2013*, the term *petroleum and other liquid fuels* includes a full array of liquid product supplies. Petroleum liquids include crude oil and lease condensate, natural gas plant liquids, bitumen, extra-heavy oil, and refinery gains. Other liquids include gas-to-liquids, coal-to-liquids, kerogen, and biofuels.

refinery gains), and other liquid fuels (coal-to-liquids [CTL], gas-to-liquids [GTL], biofuels, and kerogen). The Reference case assumes that countries in the Organization of the Petroleum Exporting Countries (OPEC) will invest in incremental production capacity in order to maintain a 39-43 percent share of total world liquids production through 2040, consistent with their share over the past 15 years. Increasing volumes of petroleum from OPEC producers contribute 13.8 million barrels per day to the total increase in world liquids production, and petroleum supplies from non-OPEC countries add another 11.5 million barrels per day (Figure 3).

Nonpetroleum liquids resources from both OPEC and non-OPEC sources grow on average by 3.7 percent per year over the projection period, but they remain a relatively minor share of total liquids supply through 2040. Production of nonpetroleum liquids is supported by sustained high prices in the Reference case; however, their development also relies heavily on country-specific regulatory policies. World production of nonpetroleum liquids, which in 2010 totaled only 1.6 million barrels per day (less than 2 percent of total world liquids production), increases to 4.6 million barrels per day in 2040, about 4 percent of total world liquids production. The largest components of future nonpetroleum liquid fuels production are biofuels in Brazil and the United States, at 0.7 and 0.5 million barrels per day, respectively, and CTL in China, at 0.7 million barrels per day. Those three countries account for 64 percent of the total increase in nonpetroleum liquids supply over the projection period.

Advances in technology make liquids production in previously inaccessible regions increasingly feasible, while higher oil prices make production in those regions economically viable. An important example of the potential impact of technological advances is the rapid growth of U.S. shale oil production in recent years, a development that has the potential to change the structure of oil markets worldwide. Although the extent of the world's shale oil resources is not yet fully understood, there is potential for shale oil production to increase non-OPEC supplies of liquid fuels substantially over the course of the *IEO2013* projection. A study commissioned by EIA to assess shale oil resources in 41 countries outside the United States,[6] taken in conjunction with EIA's own assessment of resources within the United States, indicate worldwide technically recoverable resources of 345 billion barrels of shale oil resources, which would add considerable non-OPEC liquid fuels production potential if the resources became economically competitive with other sources of liquids supply.

Natural gas

World natural gas consumption increases by 64 percent in the Reference case, from 113 trillion cubic feet in 2010 to 185 trillion cubic feet in 2040. Although the global recession resulted in an estimated decline of 3.6 trillion cubic feet in natural gas use in 2009, robust demand returned in 2010 with an increase of 7.7 trillion cubic feet, or 4 percent higher than demand in 2008, before the downturn. Natural gas continues to be the fuel of choice for the electric power and industrial sectors in many of the world's regions, in part because of its lower carbon intensity compared with coal and oil, which makes it an attractive fuel source in countries where governments are implementing policies to reduce greenhouse gas emissions. In addition, it is an attractive alternative fuel for new power generation plants because of relatively low capital costs and the favorable heat rates for natural gas generation. The industrial and electric power sectors together account for 77 percent of the total projected world increase in natural gas consumption.

Figure 3. World petroleum and other liquids production, 2010-2040 (million barrels per day)

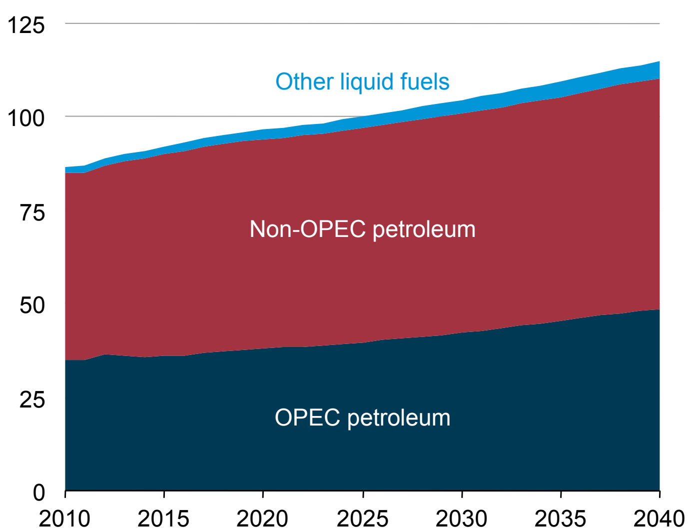
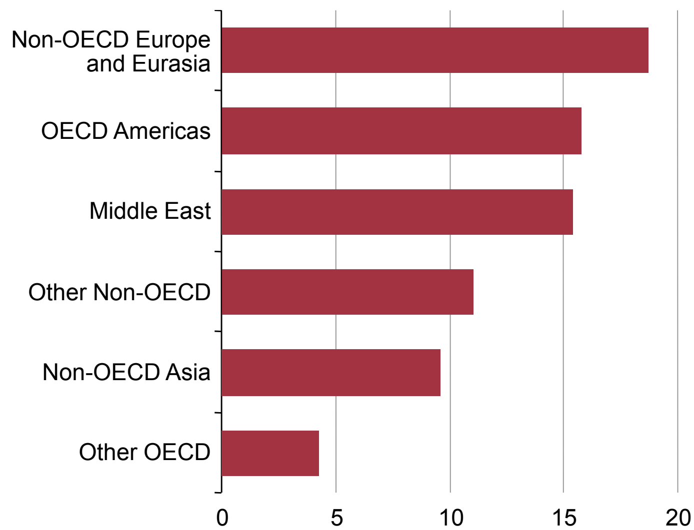


Figure 4. World increase in natural gas production by country grouping, 2010-2040 (trillion cubic feet)



[6]U.S. Energy Information Administration, *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States* (Washington, DC: June 2013).

An outlook for strong growth in reserves and production contributes to the strong competitive position of natural gas among other energy sources. Significant changes in natural gas supplies and global markets continue. The largest production increases from 2010 to 2040 in the Reference case (Figure 4) occur in non-OECD Europe and Eurasia (18.9 trillion cubic feet), the OECD Americas (15.9 trillion cubic feet), and the Middle East (15.6 trillion cubic feet). The United States and Russia each increase natural gas production by around 12 trillion cubic feet, together accounting for nearly one-third of the total increase in world gas production. Russia's production growth is supported mainly by increasing exploitation of the country's resources in the Arctic and eastern parts of the country. U.S. production growth comes mainly from shale resources.

Although there is more to learn about the extent of the world's tight gas, shale gas, and coalbed methane resource base, the *IEO2013* Reference case projects a substantial increase in those supplies—especially in the United States, Canada, and China. In the United States, one of the keys to increasing natural gas production has been advances in the application of horizontal drilling and hydraulic fracturing technologies, which made it possible to develop the country's vast shale gas resources and contributed to a near doubling of total U.S. technically recoverable natural gas resource estimates over the past decade. In the Reference case, shale gas accounts for 50 percent of U.S. natural gas production in 2040. Tight gas, shale gas, and coalbed methane resources in Canada and China account for more than 80 percent of their total domestic production in 2040 in the Reference case.

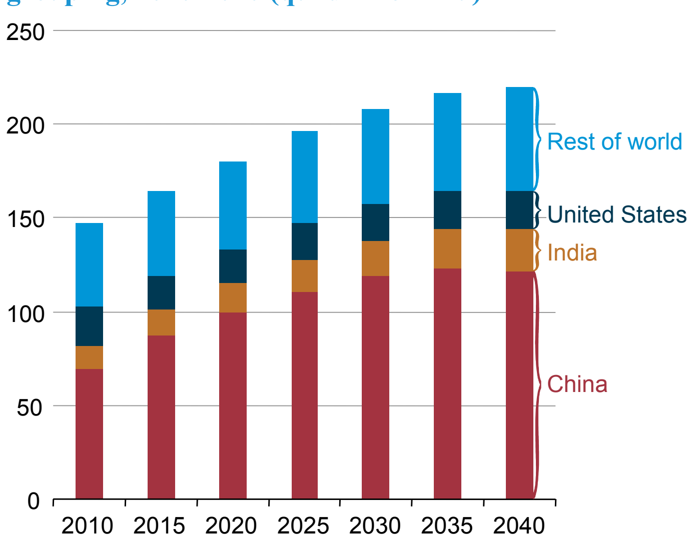
World natural gas trade, both by pipeline and by shipment in the form of liquefied natural gas (LNG), is poised to increase in the future. LNG accounts for a growing share of world natural gas trade in the Reference case, more than doubling from about 10 trillion cubic feet in 2010 to around 20 trillion cubic feet in 2040. Most of the increase in liquefaction capacity is in Australia and North America (the United States and Canada), where a multitude of new liquefaction projects are expected to be developed, many of which will become operational within the next decade. At the same time, existing facilities in North Africa and Southeast Asia have been underutilized or are shutting down as a result of production declines at older fields associated with the liquefaction facilities, and because domestic natural gas consumption is more highly valued than exports.

Although LNG trade has grown at a faster rate than pipeline trade in recent years, pipeline transportation of natural gas remains an integral part of world natural gas trade in the *IEO2013* Reference case. The outlook includes several new long-distance pipelines and expansions of existing infrastructure through 2040. The largest volumes of internationally traded natural gas by pipeline currently occur between Canada and the United States, and among a number of OECD and non-OECD countries in Europe. By the end of the projection period, the *IEO2013* Reference case also includes large volumes of pipeline flows into China from both Russia and Central Asia.

Coal

In the *IEO2013* Reference case, which does not include prospective greenhouse gas reduction policies, coal remains the second-largest energy source worldwide. World coal consumption rises at an average rate of 1.3 percent per year, from 147 quadrillion Btu in 2010 to 180 quadrillion Btu in 2020 and 220 quadrillion Btu in 2040. The near-term expansion of coal consumption reflects significant increases in China, India, and other non-OECD countries. In the longer term, growth of coal consumption decelerates as policies and regulations encourage the use of cleaner energy sources, natural gas becomes more economically competitive as a result of shale gas development, and growth of industrial use of coal slows, largely as a result of China's industrial activities. Coal consumption is dominated by China (47 percent), the United States (14 percent), and India (9 percent), with those three countries together accounting for 70 percent of total world coal consumption in 2010. Their share of world coal use increases to 75 percent in 2040 in the Reference case (Figure 5).

Figure 5. World coal consumption by country grouping, 2010-2040 (quadrillion Btu)



Despite the significant increase in coal use in developing non-OECD countries, the environmental impacts of mining and burning coal have driven policies and investment decisions in favor of cleaner and increasingly competitive energy sources—natural gas in particular. As a result, coal's share of world energy consumption stops growing in the next decade and gradually declines after 2025. Consumption of all other energy sources (except liquids) grows faster than coal use, particularly in the power sector. For example, the coal-fired share of world electricity generation declines from 40 percent in 2010 to 36 percent in 2040, while the renewables share increases from 21 percent to 25 percent, the natural gas share from 22 percent to 24 percent, and the nuclear share from 13 percent to 14 percent.

World coal production parallels demand, increasing from 8 billion short tons in 2010 to 11.5 billion short tons in 2040 and reflecting the same expansion in the near term, followed by much slower growth in later years. Global coal production is concentrated among four countries—China, the United States, India, and Australia—and in the other countries of non-OECD Asia (mainly Indonesia). Their combined share of total world coal production increases in the *IEO2013* Reference case from 78 percent in 2010 to 81 percent in 2040. China alone accounted for 44 percent of global coal production in 2010, and its share peaks at 52 percent in 2030. Projected coal production is significantly different from region to region, ranging from sustained growth in China to limited growth in the United States to steady decline in OECD Europe.

Electricity

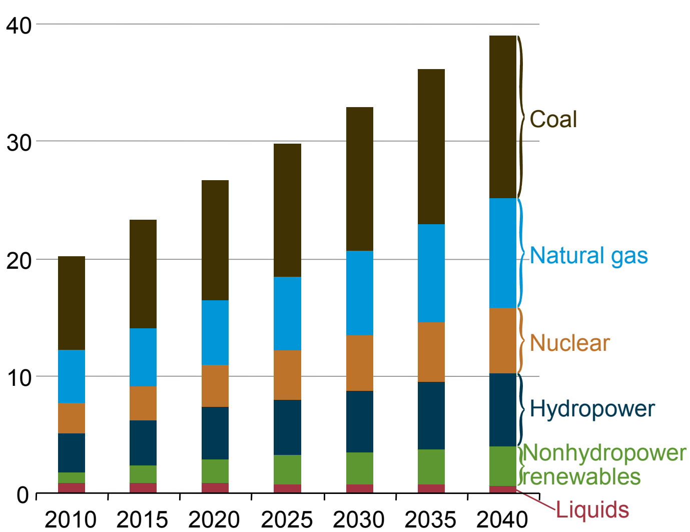
World net electricity generation increases by 93 percent in the *IEO2013* Reference case, from 20.2 trillion kilowatthours in 2010 to 39.0 trillion kilowatthours in 2040. In general, the growth of electricity demand in the OECD countries, where electricity markets are well established and consumption patterns are mature, is slower than in the non-OECD countries, where at present many people do not have access to electricity. Total net electricity generation in non-OECD countries increases by an average of 3.1 percent per year in the Reference case, led by non-OECD Asia (including China and India), where annual increases average 3.6 percent from 2010 to 2040. In contrast, total net generation in the OECD nations grows by an average of 1.1 percent per year from 2010 to 2040.

In many parts of the world, concerns about security of energy supplies and the environmental consequences of greenhouse gas emissions have spurred government policies that support a projected increase in renewable energy sources. As a result, renewable energy sources are the fastest growing sources of electricity generation in the *IEO2013* Reference case, at 2.8 percent per year from 2010 to 2040. After renewable generation, natural gas and nuclear power are the next fastest growing sources of generation, each increasing by 2.5 percent per year. Although coal-fired generation increases by an annual average of only 1.8 percent over the projection period, it remains the largest source of world power generation through 2040 (Figure 6). The outlook for coal, however, could be altered substantially by any future national policies or international agreements aimed at reducing or limiting the growth of greenhouse gas emissions.

Almost 80 percent of the projected increase in renewable electricity generation is fueled by hydropower and wind power. The contribution of wind energy, in particular, has grown rapidly over the past decade, from 18 gigawatts of net installed capacity at the end of 2000 to 183 gigawatts at the end of 2010—a trend that continues into the future. Of the 5.4 trillion kilowatthours of new renewable generation added over the projection period, 2.8 trillion kilowatthours (52 percent) is attributed to hydroelectric power and 1.5 trillion kilowatthours (28 percent) to wind. Most of the growth in hydroelectric generation (82 percent) occurs in the non-OECD countries, and more than half of the growth in wind generation (52 percent) occurs in the OECD countries. High construction costs can make the total cost of building and operating renewable generators higher than those for conventional plants. The intermittence of wind and solar energy, in particular, can further hinder the economic competitiveness of those resources, as they are not necessarily available when they would be of greatest value to the system. However, improving battery storage technology and dispersing wind and solar generating facilities over wide geographic areas could help to mitigate some of the problems associated with intermittency over the projection period.

Electricity generation from nuclear power worldwide increases from 2,620 billion kilowatthours in 2010 to 5,492 billion kilowatthours in 2040 in the *IEO2013* Reference case, as concerns about energy security and greenhouse gas emissions support the development of new nuclear generating capacity. Factors underlying the *IEO2013* nuclear power projections include the consequences of the March 2011 disaster at Fukushima Daiichi, Japan; planned retirements of nuclear capacity in OECD Europe under current policies; and continued strong growth of nuclear power in non-OECD Asia.

Figure 6. World net electricity generation by energy source, 2010-2040 (trillion kilowatthours)



Japan significantly curtailed its nuclear generation as a direct result of the Tōhoku earthquake and related tsunami on March 11, 2011. In addition to the four damaged Fukushima Daiichi reactors, Japan's 50 other nuclear reactors were shut down over the following 14 months. Japan compensated for the loss of nuclear generation by increasing its generation from natural gas, oil, and coal and by implementing efficiency and conservation measures to reduce load. Two reactors have returned to service, and additional reactors are expected to return to service soon. In the *IEO2013* Reference case, fossil fuel generation and conservation continue to bridge the gap left by the shutdown of many of Japan's nuclear plants.

The Fukushima Daiichi disaster could have long-term implications for the future of world nuclear power development in general. Even China—where large increases in nuclear capacity have been announced and are anticipated in the *IEO2013* Reference case—halted approval processes for all new reactors until the country's nuclear regulator completed a safety review. Germany and Switzerland announced plans to phase out or shut down their operating reactors by 2022 and 2034, respectively. Although the *IEO2013* Reference case considered the impacts of the disaster at Fukushima Daiichi, the uncertainty associated with nuclear power projections for Japan and for the rest of the world has increased. Still, substantial increases in nuclear generating capacity are projected, including 149 gigawatts in China, 47 gigawatts in India, 31 gigawatts in Russia, and 27 gigawatts in South Korea (Figure 7).

World delivered energy use by sector

This section discusses delivered energy consumption in the buildings, industrial, and transportation sectors. Energy losses associated with electricity generation and transmission are not included in the consumption numbers.

Residential and commercial buildings

World residential energy use increases by 1.5 percent per year, from 52 quadrillion Btu in 2010 to 82 quadrillion Btu in 2040, in the *IEO2013* Reference case. Much of the growth in residential energy consumption occurs in non-OECD nations, where robust economic growth improves standards of living and increases demand for residential energy. One factor contributing to increased demand in non-OECD nations is the trend toward replacing nonmarketed energy sources (including wood and waste, which are not fully included in the energy demand totals shown in the *IEO*) with marketed fuels, such as propane and electricity, for cooking and heating. Non-OECD residential energy consumption rises by 2.5 percent per year, compared with the much slower rate of 0.4 percent per year for OECD countries, where patterns of residential energy use already are well established, and slower population growth and aging populations translate to smaller increases in energy demand.

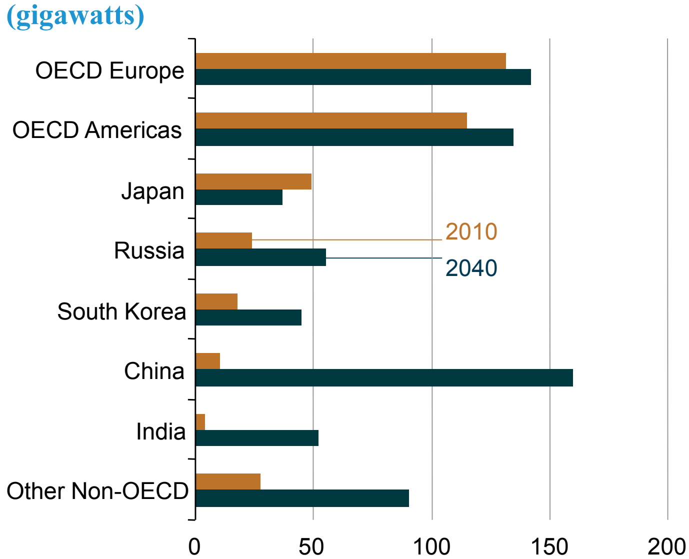
Globally, *IEO2013* projects average growth in commercial energy use of 1.8 percent per year through 2040, with the largest share of growth in non-OECD nations. OECD commercial energy use expands by 0.9 percent per year. Slow expansion of GDP and low or declining population growth in many OECD nations contribute to slower anticipated rates of growth in commercial energy demand. In addition, continued efficiency improvements moderate the growth of energy demand over time, as relatively inefficient equipment is replaced with newer, more efficient stock.

In the non-OECD nations, economic activity and commerce increase rapidly over the 2010-2040 projection period, fueling additional demand for energy in the service sectors. Total delivered commercial energy use among non-OECD nations grows by 3.2 percent per year from 2010 to 2040 in the Reference case. Population growth also is expected to be more rapid than in the OECD countries, resulting in increased needs for education, health care, and social services and the energy required to provide them. In addition, as developing nations mature, they are expected to transition to more service-related enterprises, which will increase demand for energy in the commercial sector.

Industrial

Worldwide, industrial energy consumption grows from 200 quadrillion Btu in 2010 to 307 quadrillion Btu in 2040 in the Reference case. The industrial sector accounted for most of the 2008-2009 recession-induced reduction in world energy use in 2009, primarily because the impact of substantial cutbacks in manufacturing was more pronounced than the impact of marginal reductions in energy use in other sectors. Non-OECD economies account for about 86 percent of the world increase in industrial sector energy consumption in the Reference case (Figure 8). Rapid economic growth is projected for the non-OECD countries, accompanied by rapid growth in their combined total industrial energy consumption, averaging 1.8 percent per year from 2010 to 2040. Because OECD nations have been undergoing a transition from manufacturing economies to service economies in recent decades, and have relatively slow projected growth in economic output, industrial energy use in the OECD region as a whole grows by an average of only 0.6 percent per year from 2010 to 2040.

Figure 7. World operating nuclear power generation capacity by country grouping, 2010 and 2040 (gigawatts)



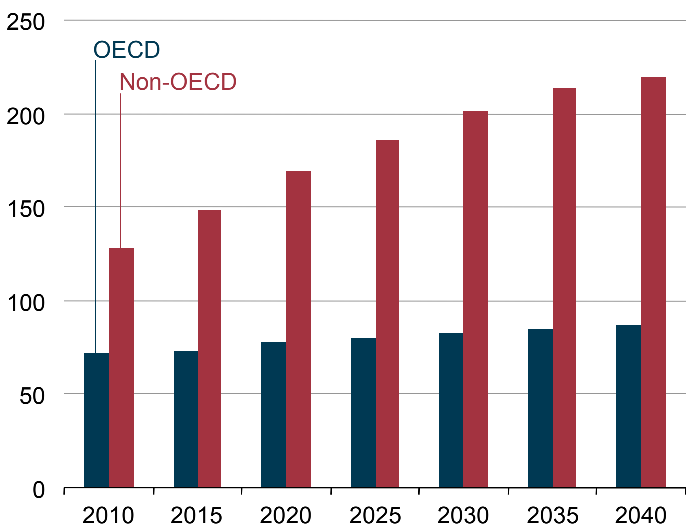
Transportation

Energy use in the transportation sector includes the energy consumed in moving people and goods by road, rail, air, water, and pipeline. The transportation sector is second only to the industrial sector in terms of total end-use energy consumption. The transportation share of world total liquids consumption increases from 55 percent in 2010 to 57 percent in 2040 in the *IEO2013* Reference case, accounting for 63 percent of the total increase in world liquids consumption. Thus, understanding the development of transportation energy use is key in assessing future trends in demand for liquid fuels.

Sustained high world oil prices throughout the projection are partly the result of a strong increase in demand for transportation fuels, particularly in the emerging non-OECD economies, where income growth and demand for personal mobility, combined with rapid urbanization, will have the greatest impact on growth in world transportation energy use. In the *IEO2013* Reference case, non-OECD transportation energy use grows by 2.2 percent per year from 2010 to 2040, and the non-OECD share of world demand for transportation liquids reaches 60 percent by the end of the projection (Figure 9). China, in particular, leads the projected global growth in transportation liquids demand, more than tripling its consumption from 8 quadrillion Btu in 2010 to 26 quadrillion Btu by 2040. In 2010, China's transportation energy use was only one-third of that in the United States; in 2040, China is projected to consume about the same amount of energy for transportation as the United States.

High oil prices and the economic recession had more profound impacts in the OECD economies than in the non-OECD economies. OECD energy use for transportation declined by 2.0 percent in 2008, followed by a further decrease of 3.1 percent in 2009, before recovering to 0.8-percent growth in 2010. Indications are that high world oil prices and slow recovery from the recession, with Japan and several key OECD economies falling back into recession in 2012, will mean that OECD transportation energy demand will continue to grow slowly in the near- to mid-term. In addition, demand for transportation liquids in OECD countries will be tempered by policies aimed at instituting strong energy efficiency improvements. Over the projection period, OECD transportation energy use declines by an average of 0.1 percent per year.

Figure 8. World industrial sector delivered energy consumption, 2010-2040 (quadrillion Btu)



World carbon dioxide emissions

World energy-related carbon dioxide emissions rise from 31.2 billion metric tons in 2010 to 36.4 billion metric tons in 2020 and 45.5 billion metric tons in 2040 in the *IEO2013* Reference case—an increase of 46 percent over the projection period. With strong economic growth and continued heavy reliance on fossil fuels expected for most non-OECD economies under current policies, much of the projected increase in carbon dioxide emissions occurs among the developing non-OECD nations. In 2010, non-OECD emissions exceeded OECD emissions by 38 percent; in 2040, they are projected to exceed OECD emissions by about 127 percent. Coal continues to account for the largest share of carbon dioxide emissions throughout the projection (Figure 10).

Carbon intensity of output—the amount of carbon dioxide emitted per unit of economic output—is a common measure

Figure 9. World transportation sector delivered energy consumption, 2010-2040 (quadrillion Btu)

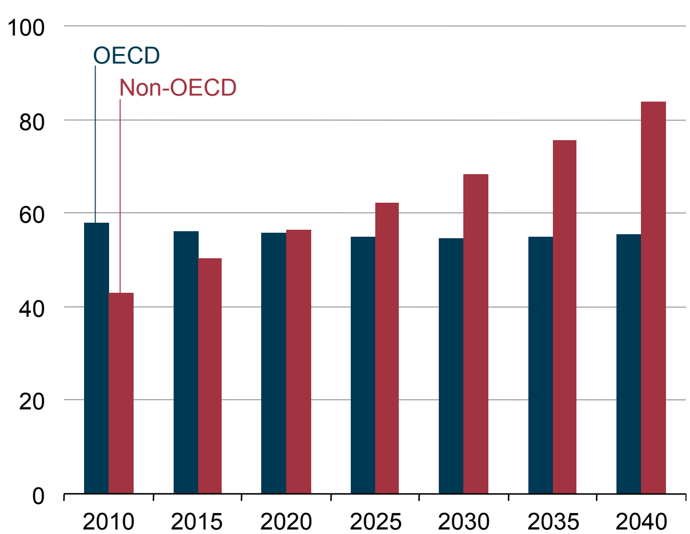
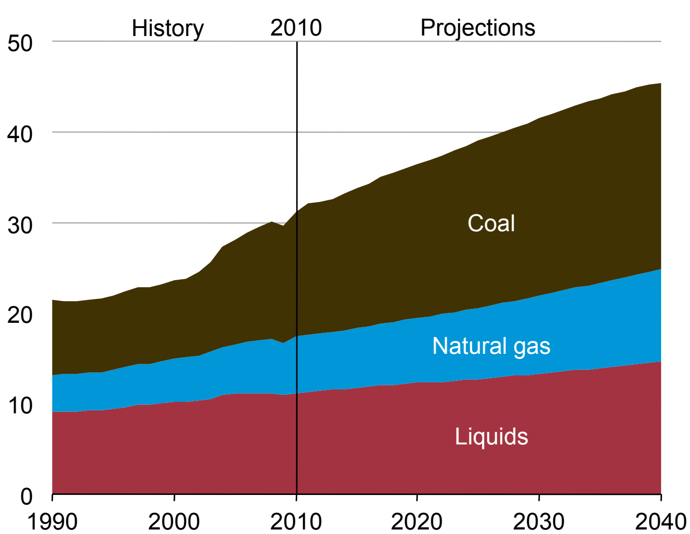
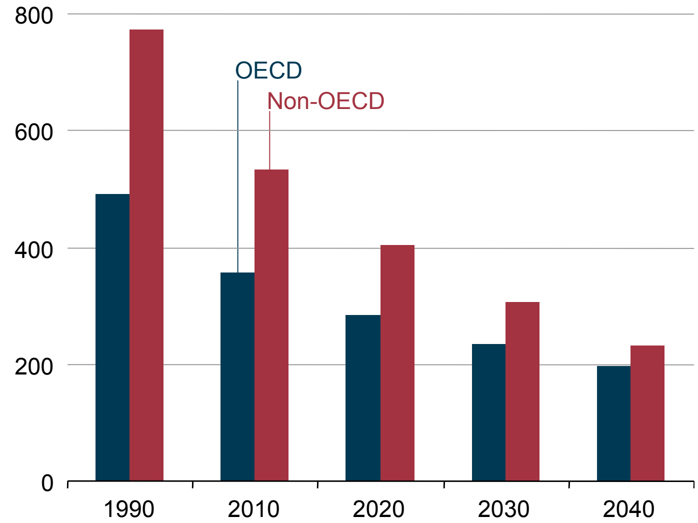


Figure 10. World energy-related carbon dioxide emissions by fuel type, 1990-2040 (billion metric tons)



used in analysis of changes in carbon dioxide emissions, and it is sometimes used as a stand-alone measure for tracking progress in relative emissions reductions. Energy-related carbon dioxide intensities improve (decline) in all *IEO* regions over the projection period, as economies continue to use energy more efficiently. Estimated carbon dioxide intensity declines by 1.9 percent per year in the OECD economies and by 2.7 percent per year in the non-OECD economies from 2010 to 2040 (Figure 11).

Figure 11. OECD and non-OECD carbon intensities, 1990-2040 (metric tons carbon dioxide emitted per million 2005 dollars of gross domestic product)



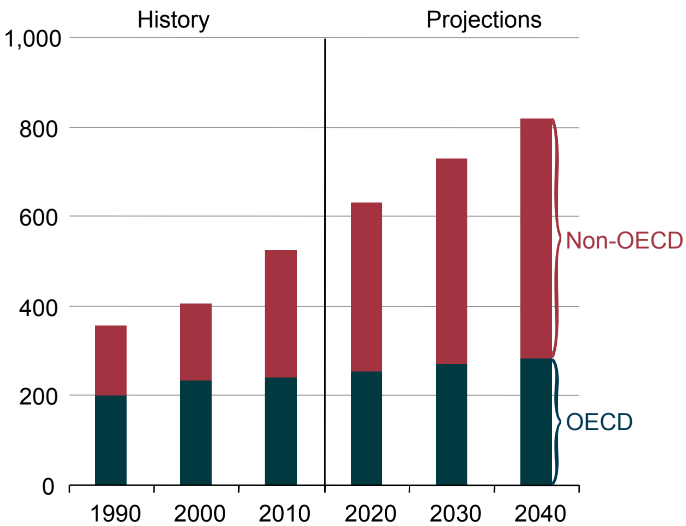
World energy demand and economic outlook

Overview

In the *IEO2013* Reference case, world energy consumption increases from 524 quadrillion Btu in 2010 to 630 quadrillion Btu in 2020 and 820 quadrillion Btu in 2040, a 30-year increase of 56 percent (Figure 12 and Table 1). More than 85 percent of the increase in global energy demand from 2010 to 2040 occurs among the developing nations outside the Organization for Economic Cooperation and Development (non-OECD), driven by strong economic growth and expanding populations. In contrast, OECD member countries are, for the most part, already more mature energy consumers, with slower anticipated economic growth and little or no anticipated population growth.[7]

Many economic and geopolitical circumstances add considerable uncertainty to any long-term assessment of world energy markets. Currently, there is wide variation in the economic performance of different countries and regions around the world. Among the more mature OECD regions, the pace of growth varies but generally is slow in comparison with the emerging economies of the non-OECD. In the United States and Europe, short- and long-term debt issues remain largely unresolved and are key sources of uncertainty for future growth. Economic recovery in the United States has been weaker than the recoveries from past recessions, although expansion is continuing. In contrast, many European countries fell back into recession in 2012, and the region's economic performance has continued to lag. Japan, whose economy had been sluggish before the devastating earthquake in March 2011, is recovering from its third recession in 3 years [*1*]. Questions about the timing and extent of a return to operation for Japan's nuclear power generators compound the uncertainty surrounding its energy outlook.

Figure 12. World total energy consumption, 1990-2040 (quadrillion Btu)



In contrast to the OECD nations, developing non-OECD economies, particularly in non-OECD Asia, have led the global recovery from the 2008-2009 recession. China and India have been among the world's fastest growing economies for the past two decades. From 1990 to 2010, China's economy grew by an average of 10.4 percent per year and India's by 6.4 percent per year. Although the two countries' economic growth remained strong through the global recession, both slowed in 2012 to rates much lower than analysts had predicted at the start of the year. In 2012, real GDP in China increased by 7.2 percent, its lowest annual growth rate in 20 years [*2*]. India's real GDP growth slowed to 5.5 percent in 2012.

Even with slower than average growth in China and India in the short-term, medium- and long-term prospects for the two nations are good. In the *IEO2013* Reference case, China and

Table 1. World energy consumption by country grouping, 2010-2040 (quadrillion Btu)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change 2010-2040
OECD	**242**	**244**	**255**	**263**	**269**	**276**	**285**	**0.5**
Americas	120	121	126	130	133	137	144	0.6
Europe	82	82	85	89	91	93	95	0.5
Asia	40	41	43	44	45	46	46	0.5
Non-OECD	**282**	**328**	**375**	**418**	**460**	**501**	**535**	**2.2**
Europe and Eurasia	47	50	53	57	61	65	67	1.2
Asia	159	194	230	262	290	317	337	2.5
Middle East	28	33	37	39	43	46	49	1.9
Africa	19	20	22	24	27	31	35	2.1
Central and South America	29	31	33	35	39	42	47	1.6
World	**524**	**572**	**630**	**680**	**729**	**777**	**820**	**1.5**

[7]For consistency, OECD includes all members of the organization as of September 1, 2012, throughout all the time series included in this report. For statistical purposes, Israel is reported as part of OECD Europe in *IEO2013*. See Appendix M for the complete list of regional definitions used in *IEO2013*.

India continue to lead both world economic growth and energy demand growth. Since 1990, energy consumption in both countries as a share of total world energy use has increased significantly; together, they accounted for about 10 percent of total world energy consumption in 1990 and nearly 24 percent in 2010. From 2010 to 2040, their combined energy use more than doubles in the Reference case, and they account for 34 percent of projected total world energy consumption in 2040. China, which recently became the world's largest energy consumer, is projected to consume more than twice as much energy as the United States in 2040 (Figure 13).

The *IEO2013* Reference case assumes that global gross domestic product (GDP) rises by an average of 3.6 percent per year from 2010 to 2040, with non-OECD economies averaging 4.7 percent per year and OECD economies 2.1 percent per year. Future energy consumption growth is driven by non-OECD demand. Whereas energy use in non-OECD nations was 16 percent greater than that in OECD nations in 2010, the non-OECD economies are projected to consume 47 percent more energy than the OECD economies in 2020 and 88 percent more in 2040 (Figure 14).

While energy use in non-OECD Asia (led by China and India) rises by 112 percent from 2010 to 2040, strong growth in energy use is also projected for much of the rest of the non-OECD region (Figure 15). With fast-paced growth in population and access to ample domestic resources, energy demand increases by 76 percent in the Middle East over the projection period, by 85 percent in Africa, and by 62 percent in Central and South America. The slowest projected growth among the non-OECD regions is for Europe and Eurasia, which includes Russia and the other former Soviet republics, at 42 percent from 2010 to 2040, as the region's population declines and substantial gains in energy efficiency are achieved through replacement of inefficient Soviet-era capital equipment.

Outlook for world energy consumption by energy source

The use of all energy sources increases over the time horizon of the *IEO2013* Reference case (Figure 16). Given expectations that world oil prices will remain at levels that are high relative to historical experience throughout the projection, petroleum and other liquid fuels[8] are the world's slowest-growing source of energy. Liquids consumption increases at an average annual rate of 0.9 percent from 2010 to 2040, whereas total energy demand increases by 1.5 percent per year. Nuclear power and renewables are the fastest-growing sources of world energy, both increasing at an average annual rate of 2.5 percent. Concerns about energy security, the impact of fossil fuel emissions on the environment, and sustained high world

Figure 13. Energy consumption in the United States, China, and India, 1990-2040 (quadrillion Btu)

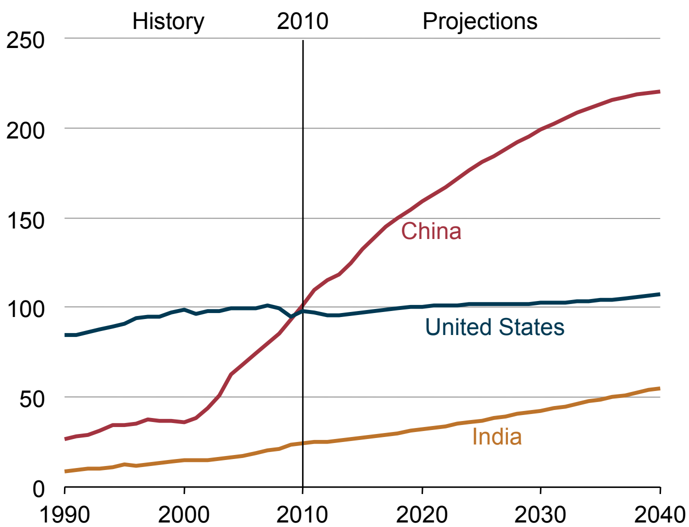


Figure 14. World energy consumption, 1990-2040 (quadrillion Btu)

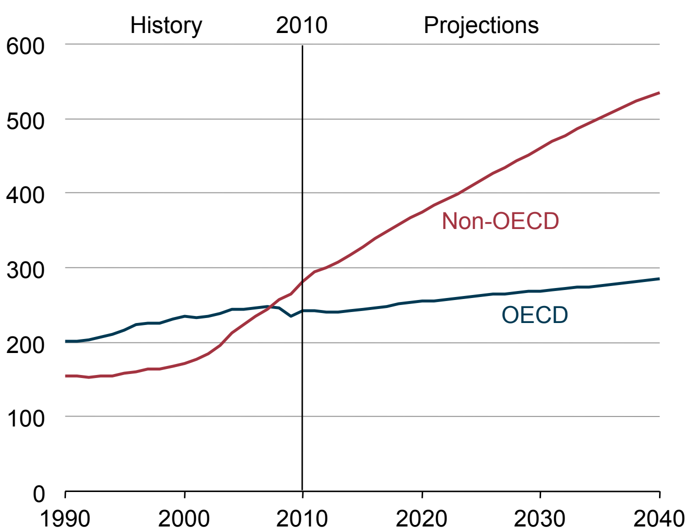
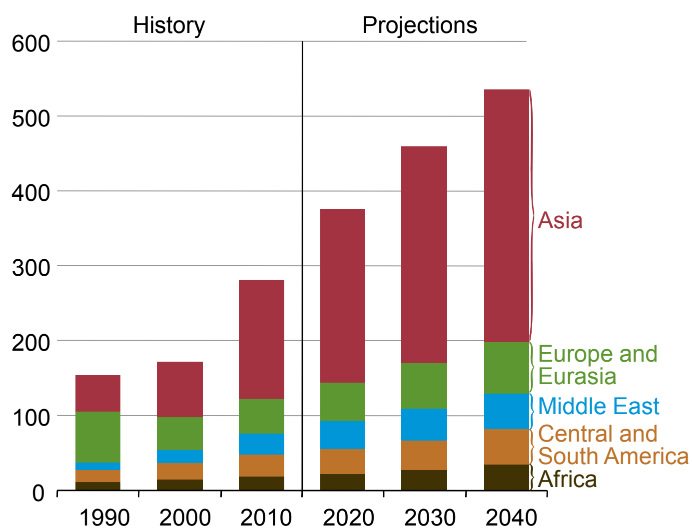


Figure 15. Non-OECD energy consumption by country grouping, 1990-2040 (quadrillion Btu)



[8]In *IEO2013*, the term *petroleum and other liquid fuels* includes a full array of liquid product supplies. Petroleum liquids include crude oil and lease condensate, natural gas plant liquids, bitumen, extra-heavy oil, and refinery gains. Other liquids include gas-to-liquids, coal-to-liquids, kerogen, and biofuels.

oil prices support expanded use of nuclear power and renewable energy over the projection. Government policies and incentives improve the prospects for non-fossil forms of energy in many countries around the world in the outlook.

Fossil fuels continue to supply most of the world's energy throughout the *IEO2013* Reference case projection. In 2040, liquid fuels, natural gas, and coal still supply more than three-fourths of total world energy consumption. Petroleum and other liquid fuels remain the largest source of energy, but their share of world marketed energy consumption declines from 34 percent in 2010 to 28 percent in 2040. On a worldwide basis, liquids consumption increases only in the industrial and transportation sectors while declining in the buildings and electric power sectors. The decrease in the use of liquid fuels in the residential, commercial, and power sectors is a result of rising world oil prices, which result in switching from liquids to alternative fuels where possible. In contrast, the use of liquids in the transportation sector continues to increase despite rising prices. World liquids consumption for transportation grows by 1.1 percent per year from 2010 to 2040 and accounts for 63 percent of the total projected net increment in liquid fuel use. The industrial sector accounts for the remainder of the increase, growing by 1.2 percent per year over the course of the projection.

In the *IEO2013* Reference case, the world's total natural gas consumption increases by 1.7 percent per year on average, from 113 trillion cubic feet in 2010 to 132 trillion cubic feet in 2020 and 185 trillion cubic feet in 2040. Increasing supplies of natural gas, particularly from shale formations in the United States and Canada, and eventually elsewhere as well, help to supply global markets. A substantial portion of China's future natural gas production is projected to come from tight gas, shale gas, and coalbed methane. In the future, advances in the application of the horizontal drilling and hydraulic fracturing technologies that have contributed to the rapid increase in U.S. natural gas production in recent years are applied in other parts of the world. As a result, natural gas prices remain below oil prices on an energy content basis, supporting the projected worldwide growth in gas consumption. Over the projection period, natural gas demand increases in all end-use sectors, with the largest increments in the electric power and industrial sectors (Figure 17). Worldwide, natural gas consumption for electric power generation increases by nearly 80 percent from 2010 to 2040, while natural gas consumption in the industrial sector increases by 58 percent. Those two sectors account for 77 percent of the net increase in global natural gas use over the projection period.

Coal continues to play an important role in world energy markets, especially in non-OECD Asia, where the combination of fast-paced economic growth and large domestic resources supports growth in coal demand. World coal consumption increases by an average 1.3 percent per year on average from 2010 to 2040, while coal use in non-OECD Asia increases by 1.9 percent per year. World coal consumption grew by 59 percent from 2000 to 2010, largely because of China's rapidly growing energy demand. In China alone, coal consumption tripled over the 2000-2010 period. Coal accounted for 23 percent of world energy consumption in 2000, compared to a 38-percent share for liquids. In 2010, the gap had narrowed substantially, with the coal share at 28 percent and the liquids share at 34 percent. In the absence of policies or legislation that would limit the growth of coal use, China—and to a lesser extent, India and the other nations of non-OECD Asia—consumes coal in place of more expensive fuels in the outlook. In 2030, coal and liquid fuels account for equal shares of world energy consumption at around 29 percent. After 2030, China's use of coal for steel and cement production slows and then declines, and the coal share of world energy use declines to 27 percent in 2040 (compared to a 28-percent share for the liquid fuels).

Electricity consumption by end users grows faster than their use of other delivered energy sources in the Reference case, as has been true for the past several decades. Net electricity generation worldwide rises by 2.2 percent per year on average from 2010 to 2040. The strongest growth in electricity generation is projected for non-OECD countries, where electricity generation increases by an average of 3.1 percent per year in the Reference case, as rising standards of living increase demand for home appliances

Figure 16. World energy consumption by fuel type, 1990-2040 (quadrillion Btu)

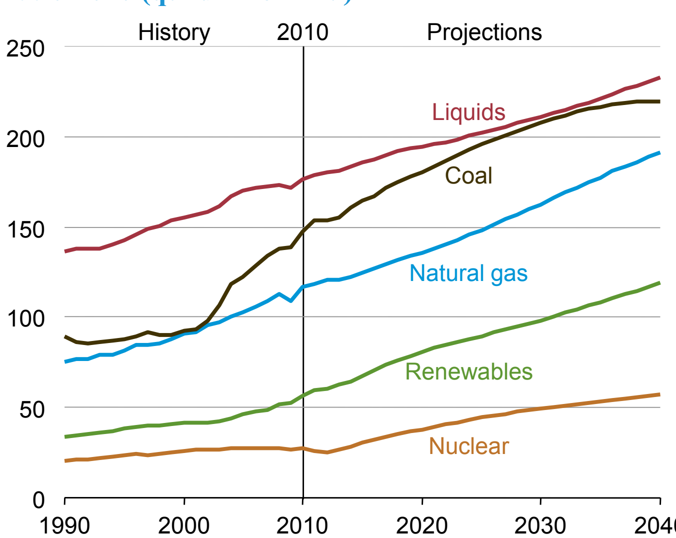
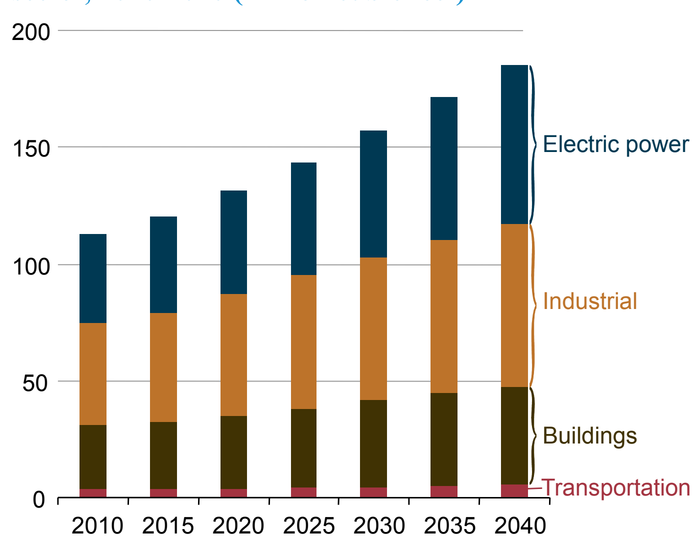


Figure 17. World natural gas consumption by end-use sector, 2010-2040 (trillion cubic feet)



and electronic devices, and commercial services, including hospitals, schools, office buildings, and shopping malls, expand. In the OECD nations, where infrastructures are more mature and population growth is relatively slow or declining, the projected growth in power generation averages 1.1 percent per year from 2010 to 2040.

Coal provides the largest share of world electricity generation throughout the Reference case projection, although its share declines from 40 percent of total generation in 2010 to 36 percent in 2040 (Figure 18). The liquids share of total generation also falls in the Reference case, as other fuels are substituted for high-priced liquids in the power generation sector where possible. The liquids share of total generation falls from 5 percent in 2010 to slightly less than 2 percent in 2040. Natural gas and renewable energy sources account for increasing shares of total generation. The natural gas share of global generation grows from 22 percent in 2010 to 24 percent in 2040, and the renewable share increases from 21 percent to 25 percent. Renewable generation (including hydropower) is the world's fastest-growing source of electric power in the *IEO2013* Reference case, rising by an average of 2.8 percent per year and outpacing the average annual increases for natural gas (2.5 percent), nuclear power (2.5 percent), and coal (1.8 percent). Government policies and incentives throughout the world support the rapid construction of renewable generation facilities.

Worldwide, hydroelectricity and wind are the two largest contributors to the increase in global renewable electricity generation, with hydropower accounting for 52 percent of the total increment and wind 28 percent. The mix of the two renewable energy sources differs dramatically between the OECD and non-OECD regions. In OECD nations, most economically exploitable hydroelectric resources already have been developed. Except in a few cases—notably, Canada and Turkey—there are few opportunities to expand large-scale hydroelectric power projects. Instead, most renewable energy growth in OECD countries is expected to come from nonhydroelectric sources, especially wind. Many OECD countries, particularly those in Europe, have government policies (including feed-in tariffs,[9] tax incentives, and market share quotas) that encourage the construction of wind and other nonhydroelectric renewable electricity facilities. In the Reference case, more than 70 percent of the projected growth in OECD renewable energy sources is attributed to nonhydroelectric renewables (Figure 19).

In the non-OECD nations, hydroelectric power is the predominant source of renewable energy growth, accounting for 63 percent of the total increment in non-OECD renewable energy use over the projection. Strong increases in hydroelectric generation, primarily from mid- to large-scale power plants, are expected in Brazil and in non-OECD Asia (especially, China and India), which in combination account for 80 percent of the total increase in non-OECD hydroelectric generation from 2010 to 2040. Growth rates for wind-powered electricity generation also are relatively high in non-OECD countries. China has one of the fastest growing non-OECD regional markets for wind power, with projected total generation from wind power plants increasing from 45 billion kilowatthours in 2010 to 637 billion kilowatthours in 2040, at an average rate of 9.3 percent per year. In China, where wind generation accounted for 6 percent of total renewable generation in 2010, its share grows to 26 percent in 2040.

Electricity generation from nuclear power worldwide increases from 2.6 trillion kilowatthours in 2010 to 5.5 trillion kilowatthours in 2040 in the *IEO2013* Reference case, as concerns about energy security and greenhouse gas emissions support the development of new nuclear generating capacity. In addition, world average capacity utilization rates have continued to rise over time, from about 68 percent in 1980 to about 80 percent in 2011. The projections assume that most of the older nuclear power plants now operating in OECD countries and in non-OECD Eurasia will be granted extensions to their operating licenses.

Figure 18. World net electricity generation by energy source, 2010-2040 (trillion kilowatthours)

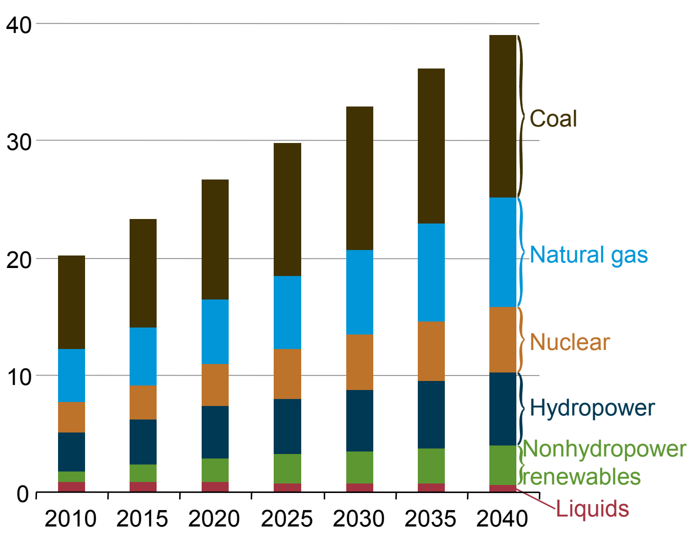
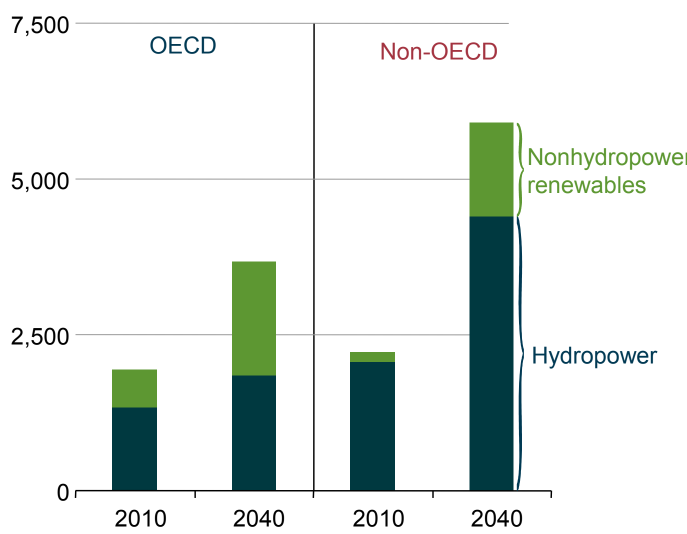


Figure 19. World electricity generation from renewable energy sources, 2010 and 2040 (billion kilowatthours)



[9]A feed-in tariff is an incentive structure to encourage the adoption of renewable energy through government legislation. Under a feed-in tariff structure, regional or national electric utilities are obligated to purchase renewable electricity at a specified premium price, in order to allow renewable energy sources to overcome cost disadvantages.

There is still considerable uncertainty about the future of nuclear power, however, and a number of issues could slow the development of new nuclear power plants. In many countries, concerns about plant safety, radioactive waste disposal, and the proliferation of nuclear waste materials may hinder plans for new installations. The March 2011 disaster at Japan's Fukushima Daiichi nuclear power plant could have long-term implications for the future of world nuclear power development in general. Following the disaster, Germany and Switzerland announced plans to phase out or shut down their operating reactors by 2022 and 2034, respectively [*3*]. China—where plans for large increases in nuclear capacity have been announced and are included in the *IEO2013* Reference case projection—instituted a temporary moratorium on new approvals for nuclear power construction that lasted 20 months before it was lifted at the end of October 2012 [*4*]. Clearly, the uncertainty associated with nuclear power projections for Japan and for the rest of the world has increased following the events of March 2011.

In the *IEO2013* Reference case, 86 percent of the world expansion in installed nuclear power capacity occurs in non-OECD countries, with China, India, and Russia accounting for the largest increment in world net installed nuclear power from 2010 to 2040 (Figure 20). China adds 149 gigawatts of nuclear capacity between 2010 and 2040 in the Reference case, India 47 gigawatts, and Russia 31 gigawatts. Within the OECD, installed nuclear capacity increases to some extent in almost every region. The extent to which governments in Europe and Japan might withdraw their support for nuclear power is uncertain, but some countries have already revised their nuclear policies after the Fukushima Daiichi disaster. Germany and Switzerland have adopted plans to phase out nuclear power. However, Turkey and Poland are moving forward with plans to install new nuclear capacity, and France, which relies heavily on nuclear power, continues to support its use [*5*].

In the United States, Title XVII of the Energy Policy Act of 2005 authorizes the U.S. Department of Energy to issue loan guarantees for innovative technologies that "avoid, reduce, or sequester greenhouse gases." In addition, subsequent legislative provisions in the Consolidated Appropriation Act of 2008 allocated $18.5 billion in guarantees for nuclear power plants [*6*]. In the *IEO2013* Reference case, U.S. nuclear power capacity increases from 101 gigawatts in 2010 to a high of 114 gigawatts in 2025, before declining to 109 gigawatts in 2036, largely as a result of plant retirements. New additions in the later years of the projection bring U.S. nuclear capacity back up to 113 gigawatts in 2040.

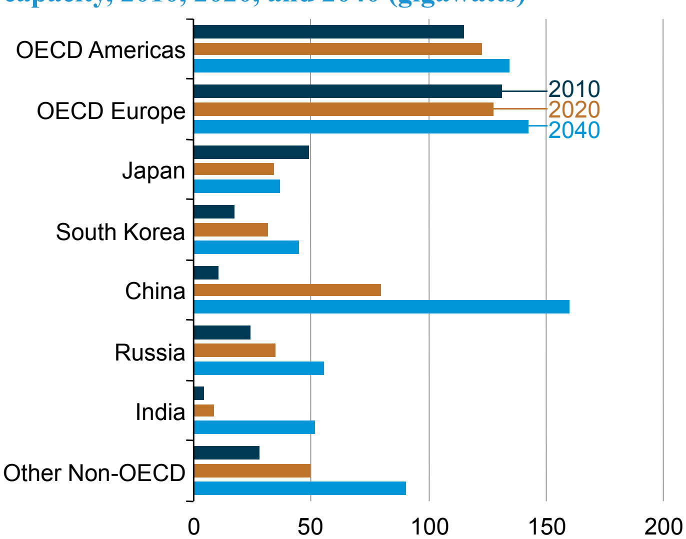
Delivered energy consumption by end-use sector

Understanding patterns in the consumption of energy delivered to end users[10] is important to the development of projections for global energy use. Outside the transportation sector, which at present is dominated by liquid fuels, the mix of energy use in the residential, commercial, and industrial sectors varies widely by region, depending on a combination of regional factors, such as the availability of energy resources, levels of economic development, and political, social, and demographic factors.

Residential and commercial sectors

Energy consumed in the buildings sector is divided between residential and commercial end users and accounts for nearly one-quarter of the total delivered energy consumed worldwide. In the *IEO2013* Reference case, total world energy consumption in buildings increases from 81 quadrillion Btu in 2010 to 131 quadrillion Btu in 2040, an average annual growth rate of 1.6 percent per year.

Figure 20. World nuclear electricity generation capacity, 2010, 2020, and 2040 (gigawatts)



Energy use in the residential sector is defined as the energy consumed by households, excluding transportation uses.[11] In the residential sector, energy is used for heating, cooling, lighting, water heating, and many other appliances and equipment. Income levels and energy prices influence the ways in which energy is consumed in the residential sector, as do various other factors, such as location, building and household characteristics, weather, equipment types and efficiencies, access to delivered energy, availability of energy sources, and energy-related policies. As a result, the types and amounts of energy use by households can vary widely within and across regions and countries.

In the *IEO2013* Reference case, energy use in homes accounts for about 14 percent of world delivered energy consumption in 2040. World residential energy consumption increases by 57 percent from 2010 to 2040, mainly as a result of growing residential demand in the non-OECD countries. Total non-OECD residential energy consumption increases at an average annual rate of 2.5 percent, compared with an average of 0.4

[10]Delivered energy consumption in the end-use sector consists of primary energy consumption and retail sales of electricity, excluding electrical system energy losses.

[11]Total delivered energy use in the residential and commercial sectors includes electricity, natural gas, liquid fuels, and coal. Although renewable energy use in the electric power sector is reported for most countries, data on the direct end use of renewable energy outside the United States can be mixed and inconsistent. As a result, the *IEO2013* projections do not include international renewable energy consumption in the end-use sectors.

percent per year in the OECD countries (Figure 21). China and India continue to lead world growth in residential energy demand in the projection, as a result of rapid economic and population growth. In 2040, their combined residential energy use is almost three times their 2010 total and accounts for nearly 31 percent of total world residential energy consumption.

The commercial sector—often referred to as the service sector or the services and institutional sector—consists of businesses, institutions, and organizations that provide services, encompassing many different types of buildings and a wide range of activities and energy-related services. Examples of commercial sector facilities include schools, stores, correctional institutions, restaurants, hotels, hospitals, museums, office buildings, banks, and sports arenas. Most commercial energy use occurs in buildings or structures, supplying services such as space heating, water heating, lighting, cooking, and cooling. Energy consumed for services not associated with buildings, such as traffic lights and city water and sewer services, is also categorized as commercial energy use. The commercial sector accounted for nearly 8 percent of total world delivered energy consumption in 2010. In the *IEO2013* Reference case, commercial energy use grows by an average of 1.8 percent per year from 2010 to 2040.

Slow expansion of GDP and low or declining population growth in many OECD nations contribute to slow rates of increase in commercial energy demand in the Reference case. In addition, continued efficiency improvements moderate the growth of energy demand over time, as less efficient energy-using equipment is replaced with newer, more efficient stock. Conversely, continued economic growth is expected to include growth in business activity, with its associated energy use, in areas such as retail and wholesale trade and business, financial services, and leisure services. Among the OECD nations, delivered energy consumption in the commercial sector increases by 0.9 percent per year from 2010 through 2040, more than twice the rate projected for the residential sector.

In the non-OECD nations, economic activity and commerce increase rapidly, fueling additional demand for energy in the service sectors. Population growth also is more rapid than in the OECD countries, increasing the need for education, health care, and social services and the energy required to provide them. In addition, as developing nations mature, they transition to more service-related enterprises, which increases the demand for energy in the commercial sector. The energy needed to fuel growth in commercial buildings will be substantial, and total delivered commercial energy use among non-OECD nations grows by 3.2 percent per year from 2010 to 2040 in the Reference case, more than three times as fast as the growth of commercial sector energy demand in the OECD nations (Figure 22).

Industrial sector

The industrial sector encompasses manufacturing, agriculture, mining, and construction—and a wide range of activities, such as processing and assembly, space conditioning, and lighting. Industrial energy use also includes natural gas and petroleum products used as feedstocks for the production of non-energy products, such as plastics and fertilizer. Industrial energy demand varies across regions and countries of the world, based on the level and mix of economic activity and technological development, among other factors. The industrial sector consumed 52 percent of global delivered energy in 2010, and its energy consumption grows by an average of 1.4 percent per year from 2010 to 2040 in the *IEO2013* Reference case.

Industrial sector energy use in the non-OECD economies increases by 1.8 percent per year in the Reference case, compared with 0.6 percent per year in the OECD economies (Figure 23). The gap in growth rates reflects both faster anticipated economic expansion outside the OECD and differences in the composition of industrial sector production. Industrial operations in the OECD economies generally are more energy-efficient than those in the non-OECD economies, and the mix of industrial output is more

Figure 21. World residential sector delivered energy consumption, 2010-2040 (quadrillion Btu)

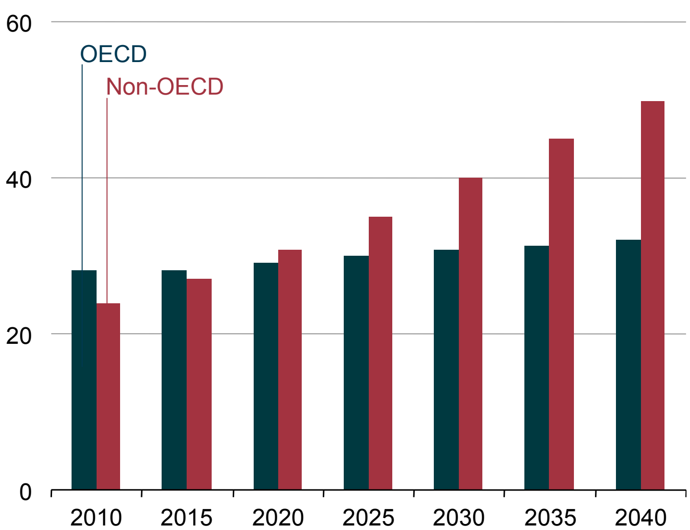
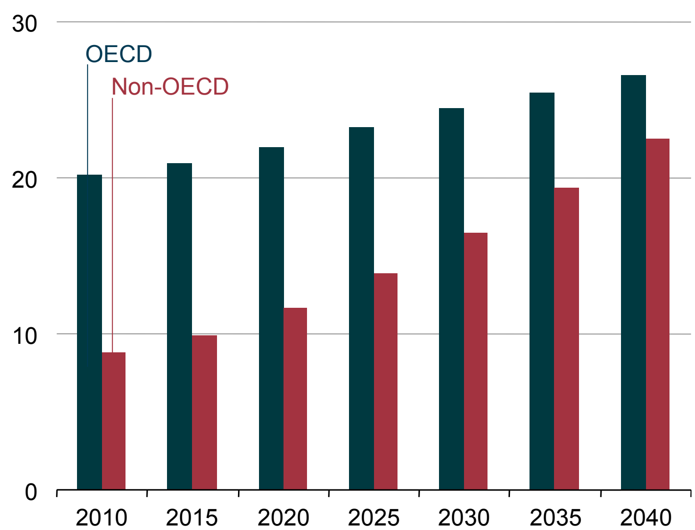


Figure 22. World commercial sector delivered energy consumption, 2010-2040 (quadrillion Btu)



heavily weighted toward non-energy-intensive industry sectors. On average, industrial energy intensity (the amount of energy consumed in the industrial sector per dollar of economic output) in non-OECD countries is triple that in OECD countries.

In 2010, liquids made up 38 percent of industrial energy use in OECD countries, compared with 23 percent in non-OECD countries, and coal represented 12 percent of OECD industrial energy use, compared with 34 percent in non-OECD countries. Of the five industrial fuel categories (renewables, electricity, natural gas, coal, and petroleum and other liquid fuels), petroleum and other liquid fuels are dominant in the OECD nations throughout the projection, due to continued significant growth in the use of natural gas liquids in the chemical sector in both the United States and the European Union and the use of motor fuels in agriculture and construction. Coal is the dominant fuel in the non-OECD countries, due in part to China's continuing heavy reliance on accessible and relatively inexpensive domestic coal resources for use in its steel and cement industries.

In the Reference case projection, there are some shifts in the overall industrial fuel mix for both OECD and non-OECD regions. From 2010 to 2040, as liquid fuel and feedstock prices remain at relatively high levels, industrial liquids use in OECD countries grows much more slowly than GDP. In addition, rising coal prices and structural shifts in the OECD industrial sector as a whole result in slow growth of coal use for industrial processes. Both coal and liquid fuels are slowly displaced by growing industrial demand for natural gas, electricity, and renewable energy sources (largely biomass). As a result, the liquids share of OECD delivered industrial energy consumption falls slightly, from 38 percent in 2010 to 37 percent in 2040, while the natural gas share increases from 27 percent to 29 percent. In the OECD countries, the electricity share of industrial energy use remains flat through 2040, while the renewable share increases from 7 percent to 8 percent. In the non-OECD countries, there is a slight shift away from liquids and coal use in the industrial sector, with natural gas and electricity showing small gains as a share of total industrial energy consumption.

Transportation sector

Energy use in the transportation sector includes energy consumed in moving people and goods by road, rail, air, water, and pipeline. The transportation sector accounted for 26 percent of total world delivered energy consumption in 2010, and transportation energy use increases by 1.1 percent per year from 2010 to 2040 in the *IEO2013* Reference case. The growth in transportation energy demand is largely a result of increases projected for the non-OECD nations, where fast-paced gains in GDP raise standards of living and, correspondingly, the demand for personal travel and freight transport to meet consumer demand for goods. Non-OECD transportation energy use increases by 2.3 percent per year, compared with an average decrease of 0.1 percent per year decrease in the OECD nations, where consuming patterns are already well established, and slower growth of national economies and populations coupled with vehicle efficiency improvements keeps transportation energy demand from increasing (Figure 24).

The road transport component of transportation energy use includes light-duty vehicles, such as automobiles, sport utility vehicles, minivans, small trucks, and motorbikes, as well as heavy-duty vehicles, such as large trucks used for moving freight and buses used for passenger travel. Growth rates for economic activity and population and trends in vehicle fuel efficiency are the key factors in transportation energy demand. Economic growth spurs increases in industrial output, which requires the movement of raw materials to manufacturing sites, as well as the movement of manufactured goods to end users. In addition, increasing demand for personal travel is a primary contributing factor to underlying increases in energy demand for transportation. Increases in urbanization and in personal incomes also contribute to increases in air travel and motorization (more vehicles per capita) in the growing non-OECD economies.

Figure 23. World industrial sector delivered energy consumption, 2010-2040 (quadrillion Btu)

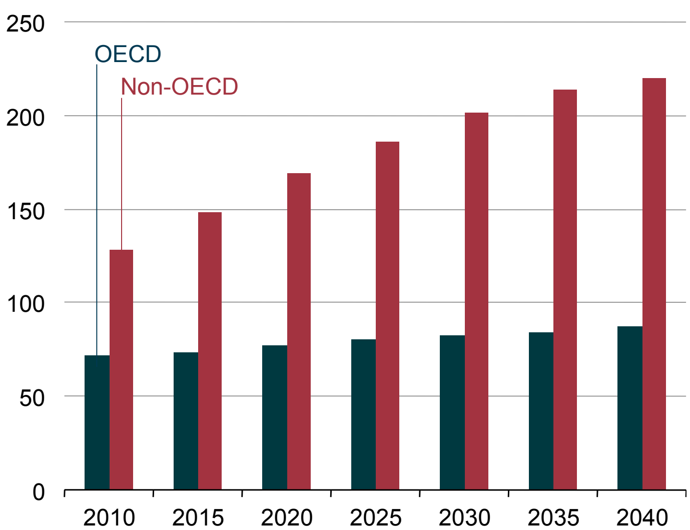
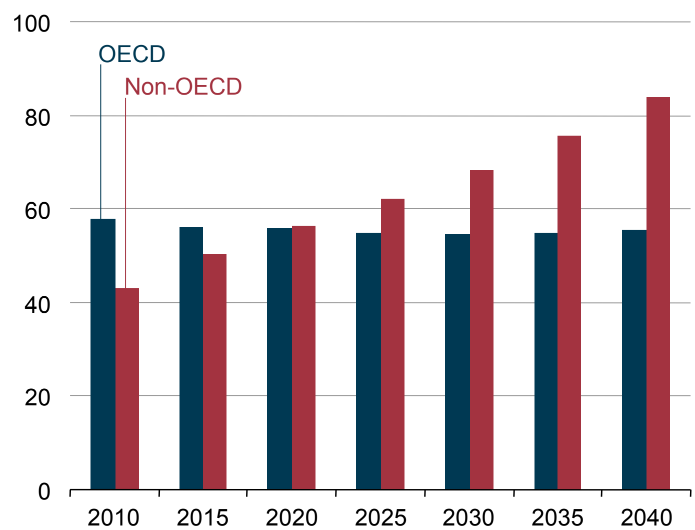


Figure 24. World transportation sector delivered energy consumption, 2010-2040 (quadrillion Btu)



World economic outlook

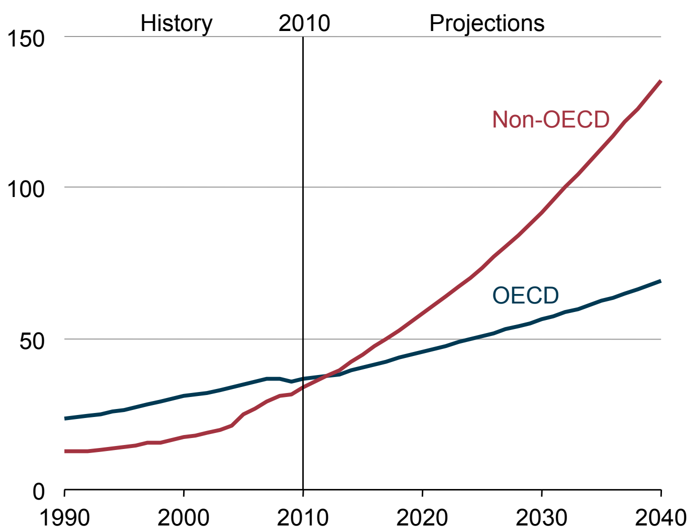
Economic growth is among the most important factors to be considered in projecting changes in world energy consumption. In *IEO2013*, assumptions about regional economic growth—measured in terms of real GDP in 2005 U.S. dollars at purchasing power parity rates—underlie the projections of regional energy demand. World economic growth has fluctuated substantially in recent years, with the global economy contracting by 1.1 percent in 2009 and growing by 4.9 percent in 2010, followed by more modest growth of 3.8 percent in 2011 and 2.8 percent in 2012. Such fluctuations are assumed to stabilize in the Reference case projection.

From 2010 to 2040, real world GDP growth averages 3.6 percent (on a purchasing power parity basis)[12] in the Reference case (Table 2). The growth rate slows over the period, peaking at 4.0 percent between 2015 and 2020 and declining to 3.5 percent between 2020 and 2040. Global economic growth in the Reference case is led by the emerging economies. Real GDP growth from 2010 to 2040 averages 4.7 percent for the non-OECD region, compared with 2.1 percent for the OECD region (Figure 25). Slower global economic growth after 2020 is primarily a result of slower growth in the emerging economies, particularly China.

OECD economies

From 2010 to 2040, real GDP growth in the OECD region averages 2.1 percent per year (on a purchasing power parity basis) in the *IEO2013* Reference case (Figure 26). In the United States, annual real GDP growth averages 2.5 percent per year from 2010 to 2040 in the Reference case. Growth in the aggregate output of the U.S. economy depends on increases in the labor force, growth of capital stock, and improvements in productivity. U.S. labor force growth slows over the projection period as the baby boom generation starts to retire, but projected growth in business fixed investment and spending on research and development offsets the slowdown. Real consumption growth averages 2.2 percent per year in the Reference case. The U.S. share of GDP accounted for by personal consumption expenditures varies between 66 percent and 71 percent of GDP from 2010 to 2040, with the share spent on services rising mainly as a result of increasing expenditures on health care. The share of GDP devoted to business fixed investment ranges from 10 percent to 17 percent of GDP through 2040. Issues such as financial market reform, fiscal policies, and financial problems in Europe, among others, affect both short-run and long-run growth, adding uncertainty to the projections.

Figure 25. World total gross domestic product, 1990-2040 (trillion 2005 dollars)



In the Reference case, Canada's economic growth averages 2.2 percent per year from 2010 to 2040. Prospects for the long term are relatively healthy, given Canada's record of fiscal prudence and structural reforms aimed at maintaining

Table 2. World gross domestic product by country grouping, 2010-2040 (billion 2005 dollars, purchasing power parity)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change 2010-2040
OECD	**36,609**	**40,391**	**45,572**	**50,832**	**56,227**	**62,328**	**69,241**	**2.1**
Americas	15,929	18,079	20,833	23,589	26,663	30,250	34,441	2.6
Europe	14,618	15,589	17,353	19,224	21,002	22,939	25,080	1.8
Asia	6,062	6,723	7,386	8,019	8,563	9,139	9,720	1.6
Non-OECD	**33,889**	**44,750**	**58,147**	**73,532**	**91,870**	**112,893**	**135,537**	**4.7**
Europe and Eurasia	4,502	5,463	6,841	8,323	9,918	11,749	13,681	3.8
Asia	18,206	25,623	34,632	45,417	58,549	73,472	89,127	5.4
Middle East	2,292	2,781	3,316	3,662	3,967	4,241	4,427	2.2
Africa	3,963	4,868	6,165	7,732	9,725	12,224	15,348	4.6
Central and South America	4,927	6,016	7,194	8,398	9,711	11,207	12,954	3.3
World	**70,498**	**85,141**	**103,719**	**124,364**	**148,097**	**175,221**	**204,779**	**3.6**

[12]The purchasing power parity exchange rate is the exchange rate at which the currency of one country is converted into that of another country to buy the same amount of goods and services in each country.

competitive product markets and flexible labor markets. Canada is, however, heavily reliant on trade with the United States for both short-term and long-term economic expansion.

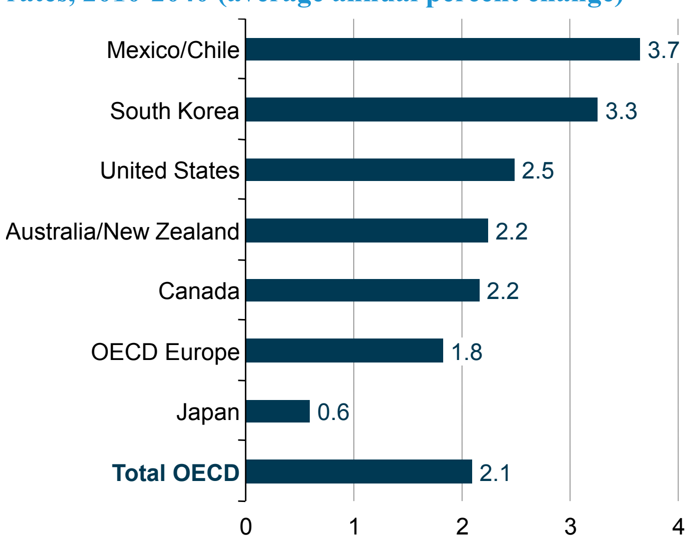
From 2010 to 2040, Chile and Mexico are the fastest growing OECD countries, with their combined GDP increasing by an average of 3.7 percent annually. The two nations are primarily exporters, and as a result their near-term growth is reliant on demand from other advanced economies, which is projected to increase through 2020 before beginning a slow decline. Short-term and long-term commodity prices will also affect export revenues in Chile and Mexico, which remain sensitive to fluctuations in exchange rates with major trading partners, including the United States, countries in OECD Europe, Japan, and China [*7*]. The two countries are well positioned for medium- to long-run growth, with expanding working-age populations and lower government debt levels than other OECD countries.

Debt and demographic changes are common problems among the slower-growing OECD countries. The debt problems have an effect both in the short term and over the long term, as governments raise taxes and cut spending to lower debt-to-GDP ratios. The demographic challenges grow stronger in the later years of the projection. Even with those concerns, however, slower-growing OECD countries still have the advantages of strong institutions and substantial human capital, along with good infrastructure. In OECD Europe, for example, many countries are carrying high government debt levels and have seen their population growth rates fall. Gross government debt relative to GDP in countries that use the euro was near 95 percent in 2010, and the region's working-age population is or soon will be in decline [*8*]. In the near term, most European countries will have to deal with the fallout from the European financial crisis and the ensuing credit issues, which have slowed recent GDP gains and depressed investment, longer term implications for GDP growth through capital formation. OECD Europe is among the slowest growing regions in the Reference case, with real GDP growth averaging 1.8 percent per year from 2010 to 2040, compared with 2.2 percent per year for the OECD as a whole.

Like OECD Europe, Japan is dealing with long-term demographic and debt issues. The ratio of gross government debt to GDP in Japan was nearly 200 percent in 2010,[13] and the working-age population is declining [*9*]. The new administration of Shinto Abe has pledged to undertake fiscal policy measures and press for expansionary monetary policy in order to stimulate economic growth [*10*], but it will be difficult for Japan to sustain higher economic growth in the medium to long term, given the decreasing number of working-age people (between 15 and 65 years old), which will cause the labor force to begin declining over the next decades [*11*]. The Reference case projection for economic growth in Japan is the lowest among the OECD regions, at 0.6 percent per year.

In contrast to Japan, South Korea is one of the fastest growing OECD economies currently and throughout the Reference case projection. The country recovered quickly from the 2008-2009 global economic crisis,[14] with real GDP increasing by 6.3 percent in 2010 and 3.6 percent in 2011, though slowing to 2.2 percent in 2012 [*12*]. With its relatively low government debt, South Korea is well placed for medium- to long-run growth, although its labor force growth is projected to slow in the short term. In the longer term, South Korea's economic growth is supported by a flexible labor market and an accelerating shift from companies owned and managed by families to shareholder-controlled companies. Consequently, capital investment remains a large component of market-driven real GDP growth [*13*]. In the *IEO2013* Reference case, South Korea's GDP expands by an average of 3.3 percent per year from 2010 to 2040.

Figure 26. OECD real gross domestic product growth rates, 2010-2040 (average annual percent change)



In Australia and New Zealand, long-term prospects are also relatively healthy, given their consistent track records of fiscal prudence and structural reforms aimed at maintaining competitive product markets and flexible labor markets. Geographically, the two countries are well positioned to benefit from export market opportunities in the emerging Asian countries, although their aging populations may be one barrier to higher rates of economic growth in the medium to long term. In the Reference case, the combined GDP of Australia and New Zealand grows by an average of 2.2 percent per year from 2010 to 2040.

Non-OECD economies

Real GDP growth from 2010 to 2040 in the non-OECD region as a whole averages 4.7 percent per year in the *IEO2013* Reference case (Figure 27). Investment, exports, and the prospects for higher commodity prices support GDP increases in the near term, although slower growth in advanced economies and potential for inflation are a concern. In the

[13] A large portion of Japanese government debt is held by domestic residents, which is not necessarily the case in other highly indebted countries.

[14] The International Monetary Fund (*World Energy Outlook 2008*, October 2008, p. 43) defines a global recession to be when the world's annual gross domestic product (GDP)—on a purchasing power parity basis—increases by less than 3.0 percent. According to Oxford Economics, world GDP grew by 2.7 percent in 2008, -1.1 percent in 2009, and 4.9 percent in 2010. However, the National Bureau of Economic Research declared that the U.S. recession began in December 2007 and ended in June 2009.

medium-to-long term, population growth, the potential for technological advancement, and lower debt levels help to support faster economic expansion in the non-OECD countries. Achieving these faster rates will require additional infrastructure investment and improvements in regulatory and financial institutions.

India has the world's fastest growing national economy in the *IEO2013* Reference case, averaging 6.1 percent per year from 2010 to 2040, even though its economic growth has been subdued recently, with household spending tepid, investment slower, and inflation a greater concern than in the past [*14*]. In the medium term, however, recently announced reforms should help to improve the economic environment if they are fully implemented [*15*]. Accelerating additional structural reforms—such as ending regulatory impediments to the consolidation of labor-intensive industries, labor market and bankruptcy reforms, and agricultural and trade liberalization—remain essential over the longer term.

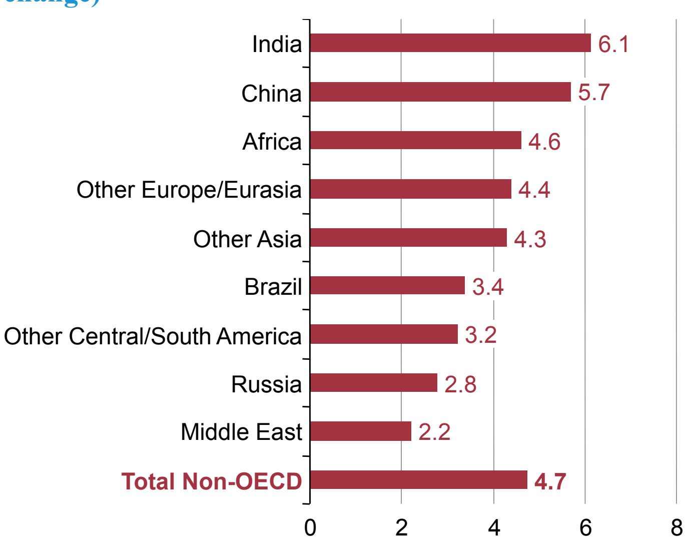
China saw its economic growth accelerate in 2011 after a slowdown that began in 2010. Supportive developments included retail sales and industrial production growth, and increases in exports as the economies of major trading partners experienced recovery [*16*]. Many structural issues remain, however, with implications for China's economic growth over the mid- to long term, including the pace of reform affecting inefficient state-owned companies and a banking system that is carrying a significant amount of nonperforming loans. Development of China's domestic capital markets continues in the Reference case, providing macroeconomic stability and ensuring that its large domestic savings are used more efficiently. China's economic expansion slows substantially toward the end of the projection period as a result of demographic factors related to its aging population and shrinking work force. From 2010 to 2030, China's real GDP grows by 6.6 percent per year in the Reference case but slows to an average of 4.0 percent per year from 2030 to 2040.

Many of the other economies of non-OECD Asia have benefited from trade ties with, and are largely dependent on, China. For those that depend on exports (including Hong Kong, Indonesia, Singapore, and Taiwan), China's strong economic rebound is likely to support growth in the near term. Many also trade heavily with the United States, Japan, and OECD Europe, however, meaning that their economic performance is intertwined with demand from the advanced economies. In the long term, growth prospects in non-OECD Asia remain favorable. Excluding China and India, real GDP in non-OECD Asia is projected to grow by an average of 4.3 percent per year from 2010 to 2040.

In Russia, short-term economic growth is more reliant on consumer spending than is the case for many other commodity-exporting countries, and investment is also important [*17*]. Russia also remains highly reliant on revenue from energy exports to support economic growth [*18*]. Structural reforms, particularly to labor markets and state-owned enterprises, will be important for Russia to generate long-term growth. The country also faces challenges related to the continuing shrinkage of its labor force and population [*19*]. In the *IEO2013* Reference case, Russia's economy grows by an average of 2.8 percent per year from 2010 to 2040.

Exports also are an important component of GDP for the countries of Central Europe and the Balkans, especially given their large fiscal deficits. Since late-2007, it has also been more difficult for banks and other entities in non-OECD Europe and Eurasia to gain access to foreign loans, as many lending institutions have restricted cross-border loans [*20*], which has lowered investment levels and may also affect future productivity. The effects have been softened somewhat by higher world market prices for commodity exports, but given the volatility of energy market prices, it is unlikely that the economies of non-OECD Europe and Eurasia will be able to sustain their recent growth rates until they have achieved more broad-based diversification from energy production and exports.

Figure 27. Non-OECD real gross domestic product growth rates, 2010-2040 (average annual percent change)



Brazil's economic performance in 2012 was disappointing, mainly because of falling investment, despite improvement in the country's trade balance. Further improvement in the trade balance is expected in the near term, which in combination with a resurgence in investment spending by firms and continuing employment gains should raise the country's GDP [*21*]. Structural reforms, particularly to state-owned enterprises and labor markets, will be important for Brazil in generating long-term growth. In the Reference case, Brazil's economic growth averages 3.4 percent per year from 2010 to 2040.

Outside Brazil, investment in the countries of Central and South America is constrained by policy uncertainty, and commodity exports are not expected to provide the level of government revenue that they have in the recent past. The proximity of the region to the United States and the trade relationships of its national economies with the U.S. economy suggest that the region's growth will be linked, in part, to that of the United States. Most countries in the region have flexible exchange rates, positive trade balances, and relatively low fiscal deficits and public debts. Regional inflation is lower than it was in the mid-1990s, and a relatively young labor force supports the region's economic growth prospects. Real GDP in non-OECD Central and South America (excluding Brazil) increases by an average of 3.2 percent per year from 2010 to 2040 in the *AEO2013* Reference case.

In Africa, economic prospects for different countries vary widely across the continent. Oil exporters in northern Africa and most of sub-Saharan Africa continue to grow strongly. Nevertheless, both economic and political factors—such as low savings and investment rates, lack of strong economic and political institutions, limited quantity and quality of infrastructure and human capital, negative perceptions on the part of international investors, protracted civil unrest and political disturbances, and the impacts of various diseases—present formidable obstacles to the economies of a number of African countries. In the *IEO2013* Reference case, Africa's combined real GDP increases by 4.6 percent per year on average from 2010 to 2040.

The slowest growing non-OECD region is the Middle East, where the average annual growth rate is 2.2 percent over the projection period. The Middle East region is challenged by continuing geopolitical instability that discourages foreign investment, as well as heavy reliance on commodity exports for economic growth. From 2003 to 2008, rising oil production and prices helped boost economic growth in the oil-exporting countries of the Middle East, many of which also benefited from spillover effects on trade, tourism, and financial flows from the region's oil exports [*22*]. In the short run, with relatively high world oil prices and rebounding demand for the region's export commodities, prospects for economic growth remain favorable. However, the medium to long term presents many challenges. Political turmoil and domestic unrest threaten to depress consumer confidence and investment. Demographic issues and the dependence of many Middle East countries on commodity exports for growth also are key challenges for regional economic growth prospects, with reliance on oil and natural gas revenues continuing through much of the projection period.

Sensitivity analyses in *IEO2013*

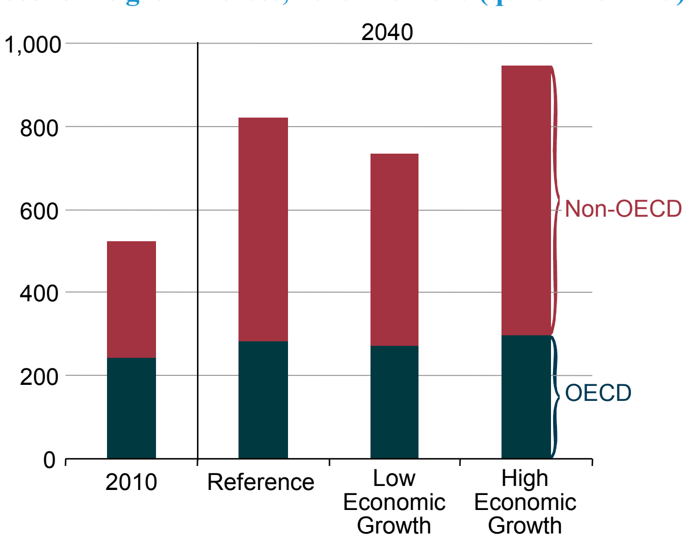
Alternative economic growth cases

Expectations for future rates of economic growth are a major source of uncertainty in the *IEO2013* projections. To illustrate the uncertainties associated with economic growth trends, *IEO2013* includes a High Economic Growth case and a Low Economic Growth case in addition to the Reference case. The two alternative growth cases use different assumptions about future economic growth paths, while maintaining the oil price path of the *IEO2013* Reference case.

In the High Economic Growth case, real GDP in the OECD region increases by 2.3 percent per year from 2010 to 2040, as compared with 2.1 percent per year in the Reference case. In the non-OECD region—where uncertainty about future growth is higher than in the developed OECD economies, the High Economic Growth case assumes GDP growth of 5.2 percent per year, or 0.5 percentage points higher than in the Reference case. In the Low Economic Growth case, OECD GDP increases by 1.9 percent per year, or 0.3 percentage points lower than in the Reference case. GDP growth in the non-OECD region is assumed to average 4.1 percent per year, or 0.6 percentage points lower than in the Reference case.

In the Reference case, world energy consumption totals 820 quadrillion Btu in 2040—285 quadrillion Btu in the OECD countries and 535 quadrillion Btu in the non-OECD countries. In the High Economic Growth case, world energy use in 2040 is 946 quadrillion Btu—127 quadrillion Btu (about 63 million barrels oil equivalent per day) higher than in the Reference case. In the Low Growth Case, total world energy use in 2040 is 733 quadrillion Btu—87 quadrillion Btu (about 43 million barrels oil equivalent per day) lower than in the Reference case. Thus, the projections for 2040 in the High and Low Economic Growth cases span a range of uncertainty equal to 213 quadrillion Btu, equivalent to 41 percent of total world energy consumption in 2010 (Figure 28).

Figure 28. World energy consumption in three economic growth cases, 2010 and 2040 (quadrillion Btu)



Alternative oil price cases

Expectations for future world oil prices are another major source of uncertainty in the *IEO2013* projections. To illustrate the uncertainties associated with future oil prices, *IEO2013* includes a Low Oil Price case and a High Oil Price case in addition to the Reference case. The two alternative oil price cases use different assumptions about future oil prices, based on four key factors: the economics of non-OPEC petroleum liquids supply; OPEC investment and production decisions; the economics of other liquids supply; and world demand for petroleum and other liquids. Each case represents one of many possible combinations of supply and demand that would result in the same price path.

In the Reference case, real oil prices (in 2011 dollars) rise from $110 per barrel in 2012 to $163 per barrel in 2040. The Reference case reflects mid-range expectations regarding exploration and development costs and accessibility of oil resources. It also assumes that OPEC producers will choose to maintain their share at 39 to 43 percent of the global liquid fuels market. In the Reference case, OECD consumption of petroleum and other liquids increases from 46.0 million barrels per day in 2010 to 46.4 million barrels per day in 2040, and non-OECD consumption of petroleum and other liquids increases from 40.7 million barrels per day to 68.6 million barrels per day.

In the Low Oil Price case, crude oil prices are $75 per barrel (2011 dollars) in 2040. GDP growth in the non-OECD countries averages 4.3 percent per year from 2010 to 2040, compared with Reference case growth of 4.7 percent per year. A combination of lower economic activity and lower prices results in non-OECD liquid fuel consumption in 2040 that is very close to that in the Reference case. In contrast, economic growth in the OECD regions is the same in the Low Oil Price case as in the Reference case, and lower prices encourage consumers to use more liquid fuels. On the supply side, OPEC countries increase their output above the Reference case level in the Low Oil Price case, obtaining a 51-percent share of total world petroleum and other liquids production by 2040. Oil production in the non-OPEC countries is lower than in the Reference case, however, because their more expensive resources cannot be brought to market economically.

In the High Oil Price case, oil prices reach $237 per barrel (2011 dollars) in 2040. GDP growth in the non-OECD countries averages 5.1 percent per year from 2010 to 2040 in the High Oil Price case, as compared with Reference case growth of 4.7 percent per year. With higher economic activity, non-OECD liquids consumption increases to 74.9 million barrels per day in 2040, 6.3 million barrels per day higher than in the Reference case. The increase is only partially offset by a decline in OECD liquids demand as consumers improve efficiency or switch to less expensive fuels where possible. On the supply side, oil production in the OPEC countries is lower in the High Price case, and their market share declines to between 37 percent and 39 percent. However, higher world oil prices allow non-OPEC countries to raise production from more costly resources, and their petroleum production is 65.7 million barrels per day in 2040, or 4.0 million barrels per day higher than in the Reference case. The economics of nonpetroleum liquids also benefit from the higher prices, and non-OPEC production totals 8.0 million barrels per day in 2040, or 3.5 million barrels per day higher than in the Reference case. Across the three price cases, OPEC production generally decreases, while non-OPEC petroleum production and other liquids production increase, when oil prices increase.

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Chapter 2
World petroleum and other liquid fuels

Overview

In the *IEO2013* Reference case, worldwide consumption of petroleum and other liquid fuels increases from 87 million barrels per day in 2010 to 97 million barrels per day in 2020 and 115 million barrels per day in 2040, notwithstanding steadily rising oil prices after 2020. Led by the emerging economies of the non-OECD regions, rapid economic development drives the increase in world consumption, as demand among the more mature economies of the OECD regions remains flat or declines. Almost 80 percent of the increase in total liquids consumption is in the nations of non-OECD Asia and the Middle East, where strong income growth and, in the case of the Middle East, access to ample and relatively inexpensive domestic resources, support the increase in demand (Figure 29).

Systemic changes in both production and consumption patterns transform global markets for petroleum and other liquids markets over the projection period. To satisfy rising demand, liquids production increases by 28.3 million barrels per day from 2010 to 2040 in the Reference case, including production of both petroleum (crude oil and lease condensate, natural gas plant liquids [NGPL], bitumen, extra-heavy oil, and refinery gains) and other liquid fuels (coal-to-liquids [CTL], gas-to-liquids [GTL], biofuels, and kerogen) (Figure 30 and Table 3). In the Reference case, a sustained rise in world oil prices after 2020 incentivizes the development of additional petroleum resources through technically difficult and expensive projects, the more widespread use of enhanced oil recovery (EOR) technologies, and the economical development of bitumen, extra-heavy oil, and nonpetroleum alternative resources.

In the *IEO2013* Reference case, OPEC member nations provide just under one-half of the growth in world liquids supply from 2010 to 2040. Middle East OPEC liquids production rises by 12.0 million barrels per day over the projection, or 85 percent of OPEC's additional output of 14.1 million barrels per day. Non-OPEC production is 14.3 million barrels per day higher in 2040 than in 2010. The most significant non-OPEC contributors to production growth are Brazil, Canada, the United States, and Kazakhstan (Figure 31), which together account for 87 percent of the total increase in non-OPEC liquids supply.

Prospects for growth in petroleum and other liquid fuels production in the Americas are particularly strong, reflecting contributions from deepwater pre-salt resources in Brazil, bitumen in Canada, and tight oil in the United States. The result is a net gain in non-OPEC production from the Americas of 7.2 million barrels per day by 2025—an increase that balances liquids production with consumption in the hemisphere as demand growth is tempered by efficiency gains, especially in the U.S. transportation sector. In the *IEO2013* Reference case, the Americas become a net exporter of liquids by the end of the projection period. There is potential for even more production growth in the Americas from both the United States, as discussed in the *Annual Energy Outlook 2013 (AEO2013)* High Oil and Gas Resource case,[15] and from OPEC's Venezuela, which has large reserves of extra-heavy oil but does not aggressively develop new fields under the current policies assumption of the *IEO2013* Reference case. U.S. production of liquid fuels surpasses that of Russia by 2015. There are a number of factors (including accounting conventions for how liquid fuels are measured) that determine the timing, extent, and significance of such a development.[16]

Figure 29. Change in world liquids consumption by region, 2010-2040 (million barrels per day)

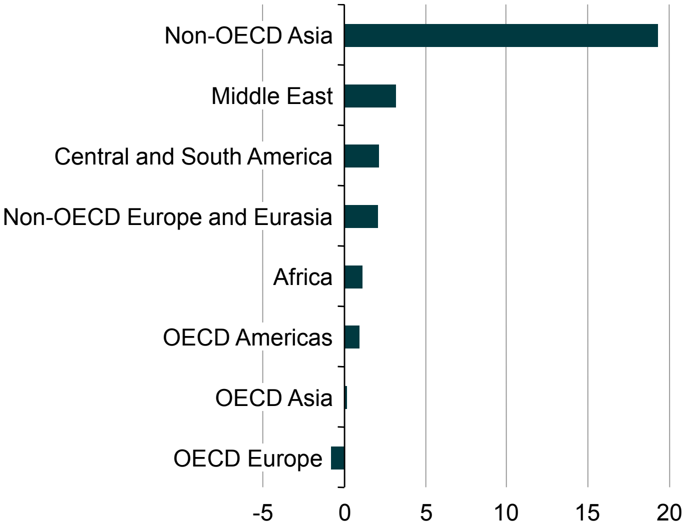
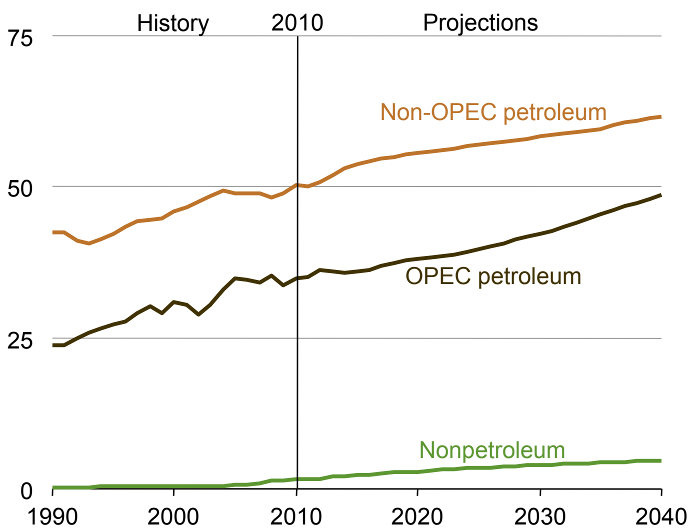


Figure 30. World liquid fuels production by region and type, 1990-2040 (million barrels per day)



[15]For a full discussion of the High Oil and Gas Resource case, see "Oil price and production trends in *AEO2013*" and "U.S. reliance on imported liquid fuels in alternative scenarios" in EIA's *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), pp. 30-39.

[16]See also "Could the United States become the leading global producer of liquid fuels, and how much does it matter to U.S. and world energy markets?" in EIA's *This Week in Petroleum* (December 19, 2012), http://www.eia.gov/oog/info/twip/twiparch/2012/121219/twipprint.html.

Nonpetroleum liquid resources remain a small but increasing source of liquids supply in the *IEO2013* Reference case. Production of nonpetroleum liquids, such as biofuels, CTL, and GTL, is spurred by sustained high prices in the Reference case (Figure 32). However, biofuels development also relies heavily on country-specific programs or mandates [*23*]. World production of nonpetroleum liquids, which in 2010 totaled only 1.6 million barrels per day (less than 2 percent of total world liquids production), increases to 4.6 million barrels per day in 2040, when it accounts for about 4 percent of total world liquids production.

In addition to summarizing the Reference case projection for liquid fuels, this chapter discusses alternative low and high oil price cases. It also provides a discussion of several special topics, including interdependence of production levels for major Persian Gulf suppliers, markets for NGPL, and the possible impact of tight oil on the global supply balance.

Table 3. World liquid fuels production in the Reference case, 2010-2040 (million barrels per day)

Source	2010	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC	**34.9**	**38.4**	**40.0**	**42.5**	**45.7**	**48.9**	**1.1**
Petroleum liquids[a]	34.8	38.2	39.7	42.2	45.4	48.7	1.1
Coal-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0	--
Gas-to-liquids	0.0	0.2	0.3	0.3	0.3	0.3	12.5
Kerogen	0.0	0.0	0.0	0.0	0.0	0.0	--
Biofuels[b]	0.0	0.0	0.0	0.0	0.0	0.0	--
Non-OPEC[c]	**51.8**	**58.2**	**60.3**	**61.9**	**63.7**	**66.0**	**0.8**
Petroleum liquids[a]	50.2	55.8	57.5	58.6	59.9	61.7	0.7
Coal-to-liquids	0.2	0.4	0.7	1.0	1.2	1.2	6.7
Gas-to-liquids	0.1	0.1	0.2	0.2	0.2	0.3	5.2
Kerogen	0.0	0.0	0.0	0.0	0.0	0.0	--
Biofuels[b]	1.3	2.1	2.3	2.5	2.7	2.9	2.7
World	**86.6**	**96.6**	**100.2**	**104.4**	**109.4**	**115.0**	**0.9**
Petroleum liquids[a]	85.1	94.0	97.2	100.9	105.3	110.4	0.9
Coal-to-liquids	0.2	0.4	0.7	1.0	1.2	1.2	6.7
Gas-to-liquids	0.1	0.4	0.4	0.5	0.5	0.6	7.3
Kerogen	0.0	0.0	0.0	0.0	0.0	0.0	--
Biofuels[b]	1.3	1.8	2.0	2.2	2.4	2.8	2.6

[a]Includes crude oil and lease condensate, NGPL, bitumen (oil sands), extra-heavy oil, and refinery gain.
[b]Ethanol volumes are reported on a gasoline-equivalent basis.
[c]Includes some U.S. petroleum product stock withdrawals, domestic sources of blending components, other hydrocarbons, and ethers.

Figure 31. Non-OPEC liquids production by region and country, 2010 and 2040 (million barrels per day)

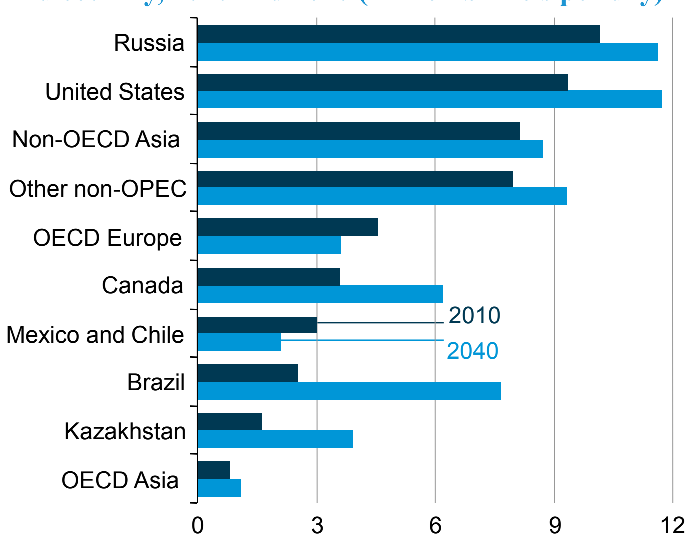
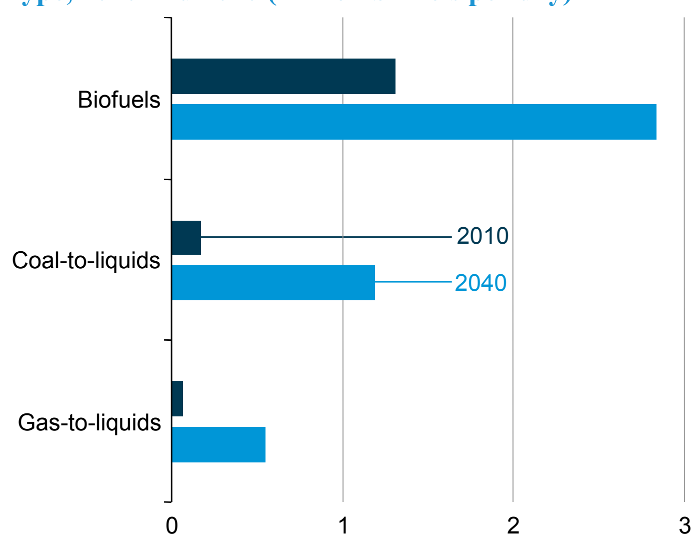


Figure 32. World nonpetroleum liquids production by type, 2010 and 2040 (million barrels per day)



Crude oil prices

The world oil price paths used in the *IEO2013* analyses represent a long-term balance between supply and demand. They do not reflect the price volatility that occurs over days, months, or years. As a frame of reference, over the past two decades, volatility within a single year has averaged about 30 percent.

After experiencing exceptional volatility during the 2008 financial crisis, when prices ranged from a high of $144 per barrel in July (daily spot price of Brent crude[17] in nominal dollars) to a low of $34 per barrel in December, oil prices have moved in a range between $90 and $130 per barrel over the past 30 months. Unrest in North Africa and the Middle East, along with prospects for improved economic growth in the years that followed the global recession of 2008-2009, have helped keep prices relatively high. The Brent crude oil spot price averaged $112 per barrel in 2012, and the July 2013 Short-Term Energy Outlook forecasts that it will average $105 per barrel in 2013 and $100 per barrel in 2014 [*24*].

In the *IEO2013* Reference case, world oil prices reach $106 per barrel (real 2011 dollars) in 2020 and $163 per barrel in 2040 (Table 4 and Figure 33). The Reference case represents current judgment regarding exploration and development costs and accessibility of oil resources. It also assumes that OPEC producers maintain their share of the market and will schedule investments in incremental production capacity so that OPEC's oil production will represent between 39 and 43 percent of the world's total petroleum and other liquids production over the projection period. In this case, OECD consumption of petroleum and other liquids is virtually flat between 2010 and 2040, while non-OECD consumption increases by 28 million barrels per day over the same period.

IEO2013 also presents High and Low Oil Price cases as alternatives to the Reference case. The price cases were developed by adjusting four key factors: (1) the economics of non-OPEC petroleum liquids supply; (2) OPEC investment and production decisions; (3) the economics of other liquids supply; and (4) economic growth in non-OECD countries, a key driver of petroleum and other liquids demand. The three price paths are consistent with those presented in EIA's *AEO2013* [*25*].

In the Low Oil Price case, crude oil prices are $75 per barrel (2011 dollars) in 2040. GDP growth in the non-OECD countries averages 4.3 percent per year from 2010 to 2040, compared with Reference case growth of 4.7 percent per year. A combination of lower economic activity and lower prices results in non-OECD liquid fuel consumption in 2040 that is close to that in the Reference case (Figure 34). In contrast, economic growth in the OECD regions is the same in the Low Oil Price case and the Reference case, and lower prices encourage consumers to use more liquid fuels.

On the supply side, OPEC countries increase their output above the Reference case level in the Low Oil Price case, obtaining a 51-percent share of total world petroleum and other liquids production by 2040. However, oil production in the non-OPEC countries is lower than in the Reference case, because their more expensive resources cannot be brought to market economically.

Table 4. Brent crude oil prices in three cases, 2010-2040 (2011 dollars per barrel)

Year	Reference	Low Oil Price	High Oil Price
2010	81	81	81
2015	96	79	134
2020	106	69	155
2025	117	70	173
2030	130	72	192
2035	145	73	213
2040	163	75	237

Figure 33. World oil prices in three cases, 1990-2040 (2011 dollars per barrel, Brent crude oil)

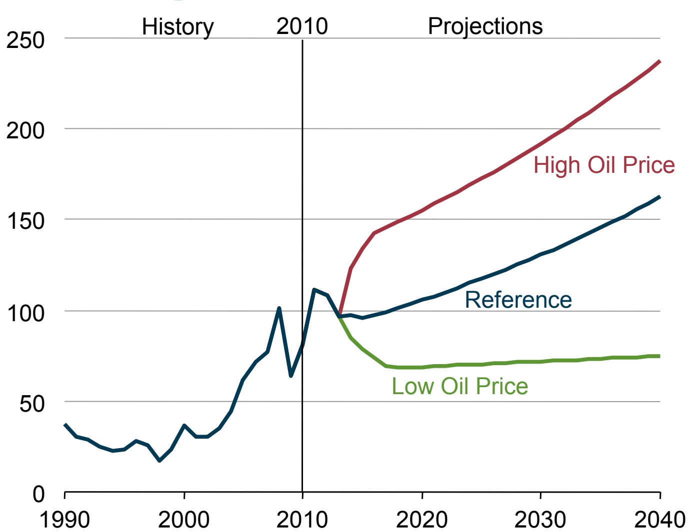
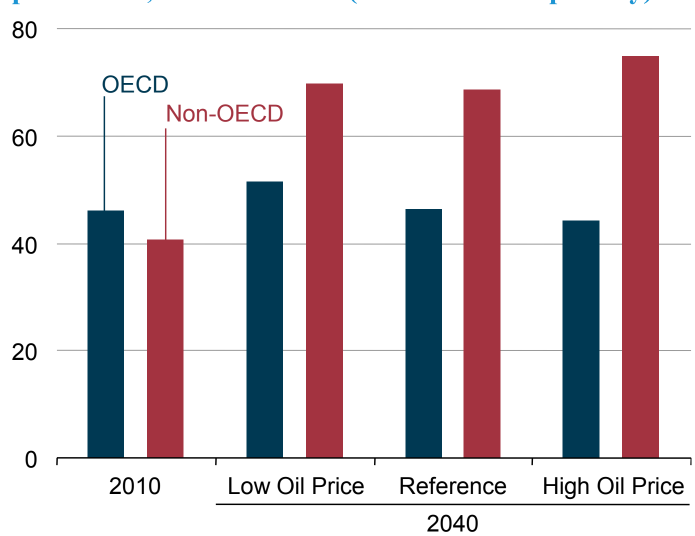


Figure 34. World liquids consumption in three oil price cases, 2010 and 2040 (million barrels per day)



[17]The benchmark oil price in *IEO2013* is based on spot prices for Brent crude oil (commonly cited as Dated Brent in trade publications), an international benchmark for light sweet crude oil.

In the High Oil Price case, oil prices are about $237 per barrel (2011 dollars) in 2040. GDP growth in the non-OECD region averages 5.1 percent per year from 2010 to 2040, compared with Reference case growth of 4.7 percent per year. Higher economic activity means that non-OECD liquids consumption reaches 74.9 million barrels per day in 2040, 6.3 million barrels per day higher than in the Reference case (Figure 34), with the increase only partially offset by a decline in OECD liquids demand as consumers improve efficiency or switch to less expensive fuels where possible.

On the supply side, liquids production in the OPEC countries is lower in the High Price case, allowing their market share to decline to between 37 and 39 percent. However, higher world oil prices allow non-OPEC countries to increase production from more costly resources. Their petroleum production is 65.7 million barrels per day in 2040, 4.0 million barrels per day higher than in the Reference case. The economics of nonpetroleum liquids also benefit from the higher prices, with production increasing to 8.0 million barrels per day in 2040, 3.5 million barrels per day higher than in the Reference case. Across the three price cases, OPEC generally decreases production as oil prices rise, while non-OPEC production of both petroleum and other liquids increases as oil prices increase (Figure 35).

World liquids consumption

In the *IEO2013* Reference case, world liquids consumption increases by about one-third (28 million barrels per day), from almost 87 million barrels per day in 2010 to 115 million barrels per day in 2040. Petroleum and other liquids remain the world's dominant fuel source through the projection period, although their share of global primary energy consumption falls. Virtually all global liquids demand growth comes from non-OECD countries (Figure 36), as strong economic growth increases consumption in the transportation and industrial sectors. The non-OECD share of world liquid fuels use rises from 47 percent in 2010 to 52 percent in 2020 and nearly 60 percent in 2040. The growth in non-OECD liquids demand is led by the countries of non-OECD Asia (particularly, China and India). Non-OECD Asia accounts for almost 70 percent of the increase in global liquids demand, rising by more than 19 million barrels per day from 2010 to 2040. Demand growth in China and India surpasses the combined liquids demand growth of the rest of the world.

Rising prices for liquids increase the cost-competitiveness of other fuels, leading many users of liquids outside the transportation and industrial sectors to switch to other sources of energy when possible. The transportation and industrial sectors account for 92 percent of global liquid fuels demand in 2040, whereas in every other end-use sector the consumption of liquid fuels decreases on a worldwide basis over the projection period.

OECD

In the *IEO2013* Reference case, OECD petroleum and other liquid fuels consumption is relatively flat throughout the projection, reaching 46.4 million barrels per day in 2040. In much of the OECD, relatively slow economic growth and static or declining population levels contribute to declines in liquids consumption. In addition, many OECD governments have adopted policies that mandate improvements in the efficiency of motor vehicles.

The United States is the largest liquid fuels consuming nation in the OECD, and it remains so through 2040. Over the course of the projection, increases in vehicle fuel economy offset growth in transportation activity in the United States, resulting in a decline in the use of petroleum and other liquids even as consumption of liquid biofuels increases. Biofuels, including biodiesel blended into diesel, E10, E15, and higher ethanol blends used in flex-fueled vehicles, account for 6 percent of all U.S. petroleum and other

Figure 35. World liquid fuels production by region and type in three oil price cases, 2010 and 2040 (million barrels per day)

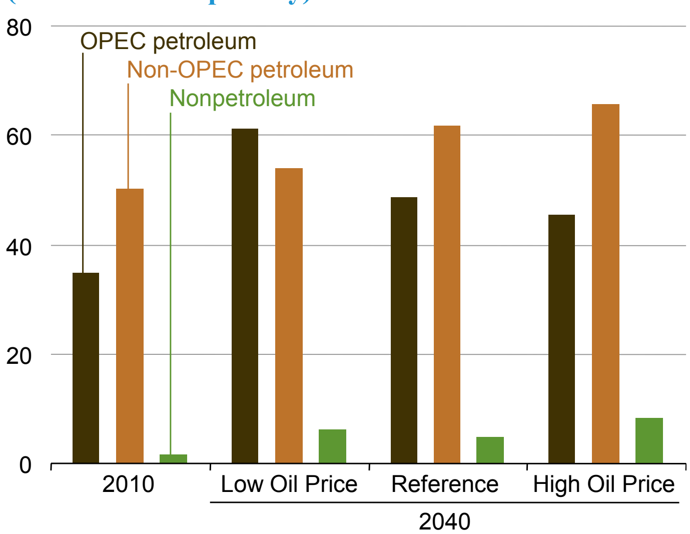
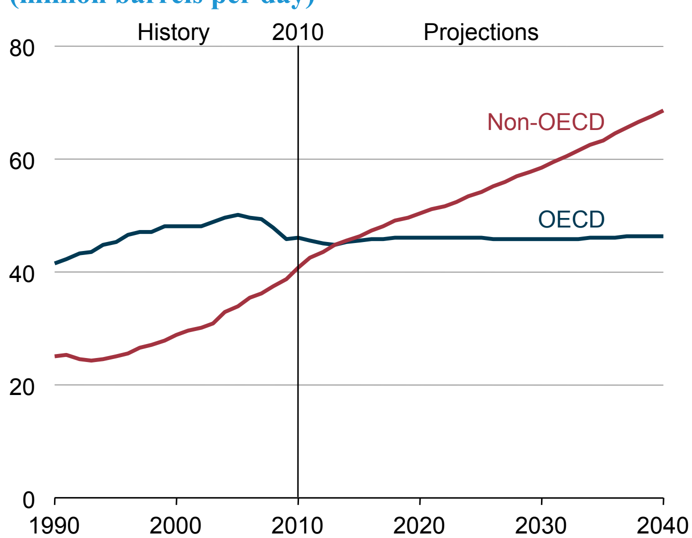


Figure 36. OECD and non-OECD liquids consumption by region, 1990-2040 (million barrels per day)



liquids consumption by energy content in 2040. Total liquid fuels consumption in the United States rises from 18.9 million barrels per day in 2010 to 19.5 million barrels per day in 2020, after which it falls to 18.7 million barrels per day in 2030 and 18.6 million barrels per day in 2040.

New motor vehicles in Canada and Mexico are likely to experience efficiency trends similar to those in the United States. In Canada, the result is relatively flat consumption of petroleum and other liquid fuels, at around 2.2 million barrels per day throughout the projection. In Mexico and Chile combined, liquids consumption rises by 1.3 percent per year, the highest growth among the OECD regions. Despite improvements in vehicle efficiency, the use of liquid fuels increases in Mexico as a result of strong growth in transportation activity and industrial demand.

Energy efficiency improvements and reductions in refining activity drive declining liquids use in OECD Europe. In addition to improvements in motor vehicle efficiency, most nations in OECD Europe have high taxes on motor fuels, well-established public transportation systems, and declining or slowly growing populations, all of which dampen growth in transportation energy use. In 2040, liquids consumption in OECD Europe totals 14.1 million barrels per day, 0.7 million barrels per day lower than its 2010 level of 14.8 million barrels per day.

In OECD Asia, liquid fuels consumption remains essentially flat throughout the projection period. Japan's liquids consumption increased after the shutdown of nuclear power plants that followed the March 2011 earthquake and tsunami—which damaged reactors at Fukushima Daiichi and led to the shutdown of all Japan's nuclear reactors by May 2012—but that increase in fuel use had already started to fall in mid-2013. Rising liquids use in South Korea largely offsets the decline in Japan's consumption in the later years of the Reference case projection.

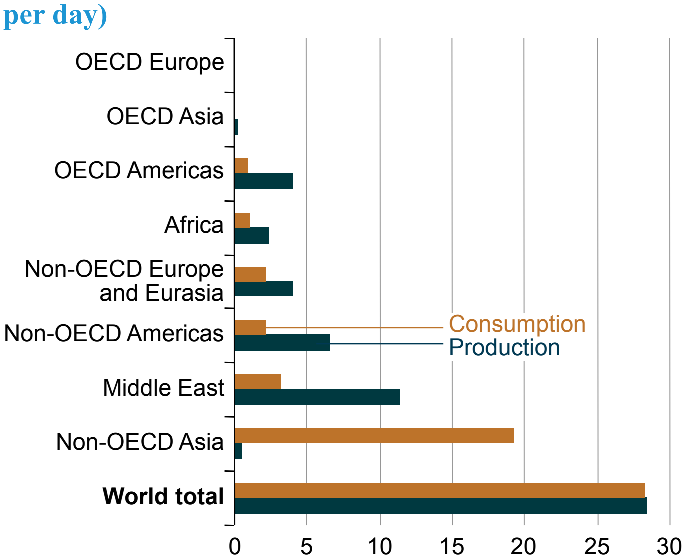
Non-OECD

The non-OECD share of world liquids consumption grows substantially over time, from 47 percent in 2010 to nearly 60 percent in 2040. Non-OECD Asia is the largest source of growth in worldwide liquids consumption in the *IEO2013* Reference case, increasing by 19.3 million barrels per day from 2010 to 2040 (Figure 37). Within non-OECD Asia, China has the largest absolute growth in demand from 2010 to 2040 (10.5 million barrels per day), and India has the second largest (5.0 million barrels per day). India has the fastest regional GDP growth in the *IEO2013* Reference case, which translates into the fastest regional growth in liquids demand (3.1 percent per year), although the absolute growth in India's liquids consumption is smaller than China's. In 2010, India's liquids fuel use was 35 percent of China's 9.3 million barrels per day; in 2040 India's liquids consumption is 42 percent of China's 19.8 million barrels per day.

As China's economy moves from dependence on energy-intensive industrial manufacturing to a more service-oriented economy, the transportation sector becomes the most important source of growth in liquid fuels use. China more than doubles its liquids consumption compared with the 2010 level, and it supplants the United States as the world's largest consumer of liquid fuels in the Reference case after 2035.

In India, petroleum consumption is heavily oriented toward diesel fuel, which represented about 42 percent of product volume in 2012. Diesel, which is used in transportation, irrigation, manufacturing, and electricity generation, has historically received significant government subsidies. In an effort to reduce budget and trade deficits, the Indian government raised diesel prices by 14 percent in late 2012, its largest price hike ever [*26*].

Figure 37. Change in world liquids production and consumption by region, 2010-2040 (million barrels per day)



With liquids consumption growth rapidly outpacing production, non-OECD Asia has increasingly relied on imports from the Persian Gulf. In 1990, 33 percent of non-OECD Asia's oil imports came from the Middle East; in 2010, 48 percent came from the Middle East [*27*]. This trend will likely continue in the future, with producers in Russia and Central Asia also increasing production in the eastern regions of the two countries to meet new Asian demand.

Liquids demand in the Middle East also grows substantially in the *IEO2013* Reference case, increasing by 3.2 million barrels per day from 2010 to 2040 as a result of strong population growth rates, which are second only to Africa, and rising incomes. Liquids-intensive industrial demand also plays a major role in the region, with consumption in the chemical sector leading industrial demand growth. Delays in petroleum subsidy reforms outside Iran also support higher regional consumption, coupled with per capita income growth that supports a significant expansion within the transportation sector. In the later years of the projection, it is likely that some subsidy reform will occur and begin to slow the growth in demand for liquids.

In the Middle East, demand for liquids in the electric power sector declines from 2010 to 2040 in the Reference case. Many of the countries that produce liquids in the region increasingly turn to lower-cost natural gas and, to a lesser extent, nuclear, renewable, and coal-fired generation, in an effort to increase the volumes of petroleum available for export. Reliance on liquids for electric power generation in the Middle East declines from more than 40 percent in 2010 to 20 percent in 2040, as total electricity use increases rapidly across the region.

The countries of non-OECD Europe and Eurasia experience moderate growth in liquid fuels demand before reaching a plateau in 2020. Russia—the largest economy in the region—currently accounts for the largest share of the region's liquids use, but its consumption increases more slowly than in other parts of non-OECD Europe and Eurasia as a result of major efficiency improvements in the country's energy-intensive industrial sector. In addition, liquids demand slows over the course of the projection in Russia's residential and commercial sectors, as fuel subsidies for people living in areas with high heating requirements are reduced [*28*].

World liquids production

The key drivers of long-run oil supply include oil prices, exploration and development of new and existing reserves, behavior of key OPEC member countries, technological innovation in the petroleum supply chain, and geopolitical events. In the *IEO2013* Reference case, the sources of production growth to meet increased global demand for liquid fuels change over time. World liquids production totals 115.0 million barrels per day in 2040, 28.3 million barrels per day above the 2010 level. The growth in liquids production in the Reference case comes from a wide range of supply around the world and an increasing supply of more costly resources, including bitumen, extra-heavy oils, tight oil, and shale oil.

Technological innovation in the petroleum and other liquids supply chain is the key component of the shift to diversified supply sources. Increases in supply come from new ways of appraising wells, such as 3-D seismic imaging, from new drilling and completion techniques, such as horizontal drilling and multi-stage hydraulic fracturing, and from better production and transportation process control for deepwater projects, such as floating vessels for production, storage, and offloading (FPSO).

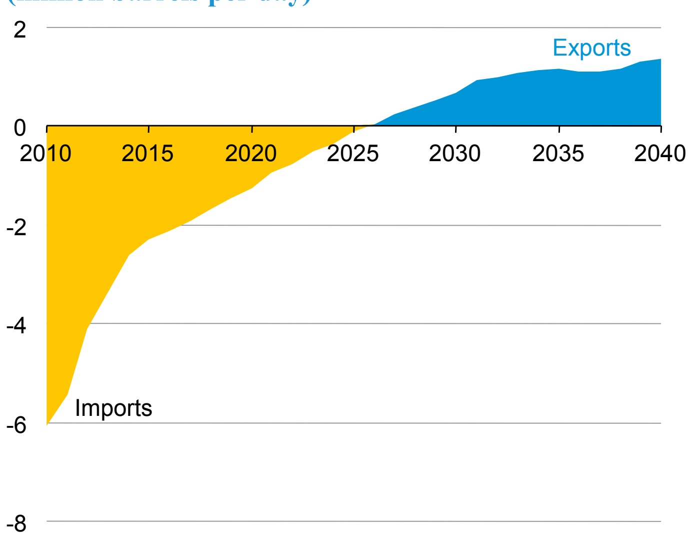
Advances in technology make production in previously inaccessible regions more feasible, while higher oil prices make production in those regions economically viable. In the *IEO2013* Reference case, global production rises strongly in the Americas, driven by tight oil plays in United States, oil sands in Canada, and pre-salt deepwater fields in Brazil. At the same time, the rising complexity of the energy sector increases the costs of oil extraction. Annual capital spending for the industry has more than tripled in the past 10 years, to $550 billion in 2011, while the amount of oil produced per dollar of investment has declined [*29*].

Regardless of other supply developments that have recently garnered considerable market attention, including tight oil in the United States and bitumen from oil sands and tar sands in Canada, OPEC petroleum liquids production continues to be critical for world oil markets. OPEC members contribute 13.8 million barrels per day to the growth of petroleum supplies from 2010 to 2040 in the *IEO2013* Reference case. Non-OPEC members contribute 11.5 million barrels per day of the growth in petroleum production over the same period, and nonpetroleum resources account for another 3.0 million barrels per day of the growth. North America's shale gas production and the anticipated growth of associated natural gas production from the Middle East and Asia lead to a strong increase in the production of natural gas liquid fuels[18] (NGL) in the outlook (see box on page 29).

Most of the growth in nonpetroleum resources—such as biofuels, CTL, and GTL—occurs in the non-OPEC countries in the *IEO2013* Reference case. High oil prices, improvements in exploration and extraction technologies, emphasis on recovery efficiency, and the emergence and continued growth of other liquids production are the primary factors supporting the growth in non-OPEC liquids production in the *IEO2013* Reference case. OPEC production of nonpetroleum liquids grows by 0.3 million barrels per day from 2010 to 2040—mainly as a result of increased GTL production from Qatar—while non-OPEC production of nonpetroleum liquids grows by 2.8 million barrels per day over the same period.

Increasing liquids production in the Americas is expected to have a significant impact on global liquids trade (Figure 38). Most new developments in Brazil and Canada produce heavy oil, which is attractive to complex refineries along the U.S. Gulf Coast and to some of the newer refineries designed to process heavy oil, which will also receive heavy oil from existing sources that is displaced from its traditional markets. In addition, tight oil developments in the United States will tend to displace light sweet crude imports from Africa, freeing Middle Eastern and African supplies of light crude oil to meet growing demand in Asian markets [*30*].

Figure 38. OECD and non-OECD Americas net imports and exports of liquid fuels, 2010-2040 (million barrels per day)



[18]Natural gas liquids (NGL) include both NGPL and refinery production of ethane, propane, butane, and pentanes plus.

Markets for natural gas liquids

While the dynamics of natural gas and oil supply are shifting across the world and especially in North America with the growth in tight oil and shale gas production, major changes are also occurring in the global market for NGL. Growing supplies of NGL are anticipated from North American shale gas production, as well as from Middle East and Asian oil and gas producers and refiners. The major markets for NGL are residential and commercial heating and cooking, petrochemical feedstocks, gasoline blending, and, to a smaller extent, transportation fuel, ethanol denaturant, and crude diluent [*31*].

Growth in shale gas production allowed the United States to become a net exporter of liquefied petroleum gases (LPG), a subset of NGL[19] in 2012 [*32*]. American exports of LPG, most of which go to Latin America, are expected to continue. Increased LPG production is also anticipated in other regions, most notably in the Middle East (which is the largest exporter of LPG) and Asia. In the Middle East, LPG supplies are expected to increase as natural gas exploration and production ramp up in the coming years [*33*], but growth in LPG exports will be moderated by their increased use as petrochemical feedstocks within the region. Extraction of NGL from gas processing (i.e., NGPL) is expected to increase if oil prices maintain their current level or increase, because the prices for LPG components that can be blended into gasoline, such as butane and pentanes plus (also known as natural gasoline), are closely linked with the price of crude oil. In Asia, LPG supply growth is driven mostly by increasing refinery throughput, although increasing natural gas processing in China also is expected to contribute to NGL supply growth in the future [*34*].

There is a concern that persistently high LPG prices, which traditionally are linked to crude oil prices, could suppress demand growth, especially in the residential sector [*35*]. However, recent experience in the United States suggests that growing NGL supply weaken linkages between NGL and oil prices, particularly for ethane and propane, the lightest NGL components. Propane prices may separate from the price of heavier NGL components, which could encourage increased residential and commercial use in place of more expensive distillate fuel oil and also provide some impetus for greater use of LPG in transportation applications. Petrochemical demand for LPG is already rising as a result of the use of existing plants with access to low-cost LPG feedstocks in preference to naphtha-based facilities. In addition, the ability of some flexible crackers to switch to LPG feedstock—especially in the United States and also to a lesser extent in Europe, Asia, and the Middle East—also supports rising LPG demand. In general, imbalances between NGL supply and demand should ultimately be resolved by increased use of NGL in petrochemical plants (crackers), given prices that make ethane and possibly other NGL more economically attractive feedstocks than naphtha for the production of ethylene and other basic chemical compounds. Much of the proposed basic petrochemical cracker capacity in the United States is being built to absorb excess ethane, rather than propane and butane, which are traditionally the traded LPG components [*36*].

OPEC supply

Middle East OPEC

The *IEO2013* Reference case assumes that OPEC producers invest in incremental production capacity that enables them to provide between 39 percent and 43 percent of total global liquids production throughout the projection period. Production from Middle East OPEC countries, which accounted for 68 percent of total OPEC production in 2010, rises by 12.0 million barrels per day in the Reference case, or 85 percent of OPEC's output growth of 14.1 million barrels per day from 2010 to 2040.

Saudi Arabia, Iran, and Iraq combined have a large share of the world's oil reserves and resources that are relatively easy to produce. Saudi Arabia, for many decades the only holder of substantial spare oil production capacity, has played a critical role as the major swing supplier in response to disruptions in other supply sources and to economic fluctuations affecting oil demand. Both Iraq and Iran have the reserves and other resources needed to raise their capacity and production well above current levels if they can successfully address some of the internal and external "above-ground" challenges that have kept their respective oil sectors from realizing their potential for more than 30 years.[20] The difficulty in determining the extent to which each of the countries will be able to overcome the particular hurdles that impede supply growth adds to the challenge of projecting country-specific production levels in the OPEC Middle East region.

In addition to the usual uncertainties surrounding oil supply projections, producers in the OPEC Middle East region are likely to continue playing a key role in the balancing of global demand and supply. For this reason, their output levels may be negatively correlated, as higher realizations of capacity and production in one country will lower the amounts of capacity and production in other countries that are needed to balance global markets. Future developments, including the development of tight oil resources, which is a widely discussed topic in the international oil community, have significant potential to affect the reliance on OPEC liquids supplies and the behavior of key Middle East OPEC producers over the next several decades.

[19]For most countries and organizations, LPG consists of propane and butane, and mixtures of the two are traded on the open waters. NGL encompasses LPG as well as ethane and pentanes plus. However, EIA's current definition of LPG does also include ethane.

[20]Above-ground constraints refer to those nongeological factors that could affect supply, including but not limited to government policies that limit access to resources; conflict; terrorist activity; lack of technological advances or access to technology; price constraints on the economic development of resources; labor shortages; materials shortages; weather; environmental protection actions; and short- and long-term geopolitical considerations.

Saudi Arabia

Saudi Arabia's oil revenues traditionally have exceeded the amounts required to fund its government expenditures, enabling it to vary production levels in response to global supply or demand developments over the past 25 years without significant concern about the revenue implications of such actions. More recently, social and economic programs funded by the Saudi government have expanded substantially. While Saudi Arabia maintains large financial reserves, revenue needs may become a more important consideration as the government considers its future responses to a situation of persistent, high growth in supply from other key OPEC or non-OPEC producers, or a sustained downturn in demand.

Iraq

Iraq has established an official oil production target of 12.0 million barrels per day in 2017 [*37*], a huge increase compared with its 2012 production level of 3.0 million barrels per day. It is unlikely to come close to reaching that target, which would exceed the amount of global incremental liquids production needed to meet projected global demand growth to 2017 in the *IEO2013* Reference case. Political disputes and infrastructure limitations are likely to continue hampering output growth in the short run. In addition, terrorism, the poor investment climate, and other problems could limit Iraq's production over the projection period. However, if those problems can be overcome, major improvements in production and export infrastructure could enable Iraq to sustain high production growth rates through 2040.

Iran

Iran's liquids production, which reached a peak of 6.1 million barrels per day in 1974, has been well below that level since 1979 [*38*]. After averaging an estimated 4.0 million barrels per day from 2001 to 2010, Iran's production has declined further. A series of international sanctions targeting Iran's oil sector have led foreign companies to cancel a number of new projects and upgrades at existing projects. Iran faces continued depletion of its production capacity, as its fields have relatively high natural decline rates (between 8 and 13 percent per year). Additional factors hampering investment include unfavorable foreign investment requirements, underinvestment, and gaps in professional expertise and technology for certain projects. U.S. sanctions on financial institutions that handle payments made for oil exports from Iran, coupled with actions by the European Union to cease imports from Iran and prevent it from accessing insurance from European Union companies for its oil shipments, caused a further reduction in Iran's oil exports in 2012. Without some agreement between Iran and the international community to end the sanctions, it will be increasingly difficult for Iran to maintain its production, let alone increase it, notwithstanding its endowment of readily accessible resources.

Other Middle East OPEC

Other Middle East OPEC producers make smaller, but important, contributions to supply. For example, nearly all of Kuwait's current reserves and production are in mature fields, but prospects could improve with the success of Project Kuwait, a plan proposed in 1998 to attract foreign participation and increase oil production capacity from four northern oil fields: Raudhatain, Sabriya, al-Ratqa, and Abdali. The four fields contain a mix of heavy and light oil resources. Additionally, it may be possible to boost oil production in Kuwait from the partitioned neutral zone (PNZ) that the country shares with Saudi Arabia, which could hold as much as 5 billion barrels of oil [*39*]. Qatar's liquids production is poised to increase over the projection period through the application of GTL technology, which produces liquid fuels such as low-sulfur diesel and naphtha from natural gas.

In summary, even if the world and regional liquids balances outlined in the *IEO2013* Reference case prove to be prescient—itself a highly uncertain prospect—above-ground factors are likely to play a major role in determining the specific sources of supply from the OPEC Middle East region over the next 30 years. The box on pages 31-32 discusses some of the alternative scenarios for Middle East liquids production consistent with regional projections in the Reference case.

African OPEC

West African OPEC production increases to 5.9 million barrels per day in 2040 in the Reference case, from 4.4 million barrels per day in 2010. Nigeria has increased its output from deepwater fields in recent years, but onshore production has declined as infrastructure constraints and incidents of oil theft and attacks on pipelines have curbed production growth and are expected to continue in the near- to mid-term. Angola is expanding its offshore deepwater production and, as relative stability improves, is likely to develop onshore exploration and production areas as well [*40*]. Reports indicate that as much as 15,500 square miles (about 25 percent) of the sub-salt layer of the Kwanza Basin extends onshore [*41*]. North African OPEC producers Libya and Algeria experience slower growth than their western counterparts, adding only a combined 0.2 million barrels per day of liquids production from 2010 to 2040.

South American OPEC

Venezuela is the dominant producer in the South American OPEC, which also includes Ecuador. There are abundant proved reserves of extra-heavy oil in the Orinoco belt, but bringing those resources to market will require substantial investment, which may be difficult for Venezuela to attract without some policy changes. In the *IEO2013* Reference case, South American OPEC production increases by only 0.4 percent per year, to 3.3 million barrels per day in 2040.

Estimates of OPEC Middle East liquids production in alternative scenarios for the major producing countries

There is a great deal of uncertainty attached to long-term projections of global petroleum and other liquids supply. It is clear, however, that the countries with most of the world's largest and most flexible liquids resources are located within Middle East OPEC. In particular, Saudi Arabia, Iran, and Iraq have large domestic petroleum resources that can be produced at relatively low cost. Assuming that key OPEC producers persist in efforts to manage world oil prices through supply adjustments, one or more of the three major producers will function as OPEC's swing supply. There is considerably more uncertainty in projecting country-specific levels of production, as there are many possible scenarios for future liquids production in Saudi Arabia, Iran, and Iraq. In this discussion, four alternative scenarios for their liquid fuels production, consistent with their combined production in the Reference case, are considered.

In the *IEO2013* Reference case, total OPEC Middle East liquids production increases from 25.4 million barrels per day in 2011 to 35.8 million barrels per day in 2040. Using the Reference case assumptions, the implied combined production of Saudi Arabia, Iran, and Iraq rises from 17.9 million barrels per day in 2011 to 25.1 million barrels per day in 2040 (Figure 39). The following scenarios are used to demonstrate how widely Saudi Arabia, Iran, and Iraq liquids production could vary, underscoring the uncertainty associated with the outlook for long-term liquids production in any single country.

Scenario 1: Past as prologue

In this scenario, Saudi Arabia, Iran, and Iraq are assumed to continue to provide the share of their combined petroleum production that they held in 2011 throughout the projection period. That is, Saudi Arabia supplied 62 percent of the petroleum produced from the three countries in 2011 and it is assumed to provide 62 percent of the supply from these three countries through 2040. The result is that Saudi Arabia production rises from 11.1 million barrels per day in 2011 to 15.5 million barrels per day in 2040. Iran's share of production from the three countries was 24 percent in 2011 and, in this scenario, its liquids production in 2040 would reach 5.9 million barrels per day. The remaining 15 percent is ascribed to Iraq, and results in 3.7 million barrels per day of liquids production in 2040. In this business-as-usual scenario Saudi Arabia continues to dominate OPEC Middle East production, and Iraq makes only minimal advances.

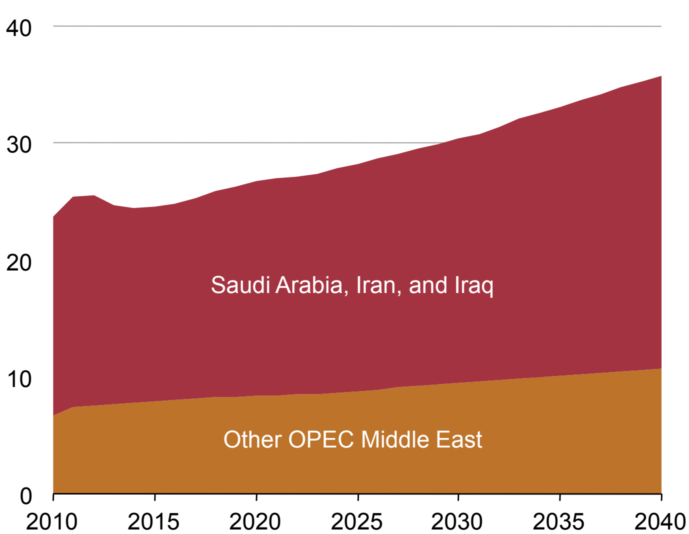
Scenario 2: Iraq success

In scenario 2, Iraq is assumed to be able to restore its petroleum production infrastructure and resolve the many above-ground issues that have negatively impacted the industry for more than two decades. In this case, Iraq's production rises to 8.0 million barrels per day by 2030 and then to 11.0 million barrels per day in 2040, from 2011 production of 2.6 million barrels per day. The remainder is prorated to Iran and Saudi Arabia based upon each country's share of combined 2011 production. That is, Iran accounted for 28 percent of combined Iran and Saudi Arabian liquids production in 2011; Saudi Arabia 72 percent. In this case, production in Saudi Arabia is lower than that of Iraq in 2040 at 10.2 million barrels per day.

Scenario 3: Iran success

This scenario is similar to scenario 2, but substituting Iran as the growth story. In this case, Iran is assumed to have resolved its above-ground issues, including resolution of international sanctions and it attracts the investment necessary to restore and expand the oil production industry. Here, Iran is able to restore production to its 1974 annual peak of 6.1 million barrels per day in 2030 and then production increases to 8.1 million barrels per day by 2040. The remaining production is allotted according to the Iraq and Saudi Arabia shares of their combined 2011 production. In this case, Saudi Arabia's share of the 2011 Iraq-Saudi Arabian combined production is 81 percent; Iraq's share 19 percent. As a result, Saudi production would increase to 13.8 million barrels per day. Iraq's 2040 production rises to only 3.3 million barrels per day, only slightly higher than its 2011 production and far from its stated ambitions.

Figure 39. OPEC Middle East liquids production by country grouping in the *IEO2013* Reference case, 2010-2040 (million barrels per day)



Scenario 4: Iraq success, Iran success, and Saudi Arabia takes the rest

This final scenario envisions production increasing strongly in both Iraq and Iran, with Saudi Arabia willing to reduce its own liquids output to hold the level of OPEC production at the level projected in the *IEO2013* Reference case. Here, Iraq's production profile is the same as in scenario 2, increasing to 8.0 million barrels per day in 2030 and then to 11.0 million barrels per day in 2040. Iran's production profile is the same as in scenario 3, increasing production to 6.1 million barrels

(continued on page 32)

per day in 2030 and then further to 8.1 million barrels per day by 2040. Saudi Arabia produces the remaining part of the Reference case production for the three countries. In this case, Saudi Arabian liquids production in 2040 is 6.0 million barrels per day, slightly more than half its 2011 liquids output.

A summary of the results of the four scenarios for 2040 appears in Table 5. These scenarios illustrate the considerable variation in future production that is possible within the three most petroleum-rich countries in the Middle East consistent with the combined total of production from these counties indicated for the *IEO2013* Reference case. Moreover, it demonstrates how difficult it is to estimate production for these large resource holders, given the variety of above-ground issues that can affect the ability or desire to increase a nation's output. In 2040, Saudi Arabia alone has production that ranges between 6.0 million barrels per day (in scenario 4) and 15.5 million barrels per day (in scenario 1), a range of 9.5 million barrels per day. Although the range of supply outlooks for Iraq and Iran is smaller than that of Saudi Arabia, there is still a fairly wide range of possible production for the two countries.

Table 5. Liquid fuels production in Middle East OPEC in four Reference case scenarios, 2011 and 2040 (million barrels per day)

		2040				
Country	2011	Scenario 1	Scenario 2	Scenario 3	Scenario 4	2040 production range
Saudi Arabia	11.1	15.5	10.2	13.8	6.0	9.5
Iran	4.2	5.9	3.9	8.1	8.1	4.2
Iraq	2.6	3.7	11.0	3.3	11.0	7.7
Other Middle East OPEC	7.5	10.7	10.7	10.7	10.7	--
Total Middle East OPEC	**25.4**	**35.8**	**35.8**	**35.8**	**35.8**	**--**

This analysis suggests there is substantial flexibility in future liquids supply from Saudi Arabia, Iran, and Iraq, but the uncertainty associated with any long-term outlook of production remains high. The scenarios do not assess the likelihood of any one of the futures outlined could be realized. There are considerable above-ground issues that could alter production from any one of the three countries. For instance, given the cost of Saudi Arabia's substantial social programs and subsidies, it is highly unlikely that the government would allow a decrease in production to the 6.0 million barrels per day outlined in scenario 4. It is equally difficult to envision Iraq production barely rising from its 2011 level as posited in scenario 3. Still, the wide range of production possibilities illustrates the number of different possible futures in production from these three countries.

How tight oil and other developments may affect the call on OPEC supply

The *IEO2013* price cases reflect a wide range of future oil prices that are influenced by both demand and supply conditions. Oil demand is sensitive to the rate at which economic activity grows, particularly in developing countries, and also responds to a sustained change in oil prices that encourages those replacing or adding oil-using equipment to choose options that either use oil more efficiently or run on other fuels. In the short run, the stock of oil-using equipment is largely fixed, and oil demand is affected by price changes only to the extent that utilization rates of oil-using equipment are reduced due to substitution and income effects.

Oil supply depends on resources, technology, prices, and producer behavior. Decisions about the use of existing production capacity and investments in additional capacity are made by national governments, acting through national oil companies or various policy mechanisms, as well as by investor-owned companies. Suppliers who act as so-called price takers, including but not limited to investor-owned oil companies, typically seek to use their available production capacity fully unless prices fall below their operating cost, which occurs rarely if ever for most of them. Price-taking suppliers also tend to increase their capacity investments in response to the expectation of sustained higher prices, which allow more candidate projects to meet or exceed their investment criteria. Suppliers that do not act as price takers, including key OPEC member countries, base their capacity utilization and investment decisions on a variety of factors related to oil market conditions, geopolitical considerations, and national revenue needs.

The market framework summarized above provides a starting point for considering how tight oil and other developments that change supply conditions might affect the outlook for global oil markets. Positive supply developments, such as the 846,000-barrel-per-day increase in U.S. crude oil production in 2012 over 2011, can have a major short-term impact. Even with this increase, global spare production capacity was low in 2012 relative to recent historical standards—without it, global spare capacity would have been considerably lower, raising the likelihood of significantly higher oil prices.

In a longer-run setting, however, the situation is likely to be quite different, with both global demand and supply forces likely to substantially reduce the sensitivity of world oil market prices to a rise in U.S. production. On the supply side, OPEC members may respond to higher U.S. production by reducing either their output or their investment in additional production capacity to offset the effects of higher U.S. production. On the demand side, growth in global consumption is likely to be more responsive to any change in prices that persists for an extended period, which would tend to counter the price-lowering effect of increased U.S. production.

U.S. crude oil production, which continues to grow through the end of the current decade and then slowly declines in the *IEO2013* Reference case, is based on EIA's *AEO2013* Reference case projections released in December 2012. However, the level of U.S. crude production is considerably higher in the *AEO2013* High Oil and Gas Resource case, rising from its 2012 level of 6.5 million barrels per day to 10.0 million barrels per day in 2026 and remaining at or near that level through 2040. As discussed in *AEO2013*,[21] projected U.S. dependence on net imports of liquid fuels is substantially lower in the High Oil and Gas Resource case than in the Reference case. In a scenario with assumptions that reduce U.S. demand for petroleum-based fuels added to the assumptions of the High Oil and Gas Resource case supply assumptions, the United States actually becomes a small net exporter of liquids in the mid-2030s. While increasing oil production and reducing and possibly eliminating net import dependence has important economic benefits for the United States, it would not insulate the nation from developments in the Middle East and elsewhere that affect world oil prices.

Although the difference between the *AEO2013* Reference and High Oil and Gas Resource cases focuses on the uncertain prospects for tight oil development in the United States, the availability of tight oil and other tight liquids production from other non-OPEC producers is another important wild card in the global oil balance. Rapid growth in tight oil production in other areas, which is not reflected in the *IEO2013* Reference case, could make a substantial difference in the world liquid fuels outlook. EIA recently commissioned an assessment of tight oil resources, covering 137 shale formations in 41 countries (see box on page 34).

To frame the forward-looking question of how supply developments could affect the evolution of markets between now and 2025, projections for the period can be considered in the context of two recent historical periods of similar length that produced dramatically different outcomes for world oil markets. The first period is 1973 to 1985, which culminated in a sharp fall of oil prices as Saudi Arabia gave up its role as swing producer in response to continued declines in its production as the call on OPEC liquids steadily declined. In round numbers, global demand grew by nearly 4 million barrels per day over the 1973-1985 period, while non-OPEC production grew by roughly 13 million barrels per day, reducing the call on OPEC by roughly 14 million barrels per day [*42*].

The second period for comparison is 2000 to 2012, which led to the current situation of historically high world oil prices. In round numbers, global demand grew by roughly 12 million barrels per day over the 2000-2012 period, driven by non-OECD demand growth that swamped the decline in OECD demand. OPEC and non-OPEC liquids supply each grew by roughly 6 million barrels per day over the period.

In the *IEO2013* Reference case, global liquids demand grows by about 10 million barrels per day over the next 12 years, with the OECD accounting for only about one-tenth of that growth. With Reference case prices, non-OPEC production growth from 2013 to 2025 totals about 6 million barrels per day, including growth in U.S. tight oil production. This projection reflects technologies, prices, and other above-ground factors, as well as resources. OPEC producers supply the difference of 4 million barrels per day between the projected growth in global demand and non-OPEC supply. Thus, while OPEC countries do not face the steep decline in the call on their supply that ultimately led Saudi Arabia to abandon the role of swing producer in 1986, the projected rise in the call on OPEC supply from 2013 to 2025 in the *IEO2013* Reference case is not as great as during the period from 2000 to 2012.

As noted above, EIA recognizes the uncertainty surrounding the supply assumptions in the *IEO2013* Reference case, and also considers alternative futures. In EIA's High Oil and Gas Resource case, U.S. crude oil production in 2025 is 3 million barrels per day higher than in the Reference case, and NGPL production is about 1 million barrels per day higher. If those production increases are fully offset by lower OPEC production, and the global economic scenario remains at or near its baseline, global liquids demand and prices would also be at or near the baseline, and the increment to U.S. production would be reflected directly as a reduction in the call on OPEC.

Even with the assumption that changes in U.S. supply in the High Oil and Gas Resource case are passed directly into the call on OPEC, the revised estimate of the change in the projected call on OPEC over the next 12 years still would not come close to replicating the large absolute decline that occurred in the 1973-1985 period. Substantially lower demand projections, much higher production estimates for the United States and other non-OPEC sources, or both, would be needed to duplicate the situation during that earlier period. Although such scenarios cannot be ruled out, they require additional changes in demand or supply.

In considering impacts on world oil markets, it should be emphasized that the implications of a given change in the projected call on OPEC for the ability and willingness of its members to influence global market prices is inevitably highly dependent on developments within OPEC itself. Currently, Saudi Arabia is the only OPEC producer with significant spare production capacity, although Iraq and Iran, each holding large reserves and resources of oil that are easy to produce, both have a strong interest in increasing their capacity and production if internal and external barriers can be overcome. Venezuela also has access to large, albeit more challenging, reserves and resources. As discussed above, the future production levels in Iraq and Iran could vary dramatically, depending on their respective success in addressing internal and external factors that have held their production well below the levels that their resources might support. The more success these countries have in raising their capacity and production, the more difficult it may be for OPEC to remain cohesive at any given level of call on its members' aggregate supply.

[21]For a full discussion of the High Oil and Gas Resource case, see "Oil price and production trends in *AEO2013*" and "U.S. reliance on imported liquid fuels in alternative scenarios" in EIA's *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), pp. 30-39.

A new EIA-sponsored assessment of shale resources in 41 countries

EIA recently issued an assessment of 137 shale formations in 41 countries outside the United States, published in the report, *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Other than the United States*. This new report expands on the 69 shale formations within 32 countries considered in a 2011 report by Advanced Resources International (ARI) that was released as part of an EIA publication entitled *World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States*. Whereas the 2011 report focused exclusively on shale gas, the new assessment also highlights the role of shale formations as a source of crude oil, lease condensate, and a variety of liquids processed from wet natural gas.

Estimates in the updated report, taken in conjunction with EIA's own assessment of resources within the United States, indicate worldwide technically recoverable resources of 345 billion barrels of shale oil resources and 7,299 trillion cubic feet of shale gas resources. Although the shale resource estimates are likely to change over time as additional information becomes available, it is evident that shale resources that were until recently not included in technically recoverable resources constitute a substantial share of total technically recoverable oil and natural gas resources. The shale oil resources assessed in the new report, combined with EIA's previous estimate of U.S. tight oil resources that are predominantly in shale formations, add approximately 11 percent to the 3,012 billion barrels of proved and unproved non-shale oil resources identified in recent assessments. The shale gas resources assessed in the new report, combined with EIA's prior estimate of U.S. shale gas resources, add approximately 47 percent to the 15,583 trillion cubic feet of proved and unproved non-shale gas resources. Globally, 32 percent of total estimated natural gas resources are in shale formations, and 10 percent of total estimated oil resources are in shale or tight formations.

In considering the market implications of abundant shale resources, it is important to distinguish between technically recoverable resources, the focus of EIA's new assessment, and economically recoverable resources. Technically recoverable resources represent the volumes of oil and natural gas that could be produced with current technology, regardless of oil and natural gas prices and production costs. Economically recoverable resources are resources that can be produced profitably under current market conditions. The economic recoverability of resources depends on three main factors: the costs of drilling and completing wells, the amount of oil or natural gas produced from an average well over its lifetime, and the prices received for oil and gas production.

Recent experience with shale gas in the United States and other countries suggests that economic recoverability can be influenced significantly by above-ground factors, as well as by geology. Key positive above-ground advantages in the United States and Canada that may not apply in other locations include major private ownership of subsurface rights (often by surface owners) that provides a strong incentive for development; availability of many independent operators and supporting contractors with critical expertise and suitable drill rigs; preexisting gathering and pipeline infrastructure; and availability of water resources for use in hydraulic fracturing.

Given variation across shale formations in both geology and above-ground conditions, it is not clear that similar proportions of technically recoverable resources will prove to be economically recoverable across different shale formations. Tight oil and shale gas resources have been revolutionary in the United States—providing 29 percent of the country's total crude oil production and 40 percent of its total dry natural gas production in 2012—because they have proven to be quickly producible in large volumes at relatively lower costs than the large amounts of other types of oil and natural gas resources that had been identified previously. The market impact of shale resources outside the United States will depend on their production costs and volumes. For example, a potential shale well that costs twice as much and produces half the output of a typical U.S. well would be unlikely to replace current supply sources of oil or natural gas. In many cases, even significantly smaller differences in costs, well productivity, or both can make the difference between a resource that is a market game changer and one that is economically unimportant.

Tight oil and other non-OPEC supply developments have the potential to augment or reduce the call on OPEC to the extent that they exceed or fall short of the projections in this outlook. However, future capacity and production levels in OPEC member countries with large resources of relatively easy oil that are not currently being exploited may play an even larger role in shaping future oil markets. Regardless of tight oil and other non-OPEC supply developments, the Middle East remains the center of global oil supply, and decisions regarding capacity and production by leading OPEC producers will remain the linchpin of the global oil supply system. Economic growth in developing countries remains a key demand driver, but demand will also respond to a significant and sustained change in oil prices. This long-term price sensitivity of demand is a key factor that will tend to limit the persistence of scenarios with extremely high or extremely low prices.

Non-OPEC supply

In the *IEO2013* Reference case, sustained high oil prices encourage producers in non-OPEC nations to continue investment in petroleum production capacity, EOR projects, and nonpetroleum liquids production. Non-OPEC total liquid fuels production increases steadily in the projection, from 51.8 million barrels per day in 2010 to 58.2 million barrels per day in 2020 and 66.0 million barrels per day in 2040, as rising prices attract investment in areas previously considered uneconomical, and fears of supply restrictions encourage some net consuming nations to expand nonpetroleum liquids production from domestic resources, such as coal and crops.

Among non-OPEC producers, the near absence of prospects for new large petroleum liquids projects, along with declines in production from existing fields, results in heavy investment in the development of smaller fields. Producers are expected to concentrate their efforts on more efficient exploitation of fields already in production, either through the use of more advanced technology for primary recovery efforts or through EOR.

Americas

Brazil

Brazil experiences the most robust production growth of any country outside OPEC, with production increasing by more than 5 million barrels per day from 2010 to 2040. Brazil's production growth relies on the successful development of its significant offshore pre-salt resources, made available by relatively high oil prices and technological improvements in extraction techniques for very deep water. The large deepwater pre-salt discoveries in Brazil are estimated to include as much as 28 billion barrels oil equivalent. In January 2013, the offshore Sapinhoa oil field began producing oil from pre-salt deposits [*43*]. Similarly, analysts expect the Papa Terra heavy crude oil field to begin producing in 2013 [*44*]. This trend continues into the future, with Brazil's offshore production consisting largely of heavy crude oil grades.

The *IEO2013* Reference case anticipates substantial increases in the production of Brazil's pre-salt resources, but future large-scale development of those resources will require the participation of companies with the technical resources and capital that are needed to produce them. Brazil delayed its 11th bid round while the country devised a new rule for distribution of oil royalties among producing and nonproducing regions, with the government unable to resume lease auctions until the royalty issue had been resolved. The result has been some delay in expanding the country's pre-salt reserves. Despite a new law outlining the rules for distributing oil royalties, the Brazilian Supreme Court postponed its implementation after Rio de Janeiro, São Paulo, and Espírito Santo claimed that the rule breached Brazil's constitution [*45*]. The bid round still is scheduled to continue in 2013 (the first in five years), with a separate licensing round for pre-salt areas toward the end of the year. There is a great deal of interest in the round, with 64 companies prequalifying to participate, indicating their optimism regarding pre-salt resource development.

In addition to rising offshore production, Brazil increases its production of biofuels, largely sugarcane ethanol. Currently, Brazil's biofuels are the highest yielding and least expensive ethanol fuel supply worldwide. Brazil's biofuels production grows in the Reference case by 700,000 barrels per day from 2010 to 2040, a tripling of current production. Rising biofuels production alone meets a large part of the growth in Brazil's liquids consumption, enabling the country to use its growing supply of petroleum liquids for export.

North America

In North America, the United States and Canada continue strong growth in their liquids production in the Reference case. Canada's production increases by an average of 1.8 percent per year, more than twice as fast as U.S. production growth of 0.8 percent per year. Liquids production in Canada comes from three principle sources: bitumen from the oil sands of Alberta; crude oil in the broader Western Canada Sedimentary Basin (WCSB); and offshore oil fields in the Atlantic Ocean. Production from oil sands accounted for more than one-half of Canada's oil output in 2011, a proportion that has increased steadily in recent decades. In total, Alberta was responsible for almost 75 percent of Canada's oil production in 2011, according to data from Statistics Canada [*46*]. Western Canadian provinces (Alberta, British Columbia, and Saskatchewan) account for an increasing proportion of the country's overall oil production in the future. The changing mix of crude oil qualities within the Americas could have a substantial impact on refined product trade in the future (see box on page 36).

United States. The potential for world production of tight oil resources could be substantial. In the United States, unproved technically recoverable resources of tight oil are estimated at 58 billion barrels. Over the 30-year projection period, the United States produces around 26 billion barrels of tight oil from the Bakken/Three Forks, Eagle Ford, Woodford, Austin Chalk, Spraberry, Niobrara, Avalon/Bone Springs, and Monterey plays in the *IEO2013* Reference case, which incorporates the *AEO2013* Reference case projections for U.S. production. However, in the *AEO2013* High Oil and Gas Resource case, U.S. tight oil production is substantially higher. As discussed above, this has some implications for world oil markets through its effect on the call on OPEC producers.

Crude oil production in the U.S. Gulf of Mexico trends upward over time, as the pace of development activity quickens and brings into production new large-development projects, predominantly in deepwater and ultra-deepwater areas. In addition to tight oil and offshore plays, relatively abundant natural gas production in the United States results in low levels of GTL production emerging around 2020 and increasing to 0.2 million barrels per day in 2040.

Total U.S. liquids production in the *IEO2013* Reference case remains at or above 11.5 million barrels per day from 2013 through 2040, peaking at 12.8 million barrels per day around 2020 and settling at 11.7 million barrels per day in 2040. Total U.S. production is significantly higher in the High Oil and Gas Resource case, as discussed in *AEO2013*.

Mexico and Chile. Unlike the other countries in the OECD Americas, Mexico and Chile see liquids production declines through the mid term and modest recoveries later in the projection period, although production remains below current levels as a result of declining output from mature fields. From a combined 3.0 million barrels per day in 2010, liquid fuels production in Chile and Mexico declines steadily through 2025, when their production totals 1.8 million barrels per day. After 2025, production in the region gradually recovers as investment in the petroleum sector improves, but total liquids supply in 2040 still is about 0.9 million barrels per day lower than in 2010.

Atlantic Basin refinery considerations

The makeup of crude oil supplies in the Atlantic Basin is beginning to change as new sources of petroleum liquids are developed. Increasing production of light sweet crude oil in the United States and heavy crude in Canada and Brazil, combined with declining crude oil production in Mexico, has a notable impact on crude oil supplies from the Atlantic Basin. In the United States, as production of light crude oil has increased, reliance on imports has decreased. The same trend is expected to continue through the mid term. Even as Mexico's production of heavy crude has decreased, production of heavy crude/bitumen in Canada and Brazil has increased. As a result, those countries have supplied a growing share of U.S. imports of heavy crude oil.

Increasing crude production from the Americas will affect refinery operations and petroleum product balances throughout the Atlantic Basin. Access to the Americas' production of light sweet and heavy crude oil and access to U.S. production of natural gas will benefit U.S. refining. In addition, access to U.S. production of tight oil will benefit refining operations in eastern Canada. The increase in refinery utilization could alter gasoline and distillate supply patterns, possibly reducing gasoline imports into the U.S. East Coast, affecting European refineries, and supporting gasoline exports from the U.S. Gulf Coast to Europe and the Americas, notably Mexico and Venezuela. However, changes in gasoline and distillate fuel subsidies or retail price controls in those countries could put downward pressure on demand for refined products that would, in turn, reduce export opportunities for U.S. refineries.

Other non-OPEC supply

Non-OECD Europe and Eurasia

Outside of the Americas, the largest increases in non-OPEC supplies come from the nations of non-OECD Europe and Eurasia. In the *IEO2013* Reference case, Kazakhstan and Russia account for virtually all production growth from the region. Liquid fuels production in Kazakhstan grows by an average of 3.0 percent per year, from 1.6 million barrels per day in 2010 to 3.9 million barrels per day in 2040. Much of the country's production growth comes from the Kashagan and Tengiz oil fields in the Caspian Sea [*47*]. In particular, Kashagan has been described as one of the largest fields discovered in the past 30 years outside the Middle East. A consortium of partners under a joint operating company, North Caspian Operating Company (NCOC), operate the field and spent $28 billion on its development through 2010 [*48*, *49*]. The *IEO2013* Reference case assumes that production at Kashagan begins in the mid term with construction of the export infrastructure needed to supply world markets with additional Caspian oil.

Russia's petroleum production shifts gradually from western Siberia to eastern Siberia because of declines in existing, mature oil fields and the opportunity to increase exports to China and other Asian markets, including India and Japan. Russia's production grows at an annual rate of around 0.5 percent from 2010 to 2040. At the same time, there is significant potential for tight oil development in western Siberia to at least offset declines from existing fields. The geology of areas like the Bazhenov shale in the Western Siberian Basin is conducive to tight oil development. An estimated 75 billion barrels of technically recoverable shale oil resources may lie in the Siberian Bazhenov shale formation [*50*]. While taxation and other issues currently impede significant expansion, Royal Dutch Shell and Gazprom have an agreement to develop the Bazhenov resource that could result in long-term commercial production [*51*].

Outside of Russia and Kazakhstan, Azerbaijan and Turkmenistan are the only other countries in the region that have sizeable liquid fuels production. In *IEO2013*, Azerbaijan's petroleum and other liquids production declines, as fields mature and maintenance periods are extended with each season. Azerbaijan gradually shifts from oil to natural gas production. In Turkmenistan, growth in liquids production consists mostly of condensate and NGPL from producing natural gas fields.

North Sea

The North Sea continental shelf contains significant oil reserves and is the largest source of oil production in OECD Europe. According to international agreements, five countries (Denmark, Germany, Netherlands, Norway, and the United Kingdom) can award licenses for crude oil production in the area. Several production streams from the North Sea constitute the Brent international benchmark for oil prices. However, since reaching peak production of almost 6.3 million barrels per day in 1996, crude oil output from the North Sea has been declining slowly, to 3.6 million barrels per day in 2010.

In the Reference case, declines in North Sea oil production continue, averaging 1.6 percent per year, from 3.6 million barrels per day in 2010 to 2.2 million barrels per day in 2040. The largest decline is in the United Kingdom's production, as a result of depleting reserves and an aging oil infrastructure [*52*]. Norway may have some potential to offset the North Sea decline but faces structural issues that may affect long-term production.

Non-OPEC Asia

Few non-OPEC Asian countries are able to increase their liquid fuels production substantially, except for China. In the *IEO2013* Reference case, China's liquids production grows by an average of 0.8 percent per year, to 5.6 million barrels per day in 2040. Much of the increase results from investments by Chinese national oil companies, such as CNPC and CNOOC, in deepwater offshore exploration in the Pearl River Mouth Basin and some onshore fields, such as Changqing and Tarim [*53*]. Liquids production in India and the other non-OECD Asian oil countries, including Vietnam, Indonesia, and Thailand, declines by an average of 0.7 percent per year through 2040 because of aging petroleum fields and a lack of substantial new discoveries.

World oil reserves

Proved reserves of crude oil are the estimated quantities that geological and engineering data indicate can be recovered in future years from known reservoirs, assuming existing technology and current economic and operating conditions. As of January 1, 2013, proved world oil reserves, as reported by the *Oil & Gas Journal*, were estimated at 1,638 billion barrels—120 billion barrels (about 7 percent) higher than the estimate for 2012 [*54*]. According to the *Oil & Gas Journal*, around one-half of the world's proved oil reserves are located in the Middle East, and more than 80 percent are concentrated in eight countries, of which only Canada (with oil sands included) and Russia are not OPEC members (Table 6). Most increases in proved reserves since 2000 have come from revisions to reserves in discovered fields rather than new discoveries [*55*].

In 2013, the largest increase in proved reserves by far was attributed to Venezuela, as the country now reports its Orinoco belt extra-heavy oil in its totals [*56*]. Venezuela's reserves alone increased by 86 billion barrels from 2012 to 2013. Russia also reported a significant gain of 20 billion barrels. Country-level estimates of proved reserves published by the *Oil & Gas Journal* are developed from data reported to the U.S. Securities and Exchange Commission, from foreign government reports, and from international geologic assessments. The estimates are not always updated annually.

In some cases in the *IEO2013* projections, country-level volumes for cumulative production through 2040 exceed the estimates of proved reserves. This does not imply that resources and the physical limits of production have not been considered in the development of production projections, or that the projections assume a rapid decline in production immediately after the end of the projection period as reserves are depleted. EIA considers resource availability in all long-term country-level projections, the aggregation of which gives the total world production projection. However, proved reserves are not an appropriate measure for judging total resource availability in the long run. For example, despite continued production, global reserves historically have not declined, because new reserves have been added through exploration, discovery, and reserve replacement.

Proved reserves include only estimated quantities of crude oil from known reservoirs, and therefore they are only a subset of the entire potential oil resource base. Resource base estimates include estimated quantities of both discovered and undiscovered liquids that have the potential to be classified as reserves at some time in the future. The resource base may include oil that currently is not technically recoverable but could become recoverable in the future as technologies advance. In the Reference case, the resource base does not pose a global constraint on oil supply.

In order to construct realistic and plausible projections for liquids production, and especially for petroleum liquids production, underlying analysis must both consider production beyond the intended end of the projection period and base production projections on the physical realities and limitations of production.

Proved reserves cannot provide an accurate assessment of the physical limits on future production but rather are intended to provide insight as to company-level or country-level development plans in the very near term. In fact, because of the particularly rigid requirements for the classification of resources as proved reserves, even the cumulative production levels from individual development projects may exceed initial estimates of proved reserves.

EIA attempts to address the lack of applicability of proved reserves estimates to long-term production projections by developing a production methodology based on the actual physical limits of production, initially-in-place volumes, and technologically limited recovery factors. By basing long-term production assessments on resources rather than reserves, EIA is able to present projections that are physically achievable and can be supported beyond the 2040 projection period. The realization of such production levels depends on future growth in world demand, taking into consideration such above-ground limitations on production as profitability and specific national regulations, among others.

Table 6. World proved oil reserves by country as of January 1, 2013 (billion barrels)

Country	Oil reserves	Percent of world total
Venezuela	297.6	18.2
Saudi Arabia	265.4	16.2
Canada	173.1	10.6
Iran	154.6	9.4
Iraq	141.4	8.6
Kuwait	101.5	6.2
United Arab Emirates	97.8	6.0
Russia	80.0	4.9
Libya	48.0	2.9
Nigeria	37.2	2.3
Kazakhstan	30.0	1.8
China	25.6	1.6
Qatar	25.4	1.5
United States	20.7	1.3
Brazil	13.2	0.8
Algeria	12.2	0.7
Angola	10.5	0.6
Mexico	10.3	0.6
Ecuador	8.2	0.5
Azerbaijan	7.0	0.4
Rest of World	78.4	4.8
Total	**1,637.9**	**100.0**

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Chapter 3
Natural gas

Overview

In the *IEO2013* Reference case, natural gas is the world's fastest-growing fossil fuel, with consumption increasing from 113.0 trillion cubic feet in 2010 to 185.0 trillion cubic feet in 2040. Growth in consumption occurs in every *IEO* region and is most concentrated in non-OECD countries, where demand increases more than twice as fast as in OECD countries (Figure 40). Non-OECD producers account for more than 70 percent of the total growth in world natural gas production from 2010 to 2040.

Natural gas continues to be favored as an environmentally attractive fuel compared with other hydrocarbon fuels. It is the fuel of choice for the electric power and industrial sectors in many of the world's regions, in part because of its lower carbon intensity compared with coal and oil, which makes it an attractive fuel source in countries where governments are implementing policies to reduce greenhouse gas emissions. In addition, it is an attractive alternative fuel for new power generation plants because of relatively low capital costs and the favorable heat rates for natural gas generation. In the Reference case, total world consumption of natural gas for industrial uses increases by an average of 1.5 percent per year through 2040, and consumption in the electric power sector grows by 2.0 percent per year. The industrial and electric power sectors together account for 77 percent of the total projected increase in natural gas consumption, and together they account for 74 percent of total natural gas consumption in 2040, up slightly from 73 percent in 2010.

Growth in natural gas consumption is particularly strong in non-OECD countries, where economic growth leads to increased demand over the projection period. Consumption in non-OECD countries grows by an average of 2.2 percent per year through 2040, more than twice as fast as the 1.0-percent annual growth rate for natural gas demand in the OECD countries. As a result, non-OECD countries account for 72 percent of the total world increment in natural gas consumption, as the non-OECD share of world natural gas use increases from 51 percent in 2010 to 59 percent in 2040.

Abundant natural gas resources and robust production contribute to the strong competitive position of natural gas among other energy sources. In the Reference case, the largest production increases from 2010 to 2040 (Figure 41) occur in non-OECD Europe and Eurasia (18.9 trillion cubic feet), the OECD Americas (15.9 trillion cubic feet), and the Middle East (15.6 trillion cubic feet). The United States and Russia each increase natural gas production by around 12 trillion cubic feet, together accounting for nearly one-third of the total increase in world gas production. Russia's production growth is supported primarily by increasing exploitation of resources in the country's Arctic and eastern regions. U.S. production growth mainly comes from shale resources (see box on page 42).

Although there is more to learn about the extent of the world's tight gas, shale gas, and coalbed methane resource base, the *IEO2013* Reference case projects a substantial increase in those supplies—especially in the United States and also in Canada and China (Figure 42). In the United States, one of the keys to increasing natural gas production has been advances in the application of horizontal drilling and hydraulic fracturing technologies, which have made it possible to develop the country's vast shale gas resources and have contributed to a near doubling of estimates for total U.S. technically recoverable natural gas resources over the past decade. In the Reference case, shale gas accounts for 50 percent of U.S. natural gas production in 2040. Tight gas, shale gas, and coalbed methane resources in Canada and China account for more than 80 percent of total domestic production in 2040 in the Reference case (see box on page 43).

Figure 40. World natural gas consumption, 2010-2040 (trillion cubic feet)

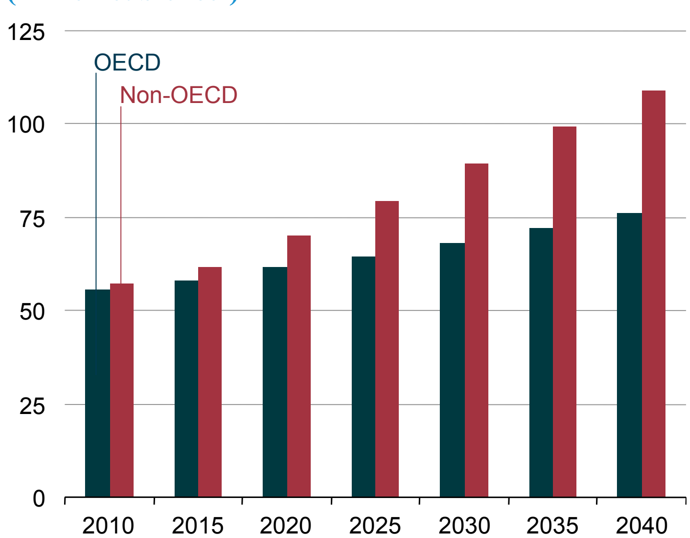
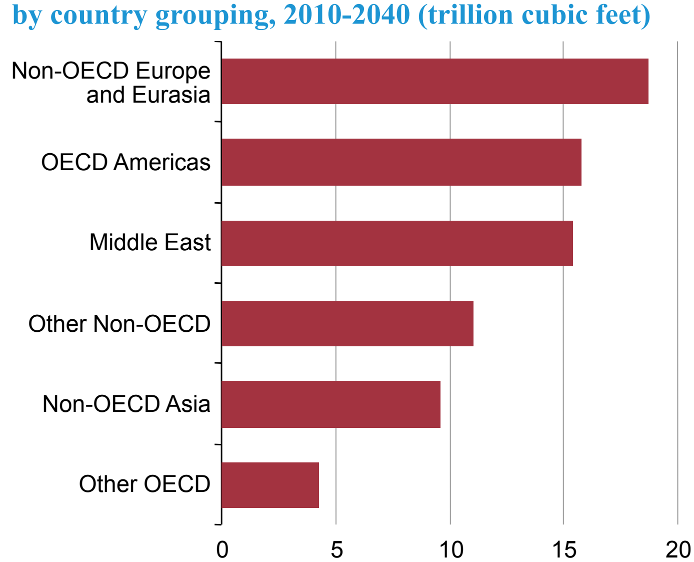


Figure 41. World increase in natural gas production by country grouping, 2010-2040 (trillion cubic feet)



What is shale gas and how is it produced?

Shale gas refers to natural gas found in shale formations. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas. While the technologies have been known for decades, it has only been over the past few years that the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce. The production of natural gas from shale formations has rejuvenated the natural gas industry in the United States, and shale production techniques could be applied globally.

Shale gas is found in shale formations, or plays, that contain significant accumulations of natural gas and have similar geologic and geographic properties. Experience and information gained from developing the Barnett Shale in Texas have improved the efficiency of shale gas development around the United States. Geophysicists and geologists identify suitable well locations in areas with potential for economical gas production by using surface and subsurface geology and seismic techniques to generate maps of the subsurface.

Hydraulic fracturing (commonly called fracking) is a technique in which water, chemicals, and sand are pumped into a well to release the hydrocarbons in a shale formation by opening cracks (fractures) in the rock and allowing the natural gas to flow from the shale into the well. When used in conjunction with horizontal drilling, hydraulic fracturing enables gas producers to extract shale gas economically.

Liquefied natural gas (LNG) accounts for a growing share of world natural gas trade in the Reference case. World LNG trade more than doubles, from about 10 trillion cubic feet in 2010 to around 20 trillion cubic feet in 2040. Most of the increase in liquefaction capacity occurs in Australia and North America, where a multitude of new liquefaction projects are planned or under construction, many of which will become operational within the next decade. At the same time, existing facilities in North Africa and Southeast Asia have been underutilized or are shutting down because of production declines at many of the older fields associated with the liquefaction facilities, and because domestic natural gas consumption is more highly valued than exports.

World natural gas consumption

OECD natural gas consumption

OECD Americas

Annual natural gas consumption in the OECD Americas region rises steadily to 41.6 trillion cubic feet in 2040 (Figure 43), including increases of 4.2 trillion cubic feet from 2010 to 2020 (1.4 percent per year) and 8.2 trillion cubic feet from 2020 to 2040 (1.1 percent per year), and accounts for 60 percent of the total increase for OECD countries and 17 percent of the total increase for the world over the projection period. Although natural gas consumption grows at faster rates in other regions, OECD Americas remains the world's largest regional consumer of natural gas through 2040.

The United States—the world's largest consumer of natural gas—has the region's highest projected annual consumption growth in absolute terms (Figure 44). U.S. natural gas consumption increases by 5.8 trillion cubic feet through 2040, accounting for 46 percent of the region's total growth. Projections for combined annual natural gas consumption in Mexico and Chile include absolute growth in the two countries of 4.7 trillion cubic feet (38 percent of total regional growth), followed by Canada (2.0 trillion cubic feet, or 16 percent of the OECD Americas total).

Figure 42. Natural gas production in China, Canada, and the United States, 2010 and 2040 (trillion cubic feet)

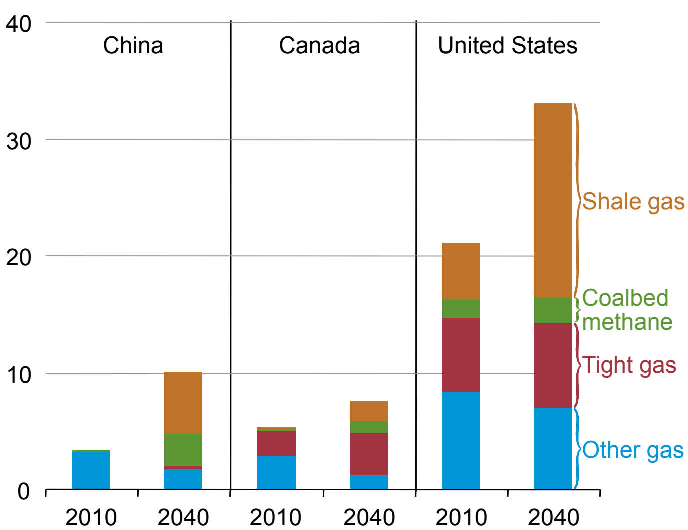
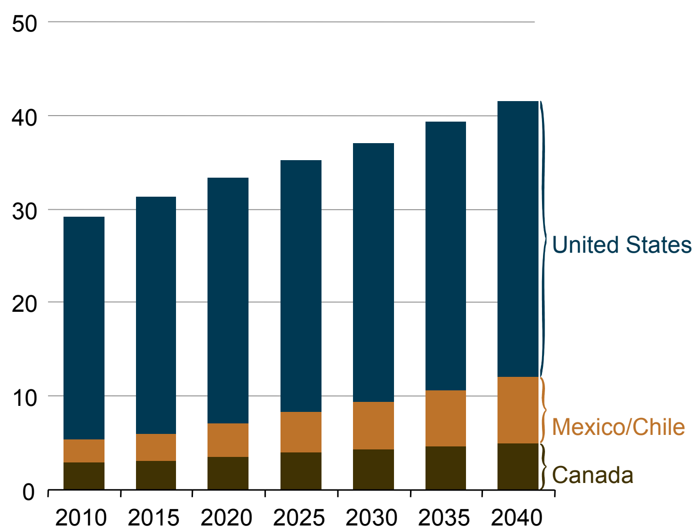


Figure 43. OECD Americas natural gas consumption by country, 2010-2040 (trillion cubic feet)



International shale gas resources

To gain a better understanding of potential international shale gas resources, EIA commissioned Advanced Resources International, Inc. (ARI) to assess shale gas resources. In April 2011, ARI estimated recoverable resources of 5,760 trillion cubic feet of wet natural gas.[22]

In June 2013, EIA released a second report, *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Other than the United States*. The new report updates the 2011 report and expands the coverage. The 2013 report also covers both shale gas and oil resources in shale formations. It focuses on regions that have relatively near-term promise for shale resource development and that have sufficient geologic data on which to base a resource estimate. Estimated risked recoverable resources covered in the 2013 report, including the United States, total 345 billion barrels of oil and 7,299 trillion cubic feet of natural gas. The updated natural gas resource estimate is 10 percent higher than the gas resource estimate in the 2011 report. Additionally, even with the expanded geographic coverage in the 2013 report, there are many important shale formations that it does not assess, such as those underlying large oil fields in the Middle East and the Caspian region.

The resource estimate for China is 13 percent lower in the 2013 report than in the 2011 report, despite covering more basins and more formations. The 2013 report covers 18 formations in 7 basins in China, as compared with 4 formations in 2 basins in the 2011 report. The main downward revision to the estimated risked recoverable resources for China was to the resources in the Tarim Basin. New data gathered since the 2011 report indicate that much of the basin is deeper than previously thought, putting much of the estimated in-place resources just outside of what is currently considered to be commercially producible (although future advances in drilling and completion technology could make production from deeper parts of the basin commercially viable).

Estimates of risked recoverable resources for Australia are 10 percent higher in the 2013 report (437 trillion cubic feet) than in the 2011 report (396 trillion cubic feet), in part because of the expanded coverage of the 2013 report. The Georgina and Beetaloo basins, which were not covered in the 2011 report, add 57 trillion cubic feet to Australia's total estimated risked recoverable resources in the 2013 report. Upward revisions to estimates for the Cooper and Canning basins also contribute to the overall increase. While the remote Canning Basin still remains largely unexplored, the Cooper Basin has been a major oil and gas producing area for years, and initial results from vertical shale test wells have been encouraging.

IEO2013 reflects production from many of the shale gas formations assessed in the two ARI studies. Shale gas production already is occurring outside the United States (in Canada) and is expected to begin in other countries with large technically recoverable resources, such as China, Australia, Mexico, and parts of OECD Europe. The timing and rate of production growth in individual countries remain uncertain, with technology transfer and above-ground factors expected to play a role.

Estimates of shale gas resources outside the United States are relatively uncertain, given that the available data are sparse. Resource estimates will continue to change as development progresses and more data become available. Even in the United States, where tight oil and shale gas production has been robust for several years, there still is considerable uncertainty about the ultimate size of U.S. resources. Resource estimates in the 2013 ARI report represent a moderately conservative resource for the basins reviewed. The methodology, which is described in more detail in the 2013 ARI report, is not directly comparable with more detailed resource assessments based on monthly production data from hundreds or thousands of wells, which provide a probabilistic range of the technically recoverable resource.

Although the United States has the highest absolute growth in natural gas consumption, the growth in Mexico and Chile combined reflects the highest rate of increase over the projection period, at 3.6 percent per year. This is the highest percentage growth rate among all the *IEO2013* OECD countries and country groupings, including the United States (0.7 percent per year) and Canada (1.7 percent per year). Increasingly, Mexico has serviced its growing demand for power generation with gas-fired units supplied by pipeline imports from the United States, particularly since 2011 [*57*]. The growth of Mexico's overall natural gas consumption has outstripped its production growth, causing its net imports to rise over time [*58*]. In Chile, approval has recently been granted to expand regasification capacity at the LNG plant in Quintero Bay by 50 percent, from 353.1 million cubic feet per day to 529.7 million cubic feet per day [*59*].

More than one-half of the growth in total annual natural gas consumption from 2010 to 2040 in the OECD Americas comes from the electric power sector (6.1 trillion cubic feet) in the *IEO2013* Reference case, and more than half of the consumption growth in the electric power sector (3.1 trillion cubic feet) occurs in Mexico and Chile. More than 70 percent (2.1 trillion cubic feet) of the remaining growth in natural gas use for electric power in the OECD Americas through 2040 occurs in the United States. The recent decline in U.S. natural gas prices will reduce the overall cost of electricity generation through 2040. However, a number of other factors are likely to affect the degree to which natural gas and electricity prices are linked, such as electricity transmission and distribution systems, as well as power pricing and purchasing mechanisms. In addition to the increased availability of supply

[22]Oil and gas in-place estimates are derived by first estimating the volume of in-place resources for a prospective area within a formation or basin and then de-rating the formation's in-place resource by applying risk factors that account for (1) the probability that the shale play will (or will not) have sufficiently attractive flow rates to become developed and (2) an expectation of how much of the prospective area set forth for each shale basin and formation will eventually be developed. A recovery factor is then applied to the risked in-place resource estimates. The recovery factor takes into consideration the capability of current technology to produce oil and gas from formations with similar geophysical characteristics, incorporating shale mineralogy, reservoir properties, and geologic complexity. The resulting estimate is referred to as the risked technically recoverable resource.

at lower prices, the U.S. electric sector's consumption of natural gas will be spurred by the retirement of 49 gigawatts of coal-fired generating capacity by 2022 [*60*].

Industrial consumption growth also adds significantly to the overall growth in OECD Americas natural gas consumption through 2040. Industrial consumption grows by 2.1 trillion cubic feet from 2010 to 2020, with 1.5 trillion cubic feet (73 percent) added in the United States, where industrial consumption increases at an average annual rate of 1.8 percent. However, growth in industrial use of natural gas in the United States slows from 2020 to 2040, rising by only 0.8 trillion cubic feet, or an average of 0.4 percent per year. Natural gas gradually loses some of its competitive advantage among U.S. industrial consumers, as international competition for its use increases and prices rise as shale gas production occurs in resources that are more expensive and harder to produce [*61*]. Industrial consumption growth also slows in Canada—from 1.7 percent annually in the 2010-2020 period to 1.3 percent annually from 2020 to 2040—but increases in Mexico and Chile, from 1.8 percent to 2.8 percent annually during those two periods.

OECD Europe

Natural gas consumption in OECD Europe grows by 0.7 percent per year on average, from 19.8 trillion cubic feet in 2010 to 24.5 trillion cubic feet in 2040 (Figure 45)—the lowest growth rate over the period, both in the OECD region and in the world. In comparison, OECD Europe's renewable energy consumption increases by an average of 2.0 percent per year, and its consumption of both liquid fuels and coal declines through 2040. The decline in demand for energy from coal and liquids results in an increase in the natural gas share of OECD Europe's total energy consumption, from about 25 percent in 2010 to 27 percent in 2040.

More than half of OECD Europe's 4.7 trillion cubic feet of growth in total natural gas consumption from 2010 to 2040 comes from the electric power sector, at 2.7 trillion cubic feet. Although the amount of natural gas consumed for electric power production increases by an average of only 0.4 percent per year from 2010 to 2020, it increases by 1.7 percent per year from 2020 to 2040, as economies recover from the global recession that began in 2008.

Many governments in OECD Europe have made commitments to reduce greenhouse gas emissions to 20 percent below 1990 levels by 2020 and have endorsed the objective of lowering emissions to between 80 and 95 percent below 1990 levels by 2050 [*62*]. Natural gas potentially has two roles to play in reducing carbon dioxide emissions in OECD Europe's electric power sector: as a replacement fuel for more carbon-intensive coal-fired generation and as a backup for intermittent generation from renewable energy sources.

Although there are many incentives for using natural gas more heavily in the electric power sector, growth has been hampered by a lack of progress in regulatory reforms in OECD Europe that would make natural gas more competitive in electric power markets. Such reforms would include measures to increase spot trading and make natural gas markets more flexible by making it easier for market participants to purchase and transmit gas supplies (see box on page 45). Although OECD Europe is largely expected to continue pricing natural gas via long-term indexed contracts in the near term, some developments—such as a recently signed deal between Germany's Wintershall and Norway's Statoil—signal movement toward spot market pricing [*63*]. Presumably, the impact of such reforms, as well as the increased use of natural gas to reduce carbon dioxide emissions from electric power generation, would occur for the most part after 2025. Additionally, recent actions by some European governments to reduce their reliance on nuclear power in the wake of Japan's Fukushima Daiichi nuclear disaster will provide an additional boost to both natural gas and renewable energy use in electricity generation. In the *IEO2013* Reference case, an increase of 1.7 percent per year in natural gas consumption for power generation from 2020 to 2040 is higher than for any other energy source used in the sector.

Figure 44. OECD Americas change in natural gas consumption by country and sector, 2010-2040 (trillion cubic feet)

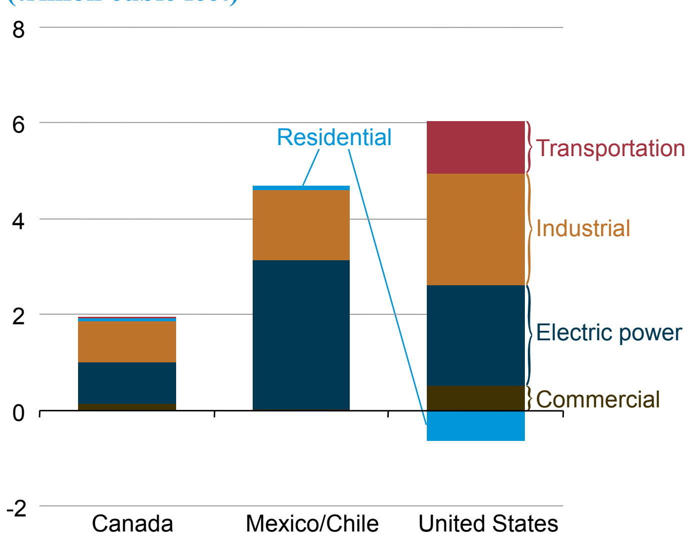
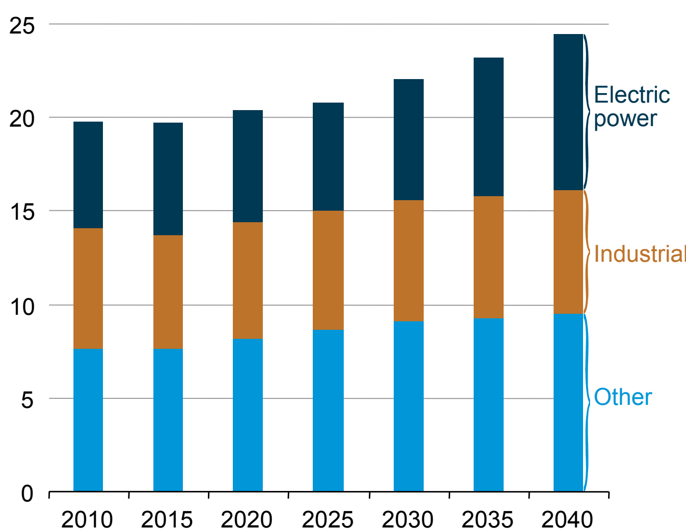


Figure 45. OECD Europe natural gas consumption by end-use sector, 2010-2040 (trillion cubic feet)



Natural gas pricing mechanisms around the world

Prices and pricing mechanisms for natural gas vary around the world. Today, the three most common pricing mechanisms are oil-linked pricing, regulated pricing, and competitive market pricing (or gas-on-gas competition). Under oil-linked pricing, natural gas generally is traded under long-term contracts with prices linked by formula to either crude oil prices or oil product prices, usually with some discount for the natural gas price relative to the oil price. Regulated prices, which are set by governments, can reflect production and other costs or provide subsidies for natural gas consumers. Under competitive market pricing, trading points or hubs are established in market areas, and competition among various suppliers and consumers of natural gas determines the price. Currently there is no globally integrated market for natural gas, and different pricing mechanisms predominate in different regional markets. As discussed below, however, markets are changing, and the move to more competitive natural gas markets may be inevitable. The timing of such a transition remains uncertain.

Historically, the regulation of U.S. natural gas prices was based on the cost of providing the natural gas (i.e., cost of service). Pipeline companies bought gas from producers at a regulated wellhead price, stored their gas and shipped it via their own facilities, and then sold it after transport, bundling the cost of the gas with its shipping and storage costs into a single price. By 1993, the U.S. natural gas industry had largely been deregulated. Wellhead prices were no longer set by the government, and pipeline companies could no longer bundle services but were required to offer transportation and storage services to third parties on a nondiscriminatory basis. Natural gas trade flourished, and multiple pricing points developed across the United States and Canada, the most active and publicized of which is the Henry Hub in Louisiana.

Until 2005, even with no direct linkage between oil prices and natural gas prices, the two tended to move together, with the market prices for oil (in dollars per barrel) and natural gas (in dollars per million Btu) maintaining a relatively stable ratio of around 7:1, with natural gas priced at a slight discount relative to the oil price on a Btu basis.[23] However, as oil prices climbed from an average of $56 per barrel in 2005 to an average of $100 per barrel in 2008, the discount for natural gas relative to oil also grew, from the 7:1 ratio in 2005 to 11:1 in 2008. After 2008, the natural gas discount relative to oil widened further, as oil prices remained relatively high while growing U.S. shale gas production helped to weaken natural gas prices. The oil-to-gas price ratio grew to an average of more than 35:1 in 2012, with a Btu of crude oil selling for more than five times the price for a Btu of natural gas. In EIA's *Annual Energy Outlook 2013* Reference case, the U.S. price differential narrows gradually to a ratio of 21:1 in 2040, as shale gas production moves to more expensive and difficult-to-produce resources and natural gas prices rise.

In Europe, natural gas historically has been traded under long-term contracts with prices linked to oil product prices (mainly diesel and heavy fuel oil) at a small discount. As in the United States, Europe has largely deregulated its natural gas industry. Deregulation was essentially completed in the United Kingdom by 2000, and more recently, European Union directives have deregulated natural gas prices in much of Continental Europe.[24]

Since deregulation began, several natural gas trading points have developed across Europe. The oldest, most active, and best known is the National Balancing Point (NBP) in the United Kingdom. However, hub pricing for natural gas has not yet become universal in Europe as it is in the United States and Canada. Pricing in Europe at present is a mix of natural gas purchased on spot markets at hub prices, gas purchased under long-term contracts with prices linked to hub prices, and gas purchased under long-term contracts with prices linked to oil prices. Through 2005, contract and spot prices for natural gas in Europe were generally lower than the prices in North America. More recently, European natural gas prices have been significantly higher than North American prices, as the natural gas discount relative to oil in Europe has grown only moderately in comparison with the deeper discount of U.S. natural gas prices. The ratio of oil prices to natural gas prices in Europe grew from between 8:1 and 9:1 in 2005 to between 10:1 and 12:1 in 2012.

In Asia, natural gas has been traded in the past under long-term contracts, with gas prices linked to crude oil prices with some discount. Asia's natural gas markets are much less integrated than those in Europe and North America, with fewer pipelines, which are governed by a number of different nations and regulations. The deregulation of the natural gas sector that helped to propel market development in North America and Europe is, so far, generally absent in Asia. However, there have been some recent changes in Asian markets. Asian buyers have gained more destination flexibility, and the volumes of LNG bought and sold on the spot market and under short-term contracts have increased. Asian buyers also have signed contracts to buy LNG from the United States, at prices linked to the Henry Hub price rather than to oil prices. At the same time, s-curves (contract terms that limit the effect of high oil prices on contract prices for natural gas) have been virtually eliminated from contracts in Asia since 2008, helping to sustain prices well above those in both North America and Europe.

Recent increases in natural gas supplies have provided an opportunity for the development of competitive natural gas markets, and global development of shale gas could hasten the advent of competitive pricing regimes around the world. Regulated natural gas prices

(continued on page 46)

[23]The ratio is calculated as the crude oil price in dollars per barrel divided by the natural gas price in dollars per million Btu. A ratio of around 6:1 indicates price parity between crude oil and natural gas on a Btu basis. A ratio above 6:1 indicates that the natural gas price is at a discount relative to the oil price on a Btu basis.

[24]For a discussion of natural gas pricing in Europe, see EIA's *International Energy Outlook 2011*, DOE/EIA-0484(2011) (Washington, DC, September 2011), "Natural gas prices in Europe," pp. 46-47.

and prices linked to oil are gradually giving way to competitive natural gas pricing, as seen first in North America and then in the United Kingdom. The transition is still in progress in Continental Europe, where the share of the natural gas market traded under hub market prices is likely to continue to grow. As regional Asian trade and consumption of LNG and natural gas increase, it is virtually inevitable that a natural gas hub will also develop in Asia, even if it is not currently apparent how or where. China, Japan, and Singapore (among other Asian nations) have expressed interest in developing such a hub. Finally, as natural gas trading hubs grow, natural gas increasingly will compete economically worldwide, based on the balance of supply and demand for natural gas itself, without reference to oil prices.

OECD Asia

Natural gas consumption in OECD Asia grows on average by 1.3 percent per year from 2010 to 2040, from 6.7 trillion cubic feet to 9.9 trillion cubic feet. Over the projection period, natural gas consumption in Japan increases by an average of 1.0 percent per year, as compared with 1.7 percent for Australia and New Zealand combined and also for South Korea. As a result, Japan's share of the OECD Asia region's total natural gas consumption declines from 58 percent in 2010 to 53 percent in 2040.

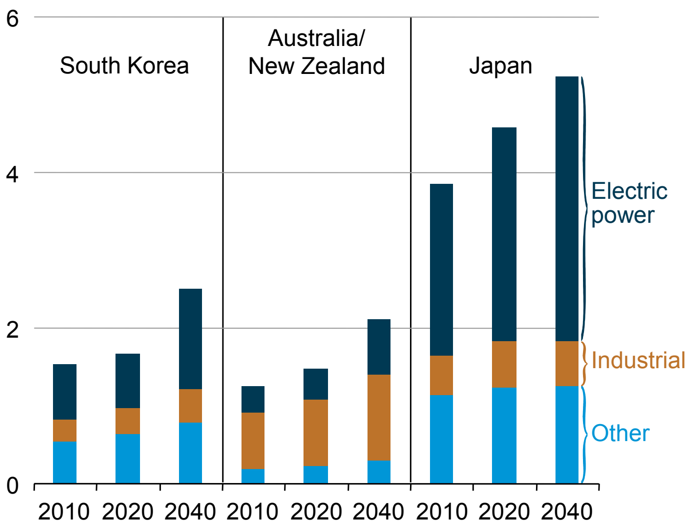
From 2010 to 2020, natural gas consumption in Japan rises at a 1.8-percent annual rate—the highest rate in OECD Asia—led by demand in the electric sector, where consumption increases by 2.3 percent annually, from 2.2 trillion cubic feet in 2010 to 2.7 trillion cubic feet in 2020 (Figure 46). Japan has relied primarily on LNG spot cargo shipments to offset the loss of nuclear generating capacity that occurred when the country shut down a large part of its nuclear generation capacity after the Fukushima Daiichi power reactors were severely damaged by the March 2011 earthquake and tsunami. All but two of the country's 50 reactors remain offline to date [*64*]. Japan receives LNG imports from 32 terminals, with 8.7 trillion cubic feet of total annual sendout capacity. Natural gas consumption has received additional priority in Japan as a way to reduce carbon dioxide emissions.

From 2020 to 2040, Japan's economic growth rate slows to 0.3 percent per year, by far the lowest rate in the region, as a result of its declining population and aging work force. With its nuclear generation capacity assumed to return to service in the *IEO2013* Reference case, annual growth rates for natural gas consumption fall below 2010-2020 levels in every sector, including almost no growth in natural gas consumption for electricity generation. Although Japan's natural gas consumption does not decline between 2020 and 2040, its consumption of energy from liquids and coal does decline. As a result, the natural gas share of Japan's total energy consumption rises from 21 percent in 2020 to nearly 25 percent in 2040.

Unlike Japan, South Korea is expected to increase its natural gas consumption at greater rates after 2020. South Korea's natural gas consumption grows by 0.8 percent per year from 2010 to 2020, after which it accelerates to 2.1 percent per year through 2040. This is largely the result of increasing natural gas consumption in South Korea's electric power sector, where natural gas consumption declines by 0.2 percent per year from 2010 to 2020 as a substantial amount of new nuclear power capacity becomes operational. From 2020 to 2040, natural gas consumption for electricity generation in South Korea increases by 3.2 percent per year on average, from 0.7 trillion cubic feet to 1.3 trillion cubic feet.

Natural gas consumption growth from 2010 to 2040 in Australia and New Zealand combined is fairly constant across all sectors. The two countries have the region's strongest growth in electricity sector natural gas consumption, averaging 2.4 percent per year and more than doubling, from 0.3 trillion cubic feet in 2010 to 0.7 trillion cubic feet in 2040. Australia gradually increases the share of natural gas in its power generation mix in order to reduce its more carbon-intensive coal-fired generation. The two countries' combined share of OECD Asia's total natural gas use for electricity generation grows from 10 percent in 2010 to 13 percent in 2040 in the Reference case.

Figure 46. OECD Asia natural gas consumption by country and end-use sector, 2010-2040 (trillion cubic feet)



Non-OECD natural gas consumption

Non-OECD Europe and Eurasia

The countries of non-OECD Europe and Eurasia relied on natural gas for 47.3 percent of their primary energy needs in 2010—the second highest of any country grouping in *IEO2013* except the Middle East. Non-OECD Europe and Eurasia consumed a total of 21.8 trillion cubic feet of natural gas in 2010, the most outside the OECD, and more than any other region in the world except the OECD Americas. Russia accounted for 69 percent of the regional total in 2010, consuming 15.0 trillion cubic feet (Figure 47).

In the Reference case, overall natural gas consumption in non-OECD Europe and Eurasia grows at a relatively modest annual rate of 1.0 percent from 2010 to 2040. Slow growth of only 0.6 percent per year is projected from 2010 to 2020, when total consumption rises by only 1.2 trillion cubic feet. The region's natural gas consumption grows by an average of 1.3 percent per year from 2020 to 2040, increasing by a total of 6.8 trillion cubic feet. The trend is especially pronounced outside Russia. In the other countries of non-OECD Europe and Eurasia, natural gas consumption grows by an average of 1.4 percent per year from 2010 to 2040, with consumption for electricity generation increasing by 2.0 percent per year, from 1.8 trillion cubic feet in 2010 to 3.3 trillion cubic feet by 2040.

Natural gas consumption increases slowly through 2040 in Russia. Russia's slow increase in natural gas consumption reflects the country's declining population, as well as a shift away from natural gas to nuclear power in its electricity sector, as the country looks to monetize natural gas through exports to markets in Asia and OECD Europe. These efforts include the recently completed construction of a second pipeline running parallel to the offshore Nord Stream line into Germany [*65*], as well as the South Stream pipeline, which after its expected completion in 2015 would transport more than 2.2 trillion cubic feet per year through Bulgaria, Serbia, Hungary, Slovenia, and Italy [*66*]. Expected efficiency improvements and other demand-side management measures also limit growth in natural gas consumption over the long term. As a result, Russia's projected 0.9-percent average annual growth in natural gas demand from 2010 to 2040 is the lowest outside the OECD and the second lowest in the world, with its share of non-OECD Europe and Eurasia's total regional natural gas consumption falling from 69 percent in 2010 to 65 percent in 2040. Nonetheless, Russia remains the largest national non-OECD consumer of natural gas through 2040 in the *IEO2013* Reference case.

Non-OECD Asia

Among all regions of the world, the fastest growth in natural gas consumption in the *IEO2013* Reference case occurs in non-OECD Asia. Natural gas use in non-OECD Asia increases by an average of 3.3 percent annually, from 13.9 trillion cubic feet in 2010 to almost triple that amount—36.3 trillion cubic feet—in 2040 (Figure 48). During the period, the non-OECD Asia region accounts for more than 30 percent of the total increment in world natural gas use. Non-OECD Asia moves from its current position as the world's fourth-largest natural gas consuming region to the second-largest gas consumer by 2030. Total natural gas consumption increases from less than one-half that of the OECD Americas region in 2010 to nearly 90 percent in 2040, and its share of total world natural gas consumption rises from 12 percent in 2010 to 20 percent in 2040.

Almost two-thirds (61 percent) of non-OECD Asia's growth in natural gas consumption from 2010 to 2040 occurs in China, where total consumption rises by more than 360 percent in the Reference case, from 3.8 trillion cubic feet in 2010 to 17.5 trillion cubic feet in 2040. China's central government is promoting natural gas as a preferred energy source and has set an ambitious target of increasing the share of natural gas in its overall energy mix to 10 percent (or approximately 8.8 trillion cubic feet) by 2020 in order to alleviate pollution from its heavy coal use [*67*]. In the *IEO2013* Reference case, natural gas consumption in China totals 7.8 trillion cubic feet in 2020, or about 5 percent of the country's total energy consumption, as a result of continued growth in consumption of energy from other sources, particularly coal. In 2040, the natural gas share of China's energy consumption is 8 percent—still far less than coal's 55-percent share. In addition, the 5.3-percent average annual growth rate for natural gas consumption from 2010 to 2040 is less than half the 10.3-percent rate for nuclear energy.

The most expansive growth in China's natural gas consumption occurs between 2010 and 2020, averaging 7.5 percent per year before slowing to 4.2 percent from 2020 to 2040, which still is higher than the non-OECD Asia regional average of 3.2 percent from 2020 to 2040. Most of China's initial growth in demand for natural gas comes from the electric power, industrial, and residential sectors, which together account for 91 percent of the increase in the country's natural gas consumption through 2020, including 8.0-percent average annual growth in the electric power sector and 10.9-percent average annual growth in the residential

Figure 47. Non-OECD Europe and Eurasia natural gas consumption by region, 2010-2040 (trillion cubic feet)

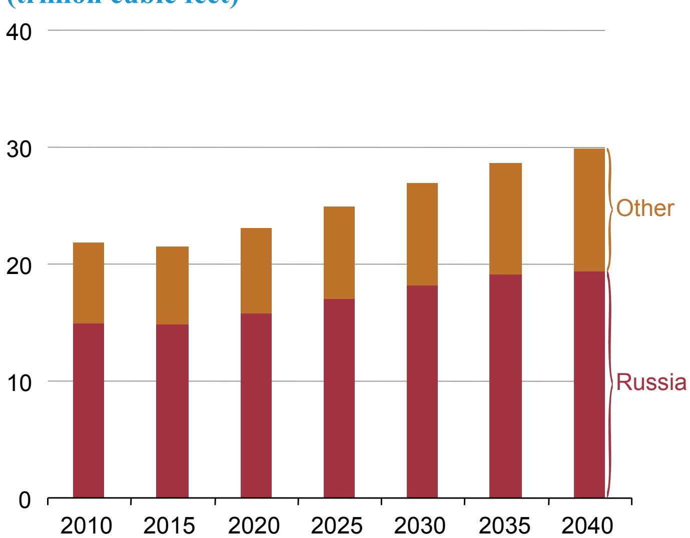
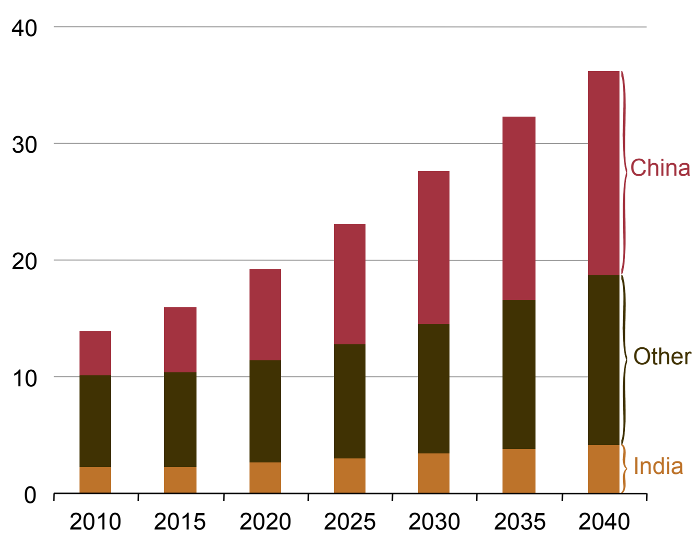


Figure 48. Non-OECD Asia natural gas consumption by country, 2010-2040 (trillion cubic feet)



sector. Growth in all three sectors levels off from 2020 to 2040, but they still account for 87 percent of the country's total growth in natural gas consumption during the period.

Natural gas accounted for about 10 percent of India's overall energy consumption in 2010, nearly 2.5 times the share in China's energy mix. India's natural gas consumption averages 2.0-percent annual growth from 2010 to 2040, lower than for all energy sources except coal and only one-fifth of the 10.0-percent annual growth rate for nuclear energy consumption during the period. This results largely from supply constraints, including continued obstacles to reaching agreement on the construction of three pipelines that would provide India with natural gas from fields in Iran, Turkmenistan, and Myanmar [*68*]. Consequently, the natural gas share of India's total energy consumption declines to 8 percent in 2040, despite consumption increases of 1.0 and 0.9 trillion cubic feet, respectively, in the industrial and electric power sectors.

In the other countries of non-OECD Asia, natural gas accounts for slightly less than one-quarter of overall energy consumption from 2010 through 2040, increasing by an average of 2.1 percent per year from 7.8 trillion cubic feet in 2010 to 14.6 trillion cubic feet by 2040. Although natural gas remains the second-largest source of energy consumption after liquids, its annual growth rate is less than the rates for coal (2.4 percent) and nuclear energy (5.1 percent).

Middle East

In the Middle East region, natural gas accounted for about one-half of total energy consumption in 2010, more than in any other region. In the *IEO2013* Reference case, Middle East natural gas consumption increases by an average of 2.2 percent per year from 2010 to 2040, when it accounts for almost 54 percent of total energy use, the highest share of any *IEO2013* world region. The industrial sector accounts for the largest share of natural gas consumption in the Middle East from 2010 to 2040 (Figure 49). Natural gas use in the industrial sector grows by 8.0 trillion cubic feet from 2010 to 2040, or two-thirds of the region's 12.0 trillion cubic feet of total natural gas consumption growth. Industrial sector natural gas consumption rises by an average 2.6 percent per year, more than doubling over the projection period. Natural gas consumption in the electric power sector, by comparison, grows to 7.6 trillion cubic feet in 2040, increasing at an average annual rate of 1.8 percent.

A significant portion of the increase in industrial natural gas consumption—particularly through 2015—is attributed to the use of natural gas in LNG liquefaction plants and in gas-to-liquids (GTL) plants in Qatar—the world's largest LNG supplier. Qatar's two main LNG producers, Qatargas and RasGas, both of which are joint ventures with majority shares held by government-owned Qatar Petroleum, are not expected to expand their annual LNG liquefaction capacity beyond the current 3.75 trillion cubic feet through the construction of new facilities. Rather, any capacity increases are expected to result from improvements at existing facilities [*69*].

Africa

In the *IEO2013* Reference case, Africa's natural gas consumption rises to 8.8 trillion cubic feet in 2040, nearly 2.5 times the 2010 total (Figure 50). The average annual growth rate of natural gas use, at 3.1 percent, is second only to that of nuclear energy, which increases by 6.8 percent per year from 2010 to 2040.

Egypt and Algeria are Africa's two largest consumers and producers of natural gas, together accounting for more than 74 percent of the region's total natural gas consumption and 70 percent of its production in 2010 [*70*]. Egypt's consumption is expected to be bolstered by government-sponsored efforts to encourage households and businesses to switch to natural gas from petroleum, coal, and liquefied petroleum gas. In addition to a Natural Gas Connections Project in Egypt that is sponsored by the World Bank, the Egyptian government currently requires one-third of the country's 77 trillion cubic feet of proved reserves be set aside for domestic consumption [*71*].

Figure 49. Middle East natural gas consumption by end-use sector, 2010-2040 (trillion cubic feet)

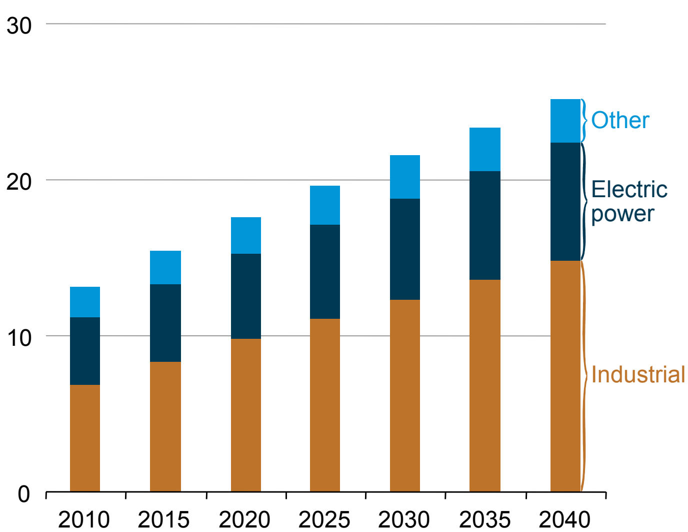
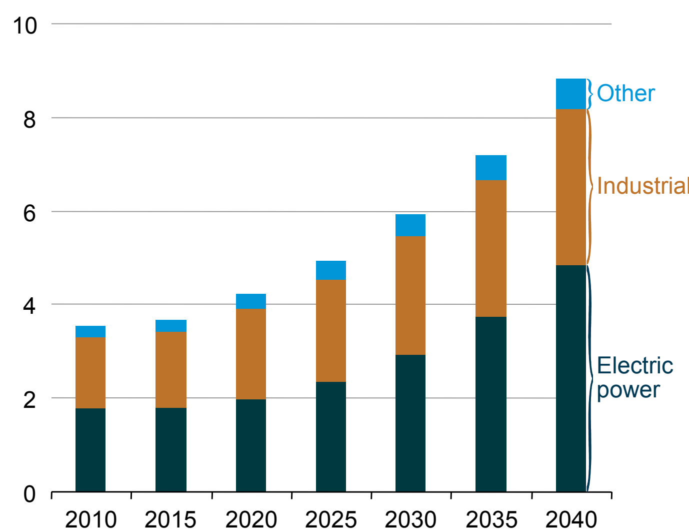


Figure 50. Africa natural gas consumption by end-use sector, 2010-2040 (trillion cubic feet)



The electric power and industrial sectors account for 93 percent of the total increase in Africa's demand for natural gas from 2010 to 2040 and 93 percent of its overall natural gas demand in 2040. The electric power sector alone accounts for 58 percent of the rise in natural gas consumption from 2010 to 2040, from 1.8 trillion cubic feet to 4.8 trillion cubic feet. Almost all of the increase in natural gas use for electricity generation in Africa occurs from 2020 to 2040, averaging 4.6 percent per year, versus an average annual increase of less than 1.0 percent from 2010 to 2020.

Nigeria holds an estimated 182 trillion cubic feet of natural gas proved reserves, the largest in the region and ninth-largest in the world. Most of Nigeria's marketed production is exported as LNG. The remainder is consumed domestically or exported to Benin, Togo, and Ghana via the West African Gas Pipeline, which also connects the nation's gas fields to its capital city, Lagos. About 85 percent of the gas transported through the pipeline is used for electricity generation, according to pipeline operator WAPCo. With an initial capacity of 170 million cubic feet per day, the pipeline is expected to be expanded over time to 460 million cubic feet per day [*72*]. Algeria holds the world's tenth-largest proved reserves of natural gas and is the world's eighth-largest producer. Like Nigeria, most of Algeria's production is exported, primarily to European consumers through both pipeline networks and LNG shipments [*73*].

Central and South America

Natural gas consumption in the non-OECD nations of Central and South America increases by an average of 2.0 percent per year in the *IEO2013* Reference case, from 4.9 trillion cubic feet in 2010 to 8.9 trillion cubic feet in 2040 (Figure 51). The electric power sector accounts for one-half of the demand growth from 2010 to 2040, followed by the industrial sector at 30 percent.

Brazil's natural gas consumption grows by an average of 3.9 percent per year from 2010 to 2040, or by a total of 1.9 trillion cubic feet, which is nearly one-half of the overall increase of 4.0 trillion cubic feet for the Central and South America region. A number of projects to expand domestic gas pipelines are planned by the state-owned Petrobras company, as well as efforts to diversify the country's electricity supply away from reliance on hydropower, in order to mitigate the risk of power shortages during dry periods [*74*].

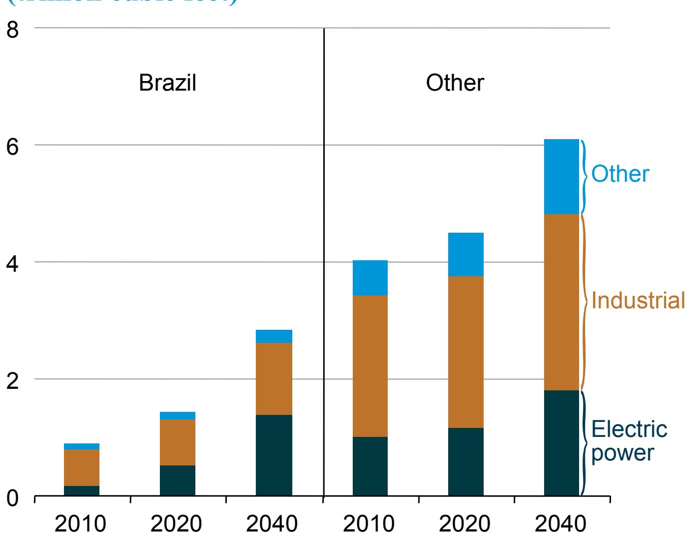
The natural gas share of Brazil's overall energy mix grows from 7 percent in 2010 to almost 12 percent in 2040. Nearly two-thirds (62 percent) of the increase in Brazil's natural gas consumption comes from the electric power sector, where natural gas use grows by 600 percent, from 0.2 trillion cubic feet in 2010 to 1.4 trillion cubic feet in 2040. The growth in natural gas consumed for electric power in Brazil averages 11.2 percent per year from 2010 to 2020 and 5.1 percent per year from 2020 to 2040. However, the 12-percent natural gas share of Brazil's overall energy consumption in 2040 remains well below the share in the rest of Central and South America, which is about 30 percent over the entire period.

One of the world's largest endowments of shale gas has been discovered in Argentina, which is also the region's largest consumer of natural gas. Construction of the Gasoducto del Noreste Argentino (GNEA) gas pipeline [*75*] is expected to connect Argentina's northern and central provinces with Bolivia's Juana Azurduy integration pipeline, which could provide nearly 1.0 billion cubic feet of natural gas per day to users in Argentina [*76*].

World natural gas production

In order to meet the consumption growth in the *IEO2013* Reference case, the world's natural gas producers will need to increase supplies by more than 70 trillion cubic feet—or around 65 percent—from 2010 to 2040. Much of the increase in supply is expected to come from non-OECD countries, which in the Reference case account for 73 percent of the total increase in world natural gas production from 2010 to 2040. Non-OECD natural gas production grows by an average of 2.0 percent per year, from 70 trillion cubic feet in 2010 to 126 trillion cubic feet in 2040 (Table 7), while OECD production grows by only 1.3 percent per year, from 41 trillion cubic feet to 61 trillion cubic feet.

Figure 51. Central and South America natural gas consumption by end-use sector, 2010-2040 (trillion cubic feet)



Production of tight gas, shale gas, and coalbed methane grows rapidly in the projection, with OECD tight gas, shale gas, and coalbed methane production growing on average by 3.4 percent per year, from 16 trillion cubic in 2010 to 43 trillion cubic feet in 2040. Over the same period, non-OECD production of tight gas, shale gas, and coalbed methane grows from less than 1 trillion cubic feet to 20 trillion cubic feet. However, numerous uncertainties could affect future production of those resources. There is still considerable variation among estimates of recoverable shale gas resources in the United States and Canada, and estimates of recoverable tight gas, shale gas, and coalbed methane for the rest of the world are more uncertain given the sparse data currently available. Moreover, the hydraulic fracturing process used to produce shale gas resources requires significant amounts of water, and in many of the areas that have been identified globally as possessing shale gas resources the available water supplies are limited. Further, environmental concerns add to the uncertainty surrounding access to shale gas resources.

OECD Production

OECD Americas

Natural gas production in the OECD Americas grows by 56 percent from 2010 to 2040. The United States, which is the largest producer in the OECD Americas and in the OECD as a whole, accounts for three-quarters of the total regional production growth, with an increase from 21.2 trillion cubic feet in 2010 to 33.1 trillion cubic feet in 2040 (Figure 52). U.S. shale gas production grows from 4.9 trillion cubic feet in 2010 to 16.7 trillion cubic feet in 2040, more than offsetting declines in production of natural gas from other sources. In 2040, shale gas accounts for 50 percent of total U.S. natural gas production in the *IEO2013* Reference case, tight gas accounts for 22 percent, and Lower 48 offshore production accounts for 9 percent. The remaining 19 percent comes from coalbed methane, Alaska, and other associated and nonassociated Lower 48 onshore resources.

One of the keys to U.S. production growth is advanced production technologies, especially the combined application of horizontal drilling and hydraulic fracturing techniques that have made the country's vast shale gas resources accessible. Rising estimates of shale gas resources have been the primary factor in nearly doubling the estimated U.S. technically recoverable natural gas resource over the past decade, and U.S. shale gas production has continued to grow despite low natural gas prices. As North American natural gas prices have remained low and liquids prices have risen with international crude oil prices, U.S. shale drilling has concentrated on liquids-rich shales such as the Bakken formation in North Dakota and the Eagle Ford formation in Texas.

Natural gas production in Canada grows by 1.1 percent per year on average over the projection period, from 5.4 trillion cubic feet in 2010 to 7.6 trillion cubic feet in 2040. As in the United States, much of the production growth comes from growing volumes of tight gas and shale gas production. Four proposed LNG liquefaction and export facilities would use feedstock gas from the Montney tight gas and Horn River shale gas formations in western Canada. If all four facilities were built and operated at their

Table 7. World natural gas production by region and country in the Reference case, 2010-2040 (trillion cubic feet)

	History	Projections						Average annual percent change,
Region/country	2010	2015	2020	2025	2030	2035	2040	2010-2040
OECD								
United States[a]	21.2	23.9	26.5	28.4	29.7	31.3	33.1	1.5
Canada	5.4	5.0	5.4	5.9	6.4	7.0	7.6	1.1
Europe	10.4	9.0	8.1	8.0	8.6	9.2	9.9	-0.2
Australia/New Zealand	1.9	2.7	3.8	4.9	5.6	6.2	6.7	4.3
Rest of OECD	2.1	1.7	1.8	1.9	2.3	3.0	3.8	2.1
Total OECD	**41.0**	**42.3**	**45.6**	**49.1**	**52.5**	**56.7**	**61.2**	**1.3**
Non-OECD								
Russia	20.9	21.6	23.6	26.3	29.4	32.1	33.3	1.6
Europe and Central Asia	5.8	7.4	8.4	9.3	10.3	11.4	12.3	2.6
Iran	5.2	6.4	7.5	8.5	9.4	10.1	10.6	2.4
Qatar	3.4	6.0	6.9	7.3	7.6	7.9	8.3	3.0
Rest of Middle East	7.3	7.7	8.4	9.5	10.5	11.4	12.6	1.8
North Africa	5.8	5.7	6.2	6.2	6.4	6.8	7.4	0.8
Rest of Africa	1.6	2.3	3.1	4.0	4.8	5.6	6.3	4.8
China	3.3	3.8	4.2	5.2	6.7	8.5	10.1	3.8
Rest of Asia	11.5	11.1	11.4	11.8	12.5	13.5	14.4	0.8
Central and South America	5.4	6.4	7.4	7.9	8.5	9.5	10.4	2.2
Total non-OECD	**70.2**	**78.5**	**87.1**	**96.0**	**106.2**	**116.8**	**125.6**	**2.0**
Total world	**111.1**	**120.8**	**132.7**	**145.1**	**158.7**	**173.5**	**186.8**	**1.7**
Discrepancy[b]	-1.8	0.4	0.6	0.9	0.5	0.8	0.6	

[a]Includes supplemental production, less any forecast discrepancy.
[b]Balancing item. Differences between global production and consumption totals result from independent rounding and differences in conversion factors derived from heat contents of natural gas that is produced and consumed regionally.

initial proposed capacity, Canada would need to supply 1.2 trillion cubic feet per year to support them—less than the decline in net pipeline exports of natural gas from Canada to the United States in the Reference case.

Currently, in addition to small but growing volumes of shale gas, Canada also produces small volumes of natural gas from coalbeds and significant volumes from tight reservoirs. In 2010, almost 40 percent of Canada's natural gas production came from tight reservoirs [*77*]. Most of the country's coalbed methane production is in the province of Alberta, which had more than 11,000 producing coalbed methane wells and 260 billion cubic feet of coalbed methane production in 2010 [*78*]. In 2001, coalbed methane activity in the province consisted of no more than a few test wells.

Mexico's natural gas production remains fairly flat in the mid-term but more than doubles in the later years of the projection, as production from shale gas resources grows. Total natural gas production increases from 1.8 trillion cubic feet in 2010 to 3.5 trillion cubic feet in 2040. Like Canada and the United States, Mexico is thought to have substantial shale gas resources, the most prospective of which are extensions of the successful Eagle Ford Shale in the United States. However, because the shale resources in Mexico are not as well explored as those in the rest of North America, there is more uncertainty surrounding estimates of their size and producibility. Mexico also faces substantial difficulties in attracting the investment and technology improvements needed to increase natural gas production generally and production from shale resources specifically.

OECD Europe

Norway, the Netherlands, and the United Kingdom are by far the three largest producers of natural gas in OECD Europe, accounting for 85 percent of total regional natural gas production in 2010. From 2000 to 2010, production in the Netherlands was fairly flat, as was production by the three largest producers combined, and in OECD Europe as a whole. Stability of total production volumes has been supported by significant growth in Norway's production, which has balanced declines in the United Kingdom's production. That balance will be broken in the mid-term, however, as production declines in the United Kingdom and much of the rest of Europe overwhelm any additional growth in Norway's production. In the *IEO2013* Reference case, OECD Europe's natural gas production declines in the mid-term and then begins to grow again in the later part of the projection, as production from tight gas, shale gas, and coalbed methane resources becomes more significant (Figure 53). Overall, natural gas production in OECD Europe in 2040 is about the same as in 2010.

OECD Europe's natural gas production is also buoyed by long-term growth in production in Israel, which became an OECD member country in September 2010 and is included in the OECD Europe totals in *IEO2013*. In 2010, Israel produced just 55 billion cubic feet of natural gas, but with significant offshore finds in the Levant Basin, including the Tamar and Leviathan fields, it has the potential to produce at least 1 trillion cubic feet per year. Israel's demand for natural gas is limited, however, and actual production growth could be affected by the economics or politics of exporting natural gas.

OECD Asia

Natural gas production in the Australia/New Zealand region grows from 1.9 trillion cubic feet in 2010 to 6.7 trillion cubic feet in 2040 in the Reference case, an average rate of 4.3 percent per year. In 2010, Western Australia, including the Northwest Shelf area of Australia's Carnarvon Basin, accounted for around 63 percent of total production in the Australia/New Zealand region [*79*], with much of the production used as feedstock at the Northwest Shelf LNG liquefaction facility. Other areas and basins in Australia provided another 28 percent of the region's total production in 2010. New Zealand's natural gas production accounted for around 9 percent of the 2010 regional total.

Figure 52. OECD natural gas production by country, 1990-2040 (trillion cubic feet)

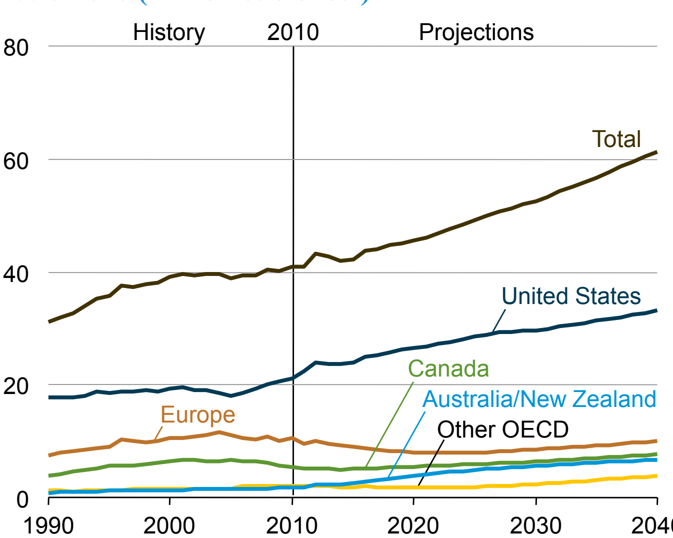
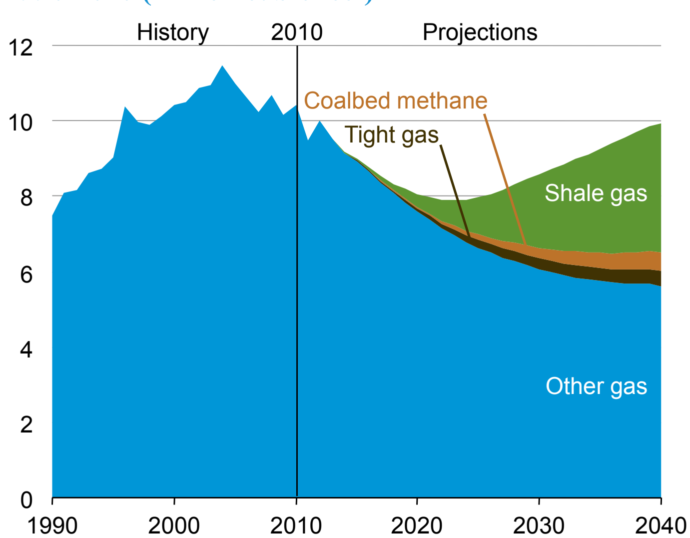


Figure 53. OECD Europe natural gas production, 1990-2040 (trillion cubic feet)



Coalbed methane from the Bowen-Surat Basin in eastern Australia accounted for between 10 percent and 11 percent of Australia's total natural gas production in 2010 [80], and its share grows as it provides natural gas supplies to satisfy the area's demand growth and to feed proposed LNG export projects.

Several companies also are pursuing tight gas and shale gas resources in Australia. Both the Perth and Canning basins in the state of Western Australia may hold economically producible resources of tight gas and shale gas. As in the United States, fracture stimulation of oil and gas wells has been common since long before the current interest in shale gas production. In Western Australia almost 800 wells have been stimulated by hydraulic fracturing since 1958, including several in the Perth Basin in 2011 and 2012 [81] as part of shale gas exploration efforts there. The Canning Basin has received less attention to date, as it is more remote and will require greater infrastructure investment to bring producible resources, if any, to market. On the other hand, shale gas development in Australia is most active in the Cooper Basin, which lies mainly in the state of South Australia and closer to existing oil and gas infrastructure and to Australia's demand centers.

Both Japan and South Korea have limited natural gas resources and, consequently, very limited current and future production. Both countries receive the vast majority of their natural gas supplies in the form of imported LNG. In 2010, natural gas production in Japan and South Korea accounted for only 4 percent and 2 percent of their natural gas consumption, respectively. The presence of substantial deposits of methane hydrates in both Japan and South Korea has been confirmed, and both countries are investigating how those resources could be safely and economically developed. However, the *IEO2013* Reference case does not include methane hydrate resources in its estimates of natural gas resources, and the widespread development of hydrates on a commercial scale is not anticipated during the projection period.

Non-OECD production

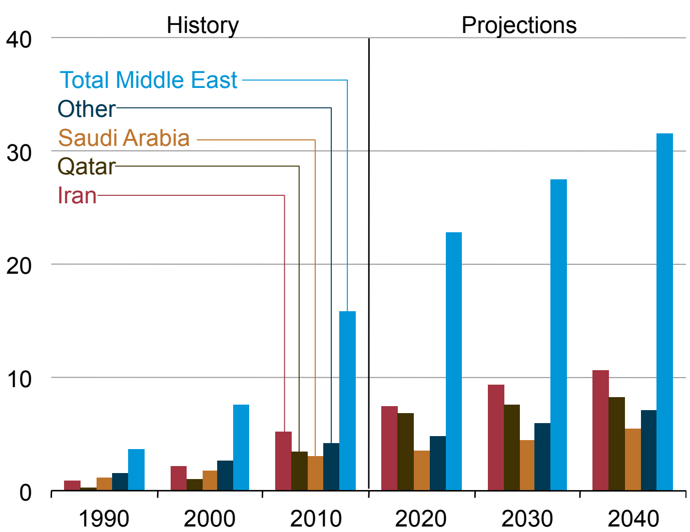
Middle East

Four major natural gas producers in the Middle East—Qatar, Iran, Saudi Arabia, and the United Arab Emirates—together accounted for 85 percent of the natural gas produced in the Middle East in 2010. With more than 40 percent of the world's proved natural gas reserves, the Middle East accounts for 21 percent of the total increase in world natural gas production in the *IEO2013* Reference case, growing from 15.9 trillion cubic feet in 2010 to 31.5 trillion cubic feet in 2040 (Figure 54).

The strongest growth among Middle East producers from 2010 to 2040 in the Reference case comes from Iran, where natural gas production increases by 5.4 trillion cubic feet, followed by Qatar (4.9 trillion cubic feet of new production) and Saudi Arabia (2.3 trillion cubic feet). Although Iraq is the region's fastest-growing supplier of natural gas, with average increases of 11.6 percent per year over the projection, it remains a relatively minor contributor to regional natural gas supplies. In 2040, Iraq's natural gas production totals 1.2 trillion cubic feet, or about 4 percent of the Middle East total.

Iran has the world's second-largest reserves of natural gas, after Russia, and is currently the Middle East's largest natural gas producer. Iran is also the Middle East's largest user of reinjected natural gas for enhanced oil recovery operations. In 2010 Iran reinjected more than 1 trillion cubic feet of natural gas, or 15 percent of its gross production, and in 2020 it is projected to use 3.7 trillion to 7.3 trillion cubic feet of natural gas per year for reinjection [82]. The higher estimate is almost equal to the total for Iran's marketed natural gas production in 2020 in the *IEO2013* Reference case. The actual figure for reinjection use, whatever it turns out to be, will have a significant impact on Iran's marketed natural gas production in the future.

Figure 54. Middle East natural gas production, 1990-2040 (trillion cubic feet)



Natural gas production in Saudi Arabia grows by an average of 1.9 percent per year, from 3.1 trillion cubic feet in 2010 to 5.4 trillion cubic feet in 2040. The Saudi Arabian national oil company, Saudi Aramco, has made several natural gas finds in the Persian Gulf that are not associated with oil fields. Three gas fields, the Karan, Arabiyah, and Hasbah, are expected to begin producing in the next 5 years, adding at least 1.3 trillion cubic feet of production when fully operational. Both Arabiyah and Hasbah are offshore, and both are sour natural gas fields,[25] making them relatively expensive to produce, especially in the context of low domestic natural gas prices set by the government [83]. The *IEO2013* Reference case assumes that Saudi Arabia's policy of reserving natural gas production for domestic use will persist throughout the projection period,

[25]Sour gas contains significant quantities of hydrogen sulfide, which is considered a contaminant, and gas with high concentrations requires special handling and treatment. Hydrogen sulfide is corrosive, and in sufficient concentrations it can damage pipelines and other infrastructure. It is also heavier than air and highly toxic.

and that no natural gas will be exported. Thus, in the long term, production is more dependent on domestic demand growth and domestic prices than on resource availability.

Non-OECD Europe and Eurasia

In the *IEO2013* Reference case, almost one-quarter of the global increase in natural gas production comes from non-OECD Europe and Eurasia, which includes Russia, Central Asia, and non-OECD Europe. Natural gas production in the region as a whole increases from 26.7 trillion cubic feet in 2010 to 45.6 trillion cubic feet in 2040 (Figure 55). Russia remains the dominant natural gas producer, accounting for more than 70 percent of the region's production throughout the projection.

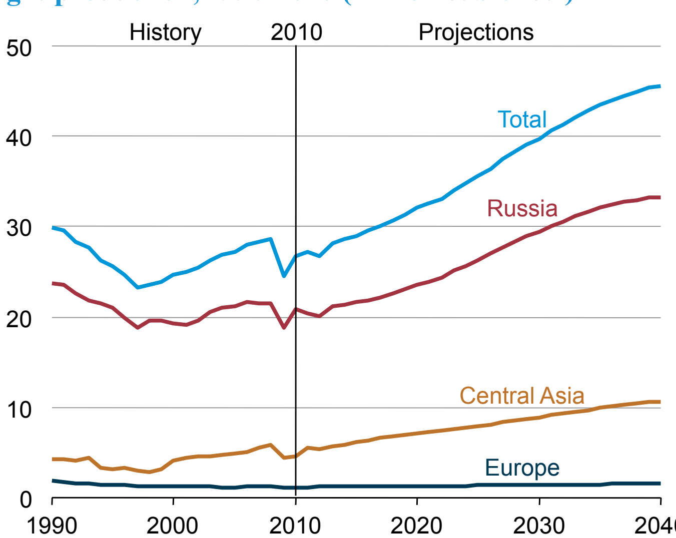
In 2010, Russia produced 20.9 trillion cubic feet of natural gas, following a 10-percent drop in production in 2009 when the global economic downturn reduced demand in Russia and in its natural gas export markets. In 2010, however, the country's production recovered most of the volume lost in 2009. In the *IEO2013* Reference case, Russia's natural gas production grows on average by 1.6 percent per year from 2010 to 2040, as domestic consumption and exports to both Europe and Asia continue to grow.

If Russia is to increase its natural gas production, it must invest in new fields. Moreover, it will require significant investment simply to maintain current production levels, because production from its three largest natural gas fields (Yamburg, Urengoy, and Medvezh'ye) is declining [*84*]. The giant Koykta field in eastern Siberia, estimated to hold 70 trillion cubic feet of natural gas and to be capable of producing 1.6 trillion cubic feet per year, is a likely candidate as a source for pipeline exports to China. Ownership of the field changed hands in early 2011, when it was bought by the Russian state firm, Gazprom [*85*]. There had been little progress on exporting natural gas from the field under the previous joint venture owners, TNK-BP.

The Yamal Peninsula is another major area for future Russian production growth. The Bovanenkovo field, which is owned by Gazprom, is estimated to hold more than 170 trillion cubic feet of recoverable natural gas. Production facilities for the field were first commissioned in October 2012, with the production from the field expected to come on line over the course of several years and grow to more than 4 trillion cubic feet per year in 2017 [*86*]. The Tambeiskoye field, which is majority-owned by Russia's largest independent natural gas producer, Novatek, lies to the northeast of Bovanenkovo. The field has estimated reserves of 44 trillion cubic feet, and Novatek has proposed building an LNG liquefaction facility with the capacity to export 0.7 trillion cubic feet of natural gas production per year [*87*]. Finally, there is the Shtokman field in the Barents Sea, which is envisioned to produce 2.5 trillion cubic feet of natural gas annually [*88*]. However, in 2012, with project costs and changes in the European natural gas market making the project uncertain, Statoil pulled out of a partnership with Gazprom to develop the field [*89*].

Natural gas production in Central Asia (which includes the former Soviet Republics) grows by 2.8 percent per year on average, from 4.6 trillion cubic feet in 2010 to 10.7 trillion cubic feet in 2040. Much of the growth is expected to come from Turkmenistan, which is already a major producer and accounted for 35 percent of the region's total production in 2010. Turkmenistan is just beginning to develop its recently reassessed giant South Yolotan-Osman field. It will be developed in several phases, with each of the initial four phases adding around 0.4 trillion cubic feet of annual natural gas production. First production from the field is expected before the end of 2013, with much of the production likely to be exported by pipeline to China. Also contributing to Central Asia's production growth is Azerbaijan, which has been planning to bring on line the second phase of natural gas production at its Shah Deniz field. Upon reaching peak production, Shah Deniz will add around 0.6 trillion cubic feet to the country's annual production.

Figure 55. Non-OECD Europe and Eurasia natural gas production, 1990-2040 (trillion cubic feet)



Africa

Natural gas production in Africa grows from 7.4 trillion cubic feet in 2010 to 9.3 trillion cubic feet in 2020 and 13.6 trillion cubic feet in 2040 (Figure 56). In 2010, 79 percent of Africa's natural gas was produced in North Africa, mainly in Algeria, Egypt, and Libya. West Africa accounted for another 19 percent of the 2010 total, and the rest of Africa accounted for just 2 percent. Remaining resources are more promising in West Africa than in North Africa, which has been producing large volumes of natural gas over a much longer period. Indeed, production growth in West Africa is even faster, with annual increases over the projection period averaging 4.5 percent, compared with an average of 0.8 percent per year in North Africa.

Nigeria is the predominant natural gas producer in West Africa, although there also have been recent production increases from Equatorial Guinea, which brought an LNG liquefaction facility on line in 2007. Angola also is expected to add to West Africa's production in the near term, with its first LNG liquefaction facility expected to come on line in 2013.

In Nigeria, security concerns and uncertainty over terms of access further delay proposed export projects and limit mid-term production growth. In the *IEO2013* Reference case, export projects in Nigeria regain their former momentum later in the projection period, raising production for the West Africa region to 5.2 trillion cubic feet in 2040. West Africa's share of total African natural gas production doubles from 19 percent in 2010 to 38 percent in 2040.

In 2010, East Africa produced just 0.1 trillion cubic feet of natural gas. Over the last few years, however, several new natural gas discoveries have been made in the Rovuma Basin off the coast of Mozambique and Tanzania. Anadarko Petroleum began exploration of the Rovuma Basin in 2006, and several other companies have since invested and made discoveries in the area as well. Recent offshore discoveries in Mozambique and Tanzania hold an estimated 85 trillion cubic feet and 18 trillion cubic feet of recoverable natural gas resources, respectively. In order to commercialize the resources, Anadarko and another company, Eni, have proposed separate LNG liquefaction facilities for Mozambique. In addition, BG and Statoil are discussing the possibility of a joint facility in Tanzania. The Anadarko proposal, which currently is the most advanced, is for a facility capable of exporting 0.5 trillion cubic feet per year initially, with room to increase the capacity to a total of 1.4 trillion cubic feet if more natural gas becomes available for the project [*90*].

Non-OECD Asia

Natural gas production in non-OECD Asia increases by 9.7 trillion cubic feet from 2010 to 2040 in the *IEO2013* Reference case, with China accounting for 70 percent of the growth and India 12 percent (Figure 57). From 2010 to 2040, China has the largest increase in natural gas production in non-OECD Asia, from 3.3 trillion cubic feet in 2010 to 10.1 trillion cubic feet in 2040, for an average annual increase of 3.8 percent. Much of the increase in the later years comes from tight gas, shale gas, and coalbed methane reservoirs (Figure 58). China already is producing small volumes of coalbed methane and significant volumes of tight gas. However, the actual volumes of tight gas are unknown, as China does not report it separately. China is trying to encourage the development of coalbed methane resources. Toward that goal, it has been offering producers a subsidy of roughly $1 per million Btu since 2008 and may increase it to just over $3 per million Btu [*91*]. In addition, there has been great interest in China's potential for shale gas production. China held its first auction for shale gas exploration blocks in June 2011, awarding contracts for four blocks, and in December 2012 it awarded another 19 shale gas blocks in a second auction [*92*]. In addition, China is considering offering a subsidy of around $2 per million Btu for shale gas produced before 2015 [*93*].

Natural gas production in India grows at an average annual rate of 1.6 percent over the projection period, from 1.8 trillion cubic feet in 2010 to 3.0 trillion cubic feet in 2040. Production at the Dhirubhai-6 block in the Krishna Godavari Basin began in April 2009 and was a major factor in increasing India's natural gas production by more than 60 percent between 2008 and 2010. However, India faces several production challenges. A large portion of its current production comes from aging western

Figure 56. Africa natural gas production, 1990-2040 (trillion cubic feet)

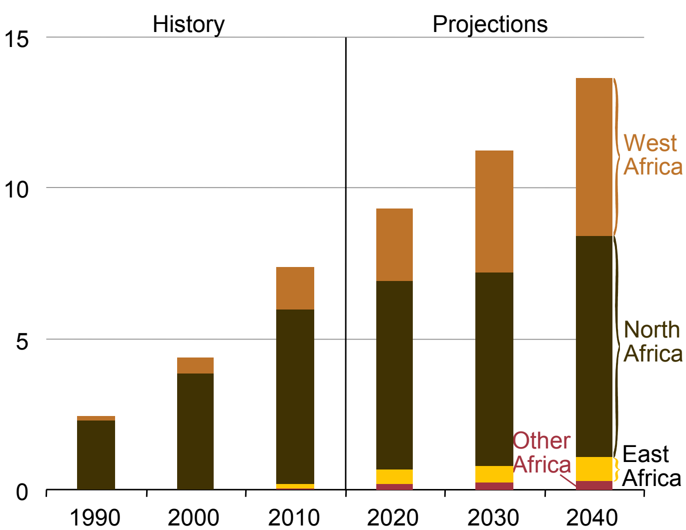


Figure 57. Non-OECD Asia natural gas production, 1990-2040 (trillion cubic feet)

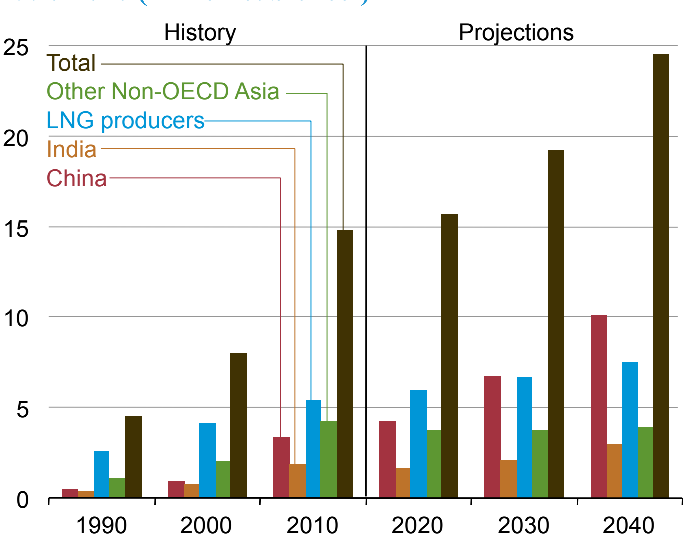
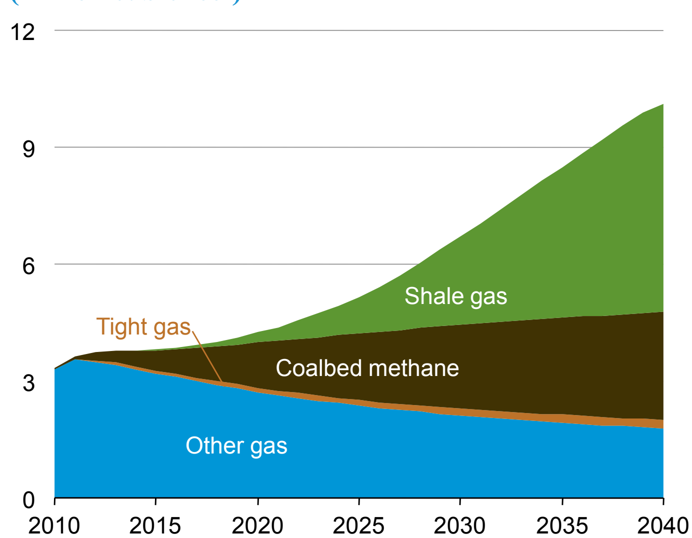


Figure 58. China natural gas production, 2010-2040 (trillion cubic feet)



offshore fields; production from the Krishna Godavari Basin has failed to meet earlier expectations for volumes [*94*]; and while India has been encouraging exploration of potential coalbed methane deposits, initial results have been discouraging and actual production is likely to fall short of the government estimate of 0.1 trillion cubic feet by 2013-2014 [*95*]. India does have several basins that are prospective for shale gas, and in the later years of the *IEO2013* Reference case production from shale resources makes a significant contribution to India's total natural gas production. According to most of the early estimates India's shale resources are much smaller than those in China or North America, and India appears to be progressing toward their development much more slowly [*96*].

Outside China and India, non-OECD Asian natural gas production grows at a relatively modest average annual rate of 0.6 percent. The two largest producers in the region, Malaysia and Indonesia, both face declining production from many older fields and must make substantial investments to maintain current production levels. While other countries are looking toward potential shale gas resources to underpin future production growth, Indonesia is focusing on its coalbed methane resources. As of late 2012, Indonesia had awarded 50 production-sharing contracts for coalbed methane areas [*97*]. The sector has attracted investment from a variety of companies, including large international oil and natural gas companies, smaller regional companies, and local Indonesian companies. At least three projects are expected to be producing commercial volumes in 2013. In 2011, the Indonesian firm Medco Energi signed an agreement to sell small volumes of coalbed methane from its Sekayu development to a local power generator beginning in 2012 [*98*]. Dart Energy, an Australia-based company that specializes in coalbed methane, expects to make the first sales of natural gas from its Sangatta project in 2013 [*99*]. Vico Indonesia, a BP-Eni joint venture, also expects first sales of natural gas from its Sanga-Sanga project in 2013, although first production from the project began in 2011 [*100*].

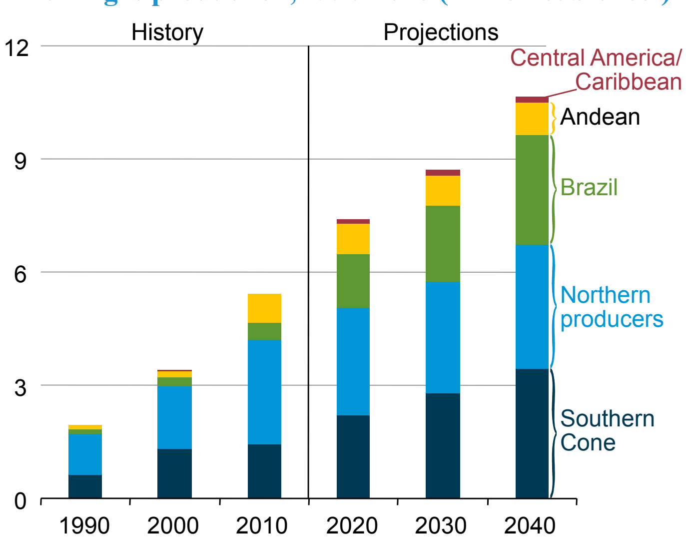
Central and South America

Natural gas production in the non-OECD economies of Central and South America nearly doubles from 2010 to 2040, from 5.4 trillion cubic feet to 10.4 trillion cubic feet (Figure 59). Brazil's production increases more than sixfold, from 0.4 trillion cubic feet in 2010 to 2.8 trillion cubic feet in 2040, at an average annual growth rate of 6.3 percent that is more than double the next highest rate for the region (except for Central America and the Caribbean, where production levels are so low that the growth rate is immaterial). As a result, Brazil's share of regional production grows from 8 percent in 2010 to nearly 27 percent in 2040.

Just over one-fifth (21 percent) of Brazil's natural gas production growth from 2010 to 2040 comes from tight gas, shale gas, or coalbed methane production. Recent discoveries of oil and natural gas in the pre-salt Santos Basin are expected to increase the country's natural gas production, particularly in the Tupi field, which could contain between 5 trillion and 7 trillion cubic feet of recoverable natural gas. Much of Brazil's natural gas production occurs in the offshore fields of the Campos Basin in Rio de Janeiro state. Although infrastructure bottlenecks in the past have hindered the transport of natural gas from those fields to the country's 4,000-mile pipeline network, Petrobras has now completed the 870-mile Southeast Northeast Interconnection Gas Pipeline (GASENE), connecting southeastern offshore supply with fields in the northeast. In addition, Brazil has recently built two new LNG terminals—the Pecem terminal in the northeast and the Guanabara Bay terminal in the southeast—with a combined sendout capacity of 740 million cubic feet per day, and plans to build a third terminal with 495 million cubic feet per day of capacity in Bahia state this year [*101*].

Despite recent declines in production, countries in the Southern Cone (mainly Argentina)[26] become the region's leading natural gas producers by 2040. In the *IEO2013* Reference case, annual production in the Southern Cone increases by 150 percent, from 1.4 trillion cubic feet in 2010 to 3.5 trillion cubic feet in 2040—enough for the Southern Cone to surpass northern producers in terms of total volume. Although the increase in the Southern Cone's natural gas production, averaging 3.0 percent per year from 2010 to 2040, is less than half the 6.3-percent average annual increase in Brazil, it is sufficient for the region's annual production to remain 0.7 trillion cubic feet above Brazil's in 2040. Almost all (93 percent) of the Southern Cone's production increase comes from tight gas, shale gas, or coalbed methane gas fields.

Figure 59. Non-OECD Central and South America natural gas production, 1990-2040 (trillion cubic feet)



Argentina is leading the non-OECD Americas region in its pursuit of tight gas and shale gas. Much of the interest in tight and shale gas can be attributed to an announcement in November 2012 that the government would allow the ceiling on natural gas wellhead prices to rise to $7.50 per million Btu [*102*]. Argentina already is producing natural gas from the Vaca Muerta shale formation in the country's western Neuquén Basin, which is estimated to contain more than one-half of Argentina's 774 trillion cubic feet of recoverable shale gas resources [*103*].

[26]The Southern Cone region also includes the countries of Chile, Paraguay, and Uruguay, whose production of hydrocarbons is a small portion of the regional total.

Growth in natural gas production in Brazil and the Southern Cone will increase overall natural gas production for the non-OECD Central and South America region. However, production from the Northern Producers region (primarily Colombia, Venezuela, and Trinidad and Tobago) grows at an average annual rate of only 0.5 percent (the region's second-lowest rate after the Andean countries). Although Venezuela's 195 trillion cubic feet of proven natural gas reserves are the Western Hemisphere's second largest after the United States, only an estimated 10 percent of its natural gas production is not associated with oil fields. The state oil company, Petróleos de Venezuela, S.A., has limited experience in developing nonassociated natural gas fields, and international partners will be needed for production to move forward in a meaningful way [*104*]. The result is that, while the Northern Producers provided 51 percent of all natural gas output in the non-OECD Central and South American region in 2010, their share falls to 30 percent in 2040. Almost all of their production comes from fields that do not include tight gas, shale gas, or coalbed methane resources. Production from those more traditional gas fields in the Northern Producers region increases by an average of 0.2 percent per year from 2010 to 2040.

World natural gas trade

International trade in natural gas is undergoing rapid transformation. Global LNG trade more than doubled from just under 5 trillion cubic feet in 2000 to just over 10 trillion cubic feet in 2010, and the subsequent 5-year period may be no less dynamic. Although little new liquefaction capacity is planned to come on line globally between 2010 and 2015, world LNG flows adjusted quickly in 2011 and 2012 to accommodate a surge in Japan's demand for LNG in the wake of the Fukushima disaster, and to account for underutilization of LNG liquefaction capacity in North Africa and Southeast Asia. Global LNG markets already have shown greater flexibility in dealing with such issues than they did during past disruptions of supply or demand. Another surge in LNG trade may be coming in the 2015-2025 timeframe, as several projects currently under construction in Australia are expected to be on line before 2020, and several projects in various stages of development in North America are planned to be on line soon after the Australian projects (Table 8).

Although LNG trade has grown considerably faster in recent years, flows of natural gas by pipeline still account for most of world natural gas trade in the *IEO2013* Reference case, which includes several new long-distance pipelines and expansions of existing infrastructure through 2040. The largest volumes of internationally traded natural gas by pipeline currently are in North America (between Canada and the United States) and in Europe (among numerous OECD and non-OECD countries). By the end of the projection period, the *IEO2013* Reference case includes large volumes of pipeline flows into China from both Russia and Central Asia.

Increased LNG trade and cross-border natural gas pipeline flows have long indicated transformation of markets around the world, including increased natural gas consumption in growing economies and changes in interregional pricing practices. Although the emergence of a global natural gas market has yet to occur with a depth rivaling other global commodities such as oil, an evolution toward greater interregional trade and pricing continues.

Interest in developing tight gas, shale gas, and coalbed methane resources has grown significantly. The results are already noticeable in North America, where the current development of shale resources has reduced the demand for imports. It is likely that significant shale resources also exist in other large consuming countries, including China and several European nations. Although development of shale resources in China and other countries could slow the growth of their demand for imports, exploitation of tight gas, shale

Table 8. Selected LNG liquefaction projects existing and under construction

Project	Country	Capacity (million metric tons per year)	Delivered cost to Asia (dollars per million Btu)	Scheduled start date
Sakhalin 2	Russia	9.6	8.70	2009
Pluto	Australia	4.8	13.50	2012
Angola LNG	Angola	5.2	9.90	2013
PNG LNG	Papua New Guinea	6.9	10.50	2014
Queensland Curtis	Australia	8.5	10.80	2014
Australia Pacific LNG	Australia	9.0	11.20	2015
Gladstone LNG	Australia	7.2	11.40	2015
Gorgon	Australia	15.6	12.30	2015
Sabine	United States	18.0	9.90[a] 14.40[b]	2015
Ichthys	Australia	8.4	10.20	2016
Wheatstone	Australia	8.9	12.20	2016
Prelude	Australia	3.6	10.40	2017

[a]$4 Henry Hub price.
[b]$8 Henry Hub price.
Note: 1 million metric tons of LNG is equivalent to approximately 48 billion cubic feet of natural gas.

gas, and coalbed methane resources is not necessarily a countervailing force to growing international trade. For example, many of the previously mentioned LNG liquefaction projects under construction in Australia are to be supplied by production from coalbed methane resources. Additionally, all the LNG export projects proposed in North America are either directly or indirectly based on growing production from tight gas and shale gas reservoirs.

OECD natural gas trade

In 2010, about one-quarter of natural gas demand in the OECD nations was met by net imports from non-OECD countries. That share falls to around 20 percent in 2040, when the total volume of net imports to OECD countries is about the same as in 2010, even as significant differences in the trade profiles within the OECD evolve. Both imports and exports from different OECD regions grow substantially over the projection period. In the mid-term, OECD imports increase, with growing demand for imports to Europe, Japan, and South Korea dominating the total. Later in the projection, however, growing exports from Australia and North America reverse the trend. In the *IEO2013* Reference case, OECD net imports grow by 1.3 percent per year on average from 2010 to 2020, peaking before 2020. For the remainder of the projection, OECD net imports as a whole decline by 0.3 percent per year, with 2040 net imports less than 10 percent higher than in 2010.

OECD Americas

Regional net imports among the nations of the OECD Americas begin a downward trend after 2010 that extends through 2040 in the *IEO2013* Reference case (Figure 60). In the United States, rising domestic production reduces the need for imports, primarily as a result of robust growth in regional production of shale gas. The United States becomes a net exporter of natural gas in 2020, with net exports growing to 3.6 trillion cubic feet in 2040. Most of the growth in U.S. net exports can be attributed to pipeline exports to Mexico, which grow steadily over the projection period, as increasing volumes of natural gas imported from the United States fill the growing gap between Mexico's production and consumption. U.S. exports to Mexico increase from 0.3 trillion cubic feet in 2010 to 2.4 trillion cubic feet in 2040.

U.S. domestically sourced exports of LNG, excluding exports from the existing Kenai facility in Alaska, begin in 2016 and grow to 1.6 trillion cubic feet per year in 2027, with one-half of U.S. LNG exports originating in the Lower 48 states. The other half of the U.S. LNG exports originate from Alaska. Continued low levels of LNG imports through the projection period position the United States as a net exporter of LNG by 2016. However, future U.S. exports of LNG depend on a number of factors that are difficult to anticipate and thus are highly uncertain.

From 2000 to 2010, Canadian pipeline exports declined by more than 25 percent, as growing shale gas production in the United States reduced the need for imports of natural gas from Canada. In the *IEO2013* Reference case, pipeline exports from Canada continue to decline (Figure 61). However, Canada becomes a net exporter of LNG before 2020, and LNG export volumes begin to replace some of the lost pipeline export volumes. Currently, there are four LNG export facilities proposed for Canada's west coast. The exports are targeted to Asian markets, and a variety of Asian companies have signed contracts to buy LNG, invested in the liquefaction projects, or invested in the development of tight gas and shale gas resources to supply the liquefaction projects. At end of the projection in 2040, Canada's total net natural gas exports are less than 10 percent higher than they were in 2010.

In the OECD Americas as a whole, the growing import dependence of Mexico and Chile partially offsets the growing exports from the United States and Canada. As Mexico's domestic production fails to keep pace with demand growth, its net imports increase from 0.5 trillion cubic feet in 2010 to 1.6 trillion cubic feet in 2020 and 3.0 trillion cubic feet in 2040. Pipeline flows

Figure 60. OECD Americas net natural gas trade, 1990-2040 (trillion cubic feet)

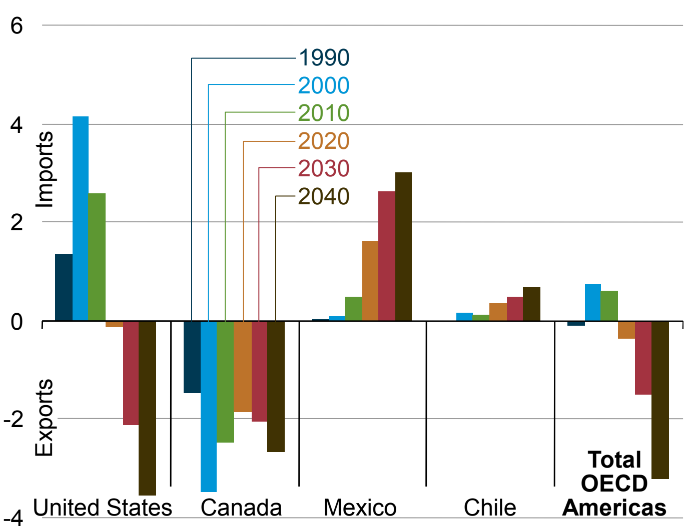
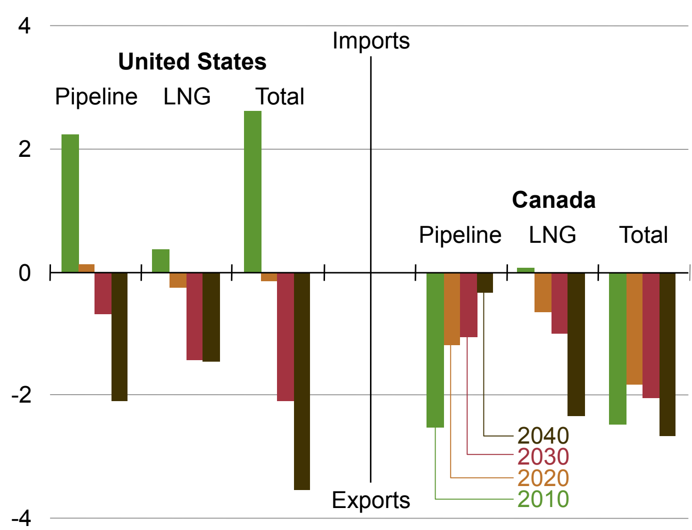


Figure 61. United States and Canada net natural gas trade, 2010-2040 (trillion cubic feet)



from the United States, which currently account for about 16 percent of Mexico's natural gas supply, increase substantially in the projection. LNG imports, which accounted for 9 percent of Mexican natural gas supply in 2010, also grow, but more moderately.

Natural gas production in Chile is limited, and significant imports are required to meet the country's demand. In the past, Chile relied on imports from Argentina for a large portion of its total supply. However, natural gas imports from Argentina to Chile peaked in 2004 at 254 billion cubic feet, or 87 percent of Chile's total natural gas supply. Subsequently, the Argentine government enacted price controls that had the dual effect of encouraging demand for natural gas and discouraging investment in exploration and production. As a result, Argentina limited the supply of natural gas available for export in order to meet domestic demand. Natural gas imports and consumption in Chile fell as demand went unmet. Chile has since moved to ensure that it will be able to receive natural gas from a wider variety of sources by opening two LNG regasification terminals in 2009 and 2010, one in Quintero near Santiago and one in the northern town of Mejillones [*105*].

OECD Europe

In OECD Europe, total natural gas imports continue to grow over the course of the projection, by an average of 1.6 percent per year from 2010 to 2040 as local production sources decline, especially in the United Kingdom. Pipeline imports of natural gas to OECD Europe peaked in 2007 and 2008, when they accounted for 37 percent of OECD Europe's total supply. Since the onset of the financial crisis in late 2008, which resulted in lower natural gas demand and excess supplies worldwide, buyers generally have preferred to buy larger volumes of LNG or other uncontracted natural gas on spot markets rather than opting for supplies tied to more expensive contracts linked to world oil prices (see box on page 45). In 2009 and 2010, the pipeline share of OECD Europe's total natural gas supply declined to 34 percent, while the LNG share grew to 13 percent in 2010. In the *IEO2013* Reference case, the pipeline share of OECD Europe's natural gas imports grows to between 40 and 50 percent of total natural gas supply. LNG imports grow to around 20 percent of supply and maintain that share through 2040.

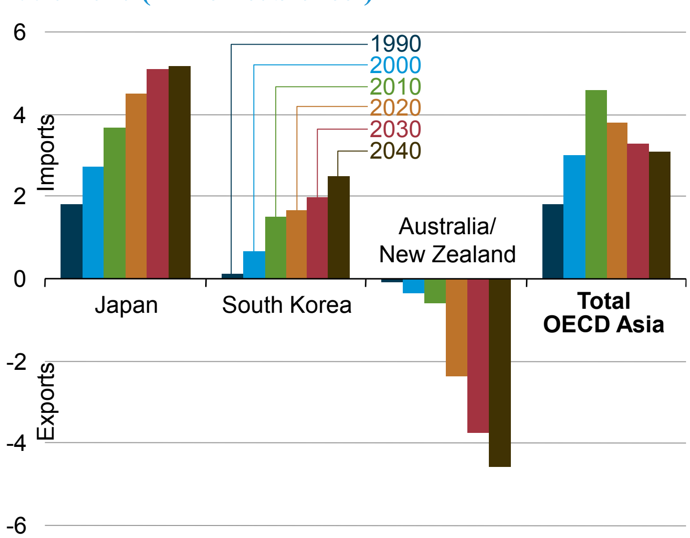
The recent increase in LNG supplies to OECD Europe, and particularly to the United Kingdom, has added complexity to natural gas pricing in the region. In comparison to long-term contracts with prices linked to oil and petroleum product prices, LNG supplies have improved the prospects for spot market trading. Continental Europe's long-term contracts with suppliers of pipeline gas, which include Russia, Algeria, and Norway, among others, have some flexibility in terms of volumes, but the prices generally are linked to lagged prices for oil products. Although some suppliers, such as Norway, switched as much as 30 percent of their contracted volumes to spot market pricing, other countries, such as Algeria, altered their pricing far less or not at all [*106*]. The subsequent loss of market share by pipeline suppliers to OECD Europe with less flexibility in pricing since 2008 may indicate eventual changes in the pricing of pipeline imports from a variety of countries—including Russia, which is by far the largest exporter to Europe. However, the extent of such changes over the long term remains to be seen.

OECD Asia

The world's two largest LNG importers, Japan and South Korea, are in OECD Asia. The Australia/New Zealand country grouping, also in OECD Asia, is on its way to becoming the world's second largest exporter of LNG (after Qatar). With Australia's export growth dominating the region as a whole in the long-term projection, OECD Asia's net demand for imports declines from 4.6 trillion cubic feet in 2010 to 3.1 trillion cubic feet in 2040 (Figure 62).

Japan and South Korea continue to be major players in world trade of LNG, despite consuming relatively small amounts of natural gas on a global scale. Combined, their natural gas consumption represented slightly less than 5 percent of world consumption in 2010. At the same time, however, it represented almost 50 percent of total global LNG imports. Because the two countries are almost entirely dependent on LNG imports for natural gas supplies, overall consumption patterns are translated directly into import requirements. South Korea's imports grow moderately over the projection period, in line with moderate growth of natural gas demand.

Figure 62. OECD Asia net natural gas trade, 1990-2040 (trillion cubic feet)



Japan has experienced dramatic growth in LNG imports since the Fukushima nuclear disaster in early 2011. LNG imports in 2012 were approximately 25 percent higher than in 2010 [*107*]. In the *IEO2013* Reference case, much of Japan's nuclear capacity is assumed to come back on line gradually, reducing the need for LNG imports. After nuclear capacities have stabilized, Japanese import demand resumes its previous slow growth, based on relatively slow economic and population growth and slow growth in natural gas demand. There is however, considerable uncertainty in any projection of how much nuclear capacity Japan is likely to bring back on line and when (see nuclear box on page 101 of the Electricity chapter).

Australia is by far the largest and most active LNG exporter among the OECD countries and remains so throughout the projection. In 2010, Australia exported just under 1 trillion cubic feet of natural gas from its two LNG export facilities that were operating at the time. Both North West Shelf LNG and Darwin LNG are located in the northwest part of the continent, an area rich in natural gas resources that is targeted for substantial development in coming years. A third liquefaction facility, Woodside's Pluto LNG, began exporting LNG in 2012.

Seven other independent liquefaction projects have been sanctioned in Australia over the past few years (Table 8), beginning in 2009 with Chevron's Gorgon LNG, the largest of the projects at 0.7 trillion cubic feet. Including Gorgon LNG, four of the seven sanctioned projects will utilize gas from reservoirs offshore northwest Australia. The three remaining LNG export projects are situated in eastern Australia and will export gas from coalbed methane reservoirs. In total, the seven sanctioned projects have a planned export capacity of 2.8 trillion cubic feet, all of which is scheduled to come on line before 2020. In the *IEO2013* Reference case, Australia's exports of natural gas more than quintuple from 2010 to 2040, with exports totaling 4.6 trillion cubic feet in 2040.

Non-OECD natural gas trade

Net exports of natural gas from the non-OECD countries grow by less than 1.0 percent per year on average in the *IEO2013* Reference case. As with the OECD countries, the slow growth on the whole masks the dynamism of trade in the separate non-OECD regions and countries. Non-OECD Europe and Eurasia accounts for more than 30 percent of the total global increase in interregional natural gas exports, and non-OECD Asia accounts for around 50 percent of the total global increase in interregional natural gas imports. The vast natural gas resource base in non-OECD countries points to their continued ability to meet incremental growth in demand for natural gas both among countries in the region and among the OECD countries. However, with demand in non-OECD countries (excluding non-OECD Europe and Eurasia) rising rapidly in the projection, non-OECD countries export progressively less of their overall production to OECD countries over time. The share of non-OECD production that is exported peaks before 2020 at around 20 percent, before declining to 13 percent in 2040.

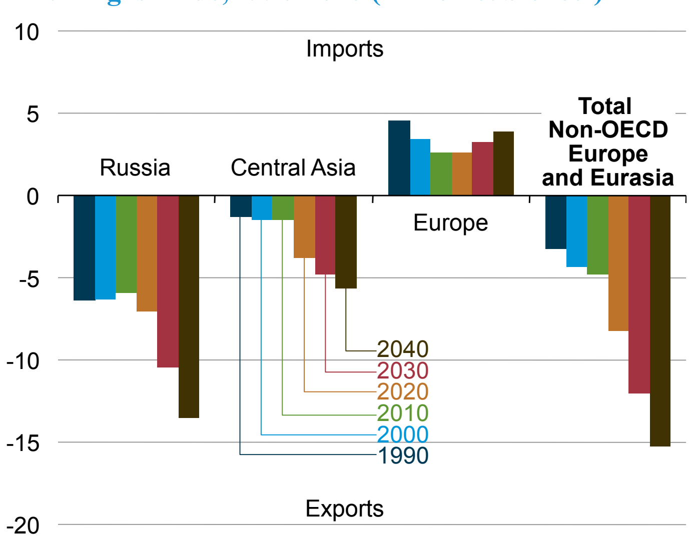
Non-OECD Europe and Eurasia

Net exports of natural gas from Russia, the largest exporter in the world, are the most significant factor in exports from non-OECD Europe and Eurasia. Net exports from non-OECD Europe and Eurasia rise from 5.5 trillion cubic feet in 2010 to 8.2 trillion cubic feet in 2020 and 15.3 trillion cubic feet in 2040, at an average annual rate of 3.5 percent (Figure 63). Russia provides the largest incremental volume to meet the increase in demand for supplies from non-OECD Europe and Eurasia, with its net exports growing by an average of 2.4 percent per year, from 6.6 trillion cubic feet in 2010 to 13.5 trillion cubic feet in 2040. LNG and pipeline exports from Russia to customers in both Europe and Asia increase throughout the projection.

Despite recent declines in demand for natural gas in Europe, Russia has recently completed a massive new pipeline project. The Nord Stream pipeline consists of two parallel lines under the Baltic Sea to Germany. The first line was commissioned in November 2011, with the second line following about a year later. The Nord Stream pipeline has a total flow capacity of 1.9 trillion cubic feet of natural gas per year, or just over 10 percent of OECD Europe's total natural gas consumption in 2010. Flows through the Nord Stream pipeline are expected to be significant, in part because the pipeline route bypasses eastern European transit states with which Russia has had pricing and payment disputes in the past. The *IEO2013* Reference case also incorporates pipeline flows from Russia to China.

Exports from Central Asia could add substantial supplies to markets in both the East and the West. In late 2009, flows of natural gas to China from Turkmenistan began with the completion of a pipeline running from the Bagtyyarlyk, Saman-Depe, and Altyn Asyr fields in Turkmenistan through Uzbekistan and Kazakhstan and eventually connecting to China's second West-East pipeline in Xinjiang province [*108*]. In 2012, China received imports from Uzbekistan for the first time, in addition to flows on the same pipeline from Turkmenistan. Chinese imports via pipeline from Central Asia in 2012 totaled approximately 0.7 trillion cubic feet [*109*]. Turkmenistan also exports natural gas to Russia via pipeline, and Azerbaijan exports natural gas to Turkey. In the *IEO2013* Reference case, exports from Central Asia grow from 1.5 trillion cubic feet in 2010 to 5.7 trillion cubic feet in 2040, with increases averaging 4.6 percent per year.

Figure 63. Non-OECD Europe and Eurasia net natural gas trade, 1990-2040 (trillion cubic feet)



Middle East

Net exports of natural gas from the Middle East grow at an annual rate of 3.0 percent, as flows from the region increase from 2.7 trillion cubic feet in 2010 to 6.7 trillion cubic feet in 2040 (Figure 64). An important factor in the increase, particularly with regard to brisk growth in volumes in the near term, is the rise of LNG supplies from Qatar, which went from exporting its first LNG in 1999 to being the largest LNG exporter in the world in 2009. Qatar's LNG exports continue to increase through 2040. Its total LNG export capacity reached 77 million tons (3.6 trillion cubic feet) per year in early 2011 with the completion of the last in a line of six large-volume liquefaction trains under construction since 2008. Each train has the capacity to produce the equivalent of 360 billion cubic feet of natural gas per year for export [*110*].

Qatar's natural gas exports grow by an average of 10.7 percent per year from 2010 to 2015 in the Reference case, then slow to an average increase of 1.1 percent per year after 2015. Because of a current moratorium on further development from the North Field, no new LNG projects are being initiated. Qatar enacted the moratorium in 2005 in order to assess the effect of the ongoing increase in production on the North Field before committing to further production increases [*111*]. If Qatar decides to lift the moratorium on North Field development in 2014, its stated development priority is to ensure that it can meet long-term domestic natural gas needs for power generation, water desalination, and local industry. Only after those needs are met will it consider further increases in exports, and any increases are expected to come primarily from optimization of current facilities.

Despite possessing the second-largest reserves of natural gas in the world, Iran continues to struggle with the formation of an export program that will result in significant commercialization of its resources. The country shares the North Field/South Pars Field with Qatar and has many export projects under consideration through the development of its portion of those reserves. Nonetheless, the country as of 2010 was just barely a net exporter, delivering slightly higher volumes of natural gas to Turkey than it received from Turkmenistan (resulting in net exports of 0.1 trillion cubic feet). Although its first LNG export plant is under construction, Iran is without international partners and without an obvious source for obtaining liquefaction technology. Other export projects continue to be discussed, but as a result of international sanctions and internal politics there has been little progress on most projects. The *IEO2013* Reference case shows moderate flows from Iran, so that by 2040 the country is a net exporter of 1.6 trillion cubic feet per year.

Elsewhere in the Middle East, Yemen, Oman, and Abu Dhabi in the United Arab Emirates (UAE) also currently export LNG, although the potential for growth in exports from those and other countries in the Middle East appears to be limited by the growth of their domestic demand. Significant volumes of LNG have been imported by Kuwait and also by Dubai in the UAE, which completed construction of an LNG import facility in November 2010 and received its first cargo a month later [*112*]. Both Oman and the UAE also are currently importing natural gas via pipeline from Qatar. The *IEO2013* Reference case projects a similar trend for smaller producers in the Arabian Peninsula region as a whole, including Kuwait, Oman, the UAE, and Yemen. As a group they exported less than 0.2 trillion cubic feet of natural gas on a net basis in 2010, and the volume of their net imports rises throughout the projection to a total of 1.3 trillion cubic feet in 2040.

Africa

Net exports of natural gas from Africa increase in the projection at a rate of 0.9 percent per year (Figure 65). In 2010, the region's net exports totaled about 3.8 trillion cubic feet, led by net exports of 2.8 trillion cubic feet from North Africa. Between one-half and two-thirds of the exports from North Africa are delivered by pipeline from Algeria, Egypt, and Libya to Spain, Italy, and parts of the Middle East. The remainder is exported as LNG throughout the world, primarily to European countries, from liquefaction facilities in Algeria, Egypt, and Libya.

Recent political events in North Africa have significantly affected natural gas exports. Flows from Libya to Italy on the Greenstream pipeline were halted in March 2011 but resumed before the end of the year, with volumes gradually increasing toward earlier levels. Even before the political unrest in 2011, utilization rates were low at Egypt's two LNG export facilities, largely due to the

Figure 64. Middle East net natural gas trade, 1990-2040 (trillion cubic feet)

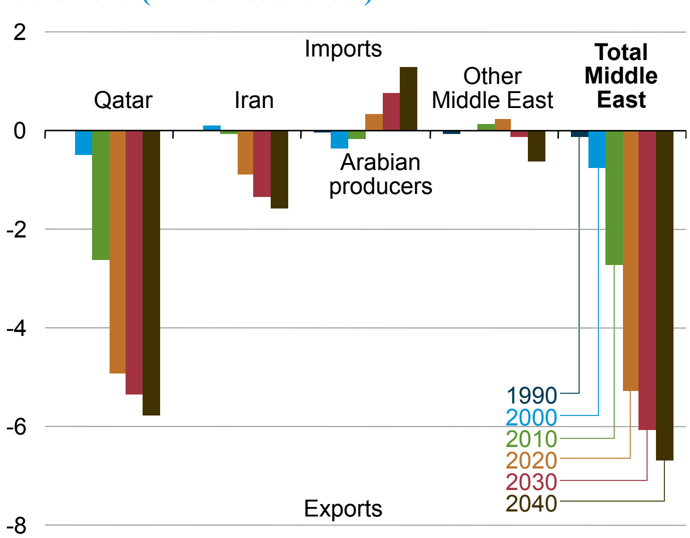
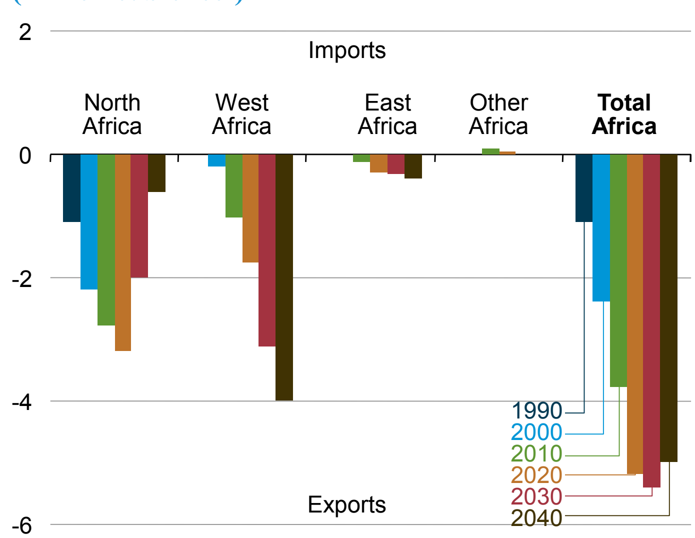


Figure 65. Africa net natural gas trade, 1990-2040 (trillion cubic feet)



prioritization of domestic consumption over exports. Exports from Egypt have declined further since 2011, as the natural gas pipelines from Egypt to Israel, Jordan, and Syria have been sabotaged repeatedly, effectively halting those flows.

In the *IEO2013* Reference case, net exports from both West Africa and East Africa grow at a robust average annual rate of 4.5 percent from 2010 to 2040, although starting from very different levels. For both regions, much of the growth comes in the later part of the projection. Security concerns and uncertainty over terms of access in Nigeria have significantly delayed any progress on currently proposed LNG export projects. East Africa also faces significant above-ground challenges, simply because recent production and export proposals represent a large change in scale of operations for the oil and gas industries in Mozambique and Tanzania, where physical and regulatory infrastructures are not yet in place to support large-scale production and export of natural gas.

Non-OECD Asia

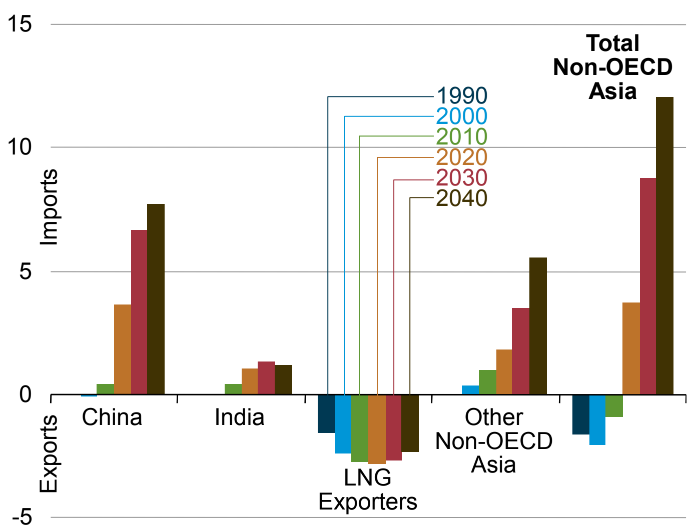
Non-OECD Asia is the only regional grouping that changes from a net exporter to a net importer of natural gas in the *IEO2013* Reference case. With net imports of 12.1 trillion cubic feet in 2040, the region becomes the world's second-largest importing region, behind only OECD Europe. China has the largest increase in import demand, requiring imports of 7.7 trillion cubic feet per year—more than 40 percent of its annual natural gas consumption—in 2040 (Figure 66).

To meet its future demand, China is actively pursuing multiple potential sources for natural gas imports. China is currently receiving LNG from four different countries under long-term contracts, with additional spot purchases occasionally coming from other countries. Chinese companies also have signed contracts to begin or increase imports from Papua New Guinea, Australia, Qatar, and Malaysia and are taking equity stakes in liquefaction projects around the world. PetroChina holds a 20-percent interest in the LNG Canada project led by Shell, which plans to export 0.6 trillion cubic feet of LNG per year from Canada's west coast.

China is also pursuing multiple sources for pipeline natural gas imports. The country's first natural gas import pipeline, completed in late 2009, transports supplies from Turkmenistan and Uzbekistan. China also has an agreement in place with Kazakhstan to begin importing natural gas in the future. Another new pipeline from Myanmar, scheduled for completion in 2013, will carry 0.4 trillion cubic feet of natural gas per year from Myanmar's offshore fields in the Bay of Bengal to Kunming in China's Yunnan province [*113*]. In addition, China and Russia continue to discuss future natural gas pipeline connections between the two countries. In 2009, the two countries reached an agreement that envisions two separate large-diameter pipelines from eastern and western Siberia by 2014 or 2015. The 2009 agreement suggested that volumes of 2.5 to 2.8 trillion cubic feet of natural gas per year would be exported through the proposed pipelines, although the countries have yet to agree on a price for the natural gas.

India's imports as a share of its total natural gas consumption grow to around 40 percent before declining in the later years of the Reference case projection, when production from shale resources starts to reverse the trend. In 2010, import growth remained muted, with LNG deliveries accounting for about 19 percent of overall supplies while new production from the Krishna Godavari Basin was brought on line [*114*]. Over the long term, as its domestic production fails to keep up with demand, India's import requirements increase. Its imports total 1.2 trillion cubic feet in 2040 in the Reference case. Accordingly, India continues to expand its LNG import infrastructure. At the beginning of 2013 there were two fully operational LNG terminals in India, and its new Kochi terminal is expected to be on line before the end of 2013. The Dabhol import facility is operational, but it can operate for only 6 months of the year until a breakwater is built [*115*]. Numerous other facilities have been proposed, but progress has been slow as industry participants have chosen first to evaluate the production potential from the Krishna Godavari Basin.

Figure 66. Non-OECD Asia net natural gas trade, 1990-2040 (trillion cubic feet)



Non-OECD Central and South America

Natural gas trade in non-OECD Central and South America has become increasingly globalized, as several countries have become involved in the LNG trade. New LNG regasification capacity facilitates growth in the region's gross imports of natural gas through 2040, but the discovery of large new natural gas reserves throughout the region increases its gross exports by a greater amount. As a result, the region's overall net exports nearly triple, from 0.5 trillion cubic feet in 2010 to 1.4 trillion cubic feet in 2040 (Figure 67), an average annual increase of 3.3 percent.

LNG regasification facilities in Brazil and the Southern Cone (excluding Chile, an OECD member state since 2010) have received LNG supplies fairly consistently over the past three years. In 2010, combined net imports for Brazil and the Southern Cone totaled 0.6 trillion cubic feet. Brazil currently receives LNG shipments—primarily from Trinidad and Tobago—at the Pecem terminal in the northeast and the Guanabrara Bay terminal in the southeast. It also receives natural gas pipeline imports via the Gasbol line, which runs from Santa Cruz, Bolivia, to Brazil's Porto

Alegre and Sao Paulo [*116*]. Argentina also imports most of its natural gas via pipeline from Bolivia, along with some LNG, principally from Trinidad and Tobago. The Southern Cone's LNG imports could increase with the construction of an offshore LNG terminal near Montevideo, Uruguay, in addition to a joint regasification project currently being pursued by the governments of Argentina and Venezuela and a potential third LNG terminal to be built by the governments of Argentina and Qatar [*117*]. Still, the Southern Cone becomes the region's largest net exporter of natural gas by 2040, largely due to the discovery of large shale gas reserves in Argentina's northwestern Neuquén province. In addition, as a result of the discovery of large amounts of natural gas in Brazil's pre-salt Santos Basin, that country's gross export and domestic production levels grow sufficiently to make the country's natural gas trade balance essentially zero in 2040.

The first LNG export project in the Andean South America region, which includes Bolivia, Ecuador, and Peru, was completed in Pampa Melchorita, Peru, in mid-2010. In February 2012, Peru exported an estimated 15 billion cubic feet of natural gas from the terminal, according to *LNG World News* [*118*]. Pipeline exports from Bolivia, also in the Andean region, remain more or less flat over the projection period but switch from being directed mainly toward Brazil to being directed mainly toward Argentina in the Southern Cone region. Overall net exports from the Andean region decline slightly from 2010 to 2040 at an average annual rate of 0.8 percent, and net exports from the Northern Producers fall by an average of 1.7 percent per year, from 0.7 trillion cubic feet in 2010 to 0.4 cubic feet in 2040. In Venezuela, projects that are expected to make more of the associated natural gas produced from its oil fields available for domestic consumption include the Interconnection Centro Occidente (ICO) system, which is designed to transport 520 million cubic feet per day of natural gas between the eastern and western parts of the country. In addition, the Antonio Ricaurte pipeline, which connects Colombia with Venezuela, allows Colombia to export natural gas to Venezuela, with contracted volumes ranging between 80 and 150 million cubic feet per day. Current plans call for the flow of the pipeline to be reversed, with Venezuela exporting 140 million cubic feet per day of natural gas to Colombia [*119*].

Reserves

As reported by *Oil & Gas Journal* [*120*], the world's proved natural gas reserves have grown by 39 percent over the past 20 years, to a total of 6,793 trillion cubic feet as of January 1, 2013 (Figure 68). Estimated proved reserves have grown particularly in non-OECD countries, by 1,915 trillion cubic feet since 1993. In contrast, proved reserves in OECD countries have decreased by 7 trillion cubic feet since 1993. As a result, the portion of proven world natural gas reserves located in OECD countries declined from 11 percent in 1993 to 8 percent in 2013.

Most of the world growth in proved natural gas reserves has taken place since 2003. Over the past 10 years, estimates of proved world natural gas reserves rose by 1,292 trillion cubic feet, at an average annual rate of 2.1 percent, as compared with 1.2 percent annually from 1993 to 2003. Estimated proved reserves in the non-OECD countries rose by 1,285 trillion cubic feet, or an average of 2.3 percent annually, over the same period, compared with 1.4 percent annually from 1993 to 2003. The most rapid increase in proved reserves in the non-OECD countries, averaging 2.8 percent per year, was from 2003 to 2008, including a massive increase from 509 to 910 trillion cubic feet in 2004 in Qatar.

As of January 1, 2013, however, almost one-half of the growth in estimates of world proved reserves was based on increases in OECD countries, where proved reserves increased by 4 percent, or 19 trillion cubic feet, from their 2012 levels. Much of that increase is accounted for by the addition of 15 trillion cubic feet of proved reserves in OECD Asian countries—a 51-percent increase from 2012. Proved reserves in the OECD Americas rose by 7 trillion cubic feet from 2012 to 2013, while proved reserves in OECD Europe declined by 3 trillion cubic feet. Estimated proved reserves in the non-OECD countries increased by 27 trillion cubic feet from 2012 to 2013, with a combined 56 trillion cubic feet of additional proved reserves in the Middle East, China, and non-OECD Europe and Eurasia partially offset by a decrease of 33 trillion cubic feet in Indonesia's proved reserves.

Figure 67. Non-OECD Central and South America net natural gas trade, 2010-2040 (trillion cubic feet)

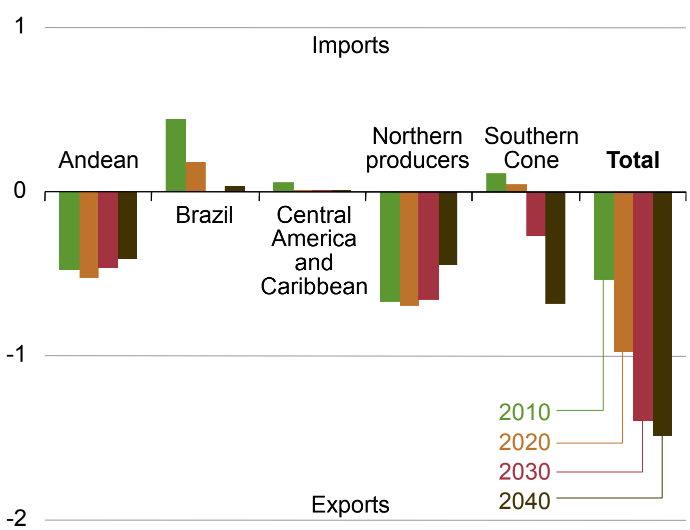
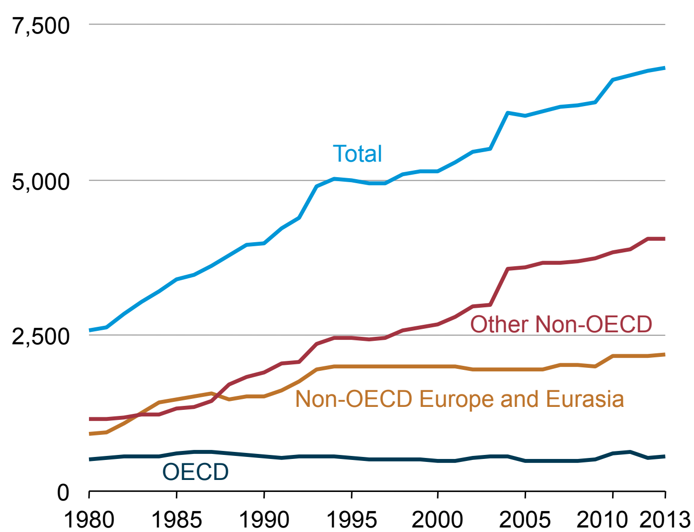


Figure 68. World proved natural gas reserves by region, 1980-2013 (trillion cubic feet)



Estimates of global proved reserves were nearly flat from 2012 to 2013, growing by only 47 trillion cubic feet (less than 1 percent). The largest change to proved natural gas reserve estimates was for Iran, which has the world's second-largest proved natural gas reserves. Iran's estimated proved natural gas reserves increased by 19 trillion cubic feet (2 percent), from 1,168 trillion cubic feet in 2012 to 1,187 trillion cubic feet in 2013. Estimated proved reserves in the rest of the Middle East also grew modestly, by 0.3 percent, from 1,622 trillion cubic feet in 2012 to 1,627 trillion cubic feet in 2013.

The second-largest change to estimated proved reserves was for China, where estimated proved reserves increased by 17 trillion cubic feet (16 percent), from 107 trillion cubic feet in 2012 to 124 trillion cubic feet in 2013. As a result, China's estimated proved reserves are now the world's eleventh largest, and Iraq's proved reserves have dropped to the twelfth largest. Russia's estimated proved reserves remained the world's largest at 1,688 trillion cubic feet.

Current estimates of worldwide natural gas proved reserves indicate a large resource base to support growth in markets through 2040 and beyond. Like reserves for other fossil fuels, natural gas reserves are spread unevenly around the world. Natural gas proved reserves are concentrated in Eurasia and the Middle East, where ratios of proved reserves to production suggest decades of resource availability. In the OECD countries, however, including many in which there are relatively high levels of consumption, current ratios of proved reserves to production are significantly lower. The impact of that disparity is reflected in the *IEO2013* projections for increased international trade in natural gas.

Almost three-quarters of the world's proved natural gas reserves are located in the Middle East and Eurasia (Figure 69), with Russia, Iran, and Qatar together accounting for about 55 percent of world proved natural gas reserves as of January 1, 2013 (Table 9). Proved reserves in the rest of the world's regions are distributed fairly evenly. Despite high rates of increase in natural gas consumption, particularly over the past decade, most regional reserves-to-production ratios have remained high. Worldwide, the reserves-to-production ratio is estimated at 63.6 years [*121*]. Central and South America has a reserves-to-production ratio of 45.2 years, Russia 73.5 years, and Africa 71.7 years. The Middle East's reserves-to-production ratio exceeds 100 years.

Proved reserves include only estimated quantities of natural gas that can be produced economically from known reservoirs, and therefore they are only a subset of the entire potential natural gas resource base. Resource base estimates include estimated quantities of both discovered and undiscovered natural gas that have the potential to be classified as reserves at some time in the future. In the Reference case, the resource base does not pose a constraint on global natural gas supply. By basing long-term production assessments on resources rather than reserves, EIA is able to present projections that are physically achievable and can be supported beyond the 2040 projection horizon. The realization of such production levels depends on future growth in world demand, taking into consideration such above-ground limitations on production as profitability and specific national regulations, among others.

Figure 69. World proved natural gas reserves by geographic region as of January 1, 2013 (trillion cubic feet)

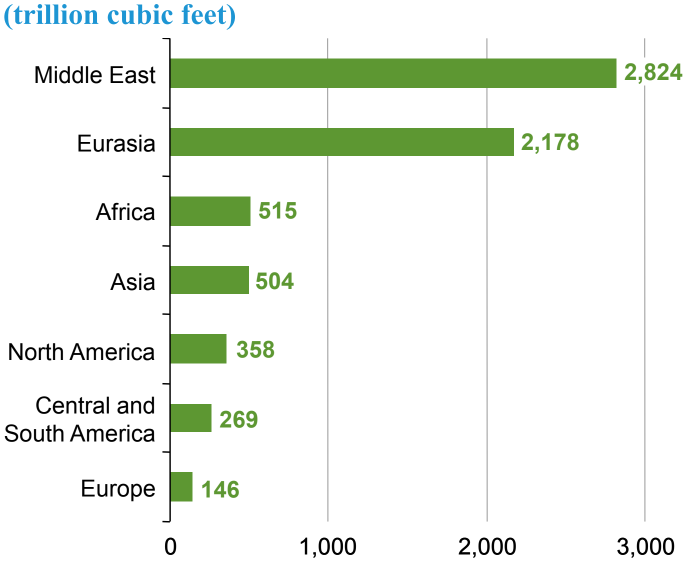


Table 9. World proved natural gas reserves by country as of January 1, 2013 (trillion cubic feet)

Country	Reserves (trillion cubic feet)	Percent of world total
World	**6,793**	**100.0**
Top 20 countries	***6,200***	***91.3***
Russia	1,688	24.9
Iran	1,187	17.5
Qatar	890	13.1
Saudi Arabia	288	4.2
United States	273	4.0
Turkmenistan	265	3.9
United Arab Emirates	215	3.2
Venezuela	195	2.9
Nigeria	182	2.7
Algeria	159	2.3
China	124	1.8
Iraq	112	1.6
Indonesia	108	1.6
Kazakhstan	85	1.3
Malaysia	83	1.2
Egypt	77	1.1
Norway	73	1.1
Canada	68	1.0
Uzbekistan	65	1.0
Kuwait	63	0.9
Rest of world	593	8.7

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Chapter 4

Coal

Overview

In the *IEO2013* Reference case, which does not include prospective greenhouse gas reduction policies, coal remains the second-largest energy source worldwide. World coal consumption rises at an average rate of 1.3 percent per year, from 147 quadrillion Btu in 2010 to 180 quadrillion Btu in 2020 and 220 quadrillion Btu in 2040 (Figure 70). The near-term increase reflects significant increases in coal consumption by China, India, and other non-OECD countries. In the longer term, growth of coal consumption decelerates as policies and regulations encourage the use of cleaner energy sources, natural gas becomes more economically competitive as a result of shale gas development, and growth of industrial use of coal slows largely as a result of China's industrial activities. Consumption is dominated by China (47 percent), the United States (14 percent), and India (9 percent), with those three countries accounting for 70 percent of total world coal consumption in 2010. Their share of world coal use increases to 75 percent in 2040 in the Reference case (Figure 71).

In the non-OECD countries, coal consumption increases at an average rate of 1.8 percent per year through 2040, more than compensating for the 0.2-percent average annual rate of decline in OECD coal use. As a result, the share of world coal consumption for non-OECD countries, led by China and India, increases from 70 percent in 2010 to 81 percent in 2040. China alone contributed 88 percent of the growth in world coal consumption from 2001 to 2009, which led to a significant increase in coal's share of world total energy consumption, from 24 percent in 2001 to 29 percent in 2009. China's share of global coal consumption increases from 47 percent in 2010 to 57 percent by 2025, followed by a decline to 55 percent in 2040. The sustained rapid expansion of coal use in India allows it to surpass the United States as the second-largest coal-consuming country after 2030.

Throughout the projection period, coal contributes more than one-fourth of the world's total primary energy supply and more than one-third of the fuel used for electricity generation. The share of coal in total world energy consumption remains relatively flat in the projection at 28 percent. Electricity generators accounted for 60 percent of total coal consumption in 2010, and industrial facilities accounted for 36 percent,[27, 28] with the remainder going primarily to the residential and commercial sectors. The combined share for the power and industrial sectors increases slightly over the projection period.

Despite the significant increase in coal use by non-OECD countries, the environmental impacts of mining and burning coal have driven policies and investment decisions in favor of cleaner and increasingly competitive energy sources—natural gas in particular—in many key coal-consuming regions. Worldwide, all other energy sources, except liquids, grow faster than coal. In the electric power sector, the coal-fired share of world electricity generation declines from 40 percent in 2010 to 36 percent in 2040, whereas the combined share of renewable energy, natural gas, and nuclear power resources increases from 56 percent to 63 percent. Coal's share of fuel consumption for electricity generation declines from 43 percent in 2010 to 37 percent in 2040 (Figure 72).

Figure 70. World coal consumption by region, 1980-2040 (quadrillion Btu)

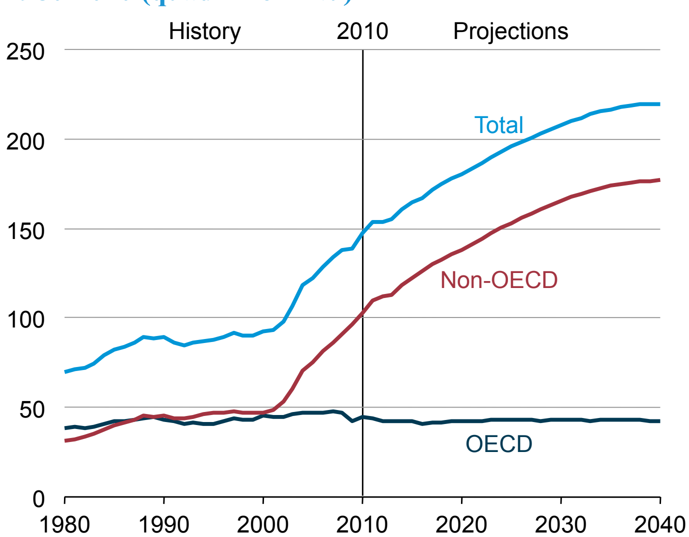
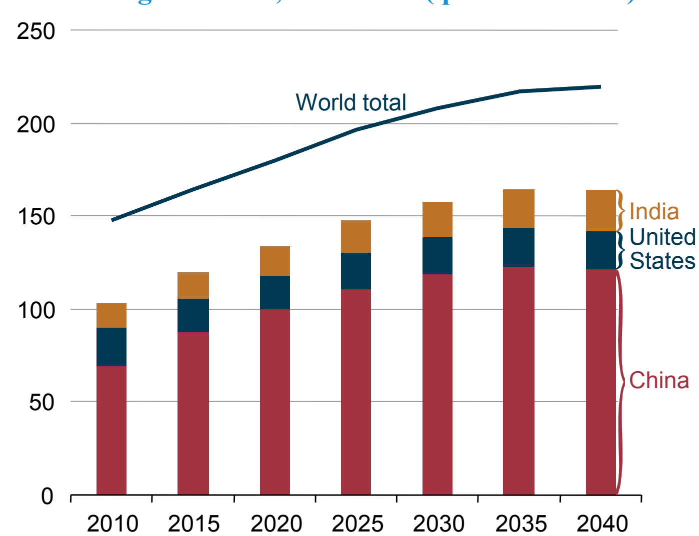


Figure 71. World coal consumption by leading consuming countries, 2010-2040 (quadrillion Btu)



[27]In *IEO2013*, *electric power sector* includes only power plants that generate electricity or electricity and heat mainly for sale to the electric grid. Unless otherwise noted, *electricity generators* refers to power plants in the electric power sector only, and electricity generation refers to electricity generated from those plants only. Coal consumed at plants that serve the electricity and heat needs of local industrial facilities is counted as industrial sector consumption.

[28]In this chapter, energy consumption expressed in percentage terms is calculated on the basis of energy content, and coal production expressed in percentage terms is calculated on the basis of physical tonnage.

World coal production parallels demand, increasing from 8.0 billion tons in 2010 to 11.5 billion tons in 2040[29] and reflecting the same expansion in the near term followed by much slower growth in later years. Global coal production is concentrated among four countries—China, United States, India, and Australia—and in the other countries of non-OECD Asia (mainly Indonesia[30]) (Figure 73). Their combined share of total world coal production increases in the *IEO2013* projections from 78 percent in 2010 to 81 percent in 2040. China alone accounts for 44 percent of global coal production in 2010 and 52 percent, at its peak share, in 2030. Growth in coal production is significantly different from region to region, ranging from strong growth in China to limited growth in the United States, to steady decline in OECD Europe.

International coal trade grows by 65 percent in the Reference case, from 24.0 quadrillion Btu in 2010 to 39.6 quadrillion Btu in 2040. The share of total world coal consumption accounted for by internationally traded coal remains near the 2010 level of 16 percent, increasing slightly to 17 percent in 2020 and 18 percent in 2040. The relatively stable share primarily reflects the ability of the world's largest coal consumers—China, the United States, and India—to satisfy most of their future coal demand with domestic production.

World coal consumption

OECD coal consumption

The OECD's role in world coal consumption diminishes as fuel market fundamentals and environmental regulations shift in favor of natural gas and renewables, particularly in the OECD Americas and OECD Europe regions. OECD coal consumption declines from 45 quadrillion Btu in 2010 to 41 quadrillion Btu in 2016, recovers to 42 quadrillion Btu in 2020, and remains slightly above that level through 2040. OECD Europe and the United States, which together consume almost three-quarters of the OECD total, lead the trend toward lower consumption. Coal consumption in most other OECD subregions or countries, except for the Mexico/Chile region and South Korea, also trends downward (Figure 74). The decline in OECD coal consumption—at an average rate of 0.2 percent per year—causes the coal share of the region's total primary energy consumption to fall from 19 percent in 2010 to 15 percent in 2040. In comparison, the share of OECD energy supply from renewable energy, including hydropower, increases from 10 percent in 2010 to 15 percent in 2040.

OECD Americas

Coal consumption in the United States remains below the 2010 level through 2040 due to the strong growth in shale gas production and tightening environmental regulations, with the share of coal in total U.S. electricity generation (including

Figure 72. Coal share of world energy consumption by sector, 2010, 2020, and 2040 (percent)

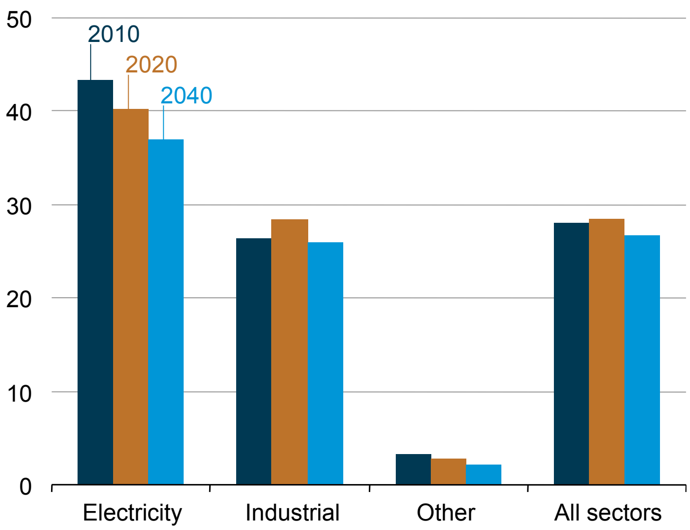


Figure 73. World coal production, 2010-2040 (billion short tons)

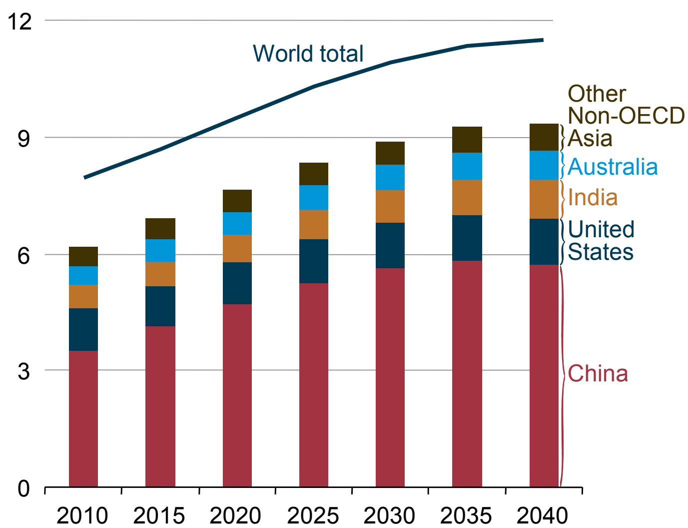
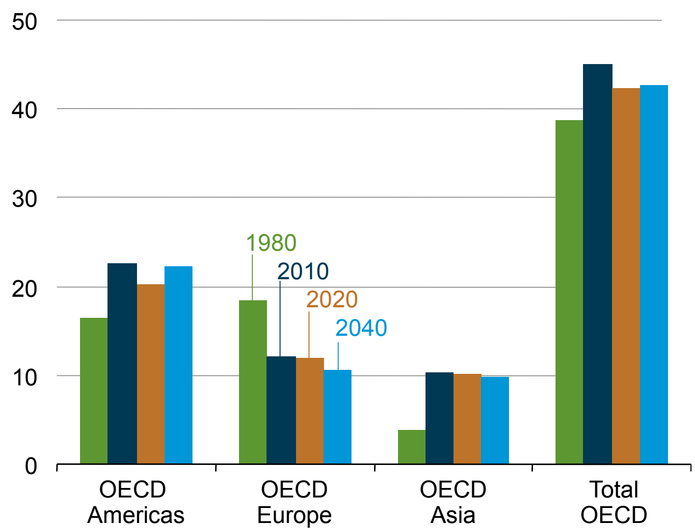


Figure 74. OECD coal consumption by region, 1980, 2010, 2020, and 2040 (quadrillion Btu)



[29]Throughout this chapter, tons refer to short tons (2,000 pounds) unless otherwise specified.
[30]Indonesia accounted for 71 percent of total coal production in the other non-OECD Asia region in 2010, up from 52 percent in 2000. Throughout the projection period, Indonesia continues to dominate the region's coal production.

electricity generated at plants in the industrial and commercial sectors) declining from 45 percent in 2010 to 35 percent in 2040. In 2010, the United States consumed 20.8 quadrillion Btu of coal, representing 92 percent of total coal use in the OECD Americas region and 46 percent of the OECD total. U.S. coal demand declined to 17.8 quadrillion Btu in 2012 as a result of weak demand for power and displacement of coal-fired generation in response to lower natural gas prices and persistently rising delivered prices for coal. The electric power sector dominates U.S. coal use, accounting for about 90 percent of total U.S. coal consumption throughout the projection.

Requirements to control emissions of nitrogen oxides, sulfur dioxide, and air toxics add to the cost of operating coal-fired power plants after 2015 and contribute to significant retirements of coal-fired generating capacity in the United States. Consequently, the U.S. coal-fired generating fleet shrinks from 317 gigawatts in 2010 to 278 gigawatts in 2040, with most of the capacity loss occurring before 2016. The overall utilization rate of the remaining coal-fired generating fleet improves steadily after 2016, as electricity demand grows and natural gas prices rise. However, because of high costs, few new additions of coal-fired generating capacity or coal-to-liquids capacity are installed. As a result, coal consumption increases only gradually, from 17.2 quadrillion Btu in 2016 to 20.4 quadrillion Btu in 2040.

Coal plays a relatively minor role in Canada's energy supply system, and it is further diminished in the long run. Driven by Canadian federal and provincial government efforts to reduce greenhouse gases, coal consumption declines by 8 percent, or 0.1 quadrillion Btu, between 2010 and 2040, and the coal share of total primary energy supply declines from 8 percent in 2010 to 6 percent in 2040. In 2010, 83 percent of the coal consumed in Canada was used to generate electricity, with most of the rest going to industrial plants. Government agencies have promulgated regulations and issued long-term plans to move away from coal-fired generation in an effort to limit greenhouse gas emissions. The Canadian federal government will enforce a strict greenhouse gas emissions standard for all coal-fired units beginning on July 1, 2015, which will encourage utilities to retire coal-fired generators [*122*]. The Ontario provincial government plans to phase out coal-fired generation in the province by the end of 2014 [*123*]. At the end of 2012, the province had three coal-fired power plants totaling about 3.3 gigawatts of remaining coal capacity. The provincial government-owned Ontario Power Generation Inc., plans to retire two of the plants, totaling nearly 3 gigawatts, by the end of 2013 and to retire the last remaining plant in 2014 [*124*]. With the coal phaseout in Ontario, the electric power sector share of Canada's total coal consumption falls to 73 percent in 2040, and the coal share of total electricity generation declines from 14 percent in 2010 to 7 percent in 2040.

Coal consumption in Mexico/Chile was relatively minor in 2010, at 0.6 quadrillion Btu, but increases by 0.2 quadrillion Btu from 2010 to 2040 as a result of rapid economic growth. Most of the increase comes from coking coal demand in the industrial sector, with the industrial share of total coal consumption growing from 19 percent in 2010 to 34 percent in 2040. There is only minimal growth in the use of steam coal in electricity generation through 2040, due to a change in Mexico's strategies to favor the development of natural gas and renewable energy resources. In recent years, an urgent need for more electricity generation and constraints on natural gas supply in Chile have forced the construction of a few coal-fired power plants, including the 470-megawatt Angamos Power Plant, which adopted battery storage and seawater cooling tower technologies [*125*]. However, environmental concerns and local opposition have resulted in delays, cancellations, and court rejections for other coal-fired power projects [*126*], and the country is shifting its focus to expansion of natural gas supplies and solar power [*127*]. In the *IEO2013* Reference case, the coal share of total electricity generation in the two countries decreases from 15 percent in 2010 to 6 percent in 2040.

OECD Europe

Total coal consumption in the countries of OECD Europe declines in the Reference case from 12.2 quadrillion Btu in 2010 (27 percent of the OECD total) to 10.7 quadrillion Btu in 2040 (25 percent of the worldwide total). Although all nations in the region consume coal, 65 percent of OECD Europe's 2010 total coal consumption was concentrated in Germany, Poland, Turkey, and the United Kingdom, with Germany alone consuming 26 percent of the regional total. The electric power sector accounted for 67 percent of the region's total coal consumption in 2010, and most of the rest was consumed in the industrial sector.

Electric power demand for coal declines steadily in the region and drives the downward trend in the region's overall coal consumption. The Industrial Emissions Directive (IED), agreed to by the European Council of Ministers and the European Parliament in 2010, as well as regional climate change policy goals, drive the decline. The IED requires the use of best available technology for reduction of sulfur dioxide and nitrogen oxides, among other pollutants, beginning in 2016, and is likely to trigger retirements of some coal-fired power plants, especially in the four leading coal-consuming countries [*128*]. The scale of the retirements outweighs the scale of new coal-fired capacity additions in Germany, Turkey, Poland, the Netherlands, and Italy, where new coal-fired capacity is needed to fill the supply gaps left by a nuclear power phaseout (in Germany), to replace less competitive power plants (such as oil-to-coal conversions and replacements in Italy), and to supply more power to meet demand growth (especially in Turkey) [*129*]. Total installed coal-fired generating capacity in OECD Europe declines from 204 gigawatts in 2010 to 169 gigawatts in 2040, and coal's share of total electricity generation declines from 24 percent in 2010 to 15 percent in 2040.

Coal consumption in the OECD Europe industrial sector remains largely flat. The effects of energy efficiency measures in OECD European countries, such as moving away from less efficient processes like open-hearth steelmaking, are more than offset by the effect of the increase in industrial output. For example, the gross output of OECD Europe's iron and steel plants increases by 26 percent from 2010 to 2040.

OECD Asia

The outlook for coal consumption in the OECD Asia region in the Reference case is relatively flat, as a net result of two divergent trends: declines in coal use in Japan, Australia, and New Zealand, totaling 0.9 quadrillion Btu, and an increase in coal use in South Korea, totaling 0.5 quadrillion Btu, from 2010 to 2040.

Japan is the region's largest coal consumer. Most of its coal is consumed in the electric power and industrial sectors, which share coal use almost equally. Although the nuclear power plant shutdowns after the Fukushima disaster necessitate an increase in coal use in the near term, a shift toward renewable energy and natural gas for electricity generation weaken electric power sector demand for coal in the long run. Japan is currently the world's second-largest steel producer, but its steel production declines after 2020 as its population and domestic demand both decline.

In Australia and New Zealand, 88 percent of the coal consumed in 2010 was used to generate electricity. Australia consumes 97 percent of the coal in the region. The introduction of a carbon price in Australia on July 1, 2012, encourages low-carbon energy use, which leads to a steady decline in the coal share of electricity generation in the region [*130*], from 63 percent in 2010 to 39 percent in 2040.

South Korea's coal consumption increases at a modest average rate of 0.5 percent per year through 2040, primarily for steel production in the industrial sector. In 2010, steel production accounted for 34 percent of South Korea's total coal consumption. Coal demand in the electric power sector, which accounted for 64 percent of total coal consumption in 2010, is roughly unchanged until 2030, due to the country's pre-Fukushima focus on nuclear expansion in the electric power sector [*131*].[31] The lack of growth in most of the projection period leads to a decline in coal's share of total electricity generation, from 44 percent in 2010 to 27 percent in 2040.

Non-OECD coal consumption

In contrast to declines in the OECD economies, coal consumption grows significantly and rapidly in the non-OECD regions, particularly non-OECD Asia. Total non-OECD coal consumption increases by 1.8 percent per year on average, to 177 quadrillion Btu in 2040—72 percent higher than the 103 quadrillion Btu in 2010 (Figure 75). Growth in coal-fired electricity generation accounts for nearly two-thirds of the increase. Coal maintains its leading role in the non-OECD energy system and provides for more than one-third of the region's total energy demand almost throughout the projection.

Non-OECD Asia

Non-OECD Asia, especially China, dictates the trend in world coal consumption throughout the projection. Providing 56 percent of non-OECD Asia's energy demand in 2010, coal plays a critical role in fueling strong economic growth and meeting energy demand in the region. Coal use in the non-OECD Asia region increases by an average of 1.9 percent per year, from 88 quadrillion Btu in 2010 to 157 quadrillion Btu in 2040, and accounts for 92 percent of the growth in total non-OECD coal consumption over the period, with China and India accounting for 70 percent and 13 percent of the total increase, respectively.

China is the leading consumer of coal in the world, using more than three times as much coal in 2010 as the world's second-largest consumer, the United States. In 2010, China's electricity-sector coal use alone was 67-percent higher than total coal consumption in the United States, and China's industrial-sector coal use alone was about 50-percent higher than the U.S. total (Figure 76). Over

Figure 75. Non-OECD coal consumption by region, 1980, 2010, 2020, and 2040 (quadrillion Btu)

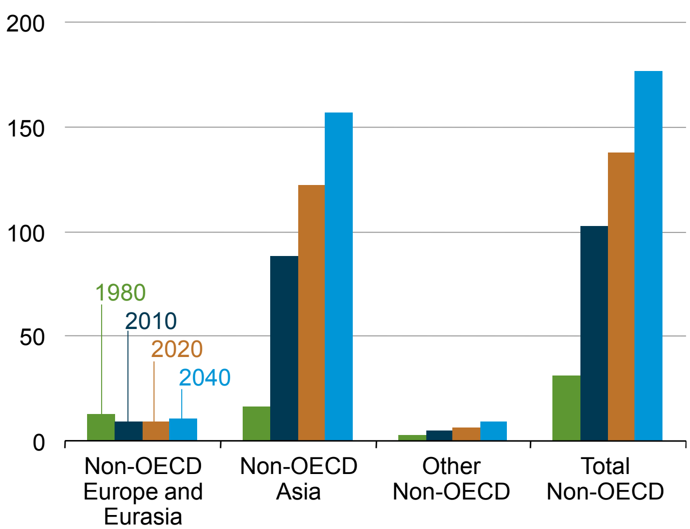
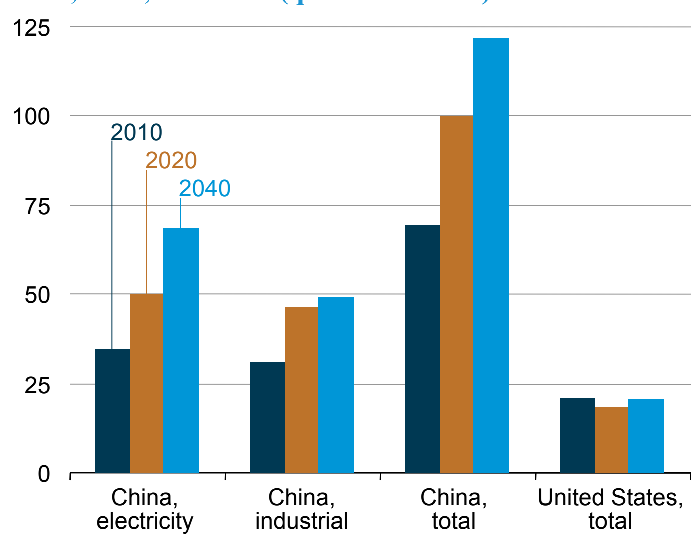


Figure 76. China coal consumption by sector and total compared with U.S. total coal consumption, 2010, 2020, and 2040 (quadrillion Btu)



[31]The refocus on thermal power expansion outlined in February 2013 by South Korea's Ministry of Knowledge Economy in its draft *6th Basic Plan for Long-Term Electricity Supply and Demand* is not included in the *IEO2013* Reference case.

time, the gap grows even wider because of China's rapid economic growth and the relatively low cost of coal that is sustained by the country's vast coal reserves and improving rail transportation infrastructure. In the Reference case, coal consumption in China grows by an average of 1.9 percent per year, from 69 quadrillion Btu in 2010 to 121 quadrillion Btu in 2040. The pace of growth slows gradually and coal consumption eventually begins to decline near the end of the projection period. At the peak around 2035, China consumes 123 quadrillion Btu of coal, or 57 percent of the world total.

Demand for coal in the electric power and industrial sectors drives all the growth in China's coal consumption. With the country's GDP growth rate averaging 5.7 percent per year from 2010 through 2040, its electricity demand grows by 3.7 percent per year. The gross output of China's iron and steel industry more than doubles from 2010 to 2030 before beginning to decline, and its other industrial gross output more than quadruples over the 2010-2040 projection period. Coal-fired power capacity expands by almost 530 gigawatts from 2010 to 2040, with net capacity additions averaging nearly 18 gigawatts per year, as compared with 59 gigawatts per year from 2005 to 2010. Coal consumption for electricity generation increases by an average of 2.3 percent per year, from 35 quadrillion Btu in 2010 to 69 quadrillion Btu in 2040. In the industrial sector, coal is used to produce steel and pig iron,[32] heat for industrial processes, and cement and coke for exports. It is also used for methanol and ammonia production, encouraged by government policy. Total coal consumption in the country's industrial sector increases from 31 quadrillion Btu in 2010 to 53 quadrillion Btu in about 2030 before falling to 49 quadrillion Btu in 2040.

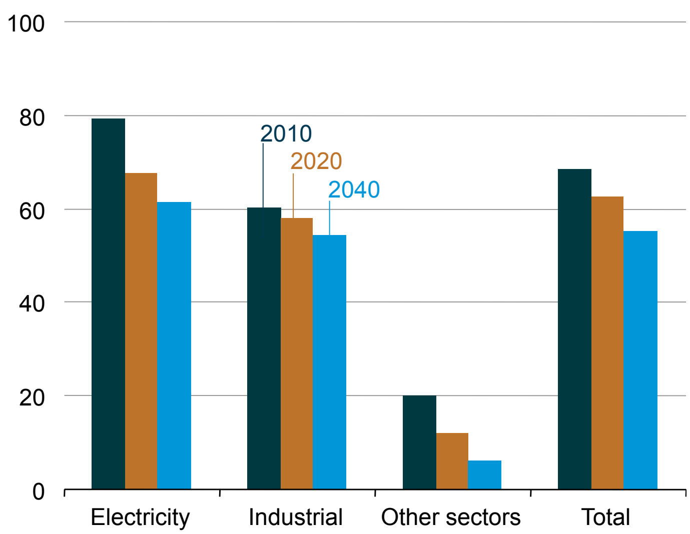
China's coal consumption is generally shifting from the industrial sector to the electric power sector along with industry electrification and the government's effort to encourage structural change in the economy toward less energy-intensive industries. Overall, nearly two-thirds of the growth in China's coal consumption comes from the electric power sector and more than one-third from the industrial sector. As a result, the electric power sector share of total coal consumption grows from 50 percent in 2010 to 57 percent in 2040, while the industrial share declines from 45 percent to 41 percent.

Central government policies are expected to mitigate the growth of China's coal consumption in the long term through efficiency improvements and a gradual shift away from coal in the energy mix. Strong policy supports and mandates, as well as economic incentives for cutting fuel costs, are expected to continue to improve the efficiency of coal use. Energy intensity, efficiency, and emission control mandates and policy goals in the central government's five-year plans have led the power, cement, and iron and steel industries to innovate and cut coal consumption per unit of output [*132*]. Those efforts are expected to continue, leading to higher efficiencies of coal conversion. In particular, coal use for electricity generation becomes more efficient as China continues to modernize its fleet of coal-fired power plants. The modernization involves retirements of less efficient coal-fired plants, as evidenced by the closing of 80 gigawatts of small coal plants between 2005 and 2010, as well as the adoption of advanced coal technologies, such as supercritical and ultra-supercritical pulverized coal-fired generation in new capacity builds. The central government's current energy policy also is expected to expand nuclear power capacity and, in the long run, natural gas-fired capacity (supported by increasing imports and the development of domestic shale gas resources) as well as hydropower and other renewable capacity [*133*]. As a result, the coal share of China's total energy consumption for electricity generation declines from 79 percent in 2010 to 62 percent in 2040 (Figure 77).

India, the world's third-largest coal consumer in 2010, surpasses the United States as the second-largest coal consumer over the next two decades. The growth of India's coal consumption, from 12.6 quadrillion Btu in 2010 to 22.4 quadrillion Btu in 2040, is led by the electric power sector, which accounted for 65 percent of its coal consumption in 2010. India's rapidly growing population and an average GDP growth rate of 6.1 percent per year through 2040 lead to electricity demand growth of 3.8 percent per year in the *IEO2013* Reference case, which is higher than in any other *IEO2013* region. India's population surpasses China's after 2020, with an expanding middle class that results in the greater use of electricity-consuming appliances. Coal fueled 68 percent of India's total electricity generation in 2010, and as the country strives to provide enough electricity to meet growing demand, coal-fired generation grows by 3.1 percent per year, even as generation totals from both nuclear and renewable energy (including hydropower) grow more rapidly than in any other *IEO2013* region. From 2010 to 2040, India's net coal-fired electricity generation grows by a total of 910 terawatthours, more than doubling from the 2010 total. Consequently, its coal consumption for electricity generation nearly doubles, from 8.2 quadrillion Btu in 2010 to 15.6 quadrillion Btu in 2040.

How effectively the Indian government can expedite regulatory procedures to help domestic mining and transportation

Figure 77. Coal share of China's energy consumption, 2010, 2020, and 2040 (percent)



[32]According to statistics from the World Steel Association, China is the world's largest producer of both steel and pig iron, accounting for 45 percent of world crude steel production and 59 percent of world pig iron production in 2011.

infrastructure catch up with demand and to provide incentives for investment in new coal-fired power capacity will affect the growth of coal consumption in the electric power sector. In the past several years, power capacity expansion and coal consumption targets set by the government in its 11th five-year plan have been missed repeatedly. Low revenues and poor profit margins have resulted from power thefts and from misalignment between coal prices and power tariffs that have discouraged investments in additional capacity. In 2011, insufficient domestic coal production forced power producers to purchase nearly 20 percent of their coal from overseas, even as regulated power tariffs constrained the quality and amounts of imported coal that power producers could afford. Coal shortages caused by difficulties in securing supply at affordable costs forced some power producers to curtail operations, which contributed to the summer 2012 power outage in India. The outage affected 680 million people and was the world's worst power outage ever in terms of population [*134*].

In 2010, 32 percent of India's total coal consumption was in the industrial sector, for the production of iron and steel, cement, bricks, and other materials. In 2011, India was the world's fourth-largest steel producer, fifth-largest pig iron producer, and second-largest cement producer. The government is planning to expand the nation's annual steel production capacity to 304 million tons by 2020, compared with 78 million tons in 2011, and its annual cement production capacity to 606 million tons by 2020, compared with about 330 million tons of capacity and 243 million tons of cement production in 2011 [*135*]. To achieve those growth targets, industries must overcome a range of challenges that have delayed regulatory approval of several large projects in recent years. A trend of long-term growth in India's steel and cement industries is essential to support its GDP growth. In the *IEO2013* Reference case, coal consumption in India's industrial sector continues to grow through 2035, after which it levels off with the stabilization of iron and steel production and energy efficiency improvements in the industrial sector.

Coal consumption in the other nations of non-OECD Asia grows by an average of 2.4 percent per year in the Reference case, from 6.4 quadrillion Btu in 2010 to 13.0 quadrillion Btu in 2040. The power and industrial sectors each accounted for 49 percent of the region's total coal consumption in 2010. Indonesia, Taiwan, Malaysia, Thailand, and Vietnam were the major contributors to coal consumption growth in the other non-OECD Asia countries over the past decade, with Malaysia's coal demand growing at the fastest pace [*136*]. Expansion of coal-fired generating capacity has led to growth of coal demand in the other non-OECD Asia countries in recent years, with multiple coal-fired power plants of 1 gigawatt capacity or more entering commercial service, under construction, or in advanced development stages. Most of the large-scale power projects are developed in Malaysia, Indonesia, and Vietnam, where the governments encourage foreign and private investment as well as involvement of foreign developers and equipment and service providers. In the longer term, such open-door policies are likely to continue facilitating the growth of coal-fired power capacity and coal demand in the other non-OECD Asia countries. Demand for coal in their industrial sectors also continues to grow in the Reference case, to meet both domestic and overseas demand for industrial sector output.

Non-OECD Europe and Eurasia

Coal accounted for 19 percent of the total primary energy supply in 2010 in non-OECD Europe and Eurasia, where natural gas use is more prevalent than other fuels. In absolute terms, coal consumption increases modestly from 9 quadrillion Btu in 2010 to 11 quadrillion Btu in 2040 in the *IEO2013* Reference case, but its share of total energy consumption falls to 16 percent in 2040. Most of the region's coal consumption and its future growth are concentrated in Russia, Kazakhstan, and the Ukraine, which together accounted for 84 percent of the 2010 total, with Russia alone accounting for 52 percent. Given the region's geographic features, direct access to seaborne markets is limited, and coal is purchased primarily from domestic production or overland imports, typically via long-distance transport, which adds significantly to the cost.

In Russia, the coal share of total primary energy supply declines from 16 percent in 2010 to 14 percent in 2040. The power and the industrial sectors are responsible for 89 percent of the country's coal consumption, which was split almost evenly between the two sectors in 2010. Coal demand in the power and industrial sectors grows on average by 0.9 percent per year and 0.5 percent per year, respectively, from 2010 to 2040. Coal use in the residential and commercial sectors, primarily for space heating and water heating, accounted for the remaining 11 percent of Russia's coal consumption in 2010—more than in any other *IEO2013* region. That share declines to 6 percent of total coal consumption in 2040, as the sector transitions to cleaner and more efficient energy sources for heating, such as electricity and natural gas.

Coal plays a relatively minor role in Russia's electric power sector, providing only 16 percent of total electricity generation in 2010, compared with 50 percent for natural gas. In January 2012, the government adopted a coal strategy that calls for a total of $120 billion of private and public investment in the coal industry and includes plans to expand coal use in the electric power sector [*137*]. The main goal of the strategy is to increase exports, especially to Asia. The success of the strategy will depend on the future cost of long-haul inland transportation. In any event, the diversification-oriented policy is likely to spur some expansion of Russia's coal-fired generating capacity and encourage higher rates of growth in coal consumption compared with the rest of the non-OECD Europe and Eurasia region, where coal fueled 34 percent of total electricity generation in 2010. However, with natural gas supplies in the other countries of the region both abundant and less expensive than coal, their total use of coal for electricity generation grows by only 0.4 percent per year on average from 2010 to 2040 in the Reference case.

Total coal consumption in the industrial sector of non-OECD Europe and Eurasia grows by 32 percent from 2010 to 2040 in the Reference case, as long-term economic growth leads to more coal use. The high energy intensity of GDP in the region, especially in Russia, and the current inefficiency of many industrial processes, such as open-hearth steelmaking, suggest the potential for energy savings that will tend to moderate coal consumption in the long term. For example, countries such as Russia and Kazakhstan have been actively engaged in various energy efficiency initiatives, including passing comprehensive energy efficiency policies and collaborating with the United States in information sharing and the development and upgrading of domestic programs [*138*, *139*].

Africa

Coal use accounts for less than one-quarter of Africa's total primary energy supply throughout the projection, despite increasing from 4.4 quadrillion Btu in 2010 to 5.2 quadrillion Btu in 2020 and 7.5 quadrillion Btu in 2040. Most of the increase in the region's coal demand is for use in the electric power and industrial sectors.

The continent's coal consumption is highly concentrated in South Africa, where coal is the most widely used fuel. In 2010, South Africa accounted for 93 percent of the continent's total coal consumption, providing 75 percent of South Africa's primary energy supply [*140*]. About 70 percent of the coal consumed in South Africa is used for electricity generation and about 20 percent for production of coal-based synthetic fuels [*141*]. The state-owned power company, Eskom, accounts for nearly two-thirds of South Africa's domestic coal consumption on a tonnage basis, supplying most of the country's electricity and also exporting electricity to neighboring countries. Most of Eskom's power plants burn coal, which is purchased mainly from domestic, privately owned mines under long-term supply contracts. The privately owned synfuel producer, Sasol, owns and operates the world's only commercial coal-to-liquids (CTL) plants, which use coal feedstocks from mines owned by Sasol.

South Africa's power shortage in recent years and projected strong economic growth indicate high potential for future coal consumption growth and also exposes the urgent need for infrastructure building in the country. To address the insufficiency of power supply, Eskom has laid out a significant capital investment plan for capacity expansion [*142*]. Given the high costs of building nuclear power plants and a lack of sufficient natural gas and renewable resources, coal-fired power plants continue to dominate Eskom's capacity expansion plans. In the near term, two multiple-unit coal-fired power plants, Medupi and Kusile, are scheduled to come on line starting in 2013 and 2014, with all units scheduled to be fully operational by 2018. The two plants will add a total of 9.6 gigawatts of coal-fired capacity and about 30 million tons of coal consumption per year. The resulting increase in demand for coal will add to the mounting challenge already faced by Eskom in its attempts to secure sufficient supplies of high-quality coal while managing the financial pressure associated with rising fuel costs. Most of the coal from domestic mines that is consumed in South Africa has high ash content and low heating value, while higher quality coal is diverted to export markets. Ensuring affordable supply to the domestic market will require significant investment in new mining and railroad transportation. Similar challenges await other African countries, such as Mozambique and Botswana, where new coal supply is coming on line and demand for power is increasing.

In addition to increasing use of coal in the electric power sector, expansion of CTL capacity may also lead to further growth in Africa's demand for coal. Sasol has proposed expanding its Secunda CTL plant by adding 30,000 barrels per day of capacity and building the 80,000-barrel-per-day Mafutha plant. The implementation of the plans hinges on trends in the commodity market, regulatory approval, and future policies to limit carbon dioxide emissions. In the *IEO2013* Reference case, South Africa's CTL production is assumed to expand from 160,000 barrels per day in 2010 to about 275,000 barrels per day in 2040.

Central and South America

Coal accounts for only 3 percent of the total primary energy supply in Central and South America, where it is used mainly in the industrial sector for steel production. Brazil accounted for 54 percent of the region's 0.9 quadrillion Btu of total coal consumption in 2010. Colombia, Peru, Argentina, and Puerto Rico accounted for most of the remainder [*143*].

Demand for metallurgical coal in Brazil, the world's ninth-largest steel producer in 2011, accounts for 84 percent of the region's coal consumption from 2010 to 2040, with demand for steel in both domestic and international markets assumed to increase throughout the period. Coal accounted for only 2 percent of the region's electricity generation in 2010. In the near term, coal consumption in Brazil's electricity sector is set to increase with the completion of the Pecem I, Pecem II, and Itaqui power plants between 2011 and 2013, totaling 1.4 gigawatts of generating capacity [*144*]. In the long term, however, the region's electric power sector continues to rely primarily on hydropower, along with some increases in generation from natural gas and nuclear power.

Middle East

Coal accounts for less than 1 percent of the total primary energy consumption in the Middle East throughout the projection period. Currently, only three countries in the region—Iran, Lebanon, and Syria—report any coal consumption. In the *IEO2013* Reference case, coal consumption in the Middle East remains below 0.1 quadrillion Btu per year through 2040.

World coal production

With the exception of Japan, coal is produced in all the *IEO2013* regions, including nearly 70 countries with combined total production of almost 8 billion tons in 2010 (Table 10). World coal production increases by 3.5 billion tons from 2010 to 2040, with the non-OECD countries contributing 94 percent of the growth. China and India together account for 73 percent of the growth, with production increases averaging 1.6 percent per year in both countries. Production growth in some OECD countries, mainly in Australia, is largely offset by steady declines in OECD Europe.

Most coal-producing regions face a number of common challenges, many of which have periodic, short-term impacts on production. For example, rainfall from tropical storms in the Pacific Basin regularly disrupts mining operations in Australia, Indonesia, and Colombia. Labor strife in South Africa and Colombia has caused supply disruptions in the past. Other challenges are associated with the rapid growth of coal demand, which exposes infrastructure constraints on mining, transportation, and port capacities. Those constraints are amplified by the environmental and safety impacts associated with coal mining, which increasingly are provoking opposition from environmental groups as well as regulatory scrutiny in many countries.

OECD Americas

As the world's second-largest coal producer, the United States accounts for more than 90 percent of total coal production in the OECD Americas region. Future growth of coal production in the United States and Canada is primarily for export. The limited increase in production in Mexico and Chile is unlikely to be sufficient to meet domestic demand and the two countries continue to rely heavily on imports in the *IEO2013* Reference case.

U.S. coal production declines from 1.1 billion tons in 2010 to just under 1.0 billion tons in 2016, as compliance with environmental regulations under the Clean Air Act in the electric power sector results in the retirement of coal-fired generating capacity that would be uneconomical with the costly retrofits required by the Act. After 2016, production increases gradually, to almost 1.2 billion tons in 2040, with increases in exports and consumption in the electricity sector as electricity demand grows and natural gas prices rise. The export share of total U.S. coal production increases from 8 percent in 2010 to 14 percent in 2040.

Most of the growth in U.S. coal production comes from mines in the Interior and Western coal supply regions, with lower-cost coals from the Interior supply region and the northern part of the Appalachian Basin gradually replacing more expensive coals from Central Appalachia (eastern Kentucky, southern West Virginia, Virginia, and northern Tennessee). Central Appalachian coal

Table 10. World coal production by region, 2010-2040 (million short tons)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD Americas	**1,171**	**1,138**	**1,174**	**1,217**	**1,256**	**1,272**	**1,283**	**0.3**
United States	1,084	1,046	1,080	1,119	1,156	1,169	1,177	0.3
Canada	75	81	83	85	87	90	93	0.7
Mexico/Chile	12	12	12	12	12	13	13	0.3
OECD Europe	**620**	**583**	**568**	**552**	**537**	**522**	**504**	**-0.7**
OECD Asia	**476**	**549**	**540**	**580**	**591**	**641**	**687**	**1.2**
Japan	0	0	0	0	0	0	0	--
South Korea	2	2	3	2	2	2	2	-0.9
Australia/New Zealand	473	547	537	578	589	638	685	1.2
Total OECD	**2,267**	**2,271**	**2,282**	**2,349**	**2,384**	**2,434**	**2,474**	**0.3**
Non-OECD Europe and Eurasia	**684**	**663**	**707**	**746**	**775**	**805**	**820**	**0.6**
Russia	359	373	400	421	434	447	446	0.7
Other	325	290	307	325	341	358	374	0.5
Non-OECD Asia	**4,625**	**5,310**	**6,003**	**6,631**	**7,116**	**7,438**	**7,478**	**1.6**
China	3,506	4,130	4,725	5,257	5,633	5,829	5,722	1.6
India	612	624	696	776	850	926	993	1.6
Other	508	557	582	598	633	683	762	1.4
Middle East	**1**	**2**	**3**	**3**	**3**	**3**	**3**	**3.6**
Africa	**286**	**315**	**358**	**400**	**432**	**462**	**501**	**1.9**
Central and South America	**91**	**131**	**145**	**168**	**195**	**209**	**224**	**3.0**
Brazil	6	6	6	6	6	7	7	0.5
Other	85	125	139	162	189	203	217	3.2
Total Non-OECD	**5,688**	**6,422**	**7,216**	**7,948**	**8,521**	**8,919**	**9,026**	**1.6**
Total World	**7,954**	**8,693**	**9,499**	**10,297**	**10,905**	**11,353**	**11,500**	**1.2**

Note: With the exception of North America, nonseaborne coal trade is not represented in EIA's projections. As a result, the projected levels of production assume that net nonseaborne coal trade will balance out across the *IEO2013* regions. Currently, a significant amount of nonseaborne coal trade takes place in Eurasia, represented by exports of steam coal from Kazakhstan to Russia and exports of coking coal from Russia to Ukraine.

production declines in response to falling demand and higher costs as the region's coal mines become less productive. Most of the remaining production from Central Appalachian coal mines is directed to the industrial and export markets. Western coal production grows steadily after 2016, satisfying much of the additional need for fuel at U.S. coal-fired power plants and providing large amounts for coal export. Production from the Interior region grows throughout the projection, as new mines in the region tap into the substantial reserves of mid- and high-sulfur bituminous coal in Illinois, Indiana, and western Kentucky.

In Canada, coal production increases moderately, primarily to provide coking coal for export. Most of the steam coal produced in Canada is subbituminous coal and lignite. Domestic demand for this coal declines as much of the country's coal-fired generation is phased out. Most of Canada's coking coal is high-quality hard coking coal, much of which is exported to Asia. Exports of coking coal from Canada increase primarily to provide the fuel needed to meet increasing demand for iron and steel in the Asian economies. With Canada's significant reserves of coal close to the Pacific market, several firms have been investing in mine expansions and productivity improvements. A report from the Coal Association of Canada indicates that coal companies have plans to invest $2.2 billion in production between 2012 and 2014 [*145*]. Several coal terminal expansion projects are also under way in British Columbia, to facilitate both Canadian and U.S. exports. In the *IEO2013* Reference case, Canada's coal production increases from 75 million tons in 2010 to 93 million tons in 2040.

OECD Europe

In OECD Europe, falling domestic demand and rising competition from imports cause indigenous coal production to decline from 620 million tons in 2010 to 504 million tons in 2040. Germany, Poland, and Turkey are the leading producers in the region, accounting for 69 percent of total production in 2010.

Coal production in Germany has been declining since the mid-1980s, from 578 million tons in 1985 to 201 million tons in 2010. In 2010, 93 percent of the country's coal production came from lignite reserves and the remainder from hard coal resources [*146*]. In Germany and many other European countries, hard coal production is dependent on subsidies, because it is significantly more expensive than imported coal. The German government's decision in 2007 to end the subsidies by 2018 could virtually eliminate the country's production of hard coal [*147*]. In contrast, lignite production, which has been relatively flat over the past decade, has the potential to increase in the near term for use as a bridge fuel toward an energy system with lower carbon emissions while Germany's nuclear power program is being phased out.

Poland has the largest coal resources in Europe. It is the world's ninth-largest coal producer and OECD Europe's leading hard coal producer, accounting for more than half of the region's hard coal production. Poland is also the third-largest lignite producer in the region, after Germany and Greece. However, lack of investment in the mining sector and rising mining costs at underground mines have led to significant declines in production in past decades, especially for hard coal. With Poland's government committed to reducing carbon dioxide emissions by 20 percent from 1990 levels by 2020, domestic coal demand and production decline in the longer term.

Coal production continues to increase in Turkey as a result of growth in GDP and electric power demand. The country's coal production has been increasing for several decades but has been outpaced by growing domestic demand, resulting in increased reliance on imports [*148*]. Limited domestic coal resources, most of which are lignite, have been a key constraint on domestic production and will present a challenge to further expansion in the future.

OECD Asia

Coal production growth in OECD Asia contributes 6 percent of the total increase in world coal production in the *IEO2013* Reference case. Australia, the world's fourth-largest coal producer, accounted for 98 percent of the region's total production in 2010, with two-thirds of the country's 2010 production being exported. Australia is the world's largest exporter of metallurgical coal and the second-largest exporter of steam coal. With its domestic coal demand declining, demand from international markets, especially Asia, spurs the growth of Australia's coal production and drives total production in Australia and New Zealand from 473 million tons in 2010 to 685 million tons in 2040.

Key producers in Australia and investors from India and China have been working to expand mining capacity in the country's existing mining regions, such as Bowen in Queensland and Hunter Valley in New South Wales, develop new mining regions, such as Surat and Galilee in Queensland and Gunnedah in New South Wales, and expand inland transportation and port infrastructure. Collectively, existing projects[33] have the potential to add nearly 200 million tons of annual production capacity by 2022, equivalent to 41 percent of Australia's 2010 coal production [*149*]. Data compiled by Australia's Bureau of Resources and Energy Economics indicate that more than 65 million tons of new coal mining capacity is set to come on line in the 2013-2016 period [*150*]. The economics of future projects may be affected by a mineral resource rent tax that became effective on July 1, 2012, imposing a 30-percent tax on mining profits. The tax has been challenged in Australia's highest court [*151*].

Non-OECD Asia

China, India, and Indonesia are the three leading producers of coal in non-OECD Asia, and they are the first-, third-, and fifth-largest producers of coal in the world, respectively, with a combined total of 4.5 billion tons of coal production in 2010, representing more

[33]Including those projects for which producers have provided or applied for regulatory approval and investors have provided financial backing.

than half the world total. China and India consume almost all of their coal production domestically and are focused on tapping into their vast domestic coal resources to secure long-term coal supplies at affordable cost. In contrast, Indonesia exports the vast majority of its relatively low-cost coal to Asia and other markets. In addition, new supplies from Mongolia are emerging as a potential source of supply to meet increasing demand from China.

China increases coal production by an average of 1.6 percent per year, from 3.5 billion tons in 2010 to 5.7 billion tons in 2040, to meet the increase in its domestic demand, mostly for thermal coal. Abundant coal resources, ongoing improvements in transportation and transmission infrastructure, and favorable government policies support the expansion.

Although China holds the world's third-largest recoverable coal reserves, the geographic mismatch between its coal supply and demand centers has created significant logistical problems in the recent past, leading to coal price increases. The newer thermal coal reserves are concentrated in the north and the northwest (especially Shanxi, Shaanxi, Inner Mongolia, and Xinjiang), where favorable geological conditions allow for larger, lower-cost mines with the greatest potential for future production growth. The power and industrial demand centers for coal, however, are located in southern and eastern China, where coal reserves, although of higher quality and economic value,[34] typically present more difficult geological conditions for mining after decades of depletion. The mismatch between coal supply and demand centers is the key reason that imports from international suppliers can compete successfully with domestic coal supplies. Rail capacity expansion, in particular, has lagged behind the growth in demand for coal transportation in recent years, causing severe bottlenecks in the supply chain and forcing costly long-haul trucking of coal, which was a key contributor to high delivered coal prices in the coastal areas and surges in imports in 2010 and 2011.

In response to the transportation bottlenecks, China's 12th Five-Year Plan includes significant investment in rail and transmission expansions. The plan calls for rail capacity able to transport 2.9 billion tons of coal per year by 2015, compared with the 2.5 billion tons of coal transported by rail in 2011 [*152*]. Some analysts expect as much as 880 million tons of rail capacity to be added between 2013 and 2018 [*153*]. The 12th Five-Year Plan also includes aggressive programs to expand high-voltage power transmission, or coal-by-wire, connecting minemouth power plants with power demand centers to facilitate indirect release of stranded coal resources to the market and relieve the logistical constraints on production growth.

The 12th Five-Year Plan also suggests that the country is attempting to improve the efficiency and safety of its mining operations through industry consolidation and coal recovery standards to better enable its domestic producers to compete with international suppliers. In the past decade, staggering death tolls at small mines have prompted the government to tighten safety regulations and clamp down on small inefficient mines with poor safety measures, leading to the closure and consolidation of small mines and the formation of large state-owned mining complexes owned by domestic industry leaders, such as Shenhua and China Coal, equipped with advanced technologies that offer higher productivity, lower costs, and improved safety. The standards for coal resource development promulgated by the Ministry of Land and Resources, issued in September 2012, require rates of coal recovery higher than the current average, which are expected to lead to more closures and consolidations of small mines [*154*].

The phaseout of government intervention in the setting of thermal coal prices for electricity generators, starting in January 2013 [*155*], provides incentive for coal producers to expand production. Historically, thermal coal prices in China have been capped through annual coal contract conferences, in which coal producers were required to sell a significant portion of utilities' coal purchases at rates far below market prices. The liberalization of coal prices, together with government's effort in recent years to reduce the numerous logistical surcharges, local taxes, and fees paid by miners, is expected to improve the competitiveness of domestic producers [*156*]. However, considerable uncertainty remains about how the government would react if coal prices again increased to levels unaffordable for power companies, given the misalignment of coal prices and power tariffs.

In India, coal production is projected to increase at a 1.6-percent annual rate, the same as production growth in China, from 612 million tons in 2010 to about 1 billion tons in 2040. Despite the significant increase, however, India increases its imports by 160 million tons over the projection, as growth in demand outpaces growth in production. Coal India, India's primary coal supplier, which accounts for approximately 80 percent of domestic supply, faces numerous challenges. With delays in regulatory approvals, as well as opposition based on environmental concerns, capacity expansion targets frequently have been missed in recent years. New coal mines are generally surface operations that require land acquisition, forest clearing, the meeting of pollution standards, and resettlement and rehabilitation, which can take significant time to resolve [*157*]. Inefficient utilization of rail capacity also is a major issue, affecting about one-half of the coal transported within India. The issue may be addressed in part by development of the Eastern Dedicated Freight Corridor, a high-capacity rail route dedicated to freight transportation only [*158*].

Indonesia provides most of the coal production from the rest of non-OECD Asia and is a primary contributor to the region's average production growth of 1.4 percent per year, from 508 million tons in 2010 to 762 million tons in 2040. Given Indonesia's relatively low-cost surface mines, its proximity to other Asian countries, and the relatively low sulfur and ash content of its coal, most of its production has been exported to other Asian countries. In response to growing demand from both domestic and international markets, Indonesia's coal producers have enhanced their efforts to expand production at existing mines, develop new mines, and develop port infrastructure. Yet the pace of future production growth to a great extent hinges on the government's regulation of exports, as required by the country's mining law of 2009, which is intended to boost the economic

[34]China's metallurgical coal reserves are concentrated largely in the south and the southeast.

value of Indonesia's coal resources and preserve a portion of coal reserves for future domestic consumption. Although recent proposals that would basically halt exports and mining activity have not advanced, some type of regulation may be instituted to meet the law's requirements [*159*].

Non-OECD Europe and Eurasia

Most of the coal production in non-OECD Europe and Eurasia comes from Russia and Kazakhstan, which accounted for 52 percent and 18 percent, respectively, of the region's total coal production in 2010. In the coming decades, coal production from the two countries, especially Russia, remains the major source of the region's relatively moderate 0.6-percent average annual production growth, from 684 million tons in 2010 to 820 million tons in 2040.

Although Russia possesses the world's second-largest coal reserves, coal production is limited by both economic and logistical challenges. Because Russia is a major natural gas producer, with abundant supply available at relatively low subsidized rates from the state-owned natural gas company, its electric power sector has favored the use of natural gas. In contrast, the privatized coal sector saw its direct subsidies eliminated during industry restructuring in the 1990s. Depletion of reserves in European (western) Russia, rising mining costs, and the high cost of transporting Siberian reserves over long inland distances further challenge the economics of Russian coal.

Over the past several years, strong export demand has boosted Russia's coal production, and exports continue to lead Russia's coal production growth in coming decades in the *IEO2013* Reference case. In 2010, approximately 40 percent of Russia's coal production was exported, with one-half being shipped to consumers in Europe. Aiming to capture export opportunities for coal, and to ensure diversified fuel supplies for domestic markets in order to accommodate rising demand for natural gas exports, Russian Prime Minister Vladimir Putin announced in January 2012 an investment program for the coal sector [*160*]. The program, for which Putin pledged $8.2 billion in public funds, calls for a total of $120 billion of private and public investment in coal mining capacity expansion and safety improvement.

Africa

Africa's coal production in the Reference case grows rapidly—at an average rate of 1.9 percent per year—from 286 million tons in 2010 to 501 million tons in 2040, based on growth in both domestic consumption and exports. South Africa is the largest producer in the region, accounting for 98 percent of its total coal production in 2010. Mozambique and Botswana are emerging as new suppliers, with their initial production targeted for export.

South Africa is a significant player in the global steam coal market, with an advantageous geographic location between the Atlantic and Pacific coal markets, the world's largest coal export terminal at Richards Bay, and substantial reserves of bituminous coal. In 2010, 26 percent of its production was exported. In general, the coal exported by South Africa is of better quality than the coal consumed domestically. The relatively low cost of mining in South Africa provides a competitive advantage for its coal in Europe and Asia. Growth in the country's coal production comes from basins in the north, such as Waterberg, which will require investment in the development of new mines and in railways to move coal out of the region. The pace of development will depend on whether the country can overcome hurdles such as a lack of focused policy support, a less stable political environment, bureaucratic delays, and issues with the allocation of prospecting and mining rights that have led to slower rates of infrastructure development in the past.

Central and South America

Coal production in Central and South America is projected to increase by an average of 3.0 percent per year in the Reference case, from 91 million tons in 2010 to 224 million in 2040. Only three countries in the region produce more than one million tons of coal per year—Colombia, Brazil, and Venezuela. Colombia is the region's largest producer, accounting for 82 million tons, or 90 percent, of Central and South America's total production in 2010. More than 90 percent of Colombia's production has been exported in the past decade, primarily to Europe, the Americas, and, increasingly, Asia. Brazil produces only 6 million tons of steam coal per year, almost all of which is consumed domestically. Venezuela's coal production has declined rapidly in recent years, to 2.5 million tons in 2011. Coal production in both Brazil and Venezuela remains relatively flat or decreases through 2040.

In contrast, Colombia's coal production could potentially double between 2010 and 2020, after nearly doubling from 2000 to 2010 in response to strong international demand. Inspired to capture more opportunities in the Asian market in the decades to come, the government continues to put a high priority on the resolution of labor issues, improvement of mine safety, and expansion of road, rail, and port infrastructure. The country's energy and mining minister announced in June 2012 that the government expects coal production to reach 127 million tons by 2014 and plans to invest more than $350 billion in inland transportation infrastructure to support 165 million tons of coal production by 2020 [*161*]. Currently, multiple projects are underway in Colombia to expand mining, rail, barge, truck transportation, and port capacity. Moreover, the current Panama Canal expansion could result in lower international shipping costs that would lead to additional shipments of Colombian coal to Asian markets. So far, most of the coal produced in the region has been steam coal, although metallurgical coal production in Colombia has the potential to grow significantly if infrastructure investment and railway modernization materialize as currently planned [*162*].

World coal trade

Most countries that consume substantial amounts of coal have domestic coal resources. For that reason, the volume of world coal trade tends to be small relative to worldwide coal consumption. In 2010, about 14 percent of the coal consumed worldwide on a tonnage basis was imported (approximately 16 percent on a Btu basis). In the *IEO2013* Reference case, seaborne coal trade grows at an average rate of 1.5 percent per year, from 1,132 million tons in 2011 to 1,757 million tons in 2040 (Table 11 and Figure 78). In the projection, the import share of world coal consumption remains near its historical level, increasing slightly to 15 percent in 2040. Almost all the projected growth in world coal trade is in response to increasing demand for coal imports in the countries of non-OECD Asia.

International coal trade typically is evaluated for two separate markets—one for steam coal, also referred to as thermal coal, and one for coking coal. Steam coal is used primarily for electricity generation and also in industrial applications for the production of steam and direct heat. Coking coal is used to produce coal coke, which in turn is used as a fuel and as a reducing agent for smelting of iron ore in blast furnaces. Steam coal has accounted for most world coal trade for many years, and its importance has grown over the past decade, with its share of total trade increasing from 66 percent in 2000 to 75 percent in 2011. From 2000 to 2011, the volume of world steam coal trade increased by 448 million tons, or 112 percent, and world coking coal trade increased by 85 million tons, or 39 percent. Although the 847 million tons of steam coal traded in 2011 represented 75 percent of total coal trade, coking coal exports have become an increasingly desirable export commodity, with prices rising sharply in recent years. In the Reference case, steam coal accounts for between 73 and 75 percent of total trade through 2040.

At the regional level, world coal trade has seen some significant shifts during the past decade. On the supply side, Indonesia has posted extraordinary gains in coal exports, satisfying more than one-half of the 529-million-ton expansion in world coal trade from 2000 to 2011 and displacing Australia as the world's leading coal exporter in 2011. Also on the supply side, China and Vietnam have emerged as major coal-exporting countries during the past decade, although China's exports are now relatively minor, and Vietnam plans to phase out exports as its own use of coal for electricity generation expands rapidly. On the demand side, China and India have emerged as major coal-importing countries, increasing their take of imported coal by more than 300 million tons from 2000 to 2011 and representing 57 percent of the growth in total international coal trade during the period [*163*]. In 2011, Japan and China were essentially tied as the top two coal-importing countries in the world, and South Korea and India were tied for the third position (Figure 79).

The *IEO2013* outlook for world coal trade is dominated by continuing growth in coal imports to Asia, primarily the countries of non-OECD Asia, with relatively little growth in imports expected for Europe and the Americas. Historically, however, international coal trade patterns and quantities have been difficult to predict, because they are determined by many factors, and, as a consequence, there is considerable uncertainty regarding the outlook for coal markets. Examples of some of the factors that have affected international coal trade in recent years include substantial increases in the costs of producing and transporting coal in both coal-exporting and importing countries; changes in bulk rates for ocean freight; the ability of coal exporters to coordinate the necessary buildup of infrastructure, including mining, inland transportation, and port capacity; increases in the costs of building new coal-fired power plants; substantial swings in the costs of competing fuels and technologies; and continuing changes in energy and environmental policies. Other factors, such as weather and labor strikes, also have affected international coal trade; and although those two factors are of a temporary nature, there are potential implications for the outlook in the longer term, such as a desire by importing countries to diversify their sources of coal and energy supplies.

Figure 78. World coal imports by major importing region, 1995-2040 (million short tons)

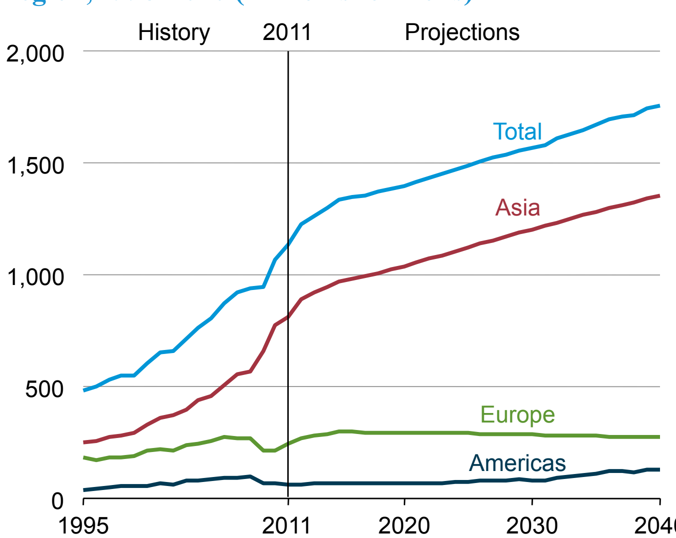


Figure 79. Coal imports to Asia by region, 2011 and 2040 (million short tons)

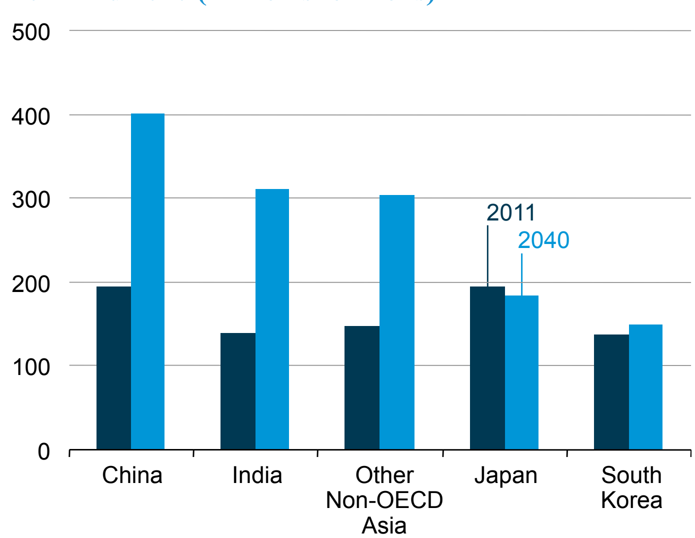


Table 11. World coal flows by importing and exporting regions, Reference case, 2011, 2020, and 2040 (million short tons)

	Importers											
	Steam				Coking				Total			
Exporters	Europe/ Other[a]	Asia	Americas	Total[b]	Europe/ Other[a]	Asia[c]	Americas	Total[b]	Europe/ Other[a]	Asia	Americas	Total[b]
2011												
Australia	1.0	157.4	3.9	**163.5**	20.4	118.7	4.0	**146.9**	21.5	276.1	7.8	**310.4**
United States	22.4	8.1	7.2	**37.7**	35.7	19.7	14.2	**69.6**	58.1	27.8	21.4	**107.3**
Southern Africa[d]	25.8	43.6	1.8	**76.2**	0.0	0.0	0.4	**1.0**	25.8	43.6	2.2	**77.2**
Eurasia	47.5	32.6	0.0	**80.1**	4.6	7.6	0.0	**12.2**	52.0	40.2	0.0	**92.3**
Poland	4.0	0.0	0.0	**4.2**	0.0	0.0	0.0	**0.0**	3.9	0.0	0.0	**4.2**
Canada	0.1	6.0	0.3	**6.4**	5.9	20.2	4.4	**30.5**	6.0	26.2	4.7	**36.8**
China	0.0	12.0	0.0	**12.0**	0.1	3.9	0.0	**4.0**	0.1	15.8	0.0	**16.0**
South America[e]	63.2	2.0	22.8	**88.1**	0.0	0.0	0.0	**0.0**	63.2	2.0	22.8	**88.1**
Vietnam	0.0	27.7	0.0	**27.7**	0.0	0.0	0.0	**0.0**	0.0	27.7	0.0	**27.7**
Indonesia[f,g]	15.3	333.3	1.5	**351.0**	0.0	20.8	0.2	**21.1**	15.3	354.2	1.7	**372.1**
Total	**179.2**	**622.7**	**37.4**	**846.9**	**66.7**	**190.9**	**23.2**	**285.1**	**245.9**	**813.5**	**60.6**	**1,132.1**
2020												
Australia	0.0	191.0	0.0	**191.0**	14.4	193.1	0.0	**207.6**	14.4	384.1	0.0	**398.5**
United States	40.6	14.7	0.9	**56.2**	29.1	26.0	21.2	**76.4**	69.7	40.8	22.1	**132.6**
Southern Africa[d]	32.5	60.5	0.0	**92.9**	13.2	3.4	0.0	**16.5**	45.6	63.8	0.0	**109.5**
Eurasia	52.1	49.9	0.0	**102.1**	4.5	11.7	0.0	**16.2**	56.6	61.7	0.0	**118.3**
Poland	4.0	0.0	0.0	**4.0**	1.0	0.0	0.0	**1.0**	5.0	0.0	0.0	**5.0**
Canada	0.0	7.1	0.0	**7.1**	5.9	17.1	12.1	**35.0**	5.9	24.2	12.1	**42.1**
China	0.0	16.5	0.0	**16.5**	0.0	1.0	0.0	**1.0**	0.0	17.5	0.0	**17.5**
South America[e]	96.7	0.0	33.2	**129.9**	0.0	0.0	0.0	**0.0**	96.7	0.0	33.2	**129.9**
Vietnam	0.0	14.1	0.0	**14.1**	0.0	0.2	0.0	**0.2**	0.0	14.3	0.0	**14.3**
Indonesia[f]	0.0	407.9	0.0	**407.9**	0.5	20.5	0.0	**21.1**	0.5	428.5	0.0	**429.0**
Total	**225.8**	**761.8**	**34.1**	**1,021.7**	**68.6**	**273.1**	**33.3**	**375.0**	**294.4**	**1,034.9**	**67.4**	**1,396.7**
2040												
Australia	0.0	315.4	0.0	**315.4**	15.8	229.6	0.0	**245.4**	15.8	545.0	0.0	**560.8**
United States	62.9	36.8	2.5	**102.2**	24.6	10.9	31.4	**66.9**	87.6	47.7	33.9	**169.2**
Southern Africa[d]	0.0	106.2	0.8	**107.0**	14.9	18.7	0.0	**33.6**	14.9	124.9	0.8	**140.6**
Eurasia	56.6	61.1	0.0	**117.6**	6.1	18.7	0.0	**24.8**	62.7	79.8	0.0	**142.5**
Poland	3.2	0.0	0.8	**4.0**	0.5	0.0	0.0	**0.5**	3.7	0.0	0.8	**4.5**
Canada	0.0	9.7	0.0	**9.7**	4.0	19.5	18.9	**42.3**	4.0	29.1	18.9	**52.0**
China	0.0	16.5	0.0	**16.5**	0.0	1.0	0.0	**1.0**	0.0	17.5	0.0	**17.5**
South America[e]	84.6	53.0	66.7	**204.2**	0.0	0.0	0.0	**0.0**	84.6	53.0	66.7	**204.2**
Vietnam	0.0	6.6	0.0	**6.6**	0.0	0.2	0.0	**0.2**	0.0	6.8	0.0	**6.8**
Indonesia[f]	0.0	431.0	6.7	**437.7**	0.5	20.5	0.0	**21.1**	0.5	451.5	6.7	**458.8**
Total	**207.3**	**1,036.3**	**77.4**	**1,321.0**	**66.4**	**319.2**	**50.3**	**435.9**	**273.6**	**1,355.5**	**127.7**	**1,756.8**

[a]Coal flows to Europe/Other include shipments to Europe, Eurasia, the Middle East, and Africa.
[b]For 2011, total world coal flows include a balancing item used to reconcile discrepancies between reported exports and imports. By coal type, the balancing items for 2011 are: steam, 7.6 million tons; coking, 4.4 million tons; and total, 12.0 million tons.
[c]Includes 19.0 million tons of coal shipped from Indonesia to Asian steelmakers in 2011 for pulverized coal injection at blast furnaces.
[d]Southern Africa consists of the countries of South Africa, Mozambique, and Botswana.
[e]Coal exports from South America are projected to originate from Colombia and Venezuela.
[f]Data exclude recent appearance of Indonesian coal export data classified as lignite and shipped to countries in Asia (primarily China). For 2011, Indonesia reported 33.0 million tons of lignite exports.
[g]For 2011, coal exports from Indonesia include shipments from other countries not modeled for the projection period. For 2011, the non-Indonesian exports by coal type were: steam, 13.6 million tons; coking, 2.1 million tons; and total, 15.7 million tons.
Note: With the exception of North America, non-seaborne coal trade is not represented in EIA's projections. According to data published in the International Energy Agency's *Coal Information 2012*, there was approximately 110 million tons of nonseaborne coal trade (excluding North America) in 2011.

Coal imports

Asia

Asia remains the world's largest importer of coal in the *IEO2013* Reference case, accounting for 87 percent of the growth in world coal imports from 2011 to 2040. As a result, the region's share of total world coal imports rises to 77 percent in 2040 from 72 percent in 2011. Asia's coal imports increase from 814 million tons in 2011 to 1,356 million tons in 2040. Five countries—Japan, South Korea, Taiwan, China, and India—accounted for approximately 90 percent of Asia's total annual coal imports during the years 2000 through 2011, but increases in coal imports by China and India have been more substantial than for other Asian countries, and as a result their combined share of the regional total has risen from 8 percent in 2000 to 41 percent in 2011. That trend continues in the *IEO2013* Reference case, with China and India accounting for slightly more than one-half of the region's coal imports in 2040.

China's seaborne coal imports double in the projection, from approximately 200 million tons in 2011 to 400 million tons in 2040. Despite that substantial increase in imports, most of the coal consumed in China in the *IEO2013* Reference case continues to be supplied from domestic coal producers, with the net import share of coal consumption increasing only slightly, from 5 percent in 2011 to 7 percent in 2040. China represents a key area of uncertainty, however, with respect to world coal trade projections. As the world's largest coal consumer and producer, even relatively small imbalances between China's supply and demand can have a substantial impact on world coal markets. In addition, a substantial amount of the intracoastal coal shipments from the eastern coast of China to southern ports can shift between domestic and international coal supplies. Although domestic coal currently satisfies most of the coal demand along China's southern coast, the situation could easily shift, requiring more imported coal.

In *IEO2013*, a number of factors limit China's seaborne imports. One is slower growth in China's coal consumption, which should enable China's domestic coal supply chain to keep up with the increase in its coal consumption. From 2010 to 2040, coal consumption in China grows by an average of 90 million tons per year, which is considerably less than the average increase of 200 million tons per year from 2000 to 2010. In addition to slower growth in coal consumption, there are a number of major infrastructure projects and policy initiatives underway to increase domestic coal production and transport. In the area of coal transportation, China currently is working on major new rail projects to facilitate additional movements of coal from the coal-producing regions in the north and west to demand centers in the east and south [*164*]. On the production side, efficiency gains at new large mining complexes and substantial expansions of domestic mine capacity in China's northern and western provinces, especially Inner Mongolia and Xinjiang, are taking place [*165*]. In an effort to limit requirements for additional coal transportation infrastructure, the government also is emphasizing the buildup of new industrial centers closer to the country's major coal-producing regions. Lastly, increasing coal imports from Mongolia, which are likely to be moved overland rather than by sea, further limit the need for seaborne imports.

India, like China, has been increasing its coal imports in recent years. In the *IEO2013* Reference case, India's coal imports increase from 140 million tons in 2011 to more than 300 million tons in 2040, spurred mainly by increasing imports of steam coal for electricity generation. Imports of coking coal increase as well, as India's steel industry expands, and domestic supply of coking-quality coals is limited. While India's coal consumption has increased substantially in recent years, the growth has been relatively modest in comparison with China's. India, however, has had problems expanding its coal production, and power companies have increasingly had to rely on the use of more expensive imported coal. Regulatory hurdles that have delayed the startup of mining activities on government-leased coal blocks often are cited as a reason for the increasing inability of coal supply to keep up with rising demand, although gaining approvals to increase production at existing mines is also a challenge. Difficulties in getting approvals to expand the country's rail transportation infrastructure also have contributed to the rising gap between consumption and domestic supply [*166*]. In addition to domestic coal supply problems, there are new coal-fired power plants being built along India's coastline with plans to use imported coal. One example is Tata Power's 4-gigawatt Mundra plant, which imports coal from Indonesia: three of its 800-megawatt units were commissioned in 2012, and the two remaining units are scheduled to come on line in 2013 [*167*].

After China and India, a small number of countries account for nearly all the remaining increase in non-OECD Asia coal imports. The region's current major coal importers—Taiwan, Malaysia, the Philippines, and Thailand—all increase their coal imports; and Vietnam, which imported very little coal in 2011, emerges as a major new coal-importing country, based on plans to build substantial amounts of new coal-fired electric generating capacity over the next 20 years. (Coal-fired electric generating capacity in Vietnam increases from 3 gigawatts in 2010 to as much as 36 gigawatts in 2020 and 76 gigawatts in 2030 [*168*].) Much of the new electric generating capacity will be sited in the southern part of the country, far from Vietnam's major coal deposits in the north.

Europe/Other

In the *IEO2013* Reference case, total coal imports to the Europe/Other region[35] increase from 246 million tons in 2011 to a peak of 297 million tons in 2015, then decline to 274 million tons in 2040. Coal becomes a less significant component of the region's fuel mix for electricity generation, with most European countries placing greater emphasis on renewable energy and natural gas for electricity generation. Other factors affecting the outlook for coal imports to Europe include environmental initiatives that further reduce emissions of sulfur dioxide, nitrogen oxide, and particulates, leading to some significant retirements of coal-fired generating capacity; the phase-out of domestic hard coal production in Germany by 2018; and Turkey's plans to increase its coal-

[35]Europe/Other includes coal importing countries in Europe, Eurasia, the Middle East, and Africa.

fired generating capacity substantially [*169*]. Restrictions on carbon dioxide emissions, primarily based on the European Union's Emissions Trading System, are another potential issue for European coal consumption and imports. Thus far, however, carbon dioxide emission prices have been relatively low and have not significantly affected Europe's coal demand [*170*].

Germany, the United Kingdom, Turkey, Italy, and Spain [*171*] accounted for more than 60 percent of Europe's total seaborne coal imports in 2011. The countries of OECD Europe account for more than 90 percent of total seaborne coal imports to the Europe/Other region both in 2011 and in the projection. Although there are significant amounts of overland coal trade between several countries in the non-OECD Europe and Eurasia region, only seaborne shipments of coal for Europe and Asia are represented in EIA's projections, primarily because of data availability issues and the increased complexity associated with modeling nonseaborne coal trade.

New coal-fired generating capacity in the *IEO2013* Reference case contributes to rising imports through 2015, especially in Turkey and Germany. Turkey has plans to add substantial amounts of new coal-fired generating capacity, much of which will burn domestic lignite coal; however, approximately 10 gigawatts of post-2010 additions, including both planned and under construction, is likely to be fueled by imports [*172*]. Germany is also adding new coal-fired generating capacity, with 8 gigawatts to be fueled by imported coal and 3 gigawatts by domestic lignite (2.1 gigawatts of new lignite capacity became operational in 2012) [*173*]. The new coal-import-based capacity additions, combined with the phasing out of its hard coal production by 2018, are factors that support increasing coal imports in Germany through 2020. Other coal-import-based capacity additions are either planned or under construction in Italy, the Netherlands, and Morocco [*174*].

In the longer term, the impact of new capacity on coal imports is diminished by the retirement of existing electric generating units in the *IEO2013* projection. The emission reduction requirements for coal-fired generating capacity established by the European Union's Large Combustion Plant Directive (LCPD) lead to some planned retirements of coal-fired capacity, particularly in the United Kingdom, where approximately 8 gigawatts of capacity will be shuttered [*175*]. On January 1, 2016, the LCPD will be superseded by the European Union's Industrial Emissions Directive (IED) [*176*], which will require additional cuts in emissions of sulfur dioxide, nitrogen oxide, and particulates. Additional retirements occur as a result of goals to increase generation from renewable energy in a number of European countries. For example, Germany has established a goal to increase the renewable share of its total electricity generation from approximately 20 percent in 2011 to 35 percent in 2020 and 65 percent in 2040 [*177*].

Americas

In the *IEO2013* Reference case, coal imports in the Americas increase from 61 million tons in 2011 to 67 million tons in 2020 and 128 million tons in 2040. The share of total imports made up by steam coal falls from more than 60 percent in 2011 to approximately 50 percent in 2020, as steam coal imports in both Canada and the United States continue to decline over the next few years, and as coking coal imports in Brazil increase. In 2040, steam coal's share of the total recovers to the 2011 level, primarily as a result of increases in steam coal imports by the United States. Relative to global coal trade, the coal import market for the Americas is relatively small, accounting for only 5 percent of the world total in 2011 and increasing only slightly to 7 percent of the world total by 2040.

Five countries accounted for approximately 90 percent of the region's total coal imports in 2011: Brazil, the United States, Chile, Canada, and Mexico [*178*]. The United States and Canada were the top two coal-importing countries in the Americas from 2001 to 2008, but imports by both countries have fallen substantially in recent years. U.S. coal imports have declined as coal-fired generating capacity fueled by imported coal has become less competitive with power plants fueled by domestic natural gas (which has become significantly less expensive since 2008), and Canada's imports have declined as a result of the ongoing phaseout of Ontario's coal-fired generating capacity.

In the *IEO2013* Reference case, U.S. coal imports decline from 11 million tons in 2011 to a low of less than 2 million tons in 2017, where they remain for several years. From 2030 to 2040, however, imported coal from South America emerges as a competitive source of fuel for generation at power plants in the U.S. Southeast, and coal imports increase from 5 million tons to 38 million tons. Increases in overall U.S. electricity demand, combined with rising natural gas prices and a lack of national-level restrictions on CO_2 emissions, lead to higher utilization of existing coal-fired generating capacity and, in turn, increasing demand for both domestic and foreign coal.

Canada, which was a major destination for U.S. coal exports over many years, has seen its coal imports decline substantially from a recent peak of 25 million tons in 2008 to 8 million tons in 2011. Further declines in Canada's coal imports are expected over the next several years, as Ontario's provincial government follows through, for environmental reasons, with the final and complete phaseout of its remaining 3.3 gigawatts of coal-fired generating capacity in 2013 and 2014 [*179*]. The phaseout will leave Canada with only a few million tons of coking coal imports, primarily for use at coke plants in Ontario, and 2 million to 3 million tons of steam coal imports for use at power plants in Nova Scotia and New Brunswick.

Brazil's steelmaking capacity increases in the Reference case, taking advantage of its domestic resources of iron ore but requiring increased use of coking-grade coal that the country does not produce domestically. Imports of coking coal to the Americas—primarily to Brazil—increase from 23 million tons in 2011 to 50 million tons in 2040. Brazil and Chile account for most of the increase in imports of thermal coal to South America through 2040. Brazil's MPX Energia is completing or has recently completed the construction of three new coal-fired generating units—Pecem I, Pecem II, and Itaqui—in northeastern Brazil, with a combined generating capacity of 1.4 gigawatts, which will be fueled with imported coal from Colombia [*180*].

Coal exports

As indicated above, most of the world's coal trade consists of steam coal. The top five exporters of steam coal in 2011 were Indonesia, Australia, South America (primarily Colombia), Eurasia (primarily Russia), and Southern Africa (primarily South Africa). Indonesia, currently the world's largest exporter of steam coal, maintains that position through 2040. The three top exporters of coking coal in 2011 were Australia, the United States, and Canada, and they remain so through 2040—although coking coal exports from Southern Africa increase substantially in the projection, as international energy companies begin to tap into and produce coking-quality coal from reserves in Mozambique.

Australia, which was the world's leading coal exporter for many years, was displaced from its position by Indonesia in 2011. While Indonesian coal exports increased by 36 million tons in 2011, Australia's exports fell by 21 million tons, as severe flooding in the state of Queensland in early 2011 significantly reduced its overall coal production and exports for the year. Nearly all of Australia's coal exports originate from two eastern states, Queensland in the northeast and New South Wales in the southeast. Queensland currently exports slightly more coal, with coking coal accounting for about 70 percent of its export tonnage [*181*]. Coal exports from New South Wales are primarily steam coal, which accounts for roughly 80 percent of its total export tonnage [*182*]. Australia exported 310 million tons of coal in 2011 (27 percent of total world coal trade), consisting of 164 million tons of steam coal and 147 million tons of coking coal.

In *IEO2013*, Australia dominates the outlook for international coal trade, with exports rising to 561 million tons and accounting for 32 percent of total world coal trade in 2040. According to a report released by the Australian government in December 2012, both the country's coal mining and coal transportation infrastructure will be expanded significantly over the next few years, with approximately 65 million tons of additional coal production capacity set to come on line, along with more than 80 million tons of port capacity expansions (40 million tons in New South Wales and 42 million tons in Queensland) [*183*].

Indonesia's coal exports increased dramatically from 63 million tons in 2000 to 356 million tons in 2011 as a result of the competitiveness of its low-cost surface mines. Indonesia lacks significant reserves of coking quality coal, and nearly all of its current coal exports are steam coal. In the *IEO2013* Reference case, Indonesia's coal exports increase to 459 million tons in 2040, with 98 percent shipped to countries in Asia, up from 95 percent in 2011.

While future increases in exports of Indonesian coal are not expected to be limited by production infrastructure or port export capacity [*184*], there are several policy-related factors that could limit export growth. One is Indonesia's domestic market obligation law, which took effect in 2009 and requires Indonesian coal producers to set aside a certain percentage of their output each year for domestic coal buyers. Because of delays in bringing new coal-fired generating capacity on line and subsequent slower growth in coal demand than expected, the law so far has not been a significant impediment to coal exports [*185*]. In addition, government plans for new generating capacity in Indonesia have recently been shifting away from coal toward renewable generating technologies, such as geothermal and conventional hydroelectric [*186*]. On another front, the government had been working on a draft regulation that would restrict exports to coals with higher heat content as a way of preserving lower quality coals for future domestic use. The ban was to take effect in January 2014, but at the beginning of 2013 the government backed away from plans to move forward with the regulation, with the director of Indonesia's Energy and Mineral Resources Ministry indicating that the regulation would have "stopped mining activity" in the country [*187*].

From 2000 to 2011, coal exports from Southern Africa varied between 69 million tons and 79 million tons, with 77 million tons of exports recorded in 2011. Historically, South Africa has accounted for virtually all of Africa's coal export shipments, but the situation is changing with coal producers in Mozambique and, to a lesser extent, Botswana gearing up to export substantial quantities of coal to international markets. In South Africa, current activities are aimed at increasing the country's coal exports, including the development of new coal mines, port capacity expansions, and projects to expand rail capacity for hauling coal. In 2010, the annual throughput capacity at Richards Bay Coal Terminal, the country's main coal export facility, was increased from 79 million tons to 101 million tons, although the rail network serving the port still is not capable of transporting that amount of coal [*188*]. In 2012, 75 million tons of coal was exported through the Richards Bay Coal Terminal, up from 72 million tons in 2011. South Africa's coal mines also export coal through the Matola Terminal in neighboring Mozambique [*189*], which currently has an annual throughput capacity of about 7 million tons. However, there is growing interest in expanding its capacity to perhaps more than 20 million tons later in the decade [*190*].

Mozambique plays an emerging role in world coal trade in the *IEO2013* Reference case. A number of large international energy and steel companies are involved with the development of new coal mining projects in Mozambique, including Brazil's Vale SA; Australia's Rio Tinto; Australia's Beacon Hill Resources; India's Jindal Steel and Power, Ltd.; and the United Kingdom's Anglo American, which is the majority stakeholder in a joint venture with Japan's Nippon Steel and South Korea's Posco [*191*]. While some minor shipments occurred in 2011, the first substantial exports were in 2012, when about 3 million tons were shipped out of Mozambique, primarily from coal produced at Vale's Moatize coal mine [*192*]. In the near term, the primary factor limiting coal exports from Mozambique is the development of rail transportation infrastructure for moving coal from mines to ports. Currently, Vale is shipping coal on the 357-mile-long Sena Railway to Mozambique's Port Beira for export to overseas markets, but the rail line has an annual capacity of only about 7 million tons [*193*]. A further upgrade of the Sena Railway line to 20 million tons could be completed as soon as the end of 2014. Construction of a new 567-mile rail line to the port of Nacala in Mozambique, with a potential capacity of 40 million tons per year, is also underway and could be ready for initial freight shipments by the end of 2014 [*194*].

In the *IEO2013* Reference case, coal exports from Southern Africa grow from 77 million tons in 2011 to 109 million tons in 2020 and 141 million tons in 2040. Coking coal exports increase from 1 million tons in 2011 to 34 million tons in 2040, with most of the additional coking coal expected to come from Mozambique, although several new mines under development in northeastern South Africa also are expected to produce some coking-quality coals for export [*195*].

Although Eurasia has several coal-exporting countries, most of the seaborne coal exports from the region originate from mines in Russia. Ukraine currently ships a few million tons of coal annually to international markets from its ports on the Black Sea, and coal exports from Kazakhstan consist primarily of nonseaborne shipments to Russia. Over the past decade, coal exports from Eurasia have increased considerably, from 31 million tons in 2000 to 92 million tons in 2011. European countries were the primary area of growth for coal exports from Eurasia during the first half of that period, but since 2008 Asia has become the new area of growth for the region's coal exports. In 2011, Eurasia exported 52 million tons of coal to Europe and 40 million tons to Asia. With coal exports, particularly exports to Asia, viewed as a growth area, Russian companies continue to make investments in both mining capacity and port capacity. Coal production in the Kuzbass region, which grew to 220 million tons in 2012, continues increasing, with four new mines coming on line in 2012 [*196*]. Investments also are being made in new mining capacity in the coal basins of eastern Siberia, as companies look to capitalize on the relatively shorter rail hauls to ports serving Asian coal markets. Mechel's Elga coal mine, in the far eastern republic of Sakha, is a good example of such an operation. With initial production in 2011, the Elga mine plans to increase production to as much as 20 million tons by the end of the decade, exporting nearly all of its output, both steam and coking coals, to Asian customers [*197*]. The coal will be transported by rail to the far eastern port of Vanino, in which Mechel recently acquired a 55-percent ownership share. In the *IEO2013* projection, Eurasia's coal exports increase from 92 million tons in 2011 to 142 million tons in 2040.

Although Russia is one of the world's top coal-exporting countries, long inland transport distances from major coal-producing areas to export terminals add substantially to the cost of its coal exports at the ports. For example, rail shipping distances from the country's top-producing Kuzbass region in western Siberia to ports in northwest Russia, such as Ust-Luga, are approximately 2,600 miles, and rail shipping distances from Kuzbass to far eastern ports, such as Vostochniy, are in excess of 3,600 miles, translating into shipping costs in excess of $40 per ton [*198*]. On the other hand, Russia's relatively low coal production costs counterbalance the high inland transportation costs, keeping its exports competitive in world markets.

South America remains one of the top five coal-exporting regions through 2040, primarily as a result of continuing increases in exports from Colombia. The government of Colombia has a goal of improving the country's coal transportation infrastructure in an effort to increase its coal production to as much as 165 million tons by 2020 from 98 million tons in 2012 [*199*]. The expansion will require sizable investments in mine capacity, rail infrastructure, and port capacity. Cerrejon, the country's largest coal producer, plans to increase its production from 38 million tons in 2012 to 44 million tons in 2014, and Prodeco, the third-largest producer, plans to increase output from 16 million tons in 2012 to 23 million tons in 2015 [*200*]. Prodeco also is in the process of completing a new 24-million-ton coal export terminal at Santa Marta, Colombia. Drummond, Colombia's second-largest coal producer, has near-term plans to increase its production by a little more than 5 million tons above the 2012 level and is also building a new coal export terminal at Santa Marta [*201*]. CCX Carvero de Colombia, a potential new entrant to the country's coal industry, has plans to develop a new underground coal mine capable of producing more than 25 million tons of coal per year, along with two surface mines with a combined capacity of more than 5 million tons. CCX is also seeking licenses to develop a new 39-million-ton coal export terminal at La Guajira, Colombia, and a 93-mile-long rail line to transport its coal to the port [*202*]. In the *IEO2013* Reference case, coal exports from South America increase from 88 million tons in 2011 to 130 million tons in 2020 and 204 million tons in 2040.

The United States ranked as the world's third-largest coal exporter in both 2011 and 2012, shipping a record-breaking 126 million tons of coal to international markets in 2012—a substantial turnaround from the early to mid-2000s, when U.S. coal producers exported roughly 50 million tons of coal per year, between 31 and 48 percent of which went to Canada alone. The recent surge in U.S. coal exports, from 59 million tons in 2009 to 126 million tons in 2012, is attributable to a number of factors, including substantial growth in total world coal trade; the recovery of coal import demand in OECD countries following the recessionary downturn in 2009; weather- and labor-related supply disruptions in some of the key coal-exporting countries; substantial declines in demand for coal in the U.S. electric power sector in 2011 and 2012; and strong pricing for both coking and steam coals in international markets. The United States has benefited from increased export sales to customers in both Europe and Asia, with exports to the Europe/Other region increasing by 39 million tons and exports to Asia increasing by 26 million tons from 2009 to 2012. U.S. coal exports to the Americas remained mostly unchanged over the same period, with declines in coal exports to Canada offset by increases in exports to Brazil, Chile, and Mexico. In 2012, the United States exported 7 million tons of coal to Canada, representing only 6 percent of total U.S. exports. Historically, U.S. coal exports have been fairly evenly divided between coking and steam coal, with coking coal generally accounting for slightly more than one-half of total export sales.

With the combination of strong growth in world coal trade, high international coal prices, and declining demand for coal in the U.S. electric power sector, there has been a surge in activity and investment in port capacity expansion projects to facilitate the growth of U.S. coal exports. Although plans to construct new coal ports along the coastlines of Washington and Oregon to support exports of western coal to Asia face some considerable hurdles, a substantial number of projects on the U.S. Gulf coast are moving ahead. Those projects will add approximately 50 million tons of additional export capacity between 2012 and 2015 [*203*]. Currently there are three coal export projects proposed for the U.S. West Coast, which together could add more than 100 million tons of annual coal export capacity [*204*]. For now, port capacity for coal exports along the U.S. West Coast (excluding Alaska) is limited to a couple of million tons, primarily out of the Port of Long Beach in California.

In addition to U.S. coal ports, several coal producers in the western United States have secured the rights to—and currently are exporting coal through—the Westshore and Ridley coal terminals in Canada (reported in EIA's *Quarterly Coal Report* as U.S. coal exports out of the Seattle, Washington, customs district). Westshore reported that it handled 9 million tons of U.S. coal exports in 2011 [*205*]. The transportation costs associated with shipping western coal to these ports are substantial, however, with rail shipping distances that can exceed 2,500 miles for U.S. coal shipments out of Ridley and 1,500 miles for coal shipped out of the Westshore Terminals near Vancouver [*206*]. Although rail shipping distances from Powder River Basin mines in Wyoming and Montana to potential port facilities in Washington and Oregon would not be substantially shorter than the distances to Westshore in Canada, U.S. coal producers could potentially export much larger quantities of coal, and they would not have to compete with Canadian mines for export terminal capacity.

In the *IEO2013* Reference case, U.S. coal exports increase from about 107 million tons in 2011 to 169 million tons in 2040, buoyed primarily by the overall increase in world coal trade. Although most of the coal exported from the United States originates from mines in the Appalachian coal basin, all of the increment in U.S. coal exports through 2040 in *IEO2013* is from the Interior and Western supply regions.

Of potential benefit to both U.S. and Colombian coal producers is the planned completion of the Panama Canal expansion project in 2015, which will allow for the transit of larger bulk shipping vessels through the canal and should result in slightly lower freight rates for coal shipped to Asian markets [*207*]. While only bulk-carrier vessels of Panamax size (approximately 80,000 deadweight tons) or smaller can use the canal currently, the expansion will allow for the transit of post-Panamax or smaller capesize vessels with rated capacities of up to 140,000 deadweight tons [*208*]. Currently, capesize shipments of coal from ports in Colombia and the U.S. East and Gulf coasts to Asia generally travel a longer route around the tip of Africa (Cape of Good Hope). As an example, the shipping distance from Puerto Prodeco, Colombia, to Guangzhou, China, is approximately 13,000 nautical miles via the Cape of Good Hope but only about 9,700 nautical miles through the Panama Canal [*209*]. During fiscal year 2011 (ending on September 30, 2011), the Panama Canal Authority reported that 12 million tons of coal were shipped from the Atlantic to the Pacific, including some going to the west coast of South America and the remainder going primarily to Asia [*210*]. In comparison, 24 million tons of coal were shipped to Asia in calendar year 2011 from the U.S. East and Gulf coasts, Colombia, and Venezuela [*211*].

Canada exported 37 million tons of coal in 2011—the highest level since 2000, when exports totaled 38 million tons. Canada is primarily a coking coal exporter, with steam coal accounting for less than 20 percent of its total exports. Currently, Canada's exports originate solely from mines located in the province of British Columbia and are shipped out of three coal export terminals (Westshore, Neptune, and Ridley) located along the Pacific Coast (although some coking coal is shipped by rail to coke plants in the U.S. Midwest). All of Canada's western coal export terminals have either recently increased or are in the process of expanding their capacity, primarily as a result of increasing demand for coal imports by Asian countries. Westshore Terminals recently increased its annual capacity from 32 million tons to 36 million tons, and its plans for upgrading equipment at the terminal will increase capacity by another 2 to 3 million tons by 2018 [*212*]. Neptune Terminals is planning to increase capacity from 13 million tons per year to 20 million tons, and Ridley plans to double annual throughput capacity from 13 million tons to 26 million tons [*213*]. Two export-oriented mining projects currently in the works in western Canada are the planned restart of Teck Resources Ltd.'s coking coal mine in British Columbia in 2014, with a planned capacity of 4 million tons per year, and plans by the Australian company Coalspur to develop a new coal mine in Alberta that would ship as much as 12 million tons of steam coal to Asian markets by the end of the decade, with initial shipments out of Ridley Terminal beginning as early as 2015 [*214*]. In the *IEO2013* Reference case, Canada's coal exports increase from 37 million tons in 2011 to 52 million tons in 2040.

World coal reserves

As of January 1, 2009, total recoverable reserves of coal around the world were estimated at 946 billion tons—reflecting a reserves-to-production ratio of approximately 120 years (Table 12).[36] Historically, estimates of world recoverable coal reserves, although relatively stable, have declined gradually from 1,145 billion tons in 1991 to 909 billion tons in 2008 [*215*]. In 2009, however, the estimate increased to 946 billion tons with the upward revision of 37 billion tons reflecting a new assessment of Germany's lignite reserves. Although the overall decline in estimated reserves from 1991 to 2009 is sizable, the large reserves-to-production ratio for world coal indicates that sufficient coal will be available to meet demand well into the future. Further, because recoverable reserves are a subset of total coal resources, recoverable reserve estimates for a number of regions with large coal resource bases—notably, China and the United States—could increase substantially as coal mining technology improves and additional geological assessments of coal resources are completed.

[36]Recoverable reserves are those quantities of coal that geological and engineering information indicates with reasonable certainty can be extracted in the future under existing economic and operating conditions. The reserves-to-production ratio is based on the reserves estimates and data on world coal production for 2010, shown in Table 10.

Although coal deposits are widely distributed, 79 percent of the world's recoverable reserves are located in five regions: the United States (27 percent), Russia (18 percent), China (13 percent), non-OECD Europe and Eurasia outside of Russia (11 percent), and Australia/New Zealand (9 percent). In 2010, the five regions together produced 5.7 billion tons (113.0 quadrillion Btu) of coal, representing 72 percent of total world coal production by tonnage and 75 percent on a Btu basis [*216*]. By rank, anthracite and bituminous coal account for 47 percent of the world's estimated recoverable coal reserves on a tonnage basis, subbituminous coal accounts for 30 percent, and lignite accounts for 23 percent.

Quality and geological characteristics of coal deposits are important parameters for coal reserves. Coal is heterogeneous, with quality (for example, characteristics such as heat, sulfur, and ash content) varying significantly by region and even within individual coal seams. At the top end of the quality spectrum are premium-grade bituminous coals, or coking coals, used to manufacture coke for the steelmaking process. Coking coals produced in the United States have an estimated heat content of 26.3 million Btu per ton and relatively low sulfur content of approximately 0.9 percent by weight [*217*]. At the other end of the spectrum are reserves of low-Btu lignite. On a Btu basis, lignite reserves show considerable variation. Estimates published by the International Energy Agency for 2010 indicate that the average heat content of lignite in major producing countries varies from a low of 4.9 million Btu per ton in Greece to a high of 12.9 million Btu per ton in Canada [*218*].

Table 12. World recoverable coal reserves as of January 1, 2009 (billion short tons)

	Recoverable reserves by coal rank					
Region/Country	Bituminous and anthracite	Subbituminous	Lignite	Total	2010 production	Reserves-to-production ratio (years)
World total	**445.0**	**285.9**	**215.2**	**946.1**	**7.954**	**119**
United States[a]	118.4	107.2	33.1	**258.6**	1.084	238
Russia	54.1	107.4	11.5	**173.1**	0.359	482
China	68.6	37.1	20.5	**126.2**	3.506	36
Other non-OECD Europe and Eurasia	42.2	18.9	39.9	**100.9**	0.325	311
Australia and New Zealand	40.9	2.5	41.4	**84.8**	0.473	179
India	61.8	0.0	5.0	**66.8**	0.612	109
OECD Europe	6.2	0.9	54.5	**61.6**	0.620	99
Africa	34.7	0.2	0.0	**34.9**	0.286	122
Other non-OECD Asia	3.9	3.9	6.8	**14.7**	0.508	29
Other Central and South America	7.6	1.0	0.0	**8.6**	0.085	101
Canada	3.8	1.0	2.5	**7.3**	0.075	97
Brazil	0.0	5.0	0.0	**5.0**	0.006	842
Other[b]	2.6	0.8	0.1	**3.6**	0.015	233

[a]Data for the United States represent recoverable coal estimates as of January 1, 2012.
[b]Includes Mexico, Chile, Middle East, Japan, South Korea, and Greenland.

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Chapter 5
Electricity

Overview

World net electricity generation increases by 93 percent in the *IEO2013* Reference case, from 20.2 trillion kilowatthours in 2010 to 39.0 trillion kilowatthours in 2040 (Table 13). Electricity supplies an increasing share of the world's total energy demand and is the world's fastest-growing form of delivered energy (Figure 80). World electricity delivered to end users rises by 2.2 percent per year from 2010 to 2040, as compared with average growth of 1.4 percent per year for all delivered energy sources.

In general, projected growth in OECD countries, where electricity markets are well established and consumption patterns are mature, is slower than in non-OECD countries, where at present many people do not have access to electricity. The electrification of historically off-grid areas plays a strong role in determining relative growth. The International Energy Agency estimates that 19 percent of the world's population, or about 1.3 billion people [*219*], did not have access to electricity in 2010. Moreover, almost 57 percent of the population in Africa currently remains without access to electric power.

Non-OECD nations consumed 49 percent of the world's total electricity supply in 2010, and their share of world consumption is expected to increase over the projection period. In 2040, non-OECD nations account for 64 percent of world electricity use (Figure 81). Total net electricity generation in non-OECD countries increases by an average of 3.1 percent per year in the Reference case, led by annual increases averaging 3.6 percent in non-OECD Asia (including China and India) from 2010 to 2040 (Figure 82). In contrast, total net generation in the OECD nations grows by an average of only 1.1 percent per year from 2010 to 2040.

The *IEO2013* Reference case projections do not incorporate assumptions about future policies and regulations related to limiting or reducing greenhouse gas emissions, such as caps or taxes on carbon dioxide emissions. The Reference case does, however, incorporate existing regulations and national energy policies, such as the European Union's 20-20-20 plan and its member states' nuclear policies; China's wind capacity targets; and India's National Solar Mission. Any new and unanticipated government policies or legislation aimed at limiting or reducing greenhouse gas emissions could substantially change the trajectories of fossil and nonfossil fuel consumption presented in this outlook.

Table 13. OECD and non-OECD net electricity generation by energy source, 2010-2040 (trillion kilowatthours)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
Liquids	0.3	0.3	0.2	0.2	0.2	0.2	0.2	-1.1
Natural gas	2.4	2.7	2.9	3.1	3.5	3.9	4.3	2.0
Coal	3.5	3.3	3.3	3.3	3.3	3.3	3.3	-0.2
Nuclear	2.2	2.1	2.4	2.6	2.7	2.7	2.7	0.7
Renewables	1.9	2.4	2.8	3.0	3.2	3.4	3.7	2.2
Total OECD	**10.3**	**10.8**	**11.5**	**12.2**	**12.9**	**13.5**	**14.2**	**1.1**
Non-OECD								
Liquids	0.6	0.6	0.6	0.6	0.5	0.5	0.5	-0.9
Natural gas	2.1	2.3	2.6	3.1	3.7	4.4	5.0	3.0
Coal	4.6	5.9	6.9	8.0	9.0	9.9	10.6	2.9
Nuclear	0.4	0.8	1.3	1.7	2.1	2.5	2.8	6.3
Renewables	2.2	2.9	3.7	4.2	4.7	5.3	5.9	3.3
Total non-OECD	**9.9**	**12.5**	**15.1**	**17.6**	**20.1**	**22.6**	**24.8**	**3.1**
World								
Liquids	0.9	0.9	0.8	0.8	0.7	0.7	0.7	-1.0
Natural gas	4.5	5.0	5.5	6.2	7.2	8.3	9.4	2.5
Coal	8.1	9.2	10.1	11.3	12.3	13.2	13.9	1.8
Nuclear	2.6	2.9	3.6	4.3	4.8	5.1	5.5	2.5
Renewables	4.2	5.3	6.5	7.2	7.9	8.8	9.6	2.8
Total World	**20.2**	**23.3**	**26.6**	**29.8**	**33.0**	**36.2**	**39.0**	**2.2**

Electricity generation by source

The worldwide mix of primary fuels used to generate electricity has changed a great deal over the past four decades. Coal continues to be the fuel most widely used in electricity generation, although generation from nuclear power increased rapidly from the 1970s through the 1980s, and natural gas-fired generation grew rapidly in the 1980s, 1990s, and 2000s. The use of oil for electricity generation has declined since the late 1970s, when oil prices rose sharply [220].

Beginning in the early 2000s, high fossil fuel prices in combination with concerns about the environmental consequences of greenhouse gas emissions resulted in interest in developing alternatives to fossil fuels for generation—specifically, nuclear power and renewable energy sources. In the *IEO2013* Reference case, long-term global prospects continue to improve for generation from both nuclear and renewable energy sources. Renewable energy sources are the fastest-growing sources of electricity generation in the *IEO2013* Reference case, with annual increases averaging 2.8 percent per year from 2010 to 2040 (Figure 83). In particular, nonhydropower renewable resources are the fastest-growing sources of new generation in the outlook, in both OECD and non-OECD regions. Nonhydropower renewables, which accounted for 4 percent of the generation market in 2010, increase their share of the market to 9 percent in 2040, with much of the growth coming from wind generation.

After renewable energy sources, natural gas and nuclear power are the next fastest-growing generation sources, both increasing by 2.5 percent per year from 2010 to 2040. Although coal-fired generation increases by a slower annual average of 1.8 percent over the projection period, it remains the largest source of generation through 2040 and grows by the largest absolute amount over the period. The outlook for coal could be altered substantially, however, by any future national policies or international agreements

Figure 80. Growth in world total electricity generation and total delivered energy consumption, 1990-2040 (index, 1990 = 1)

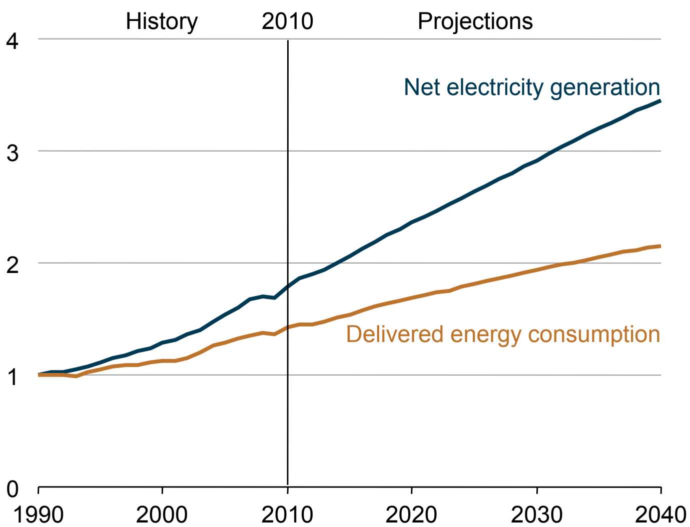


Figure 81. OECD and non-OECD net electricity generation, 1990-2040 (trillion kilowatthours)

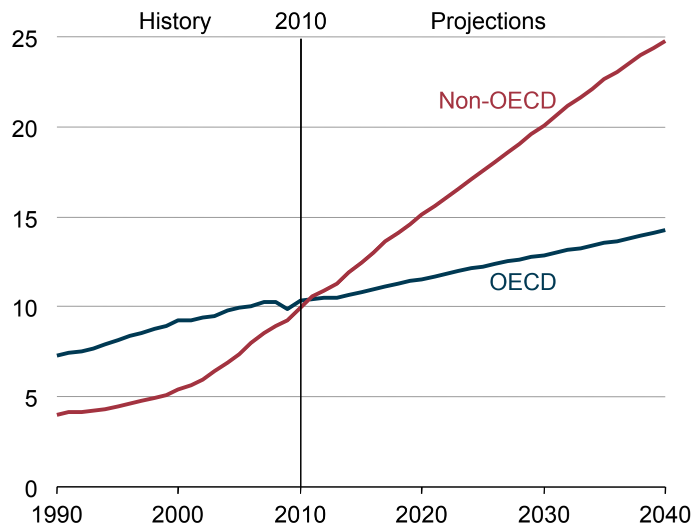


Figure 82. Non-OECD net electricity generation by region, 1990-2040 (trillion kilowatthours)

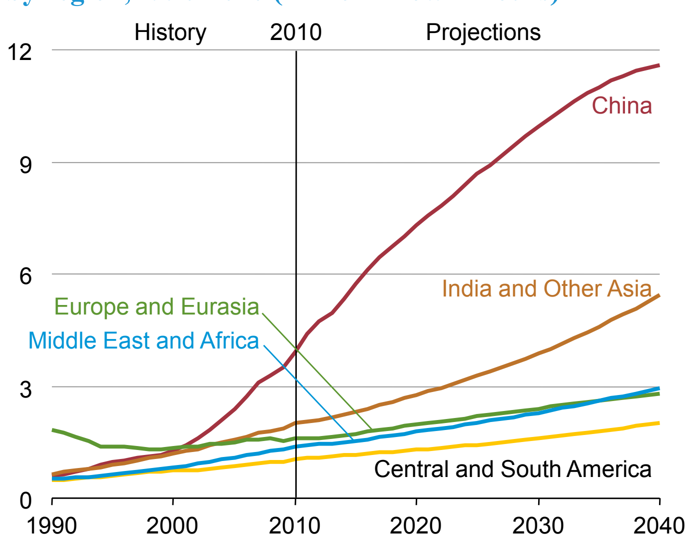
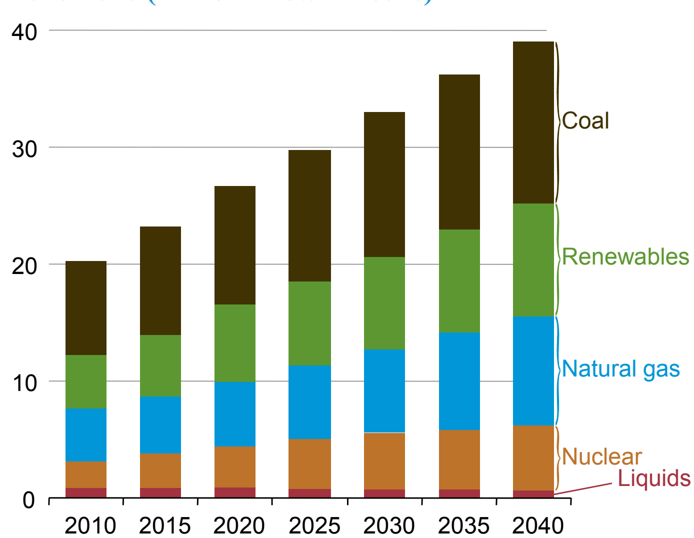


Figure 83. World net electricity generation by fuel, 2010-2040 (trillion kilowatthours)



aimed at reducing or limiting the growth of greenhouse gas emissions. In addition, should the fast-paced growth in U.S. shale gas production in recent years be replicated in other nations with shale gas resources (notably China), the outlook for world natural gas-fired electricity generation could be much different from that presented in the *IEO2013* Reference case.

Coal

Coal is the predominant fuel used for electricity generation worldwide. In 2010, coal-fired generation accounted for 40 percent of overall worldwide electricity generation. Coal-fired electricity generation grows in the Reference case at a 1.8-percent annual rate from 2010 to 2040. In 2040, total world electricity generation from coal is 73 percent higher than the 2010 level, although coal's share of the electricity market falls to 36 percent in 2040. China and India alone account for 89 percent of the projected growth in coal-fired generation. In contrast, OECD nations reduce their reliance on coal-fired electricity generation, with environmental factors, particularly in OECD Europe, playing a sizable role in the reduction.

Natural gas

In 2010, natural gas accounted for 22 percent of the world's electricity generation. Its projected share rises to 24 percent in 2040. Prospects for natural gas have improved substantially over the past several years, in large part because of revised expectations for shale gas, tight gas, and coalbed methane—especially shale gas—both within the United States and globally. The additional resources will allow natural gas supplies to be used as LNG to supply markets that have few domestic resources. As a result, natural gas markets remain well supplied, with prices relatively low in the mid-term, as many nations turn to natural gas, rather than more expensive or more carbon-intensive sources of electricity, to supply their future power needs.

Petroleum and other liquid fuels

Electricity generation from petroleum and other liquid fuels declines over the *IEO2013* projection period, continuing a two-decade-long trend. Worldwide, electricity generation derived from liquids falls from 5 percent of total production in 2010 to 2 percent in 2040. Nations respond to high, sustained oil prices by reducing or eliminating their use of oil for generation—opting instead for alternative sources of electricity, including natural gas and nuclear. Even in the petroleum-rich Middle East, there is an effort to reduce the use of liquids for generation in favor of natural gas and other resources, in order to maximize revenues from oil exports. The liquids share of total generation in the Middle East region declines from 34 percent in 2010 to 14 percent in 2040.

Nuclear power

Electricity generation from nuclear power worldwide increases from 2,620 billion kilowatthours in 2010 to 5,492 billion kilowatthours in 2040 in the *IEO2013* Reference case, as concerns about energy security and greenhouse gas emissions support the development of new nuclear generating capacity. In addition, world average capacity utilization rates have generally risen over time, from about 68 percent in 1980 to about 80 percent in 2011. Factors underlying the *IEO2013* nuclear power projections include the consequences of the March 2011 disaster at Fukushima Daiichi, Japan; planned retirements of nuclear capacity in OECD Europe under current policies; and continued strong growth of nuclear power in non-OECD Asia.

Japan significantly curtailed its nuclear generation as a direct result of the Tōhoku earthquake and related tsunami on March 11, 2011. In addition to the four damaged Fukushima Daiichi reactors, Japan's 50 other nuclear reactors were shut down over the following 14 months. Japan compensated for the loss of nuclear generation by increasing its generation from natural gas, oil, and coal and by implementing efficiency and conservation measures to reduce load. Two reactors have returned to service, and additional reactors are expected to return to service soon. In the *IEO2013* Reference case, fossil fuel generation and conservation continue to bridge the gap left by the shutdown of Japan's nuclear plants.

The Fukushima Daiichi disaster could have long-term implications for the future of world nuclear power development in general. Even China—where large increases in nuclear capacity have been announced and are anticipated in the *IEO2013* Reference case—halted approval processes for all new reactors until the country's nuclear regulator completed its safety review. Germany and Switzerland announced plans to phase out or shut down their operating reactors by 2022 and 2034, respectively. Although the *IEO2013* Reference case considered the impacts of the disaster at Fukushima Daiichi, the uncertainty associated with nuclear power projections for Japan and for the rest of the world has increased.

On a regional basis, the *IEO2013* Reference case projects the strongest growth in nuclear power for the countries of non-OECD Asia, which average 9.2 percent per year from 2010 to 2040, including average increases of 10.2 percent per year in China and 10.6 percent per year in India (Figure 84). China leads the region with 43 percent of the world's active reactor projects under construction in 2011 and installs the most nuclear capacity over the period, building 160 gigawatts of net generation capacity by 2040. Outside Asia, the largest increase in nuclear generation is in OECD Europe, at a relatively modest average rate of 0.7 percent per year. Worldwide, nuclear generation increases by 2.5 percent per year in the Reference case.

In *IEO2013*, the rate of growth in nuclear power generation worldwide is slower than in previous *IEO* projections. High capital and maintenance costs may keep some countries from expanding their nuclear power programs, while a lack of trained labor resources, concerns about safety, and limited global nuclear supply chain capability could keep national nuclear programs from meeting previously planned schedules.

To address the uncertainty inherent in projecting nuclear power growth in the long term, a two-step approach is used. In the short term (through 2020), projections are based primarily on the current activities (planning documents, energy policies, forecasts, etc.) of the nuclear power industry and national governments. Because of the long permitting and construction lead times associated with nuclear power plants, there is general agreement among analysts on which nuclear projects are likely to become operational in the short term. After 2020, the projections are based on a combination of announced plans or goals at the country and regional levels and consideration of other long-term issues facing the development of nuclear power, including economic issues, geopolitical issues, technology advances, environmental policies, uranium availability, and the viability of alternative technologies for electricity production.

Hydroelectric and other renewable resources[37]

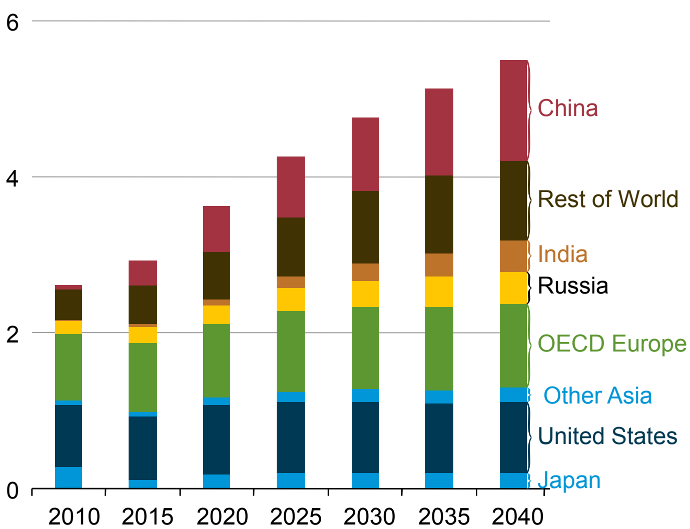
Renewable energy is the fastest-growing source of electricity generation in the *IEO2013* Reference case. Total generation from renewable resources increases by 2.8 percent annually, and the renewable share of world electricity generation grows from 21 percent in 2010 to 25 percent in 2040. About 80 percent of the increase is in hydroelectric and wind power. The contribution of wind power, in particular, has grown swiftly over the past decade, from 31.4 billion kilowatthours of net generation in 2000 to 341.5 billion kilowatthours in 2010—a trend that continues in the Reference case projection. Of the 5.4 trillion kilowatthours of new renewable generation added over the projection period, 2.8 trillion kilowatthours (52 percent) is attributed to hydroelectric power and 1.5 trillion kilowatthours (28 percent) to wind (Table 14).

Although renewable energy sources have positive environmental and energy security attributes, most renewable technologies other than hydroelectricity do not compete economically with fossil fuels, except in a few regions or in niche markets. Solar power, for instance, is currently a niche source of renewable energy, but it can be competitive where electricity prices are especially high, where peak load pricing occurs, where government incentives are available, or where infrastructure interconnection issues pose large costs. Government policies or incentives often provide support for construction of renewable generation facilities.

Changes in the mix of renewable fuels used for electricity generation differ between the OECD and non-OECD regions in the *IEO2013* Reference case. In the OECD nations, most of the hydroelectric resources that are both economical to develop and also meet environmental regulations have already been exploited. With the exceptions of Canada and Turkey, there are few large-scale hydroelectric projects planned for the future. As a result, most renewable energy growth in OECD countries comes from nonhydroelectric sources, especially wind and solar. Many OECD countries, particularly those in Europe, have government policies, including feed-in tariffs (FITs),[38] tax incentives, and market share quotas, that encourage the construction of such renewable electricity facilities.

In non-OECD countries, hydroelectric power is the predominant source of renewable electricity growth. Strong growth in hydroelectric generation, primarily from mid- to large-scale power plants, is expected in China, India, Brazil, and a number of nations in Southeast Asia, including Malaysia and Vietnam. Growth rates for wind-powered generation are also high in non-OECD countries. The most substantial additions to electricity supply generated from wind power are in China.

Figure 84. World net electricity generation from nuclear power by region, 2010-2040 (trillion kilowatthours)



The *IEO2013* projections for renewable energy sources include only marketed renewables. Nonmarketed (noncommercial) biomass from plant and animal resources—while an important source of energy, particularly in the developing non-OECD economies—is not included in the projection, because comprehensive data on its use are not available. For the same reason, off-grid distributed renewables—renewable energy consumed at the site of production, such as off-grid photovoltaic (PV) panels—are not included in the projection.

Regional electricity markets: OECD

Americas

In the *IEO2013* Reference case, electricity generation in the OECD Americas (Canada, Chile, Mexico, and the United States) grows by an average of 1.2 percent per year from 2010 to 2040 (Figure 85). Although generating far less electricity, the less advanced economies of Chile and Mexico grow more rapidly than other parts of the OECD Americas. Both Canada and the United States have established electricity

[37]Other renewable energy sources include wind, solar, geothermal, biomass, waste, and tidal/wave/ocean.

[38]A feed-in tariff is a financial incentive that encourages the adoption of renewable electricity technologies. Under a feed-in tariff, government legislation requires electric utilities to purchase renewable electricity at a higher price than the wholesale price, allowing the renewable generator to achieve a positive return on investment despite higher costs.

markets that grow more slowly than those in Chile and Mexico. Electricity generation in Chile and Mexico nearly triples over the projection period.

Almost all coal-fired generation capacity in the OECD Americas region is in the United States (92 percent in 2010). Although coal accounted for 51 percent of electricity generation in the United States as recently as 2003, its share declined to 37 percent in 2012 as extremely low natural gas prices allowed efficient plants fueled by natural gas to have lower operating costs than coal-fired plants in many U.S. regions [*221*]. With the rise in natural gas prices at the start of 2013, the coal share of generation is likely to increase slightly in the near term. However, in the face of competition from natural gas and more stringent environmental regulations, the market share of coal-fired generation continues to fall in the Reference case, to 35 percent in 2040 (Figure 86).

Natural gas, which produced 1,162 billion kilowatthours of electricity in 2010 (23 percent of the total) in the OECD Americas, generates 2,348 billion kilowatthours in 2040 in the *IEO2013* Reference case, with the United States accounting for most of the regional growth. With access to ample shale gas reserves and concurrent low natural gas prices, U.S. natural gas-fired electricity generation increases by 63 percent from 2010 to 2040. Liquids, which in 1978 commanded a 17-percent share of U.S. electricity generation, continue to decline in the outlook to less than 1 percent of total generation in 2040.

In 2010, 20 percent of the U.S. electricity supply was generated by 104 operating commercial nuclear reactors. In the Reference case, annual generation from nuclear power in the United States increases from 807 billion kilowatthours in 2010 to 903 billion kilowatthours in 2040. The nuclear share of the total generation mix declines, however, to 17 percent in 2040, as nuclear loses market share to natural gas and renewable energy sources. The growth in nuclear generation results from new builds, such as Vogtle Units 3 and 4 and Virgil C. Summer Units 2 and 3, as well as uprates at existing nuclear power units [*222*]. In addition, ongoing construction at the Tennessee Valley Authority's Watts Bar Unit 2 is incorporated into the projection. As a result of license renewals, most nuclear power plant retirements occur after 2030. The *IEO2013* Reference case includes the retirement of 0.6 gigawatts at Oyster Creek in 2019 and an additional 6.5 gigawatts of nuclear capacity toward the end of the projection. It does not include the recently announced retirements of the Kewaunee and Crystal River single reactors or the two reactors at San Onofre.

Nonhydroelectric renewable generation is the fastest-growing source of new U.S. electricity generation over the projection period. The nonhydroelectric renewables share of total U.S. generation more than doubles from 2010 to 2040. Wind plays an increasingly important role, with wind generation comprising about 5 percent of the total generation market in 2040, as compared with 2

Table 14. OECD and non-OECD net renewable electricity generation by energy source, 2010-2040 (billion kilowatthours)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
Hydroelectric	1,338	1,412	1,497	1,574	1,661	1,749	1,841	1.1
Wind	269	531	718	855	903	961	1,052	4.7
Geothermal	41	52	68	79	93	104	115	3.5
Solar	32	123	145	165	181	211	253	7.1
Other	263	290	346	373	385	401	426	1.6
Total OECD	**1,943**	**2,408**	**2,774**	**3,046**	**3,222**	**3,426**	**3,687**	**2.2**
Non-OECD								
Hydroelectric	2,064	2,393	2,955	3,188	3,516	3,943	4,390	2.6
Wind	73	235	418	527	641	733	787	8.3
Geothermal	25	60	65	67	78	91	105	4.9
Solar	1	34	95	124	146	183	199	18.6
Other	69	137	202	270	344	400	432	6.3
Total non-OECD	**2,232**	**2,859**	**3,736**	**4,177**	**4,725**	**5,350**	**5,914**	**3.3**
World								
Hydroelectric	3,402	3,805	4,452	4,762	5,177	5,692	6,232	2.0
Wind	342	767	1,136	1,383	1,544	1,694	1,839	5.8
Geothermal	66	112	133	146	171	195	220	4.1
Solar	34	157	240	288	327	394	452	9.1
Other	332	427	549	643	729	800	858	3.2
Total World	**4,175**	**5,267**	**6,509**	**7,222**	**7,948**	**8,775**	**9,601**	**2.8**

percent in 2010. Hydroelectricity's share of U.S. electricity generation remains flat at 6 percent throughout the projection, as few large-scale hydroelectricity projects are undertaken.

In contrast to the United States, hydroelectric power accounts for the largest share of electricity generation in Canada—59 percent in 2010—although its share declines slightly in the projection. With almost 350 billion kilowatthours of hydroelectric generation in 2010, Canada was the third-largest producer of hydroelectricity in the world, with the province of Quebec accounting for more than one-half of the country's total generation from hydropower. Among the other Canadian provinces, British Columbia (16 percent), Newfoundland and Labrador (combined 11 percent), Manitoba (9 percent), and Ontario (9 percent) are also large producers [*223*]. Canada has significant undeveloped hydropower reserves and expects significant growth in hydroelectric generation. In 2040, hydroelectric power production is 50 percent higher than in 2010, with growth concentrated in Quebec [*224*].

In 2010, nuclear power was the second-largest source of electricity generation in Canada. Although nuclear power's share of the generation market declines from 15 percent in 2010 to 12 percent in 2040, as natural gas generation grows more rapidly, nuclear generation grows in absolute terms. For example, in August 2012, the Canadian Nuclear Safety Commission formally issued a site preparation license allowing pre-construction activities for up to four proposed nuclear reactors at Ontario Power Generation's Darlington site near Toronto. The issuance of the site preparation license was Canada's first in nearly 30 years [*225*].

Natural gas, which had an 8-percent share of the Canadian electricity market in 2010, increases its share of total generation to 18 percent in 2040. Nonhydropower renewables, primarily wind and biomass, double their share of the electricity market to nearly 7 percent in 2040. A feed-in tariff, enacted in October 2009, has helped Ontario become a major source of wind generation. In 2040, wind accounts for 5 percent of Canada's electricity generation—a slightly larger share than in the United States. Canada's coal-fired share of total generation, which amounted to 14 percent in 2010, declines to 7 percent in 2040, in part as a result of the mandated phaseout of coal-fired capacity in Ontario province and government efforts to regulate greenhouse gas emissions. In 2012, the Canadian government announced final regulations to reduce the nation's greenhouse gas emissions to 17 percent below 2005 levels [*226*].

In the *IEO2013* Reference case, electricity generation in Chile and Mexico grows at a combined annual average rate of 3.7 percent, more than triple the U.S. growth rate. The electricity profiles for the two countries are significantly different. Whereas Mexico relies heavily on hydrocarbon fuels to meet its electricity needs, hydroelectric power dominates Chile's generation mix. Mexico plans to increase its nuclear power production, as reflected in its national energy strategy issued in March 2012 [*227*]. Although Chile currently has no nuclear power plants, it has announced that it intends to pursue nuclear power to meet its future electricity needs [*228*]. Chile has a smaller population and a smaller electricity generation market than Mexico, and as a consequence the aggregated regional electric power data is dominated by Mexico.

For Chile and Mexico combined, natural gas provided the largest source of electricity generation in 2010. Natural gas-fired generation increases by 4.9 percent annually over the projection period, and in 2040 it provides 63 percent of the total electricity generation for the two countries, compared with 45 percent in 2010. Growth in natural gas consumption in Chile is fueled by imports, largely in the form of LNG. Historically, Chile imported a significant share of its natural gas from Argentina, but in recent years it has developed a sizable LNG import industry to reduce its reliance on natural gas from Argentina, which has cut off supplies to Chile periodically since 2004 [*229*].

Compared with other mid-income nations, industrial demand for electricity accounts for an unusually large share of Chile's electricity demand, largely because of Chile's large mining sector and metals industries [*230*]. Periodic hydroelectricity shortages

Figure 85. OECD Americas net electricity generation by country, 2010-2040 (trillion kilowatthours)

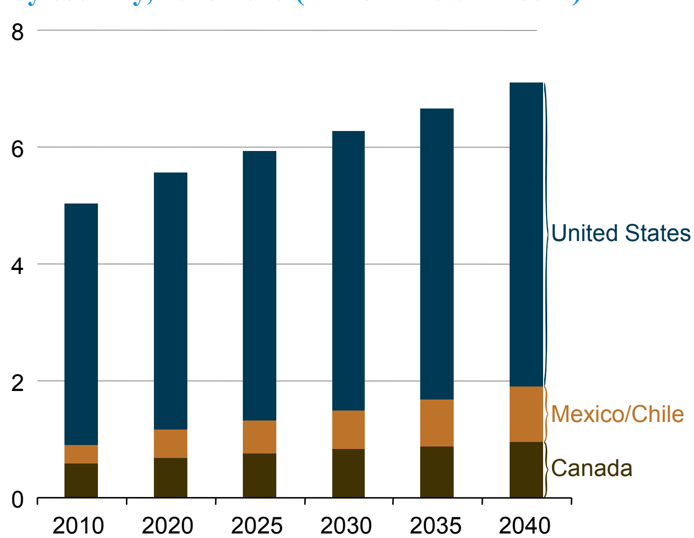
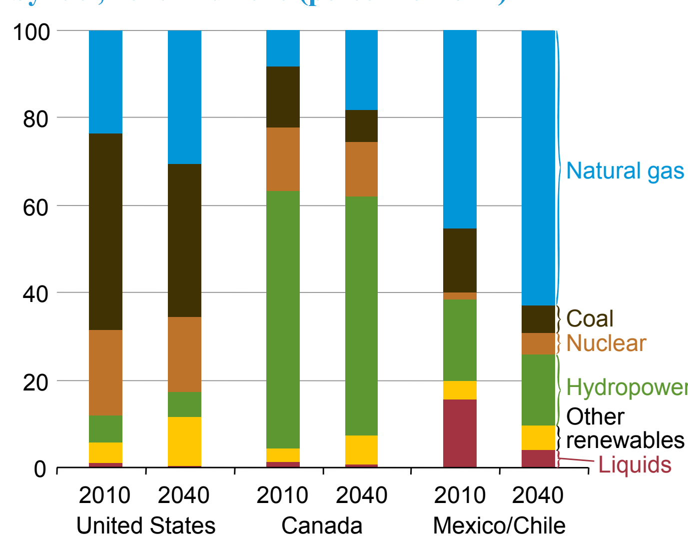


Figure 86. OECD Americas net electricity generation by fuel, 2010 and 2040 (percent of total)



(due to low precipitation) and past Argentine natural gas cutoffs have motivated Chile's government to seek greater diversity in the fuel mix for its electric power generation and spurred the government to study the extent to which nonhydropower renewables could contribute to the electricity fuel mix [*231*].

In recent years, Mexico has gradually shifted its generation mix away from oil toward natural gas [*232*]. For Chile and Mexico combined, liquids, which accounted for 16 percent of electricity generation in 2010, account for 4 percent of generation in 2040 in the *IEO2013* Reference case. Although Mexico is a major natural gas producer, it also relies on a significant volume of natural gas imported by pipeline from the United States, as well as LNG from Peru, Trinidad and Tobago, Indonesia, Nigeria, and the Middle East [*233*].

Although Chile produced 20.8 billion kilowatthours of hydroelectricity in 2010, compared with Mexico's 35.4 billion kilowatthours, Chile's hydropower sector accounted for a significantly larger share of its power mix (33 percent, compare with 14 percent in Mexico [*234*]. For the region, hydroelectric power grows at an annual rate of 3.3 percent from 2010 to 2040. Generation from other renewables grows at a faster rate than generation from hydropower, spurred on by policies such as Mexico's Income Tax Law (ITL), which provides a 100-percent tax deduction to investors in biomass, geothermal, solar, hydroelectric, and wind equipment [*235*].

OECD Europe

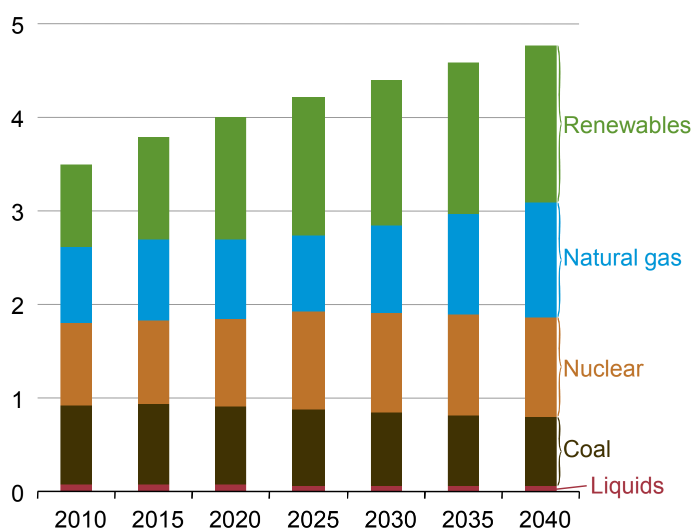
Electricity generation in the nations of OECD Europe increases by an average of 1.0 percent per year in the *IEO2013* Reference case, from 3,496 billion kilowatthours in 2010 to 4,765 billion kilowatthours in 2040. Because most of the countries in OECD Europe have relatively stable populations and mature electricity markets, most of the region's growth in electricity demand comes from those nations with more robust population growth (such as Turkey) and from the newest OECD members (including the Czech Republic, Estonia, Hungary, Poland, and Slovenia), whose projected economic growth rates exceed the OECD average.

Renewable energy is OECD Europe's fastest-growing source of electricity generation in the Reference case (Figure 87), at 2.2 percent per year on average from 2010 to 2040. The increase is almost entirely from wind, hydroelectric power, and solar. In 2011 alone, Germany doubled its solar photovoltaic generation capacity [*236*]. Solar powered generation in OECD Europe increases by an average of 5.1 percent per year. Further, OECD Europe's leading position worldwide in wind power capacity is maintained through 2040, with growth in generation from wind sources averaging 5.0 percent per year.

Offshore wind is becoming an important source of renewable electricity in OECD Europe, particularly among those countries surrounding the Baltic, Irish, and North seas, where 90 percent of the world's offshore wind capacity is located. In 2012, 293 wind turbines with a capacity of 1,166 megawatts were installed in offshore OECD Europe. The United Kingdom has the most offshore wind capacity, with 59 percent of OECD Europe's total market, followed by Denmark (18 percent), Belgium (8 percent), and Germany (6 percent). An additional 3,000 megawatts of capacity is scheduled for completion in 2013 and 2014, bringing the region's total offshore wind capacity to 8,300 megawatts [*237*]. In 2012, work was completed on the first phase of the London Array, a 630-megawatt project with 175 turbines that is the largest offshore wind power project in the world. The project has now surpassed the United Kingdom's 300-megawatt Thanet Wind Farm, which was the world's largest offshore wind facility at the time of its completion in September 2010 [*238*].

The growth of nonhydropower renewable energy sources in OECD Europe is influenced by some of the world's most favorable renewable energy policies. The European Union mandates that 20 percent of total energy production must come from renewables by 2020, up from about 13 percent in 2010 [*239*]. Approximately 25 percent of OECD Europe's total electricity supply came from renewable sources in 2010. Although the *IEO2013* Reference case does not anticipate that all future renewable energy targets in the European Union will be met on time, the renewable share (including hydroelectric power) of total electricity generation in OECD Europe still reaches 35 percent in 2040.

Figure 87. OECD Europe net electricity generation by fuel, 2010-2040 (trillion kilowatthours)



In addition to the European Union targets, some individual countries provide economic incentives to promote the expansion of renewable electricity. For example, Germany, Spain, Denmark, and the United Kingdom—leaders in OECD Europe's installed wind capacity—have enacted feed-in tariffs that guarantee above-market rates for electricity generated from renewable sources and, typically, are applicable for 20 years after the completion of a project [*240*]. As long as European governments support price premiums for renewable electricity, robust growth in renewable generation is likely to continue. However, exceptionally generous feed-in tariffs have been falling out of favor in recent years. Renewable energy subsidies in Germany and Spain have been particularly expensive. In Germany, electricity consumers bore the cost of an estimated $27 billion in subsidies in 2012 alone [*241*]. Given their economic cost, Germany, Spain, and the United

Kingdom have undertaken measures to reduce feed-in tariffs. When the United Kingdom reduced its feed-in tariff for solar power, consumer installations of solar panels fell sharply [*242*].

Natural gas is OECD Europe's second-fastest growing source of power generation, after nonhydropower renewable energy, increasing at an average rate of 1.3 percent per year from 2010 to 2040 in the Reference case. The natural gas share of electricity production in OECD Europe rises from 23 percent in 2010 to 26 percent in 2040, and its growth could be faster if two impediments—the lack of market-based pricing and resource development constraints—were removed. Currently, many of OECD Europe's natural gas purchases are based on an oil price index, unlike natural gas pricing in the United States. As a result, the lack of competitive natural gas markets has resulted in slower penetration of natural gas into the electricity market. Moreover, although OECD Europe has significant shale gas resource potential, the emergence of a shale gas industry occurs much more slowly than in the United States, leaving OECD Europe dependent on imports of natural gas from Russia and LNG from North Africa for incremental supply increases.

Coal accounted for 24 percent of OECD Europe's net electricity generation in 2010, but concerns about the contribution of carbon dioxide emissions to climate change reduce that share over the projection period. The coal share of OECD Europe's electricity generation declines to 15 percent in 2040, and the region's total coal-fired generation in 2040 is nearly 14 percent lower than in 2010. In the *IEO2013* Reference case, electricity generation from coal in OECD Europe declines by 0.5 percent per year from 2010 to 2040.

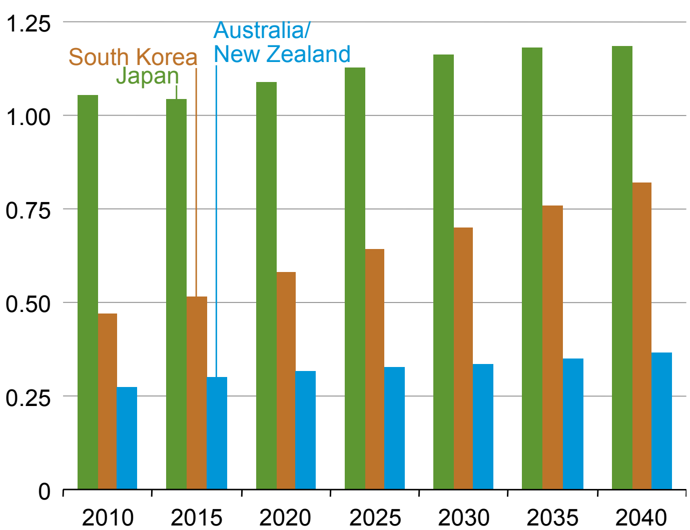
Coal consumption in the electric power sector is not decreasing uniformly in all the countries of OECD Europe. For instance, Spain's Coal Decree, which subsidizes the use of domestic coal in the country's power plants, went into effect in February 2011, and coal-fired generation nearly doubled that year [*243*]. The policy results in more electricity generation from coal-fired plants at least through 2014, when the subsidy is scheduled to expire [*244*]. Germany, Poland, and the United Kingdom, which accounted for nearly two-thirds of coal-fired electricity generation in OECD Europe in 2010, are also expected to retain sizable portions of their coal fleets, especially if Germany follows through on its plan to shut down all its nuclear power plants by 2022. On the other hand, the United Kingdom may close the majority of its existing coal-fired power plants if its 2012-2013 draft Energy Bill, which calls for new coal-fired plants to be built with carbon capture and storage technology (CCS), is enacted [*245*].

Nuclear power accounted for 25 percent of OECD Europe's electricity generation in 2010. On a regional basis, OECD Europe is the second-largest producer of nuclear electricity after the OECD Americas. Although Germany and Switzerland have decided to retire their nuclear power plants in the aftermath of the 2011 accident at Fukushima Daiichi (and those decisions have been incorporated in the *IEO2013* Reference case), other European countries plan to continue supporting nuclear power. More than one-half of OECD Europe's total nuclear generating capacity is in France, which is not expected to reduce its nuclear program in the Reference case. The construction of new nuclear power generating capacity in OECD Europe is led by the United Kingdom, Poland, and Turkey. In the United Kingdom, designs for the country's first new nuclear power plants in 25 years have been approved by the Office of Nuclear Regulation and the Environment Agency [*246*]. Poland recently announced that it expects to commence operations at its first nuclear power plant by 2025 [*247*]. Construction of Turkey's first nuclear power plant is scheduled to begin before the end of 2013 [*248*].

OECD Asia

Total electricity generation in OECD Asia increases by an average of 1.0 percent per year in the *IEO2013* Reference case, from 1,794 billion kilowatthours in 2010 to 2,374 billion kilowatthours in 2040. Japan accounted for the largest share of electricity generation in the region in 2010 and continues to do so throughout the projection, despite having the slowest-growing electricity market in the region and the slowest among all the OECD countries, averaging 0.4 percent per year—as compared with 1.0 percent per year for Australia/New Zealand and 1.9 percent per year for South Korea (Figure 88). Japan's electricity markets are well established, and its aging population and relatively slow projected economic growth translate into slow growth in demand for electric power. In contrast, Australia/New Zealand and South Korea experience more robust economic growth and population growth than Japan in the long term, leading to more rapid growth in demand for electricity.

Figure 88. OECD Asia net electricity generation by country, 2010-2040 (trillion kilowatthours)



Japan's use of nuclear power following the March 2011 disaster at the Fukushima Daichi nuclear power plant is discussed earlier in this chapter. In the *IEO2013* Reference case, the nuclear share of Japan's electricity generation, which declined from 26 percent in 2010 to 1 percent in 2012, rises to about 18 percent in 2040, with generation from fossil fuels and renewables offsetting the loss of nuclear power (see box on page 101).

Japan will use more fossil generation in the next several years to compensate for nuclear power plant outages

Japan has curtailed its nuclear generation significantly as a result of the Fukushima disaster and subsequent outages at other nuclear power plants. Historically, nuclear power plants have accounted for about 33 percent of Japan's total generation. To compensate for the nuclear plant shutdowns, power plants using natural gas, oil, and coal were called upon to increase their generation. For the 9-month period from April to December, use of fossil generation by the 10 general electric utilities (GEUs) that own and operate Japan's nuclear power generators was 16 percent higher in 2012 than in 2011 and 40 percent higher than in 2010 (Figure 89).[39]

The fossil share of total generation for the period April to December increased from 57 percent in 2010 to 74 percent in 2011 and 90 percent in 2012. In contrast, the share of nuclear generation fell from 34 percent in 2010 to 16 percent in 2011 and 2 percent in 2012. The nuclear share of generation is projected to increase as additional reactors beyond the two currently operating units meet government requirements and conditions to resume operation.

In September 2012, Japan established the Nuclear Regulation Authority (NRA) to ensure the safe operation of its nuclear reactors [*249*]. The NRA is an administrative part of the Japanese Cabinet and replaces its predecessor, the Nuclear and Industrial Safety Agency. The restart of Japan's nuclear power plants requires the approval of the NRA as well as the Economy, Trade and Industry Ministry's Natural Resources and Energy Agency [*250*]. Against the backdrop of increased fossil generation and trade deficits [*251*], Japan's NRA announced in January 2013 that final safety regulations will be issued in July 2013 [*252*]. The new regulations are expected to address severe accidents and direct attacks, emergency preparedness and response, and seismic conditions near existing reactors. Likely plant modifications include a secondary control room that is not located near the primary control room, filtered and hardened containment vents to limit radioactive releases, and movable emergency power supplies that will facilitate reactor cooling for seven days in the event of an extended loss of power.

Japan's reactors must meet the new regulations and pass seismic inspections before being restarted. The economic impacts on Japan's electric power utilities of implementing the new regulations are unclear at this time, and Japan's national policy on nuclear power as a component of its future energy mix is evolving. These two circumstances result in uncertainty about the future of nuclear power in Japan. In the *IEO2013* Reference case, Japan's total electricity generation from fossil fuels declines from the 2012 level as nuclear generation gradually returns to the power supply mix over the next several years; however, fossil generation remains higher than pre-Fukushima levels as a result of long-term growth in natural gas-fired generation (Figure 90).

Coal consumption in 2012 was largely unchanged from its pre-disaster level, because increased coal-fired generation at operating coal-fired plants was offset by lost generation at coal plants disabled by the earthquake. Until more nuclear power plants return to service and new natural gas-fired capacity comes on line, coal consumption in Japan will increase. The increase in coal consumption is the result of the planned completion of two new coal plants, totaling 1.6 gigawatts, by the end of 2013 and the resumption of normal operations at coal-fired power plants affected by the disaster. The government's relaxation of environmental rules also encourages more coal use.

The *IEO2013* Reference case assumes that, while many of the nuclear reactors that have been shut down will resume operation in the 2015-2020 timeframe, others will be retired permanently and replaced—primarily by natural gas and renewables. From 2015 to 2040, 11 gigawatts of additional natural gas capacity is projected to come on line, increasing natural gas-fired generation by 7 percent from 2012 to 2040. On a national level, the nuclear share of Japan's total generation increases from 1 percent in 2012 to 18 percent in 2040, and the fossil share of total generation declines from 86 percent in 2012 to 66 percent in 2040.

Figure 89. Gross electricity generation by Japan's ten general electric utilities, April-December 2010, 2011, and 2012 (billion kilowatthours)

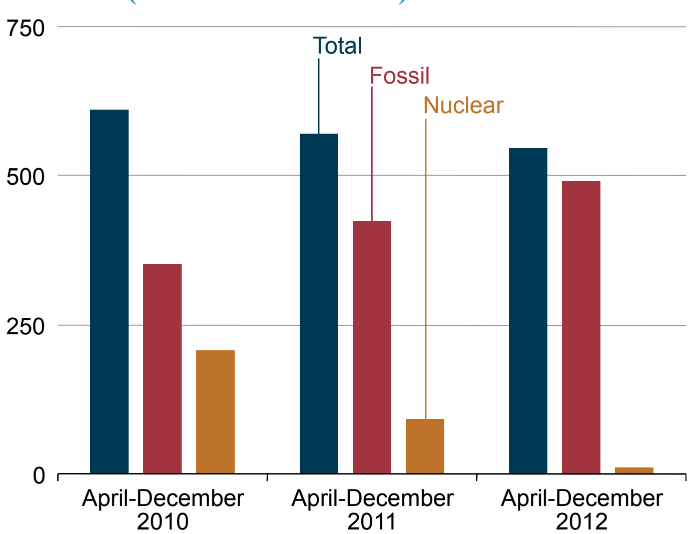
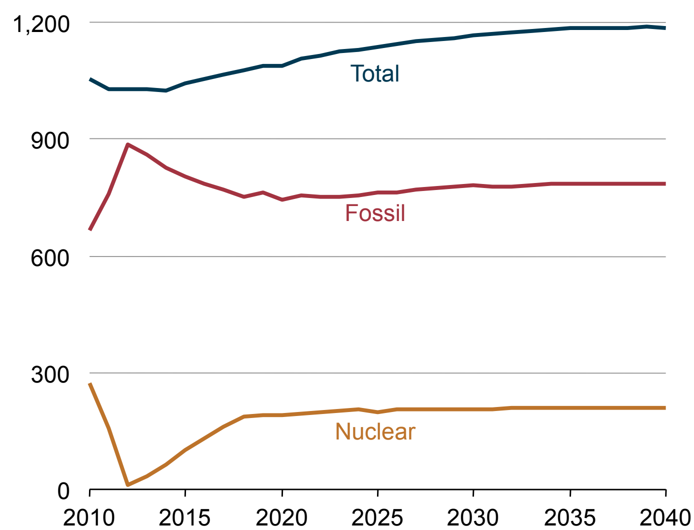


Figure 90. Total net electricity generation in Japan by fuel, 2010-2040 (billion kilowatthours)



[39] The 10 GEUs accounted for 73 percent of Japan's total generating capacity and 71 percent of its total generation in 2010.

Together, Australia and New Zealand relied on coal for about 63 percent of their electricity generation in 2010, based largely on Australia's rich coal resource base (9 percent of the world's total coal reserves). Australia relies on coal for nearly 80 percent of its electricity generation, compared with less than 10 percent in New Zealand. In 2010, hydropower provided more than one-half of New Zealand's electricity generation, and geothermal energy provided another 13 percent. In total, renewables account for almost three-fourths of New Zealand's electricity generation.

Australia and New Zealand continue to make advances in wind energy, with 3,146 megawatts of capacity installed at the end of 2011, compared with 908 megawatts in 2005. To help meet its 2025 goal of having 90 percent of electricity generation come from renewable sources, New Zealand is focusing on harnessing more of its geothermal potential [*253*]. Two projects are currently under construction: the 82-megawatt Ngatamariki plant and the 166-megawatt Te Mihi plant. The Australia/New Zealand region uses negligible amounts of oil for electricity generation and no nuclear power, and this pattern does not change over the projection period. Natural gas-fired generation grows strongly in the region, however, averaging 3.0 percent per year from 2010 to 2040, helping to reduce the coal share to 39 percent in 2040.

In South Korea, coal and nuclear power currently provide 44 percent and 30 percent of total electricity generation, respectively. The country's natural gas-fired generation grows rapidly in the *IEO2013* Reference case, nearly doubling from 2010 to 2040, but the natural gas share of total generation increases only slightly, from 21 percent in 2010 to 23 percent in 2040. Generation from nuclear power plants more than doubles from 2010 to 2040, and in 2040 the nuclear share of South Korea's electricity is 44 percent, with coal providing another 27 percent. Liquid fuels accounted for 4 percent of the country's power generation in 2010, and that share declines to less than 2 percent in 2040.

Regional electricity markets: non-OECD

Non-OECD Europe and Eurasia

Total electricity generation in non-OECD Europe and Eurasia grows at an average rate of 1.9 percent per year in the *IEO2013* Reference case, from 1,605 billion kilowatthours in 2010 to 2,807 billion kilowatthours in 2040. Russia, with the largest economy in non-OECD Europe and Eurasia, accounted for 61 percent of the region's total generation in 2010 and retains approximately that share throughout the projection (Figure 91).

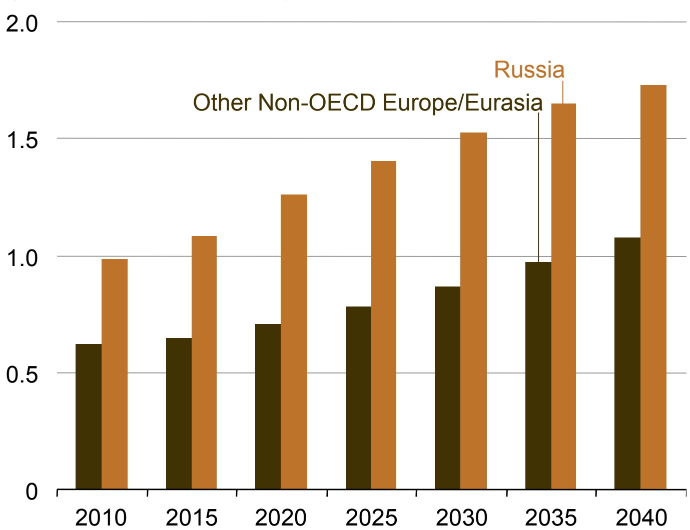
Natural gas and nuclear power fuel most of the growth in electricity generation in the non-OECD Europe and Eurasia region, which has nearly one-third of the world's total proved natural gas reserves. The region's natural gas-fired generation grows by an average of 2.0 percent per year from 2010 to 2040, and generation from nuclear power also grows strongly, averaging 2.8 percent per year and more than doubling from 2010 to 2040 in the Reference case.

Most of the coal-fired generating capacity in non-OECD Europe and Eurasia is in Russia and Ukraine. In the *IEO2013* Reference case, coal-fired generation in Russia and the other non-OECD Europe and Eurasia nations (including Ukraine) increases slightly from 2010 to 2040.

Renewable generation in non-OECD Europe and Eurasia, almost entirely from hydropower facilities, increases by an average of 1.5 percent per year, largely as a result of repairs and expansions at existing hydroelectric sites. Other than increases in hydropower, only modest growth in renewable generation is projected for the nations of non-OECD Europe and Eurasia, given the region's access to fossil fuel resources and a lack of financing available for relatively expensive renewable projects. Nonhydropower renewable capacity in the region increases by 7.0 gigawatts from 2010 to 2040 in the Reference case.

Nuclear generation in non-OECD Europe and Eurasia grows strongly in the *IEO2013* Reference case. With about 9 gigawatts of nuclear capacity currently under construction, Russia provides much of the increase. When they become operational by 2020, the new nuclear power plants will increase Russia's nuclear power capacity by more than 50 percent. An additional 24 gigawatts of new nuclear capacity is planned but not yet under construction in Russia. The country is also building a first-of-a-kind floating nuclear power plant, with a capacity of 70 megawatts. The plant is scheduled to begin operating in 2016 [*254*]. Ukraine also relies heavily on nuclear power, and its energy strategy update in 2012, if achieved, would include more nuclear capacity additions by 2030 [*255*]. Full implementation of the strategy has not been incorporated in the *IEO2013* Reference case projection.

Figure 91. Non-OECD Europe and Eurasia net electricity generation by region, 2010-2040 (trillion kilowatthours)



Non-OECD Asia

Non-OECD Asia—led by China and India—has the fastest projected growth rate for electric power generation worldwide, averaging 3.6 percent per year from 2010 to 2040 in the *IEO2013* Reference case. The economies of non-OECD Asia expand strongly in the long term, with corresponding increases in demand for electricity. Total electricity generation in non-OECD Asia grows from 5,899 billion kilowatthours in 2010 to 17,023 billion kilowatthours in 2040 (Figure 92), when the region accounts for 44 percent of world electricity generation.

Although China's 3.0-percent average annual growth in coal-fired electricity generation over the *IEO2013* projection period is high in comparison with other nations, it is less than one-third the country's growth rate over the past decade. The slowdown in the country's coal generation is in part a result of lower economic growth (which still is rapid in comparison with most other countries) and the Chinese government's efforts to lower the nation's energy intensity, as outlined in its latest five-year plan [*256*].

In 2010, the coal share of China's total electricity generation was an estimated 77 percent. In the *IEO2013* Reference case, that share declines to 63 percent in 2040. Although China has been closing old, inefficient coal-fired power plants (71 gigawatts of capacity has been retired since 2006), it continues to experience a rapid increase in its coal-fired generating capacity [*257*]. In 2010, coal plants in China represented 40 percent of total world coal-fired electric generating capacity; in 2040, China accounts for more than one-half of the world total. From 2010 to 2020 alone, China adds more coal-fired capacity in the Reference case projection than the current total in OECD Europe.

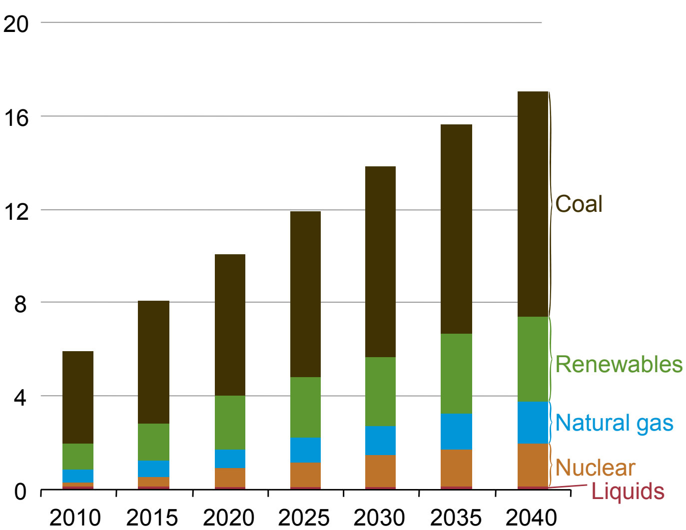
In the later years of the Reference case projection, China's natural gas consumption sees a sizable increase, made possible in part by domestic shale gas discoveries [*258*] that provide fuel for the fastest growth of natural gas-fired electricity generation among the *IEO2013* regions, averaging 7.7 percent per year from 2010 to 2040. In absolute terms, only the United States and the Middle East experience larger expansions of natural gas-fired generation. Ambitions to address China's air quality issues are, in part, driving the country's move toward greater reliance on natural gas and reduced reliance on coal. From 2010 to 2040, the market share of natural gas in China's power generation sector increases from 2 percent to more than 5 percent.

Non-OECD Asia leads the world in installing new nuclear capacity in the *IEO2013* Reference case, accounting for 64 percent of the net increase in nuclear capacity worldwide from 2010 to 2040 (or 215 gigawatts of the total 336-gigawatt increase). In 2040, the non-OECD Asia region accounts for about 34 percent of the world's nuclear generation and 33 percent of its nuclear capacity. China, in particular, has ambitious plans for nuclear power, with 16 nuclear power reactors in operation and 28 currently under construction. About 155 gigawatts of new nuclear capacity is installed in China by 2040 in the Reference case.

There is significant uncertainty in the *IEO2013* Reference case projections for China's nuclear capacity. Officially, its nuclear capacity targets are 70 to 80 gigawatts by 2020, 200 gigawatts by 2030, and 400 to 500 gigawatts by 2050 [*259*]. The long-term impacts of the March 2011 disaster at Japan's Fukushima Daiichi nuclear power plant on China's nuclear energy program remain uncertain. In the aftermath of the disaster, China announced that it would halt approval processes for all new reactors until the country's nuclear regulator completed a safety review [*260*]. The moratorium was lifted in late 2011, however, and it appears that construction has returned to pre-Fukushima trends.

The *IEO2013* Reference case assumes that the global lack of heavy forging facilities[40] and the long lead times needed to build or upgrade forging facilities, build new nuclear power plants, and train new personnel may cause China's nuclear power industry to grow more slowly than seen in official government predictions. The *IEO2013* Reference case assumes that China's nuclear capacity will increase from 11 gigawatts in 2010 to 160 gigawatts in 2040, with the nuclear share of its total electricity generation growing from slightly less than 2 percent in 2010 to 11 percent in 2040.

Figure 92. Non-OECD Asia net electricity generation by fuel, 2010-2040 (trillion kilowatthours)



China's energy policies in recent years have shown increased support for nonhydroelectric renewables. In 2010, China ranked second to the United States in wind-powered electricity generation and number three worldwide in offshore wind capacity, having developed the first commercial offshore wind project outside of Europe. Rich in wind resources, Inner Mongolia leads China's wind power production, followed by the Hebei, Gansu, and Lianoning provinces [*261*]. Currently, China has several offshore wind projects in the assessment phase and intends to develop 5 gigawatts of offshore wind by 2015 and 30 gigawatts by 2020 [*262*]. As with solar power, China has quickly built one of the largest wind generator manufacturing industries in the world. Four of the ten largest manufacturers of wind turbines are Chinese companies [*263*]. In 2011, China surpassed the United States in terms of installed wind capacity, although not in wind-powered electricity generation.

[40]Heavy forging facilities are plants that are able to manufacture large-scale, strong steel or aluminum parts for machinery and heavy transportation purposes.

Although India relied on coal for 68 percent of its electricity generation in 2010, in the *IEO2013* Reference case that share falls to 56 percent in 2040. Transportation bottlenecks, land rights issues, and growing concerns over pollution have worked to reduce the growth rate of India's coal-fired electricity generation in recent years. In addition, coal shortages caused by difficulties in securing supplies at affordable prices forced some power producers to curtail operations in 2012, contributing to a widespread power outage in July 2012 that affected some 680 million people, making it the world's worst outage ever in terms of population affected [*264*]. The problems associated with India's electric power sector continue throughout the projection.

Over the next decade, nuclear power supplants some coal-fired generation in India. The country has a goal of increasing its total nuclear generating capacity to 14.6 gigawatts by 2020. Seven nuclear reactors are currently under construction in India, all of which are scheduled to be operational by 2016 [*265*]. Given past delays in India's ability to meet its nuclear capacity targets on time, the *IEO2013* Reference case assumes a more conservative expansion of India's nuclear capacity—from 4.6 gigawatts in 2010 to 9.3 gigawatts in 2020 and then to 52.0 gigawatts in 2040, an average increase of 8.5 percent per year.

In addition to efforts to increase nuclear power, India is also encouraging the development of renewable sources of electricity. The country's 2003 New Electricity Act contained specific provisions to promote the development of hydroelectric resources, which are reflected in the growing share of hydropower in India's electricity market, from 13 percent in 2010 to 16 percent in 2040 in the *IEO2013* Reference case. India's wind-powered electricity generation also grows rapidly in the projection, although starting from a relatively small base. In 2040, India is the second-largest producer of wind-based electricity among the non-OECD regions. Ninety-five percent of India's wind generating plants are concentrated in the southern and western parts of the country in the five states of Tamil Nadu, Andhra Pradesh, Gujarat, Karnataka, and Maharashtra [266]. Future wind power development may be constrained by finances and grid connections rather than resources. In a 2012 assessment of wind energy potential, Lawrence Berkeley National Laboratory estimated that India's wind energy potential exceeds government estimates by a factor of 20 [*267*].

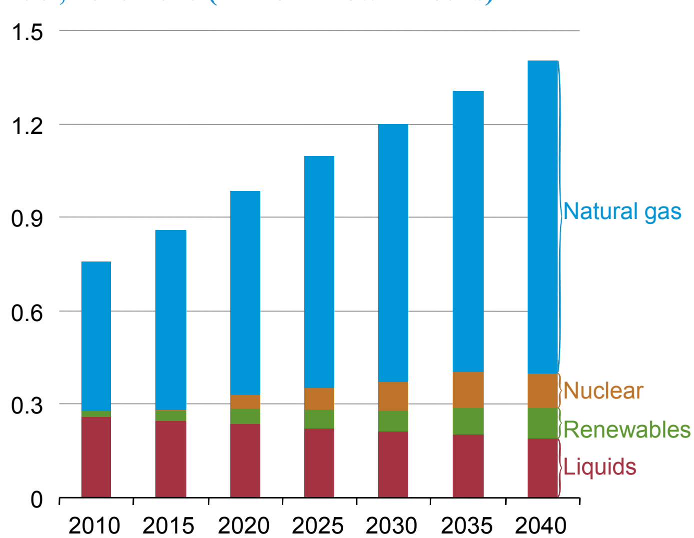
Outside China and India, the other nations of non-OECD Asia have some of the world's largest untapped hydropower resources, with some large hydroelectric dams in planning or construction phases. In December 2012, Vietnam completed the final portion of its 2,400-megawatt Son La dam, the largest hydroelectric project yet built in non-OECD Asia (excluding China and India). Hydroelectric power generation in other non-OECD Asia grows at a 4.6-percent average annual rate in the *IEO2013* Reference case, to 550 billion kilowatthours in 2040—nearly four times the 2010 total. Many of the region's hydropower projects are sited on the Mekong, Irrawaddy, and Indus rivers.

There are some constraints on future hydroelectric development in non-OECD Asia that add uncertainty to the outlook. The Mekong River, which flows through China, Thailand, Laos, Vietnam, and Cambodia, has become a source of both regional economic development and political conflict in recent years. China, the world's largest generator of hydroelectricity, has built several large dams on the upper Mekong, leading to conflicts with countries downstream. Although Southeast Asia has ample potential and expansive plans for future development of hydroelectric power, there has been significant political opposition to several high-profile projects. Damming the Mekong has resulted in regional conflict between electricity consumers in upstream nations generally in favor of the construction and downstream nations that are dependent on the Mekong for agriculture and fish harvesting [*268*].

Middle East

Electricity generation in the Middle East grows by 2.1 percent per year on average in the Reference case, from 758 billion kilowatt hours in 2010 to 1,405 billion kilowatthours in 2040, reflecting the region's rapid growth in population, economic activity, and income. With large reserves of crude oil and natural gas, the Middle East has relied primarily on the two fuel sources for its electricity generation. Over the projection period, natural gas-fired generation rises at a 2.5-percent average annual rate and slowly displaces oil-fired generation, which declines slightly, while its share of the region's power generation market falls from 34 percent in 2010 to 14 percent in 2040 (Figure 93). Hydropower plays a relatively small role in providing electricity for the Middle East, and coal use is negligible.

Figure 93. Middle East net electricity generation by fuel, 2010-2040 (trillion kilowatthours)



Although Iran currently operates the only commercial nuclear power plant in the Middle East, several nations in the region, including Saudi Arabia and the United Arab Emirates, have signaled their intent to install nuclear power facilities in the future [*269*, *270*]. Even though there is considerable interest in nuclear power in the region, economic and political issues, as well as the long lead times associated with beginning a nuclear program, constrain the growth of nuclear capacity in the Middle East to a relatively modest total of 15 gigawatts in 2040 in the Reference case.

Africa

Demand for electricity in Africa grows at an average annual rate of 3.0 percent from 2010 to 2040 in the Reference case. Fossil fuel-fired generation supplied 80 percent of the region's total electricity in 2010, and that heavy reliance continues through 2040 in the *IEO2013* Reference case. Coal-fired power plants, which were the region's largest source of electricity in 2010, accounting for 39 percent of total generation, supply only 28 percent of total electricity in 2040. In comparison, natural gas-fired generation expands strongly, from 30 percent of the total in 2010 to 43 percent in 2040 (Figure 94). Nuclear generation increases by an average of 6.7 percent per year over the projection period but remains a fairly minor part of Africa's total generation, growing from a 2-percent share in 2010 to 6 percent in 2040.

South Africa is the region's largest generator of electricity, accounting for 38 percent of the continent's total in 2010. Although coal currently accounts for 93 percent of South Africa's electricity generation, making the nation one of the most coal-intensive generators of electricity worldwide, the government is intent on diversifying its electric power fuel mix. The nation's 2011 Integrated Resource Plan, covering the period 2010 through 2030, calls for the construction of 9.6 gigawatts of new nuclear generation capacity, 6.3 gigawatts of new coal-fired capacity, 11.4 gigawatts of renewable capacity, and 11.0 gigawatts of unspecified capacity [*271*]. Despite the pivot toward investments in energy sources other than coal, South Africa still has some major coal expansion projects in the pipeline. Eskom, South Africa's primary electric utility, expects to complete two major coal-fired plants by 2018: Kusile, at 4,800 megawatts, and Medupi, at 4,764 megawatts [*272*].

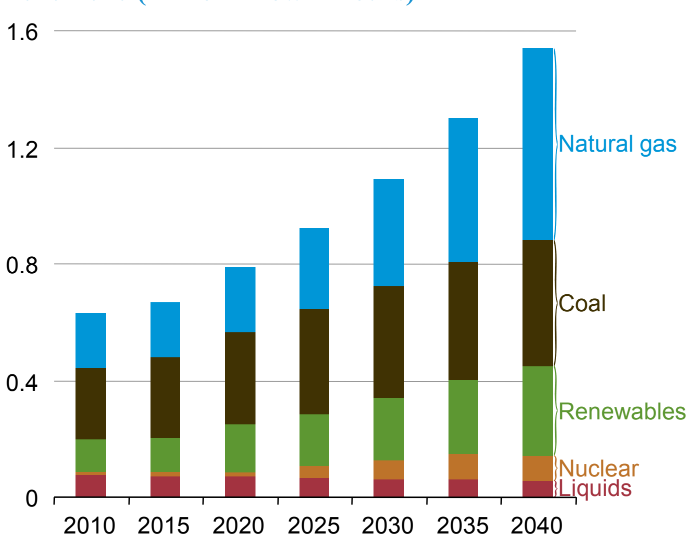
At present, South Africa's two nuclear reactors are the only commercial reactors operating in the region, accounting for about 2 percent of Africa's total electricity generation and 5 percent of South Africa's generation. Although the construction of a new pebble bed modular reactor in South Africa was canceled in 2010, the South African government's Integrated Electricity Resource Plan calls for new nuclear capacity to be built between 2023 and 2030 [*273*]. In February 2013, South Africa's Energy Minister reaffirmed the country's commitment to developing nuclear capacity [*274*].

Egypt is the second-largest electricity producer in Africa, accounting for 22 percent of the continent's total generation in 2010. Ninety percent of Egypt's electricity generation comes from fossil fuels and the remaining 10 percent largely from hydropower. In addition, Egypt has recently installed a small amount of wind capacity. The country expects to diversify its electricity sector further by building nuclear power plants, but recent political unrest has slowed its progress toward nuclear power. Nevertheless, Egypt's Ministry of Electricity and Energy in March 2011 announced its intention to construct four nuclear power plants by 2025 [*275*]. In 2013, the Ministry reaffirmed its intention to pursue a nuclear power program but indicated that progress is contingent on improvements in the country's political and economic circumstances, as well as approval by Egypt's president [*276*].

In the *IEO2013* Reference case, generation from hydropower and generation from other marketed, on-grid renewable energy sources grow relatively slowly in Africa. Plans for several significant hydroelectric projects in the region have been advanced recently, and they may help to boost supplies of renewable energy in the mid term. The announced projects are consistent with the 2.8-percent average annual increase in hydroelectric power generation over the projection period. Excluding coal-dependent South Africa, hydroelectricity represents the largest source of electricity generation in Africa.

Although Africa has little in the way of developed solar power resources at present, its total solar electricity generation increases rapidly in the later years of the Reference case projection, from 8.1 billion kilowatthours in 2020 to 21.1 billion kilowatthours in 2040. In Ghana, construction of the largest solar project in Africa, at 155 megawatts, is scheduled to be started in 2013 and completed in 2015 [*277*]. Morocco awarded a $1 billion contract to a Saudi Arabian company to complete the first phase of five solar plants, which in 2020 will provide 2,000 megawatts of capacity. The initial phase calls for construction of 160 megawatts of capacity to be completed by 2014 [*278*]. In 2012, the Development Bank of Southern Africa approved funding for 762 megawatts of solar power in South Africa.

Figure 94. Africa net electricity generation by fuel, 2010-2040 (trillion kilowatthours)



Central and South America

In the *IEO2013* Reference case, electricity generation in Central and South America increases by an average of 2.2 percent per year, from 1,039 billion kilowatthours in 2010 to 2,023 billion kilowatthours in 2040. The fuel mix for electricity generation in the region is dominated by hydropower, which accounted for nearly two-thirds of total net electricity generation in 2010. Of the top five electricity-generating countries in the region, three—Brazil, Venezuela, and Paraguay—generate more than 70 percent of their total electricity from hydropower.

Brazil, the region's largest economy, produces nearly one-half of the region's total electricity generation, but with strong projected economic growth, its share rises to 60 percent in 2040 (Figure 95). Although hydroelectricity accounted for nearly 80 percent of the Brazil's electricity generation in 2010 (Figure 96), the government has been trying to diversify Brazil's electricity generation fuel mix and reduce its reliance on hydropower to mitigate the risk of power shortages during times of severe drought.

In its National Energy Plan for 2010-2019, Brazil's government set a goal to build 63 gigawatts of new capacity, with nonhydroelectric capacity making up most of the additions [*279*]. To help achieve that target, the government announced plans to increase nuclear power capacity, beginning with the completion of the long-idled 1.3-gigawatt Angra-3 project [*280*]. Construction resumed in June 2010, and Angra-3 is scheduled to be operational at the end of 2016. Brazil also has plans to construct four new 1-gigawatt nuclear plants, scheduled to be operational before 2035 [*281*].

For Central and South American as a whole, hydropower remains the dominant energy source for electricity generation through 2040 in the *IEO2013* Reference case, followed by natural gas. After Brazil, the region's next largest economies, Argentina and Venezuela, account for nearly one-quarter of the region's electricity generation. Unlike Brazil, Argentina relies on hydropower for only 28 percent of its electricity supply. Argentina is the largest producer of natural gas in South America and relies on natural gas for 50 percent of its electricity supply. Brazil and Argentina are the only countries in the region with operating nuclear power plants. Although nuclear power provides only 7 percent of its electricity generation at present, Argentina intends to increase that share when the Atucha II nuclear station commences operation before the end of 2013 [*282*].

Hydropower accounts for nearly 75 percent of Venezuela's electricity generation, with most of the remainder coming from oil and natural gas. In recent years, Venezuela's power sector has suffered from recurring blackouts as a result of underinvestment in the generation, transmission, and distribution infrastructure [*283*], leading the country's government to encourage conservation measures in an effort to reduce electricity demand [*284*]. In the near term, Venezuela's nationalized electricity company, Corpoelec, working with Chinese investors, intends to upgrade the nation's transmission and distribution system at a cost of $1.3 billion [*285*].

Figure 95. Brazil and Other Central and South America net electricity generation, 2010-2040 (trillion kilowatthours)

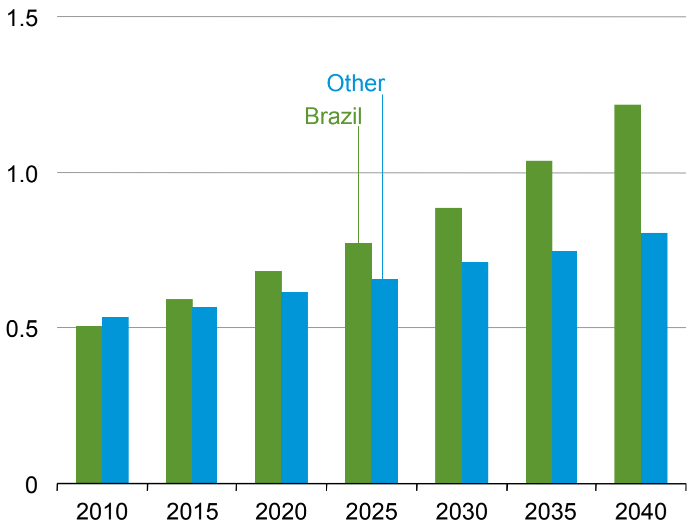
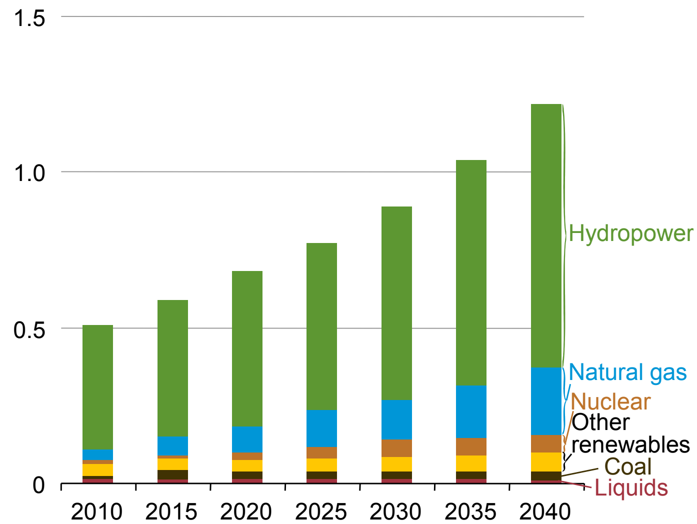


Figure 96. Brazil net electricity generation by fuel, 2010-2040 (trillion kilowatthours)



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Chapter 6

Buildings sector energy consumption

Overview

The buildings sector represents energy use in places where people reside, work, and buy goods and services. The sector excludes industrial facilities used for producing, processing, or assembling goods. In 2010, the buildings sector accounted for more than one-fifth of total worldwide consumption of delivered energy. While energy consumption increases in all end-use demand sectors, energy use in the buildings sector grows fastest throughout the projection. This growth, along with unprecedented changes in the underlying living standards and economic conditions, will make developments within the buildings sector important in understanding future world energy markets.

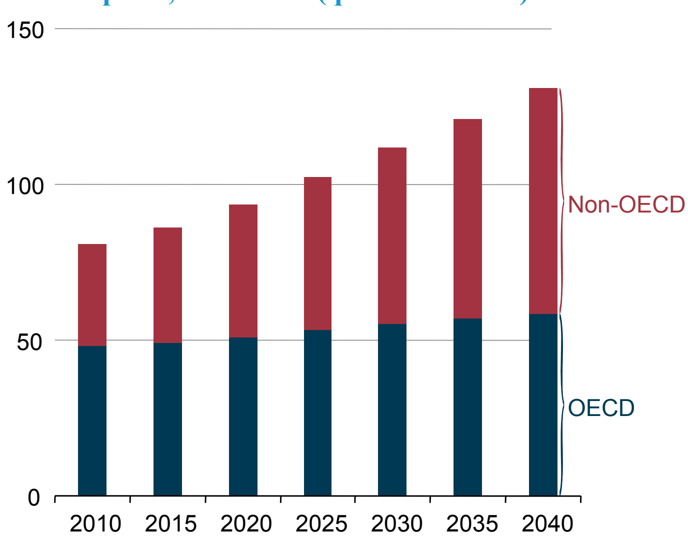
In the *IEO2013* Reference case, total world delivered energy demand for buildings increases from 81 quadrillion Btu in 2010 to nearly 131 quadrillion Btu in 2040, an average annual growth rate of 1.6 percent per year (Figure 97). In the OECD, consuming patterns are well-established and are slow to change, given aging populations and relatively mature economies. This is not the case in the non-OECD countries, where developing economies experience strong economic growth as living standards rise and the energy infrastructure expands, leading to increased energy demand for space heating and cooling, lighting, and energy-using appliances. The higher level of economic activity in the non-OECD region also leads to increased energy demand in commercial and service industries, as square footage grows to house and operate new and expanding enterprises. Non-OECD buildings sector energy consumption increases by 2.7 percent per year and accounts for nearly 80 percent of the growth in the world's total buildings sector energy consumption over the projection period. OECD buildings sector energy use grows much more slowly, increasing by an average of 0.6 percent per year from 2010 to 2040.

Households in many non-OECD countries still rely heavily on traditional, nonmarketed energy sources, including wood and waste, for heating and cooking. Much of Africa remains unconnected to power grids, and the International Energy Agency estimates that 1.3 billion people do not have access to electricity, most of them located in sub-Saharan Africa [*286*]. About 2.6 billion people, mostly in Africa and non-OECD Asia, still rely on traditional biomass for cooking fuel. As incomes rise and more people gain access to electricity and move from rural areas to cities in the developing world [*287*], households replace traditional fuels with modern fuels, such as natural gas and electricity. The trend toward replacing traditional fuel sources (including fuel wood, charcoal, animal dung, and agricultural residues) is reflected in the growth in demand for marketed fuels.

Residential energy consumption

Energy use in the residential sector is defined as the energy consumed by households, excluding transportation uses.[41] In the residential sector, energy is used for equipment and appliances that provide heating, cooling, lighting, water heating, and other household demands. Energy consumption, income, and energy prices all affect the way energy is consumed in the residential sector. However, residential energy use also is affected by various other factors, such as location, building and household characteristics, weather, type and efficiency of equipment, energy access, availability of energy sources, and energy-related policies. As a result, the type and amount of energy use by households can vary widely within and across regions and countries.

Figure 97. World buildings sector delivered energy consumption, 2010-2040 (quadrillion Btu)



In general, the average household in OECD nations uses more energy than those in non-OECD nations, largely because higher income levels allow OECD households to have larger homes and purchase more energy-using equipment. In the United States, for example, average GDP per capita in 2010 was $42,130 (in real 2005 dollars per person), and annual residential energy use per capita was estimated at 36.8 million Btu. In contrast, India's per-capita income in 2010 was $2,989 (about 7.1 percent of the U.S. level), and its residential energy use per capita was 1.4 million Btu (about 4 percent of the U.S. level).

Residential energy consumption is also affected by fuel prices. For example, if energy prices increase, householders may react in the short run by adjusting their thermostats to reduce fuel use. In the long run they may also switch to less expensive fuels or use more efficient appliances or equipment, to the extent possible. On the other hand, in many emerging

[41]Total delivered energy use in the residential and commercial sectors includes electricity, natural gas, liquid fuels, and coal. While renewable energy is reported in the electric power sector, energy data on the direct use of renewable energy outside the United States is not readily available and, as a result, is not included in the *IEO2013* projections. The term delivered is used to indicate that the measurement is made at the point of entry into a home or building—the point of delivery. Delivered electricity, for example, excludes electric generation losses.

economies energy prices may be subsidized, which can affect consumption growth, particularly growth of electricity use in urban areas with access to electricity.

For residential buildings, the physical size of a structure also influences the amount of energy used by its occupants. Controlling for other factors, larger homes generally require more energy to provide heating, air conditioning, and lighting. In addition, occupants of larger homes tend to be more affluent and, as a result, tend to own more energy-using appliances, including multiple television sets, computers, and a wide array of other electronic devices. The operation of those devices can consume considerable amounts of electric power [*288*].

The number of people living in a home also affects the amount of energy consumed. Energy consumption per person generally increases as household size gets smaller, in part because major energy end-use services (heating, cooling, major appliances) tend to be shared within a household. Population growth, particularly in urban areas, leads to higher demand for housing and an increase in the number of smaller households. According to a study by Lawrence Berkeley National Laboratory, the average urban household size in China will decline to 2.9 persons in 2020 from 3.1 persons per household in 2000, as more people migrate to urban areas [*289*]. Other household characteristics that affect the amount and type of energy consumption are labor force participation rates and the age of household members.

Local climates are a key factor causing fluctuations in energy use for space heating and cooling. In the United States, for example, population growth has shifted generally to the South and West over the past 30 years, affecting the mix of energy services and energy used. Because the southern United States is warmer than the national average, cooling demand in the South is higher and heating demand is lower.

Lifestyle and behavior also affect residential energy consumption. In emerging economies, such as India, there are significant differences in energy consumption patterns between rural and urban areas [*290*]. Biomass is widely used for cooking in rural areas. As people's quality of life improves, they switch to more efficient and modern fuels. Over the years, improvements in energy efficiency standards and building codes have affected world residential delivered energy consumption, particularly in the developing nations. However, a lack of consistent and detailed data makes it difficult to quantify their effects.

In the *IEO2013* Reference case, energy use in the residential sector accounts for about 14 percent of world delivered energy consumption in 2040, excluding traditional fuels. World residential delivered energy consumption increases by 57 percent from 2010 to 2040 in the Reference case, mainly as a result of growth in non-OECD residential demand (Table 15). Total non-OECD residential delivered energy consumption increases at an average annual rate of 2.5 percent, compared with 0.4 percent in the OECD regions. China and India continue to lead the growth in world residential delivered energy demand as a result of their rapid economic and population growth. In 2040, their combined residential energy use is almost three times higher than in 2010 and accounts for nearly 31 percent of total world residential delivered energy consumption.

In 2010, the average OECD resident used more than five times as much residential energy as the average person living in the non-OECD (Table 16). Per capita residential energy use in the OECD does not change very much over the projection period due to improvements in energy efficiency and energy management. In the non-OECD nations, per capita residential energy use grows by almost 60 percent from 2010 to 2040, as energy infrastructure expands to more homes and living standards rise with a corresponding increase in the penetration and use of energy-using equipment and appliances in homes. This trend is most evident in the non-OECD Asia region, where per capita energy use in the residential sector grows from 2.9 million Btu per person in 2010 to 6.7 million Btu per person in 2040.

Table 15. Residential sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD	**28.2**	**28.1**	**29.0**	**29.9**	**30.8**	**31.3**	**32.0**	**0.4**
Americas	13.2	12.8	12.9	13.2	13.5	13.9	14.2	0.3
Europe	11.7	11.9	12.5	13.1	13.5	13.7	13.9	0.6
Asia	3.3	3.4	3.5	3.7	3.8	3.8	3.9	0.5
Non-OECD	**23.9**	**27.0**	**30.8**	**35.1**	**40.0**	**45.0**	**49.8**	**2.5**
Europe and Eurasia	6.3	6.3	6.7	7.1	7.7	8.1	8.6	1.0
Asia	10.6	12.8	15.6	18.7	22.2	25.9	29.6	3.5
Middle East	3.4	3.9	4.2	4.4	4.6	4.7	4.8	1.2
Africa	1.6	1.7	1.9	2.2	2.5	2.8	3.2	2.4
Central and South America	2.0	2.3	2.4	2.7	3.0	3.4	3.7	2.1
World	**52.0**	**55.1**	**59.8**	**65.0**	**70.8**	**76.3**	**81.8**	**1.5**

Electricity and natural gas are the main energy sources for marketed residential use worldwide; together, they account for 72 percent of world residential delivered energy consumption in 2010 and 84 percent in 2040 (Figure 98). Nevertheless, households in many developing, non-OECD countries still rely heavily on traditional fuels, including wood and waste. In general, traditional fuels are used because of a lack of access to modern fuels and low per-capita income. As incomes and living standards improve, the use of the traditional fuels will decline.

The residential sector share of world electricity use increases in the *IEO2013* Reference case, from 28 percent in 2010 to 31 percent in 2040. By 2020, electricity overtakes natural gas as the major source of residential delivered energy consumption, increasing from 34 percent in 2010 to 46 percent in 2040. The natural gas share remains flat at about 38 percent throughout the projection. The shift is more pronounced in non-OECD regions.

OECD

In the *IEO2013* Reference case, residential delivered energy consumption in the OECD increases from 28 quadrillion Btu in 2010 to 32 quadrillion Btu in 2040, an average increase of 0.4 percent per year (Figure 99). The slow growth is a result of relatively slow growth in GDP and population, along with improvements in building shells and the efficiency of appliances and equipment. The OECD share of the world's residential delivered energy consumption declines from 54 percent in 2010 to 39 percent in 2040, as demand among the non-OECD emerging economies rises.

Electricity replaces natural gas as the main source of OECD residential energy consumption, accounting for 46 percent of total residential consumption in 2040, as demand for household electronics increases. Shares of other fuels, mainly natural gas, liquids,

Figure 98. World residential sector delivered energy consumption by energy source, 2010-2040 (quadrillion Btu)

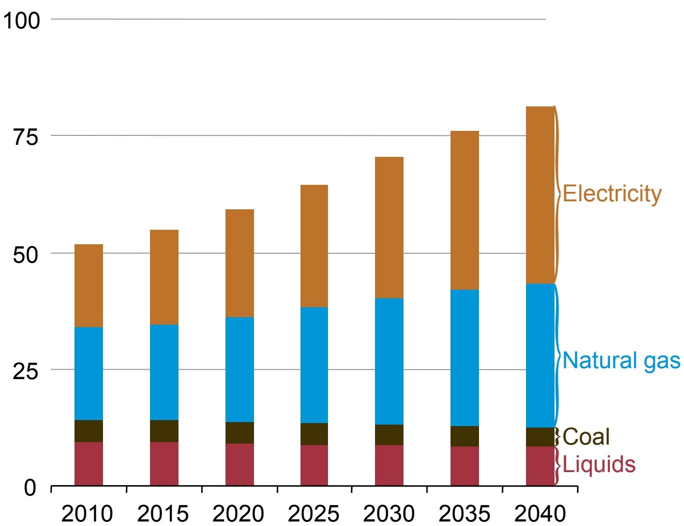


Figure 99. Average annual change in OECD residential sector energy consumption, 2010-2040 (percent per year)

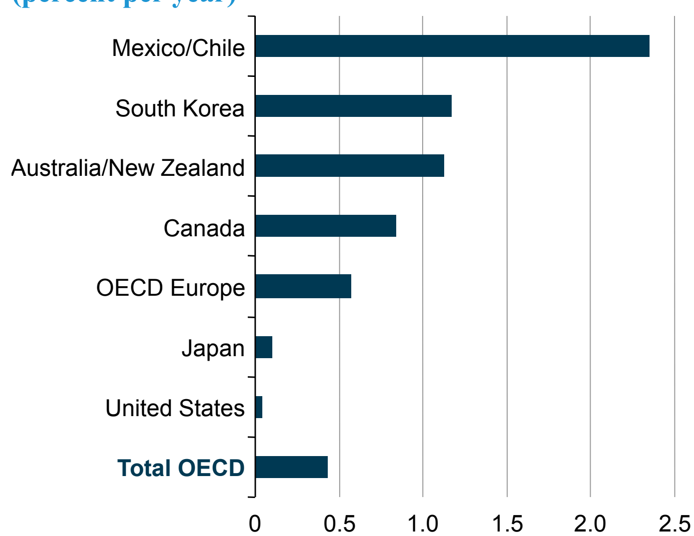


Table 16. Per capita residential sector delivered energy consumption by region, 2010-2040 (million Btu per person)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD	**22.8**	**22.1**	**22.2**	**22.4**	**22.5**	**22.5**	**22.7**	**0.0**
Americas	27.7	25.8	24.7	24.1	23.8	23.4	23.3	-0.6
Europe	21.0	20.9	21.6	22.2	22.7	22.8	23.1	0.3
Asia	16.3	16.5	17.3	18.0	18.6	19.1	19.5	0.6
Non-OECD	**4.2**	**4.5**	**4.9**	**5.3**	**5.8**	**6.3**	**6.8**	**1.6**
Europe and Eurasia	18.7	18.5	19.5	20.9	22.6	24.0	25.7	1.1
Asia	2.9	3.4	3.9	4.5	5.2	6.0	6.7	2.8
Middle East	16.1	17.0	16.6	16.4	16.2	15.5	14.8	-0.3
Africa	1.6	1.5	1.5	1.6	1.7	1.8	1.8	0.5
Central and South America	4.3	4.6	4.8	5.1	5.6	6.0	6.5	1.3
World	**7.6**	**7.6**	**7.8**	**8.2**	**8.6**	**8.9**	**9.3**	**0.7**

and coal, decrease in the IEO2013 Reference case. Electricity and natural gas consumption grow by 1.1 percent and 0.3 percent per year, respectively, while coal use in the sector decreases by 1.4 percent per year, and liquid fuels consumption decreases by 0.8 percent per year.

OECD Americas

The countries of the OECD Americas (United States, Canada, Chile, and Mexico) accounted for about one-fourth of the world's total residential delivered energy consumption in 2010. Within the OECD Americas, the United States is by far the largest consumer of residential energy, accounting for 87 percent of total residential delivered energy consumption in 2010, but its share is expected to decline to 81 percent in 2040. Residential energy consumption in the United States grows minimally between 2010 and 2040, as state and federal energy efficiency standards for residential equipment restrain the growth in energy use (Figure 100).

The energy efficiency of residential equipment and appliances in the United States plays a key role in determining the amount of energy used in homes. Since their inception in the 1970s, federal efficiency standards have expanded to cover an extensive range of residential equipment. After 2020, lighting sees the largest efficiency gains, as the Energy Independence and Security Act of 2007 (EISA2007) requires the phased replacement of most incandescent lamps with technologies that are roughly three times more efficient than those widely marketed today [*291*].

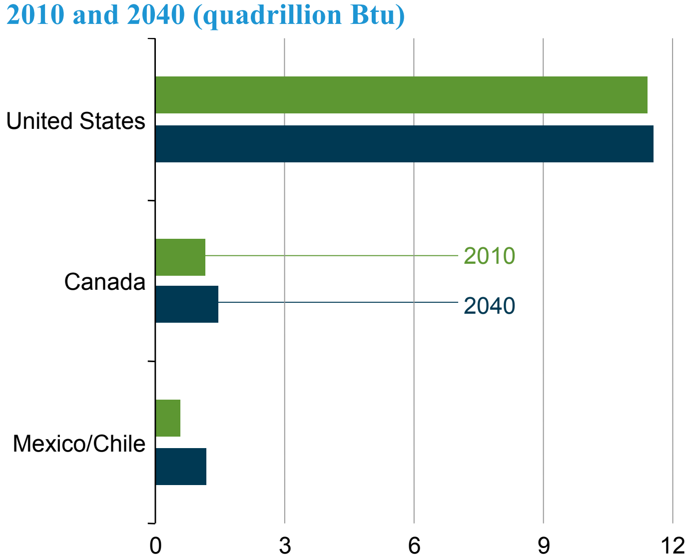
In addition to realizing substantial energy savings through efficiency gains, the U.S. residential energy mix also changes. Consumption of liquids and natural gas in the U.S. residential sector declines, while the use of electricity increases in the IEO2013 Reference case. Electricity remains the main energy source, with its share increasing from 43 percent in 2010 to 52 percent in 2040, partially due to the increasing penetration and saturation of new electronics and small appliances in U.S. households.

In Canada, where residential energy is used mostly for space heating, residential energy consumption increases by an average of 0.8 percent per year in the *IEO2013* Reference case. By 2020, Canada's residential energy consumption per capita overtakes the United States, because of greater energy demand for space heating in Canada's colder climate [*292*]. Canada's residential energy use per capita declines in the Reference case by 0.1 percent per year on average from 2010 to 2040, compared with an average decline of 0.8 percent per year in the United States.

Canada's residential delivered energy consumption is influenced by recent improvements in the energy efficiency of residential buildings and equipment, particularly after 1990. The 1992 Energy Efficiency Act, Canada's first comprehensive law on energy efficiency, took effect in 1995, covering more than 30 products including space heating and cooling and water heating [*293*]. The ENERGY STAR program was introduced in Canada in 2001 [*294*]. At present about 50 items are eligible for the ENERGY STAR label [*295*]. The buildings code, which was modified in 2012, has a significant impact on improving Canadian residential energy consumption efficiencies in the *IEO2013* Reference case [*296*].

Mexico and Chile combined accounted for about 5 percent of total residential delivered energy consumption in the OECD Americas in 2010, and their share nearly doubles by 2040. Mexico/Chile have the highest GDP growth rates within the OECD, at 3.7 percent per year from 2010 to 2040, compared with 2.5 percent per year for the United States and 2.2 percent per year for the OECD overall. This strong economic growth translates to rising living standards and an increase in energy demand for residential space conditioning and energy-consuming household appliances. Residential energy consumption in Mexico/Chile grows by 2.4 percent annually.

Figure 100. OECD Americas residential sector delivered energy consumption by country, 2010 and 2040 (quadrillion Btu)



Petroleum and other liquid fuels accounted for the largest share of residential energy use in Mexico/Chile in 2010. High sustained world oil prices and opportunities for switching to more efficient energy technologies mean that liquid fuels consumption grows by only 0.1 percent per year, while consumption of electricity and natural gas grows by 4.0 and 3.4 percent per year, respectively. The share of liquids declines from 54 percent in 2010 to 28 percent in 2040, as electricity becomes the major energy source in Mexico/Chile, with its share growing from 38 percent in 2010 to 61 percent in 2040.

OECD Europe

Households in OECD Europe accounted for 22 percent of the world's total residential delivered energy consumption in 2010; however, their share falls to 17 percent in 2040. Increasing efficiency and low population growth translate to slower growth in energy consumption than in most other nations in the world. Total residential demand for energy in OECD Europe increases from 12 quadrillion Btu in 2010 to 14 quadrillion Btu in 2040, an average of 0.6 percent per year

(Figure 101). Electricity use accounts for most of the increase in OECD Europe's residential sector energy consumption, rising by an annual average rate of 1.4 percent. This is followed by natural gas consumption, which increases by 0.7 percent per year. All other energy sources decline in Europe's residential sector over the projection period.

Many countries in OECD Europe have enacted measures to improve energy efficiency in the buildings sector. Those efforts are, in part, reflected in the slow increase in residential energy use. For instance, the European Union, which includes the largest economies in OECD Europe, has enacted "a set of binding legislation which aims to ensure the European Union meets its ambitious climate and energy targets for 2020" [*297*]. In March 2007, the European Commission enacted the 20-20-20 plan, which creates a 20-percent improvement target for energy efficiency in the European Union. Recently, the European Union moved to strengthen the energy efficiency provisions of the 20-20-20 plan, and on October 25, 2012, it adopted the European Energy Efficiency Directive 2012/27/EU [*298*]. The key provision of the directive is to obligate energy suppliers to achieving energy savings of 1.5 percent per year among their customers [*299*].

OECD Asia

The nations of OECD Asia (Japan, South Korea, Australia, and New Zealand) account for 12 percent of the OECD's total residential delivered energy consumption through the projection. Residential demand for energy in OECD Asia increases by 0.5 percent per year from 2010 to 2040. Japan has the largest residential energy sector in the region (Figure 102), accounting for about 57 percent of total delivered residential energy consumption in OECD Asia in 2040. Japan's residential sector energy consumption grows by 0.1 percent annually from 2010 to 2040 in the *IEO2013* Reference case, as its GDP grows by 0.6 percent and its population declines by 0.4 percent a year. A key factor affecting current residential energy consumption is the impact of Japan's strict Top Runner standards [*300*]. These standards set mandatory efficiency standards for a variety of energy-consuming goods, including residential heating and cooling systems, lighting, refrigerators, and electronics.

The residential sector accounts for more than one-third of total electricity consumption in Japan through the projection, mostly for residential electronics. After the earthquake and tsunami that struck the northeast coast of Japan in March 2011 and the disruption of electricity generation that followed, a Restriction on Use of Electricity law was approved in 2011, which encouraged electricity users in the buildings sector to conserve energy to meet the government's goal of a 15-percent reduction in total electricity consumption [*301*]. As a result, residential electricity use declined and is not expected to reach 2010 levels again until 2015.

The *IEO2013* Reference case assumes that demand for electricity in Japan will recover to pre-earthquake and tsunami levels as the infrastructure is repaired and electricity supplies return to pre-disaster levels. Electricity remains Japan's main residential energy source throughout the projection period, increasing by 0.6 percent per year on average from 2010 to 2040. The country continues to account for the largest portion of OECD Asia residential energy consumption throughout the projection, but its share declines between 2010 and 2040.

South Korea has the highest rate of GDP growth in OECD Asia in the *IEO2013* Reference case, averaging 3.3 percent per year from 2010 to 2040. In 2008, space and water heating accounted for 68 percent of the country's residential delivered energy consumption [*302*]. Residential energy consumption in South Korea grows by 1.2 percent per year from 2010 to 2040, but its share of total residential energy consumption in OECD Asia increases from 23 percent to 28 percent over the projection period. In 2010,

Figure 101. OECD Europe residential sector delivered energy consumption by energy source, 2010-2040 (quadrillion Btu)

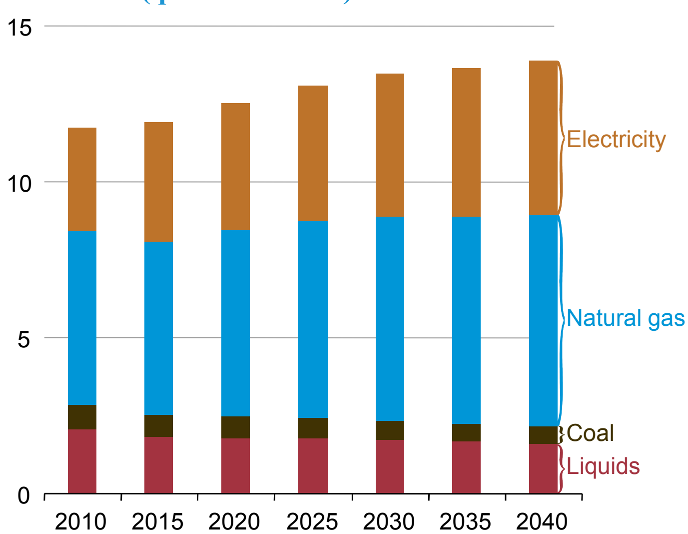
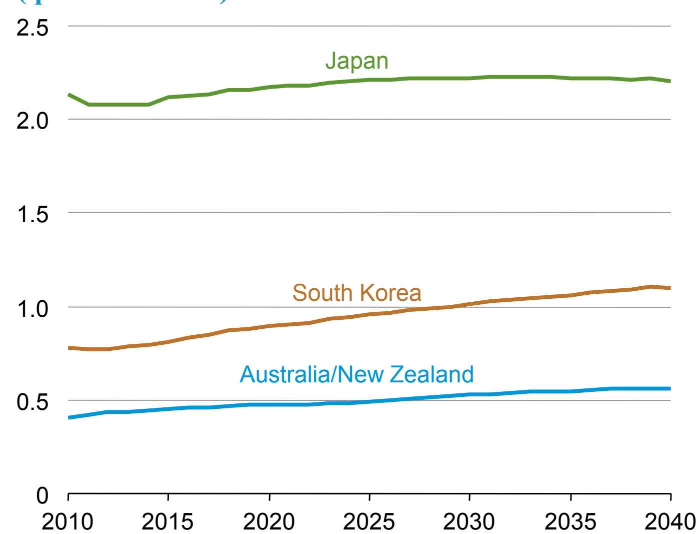


Figure 102. OECD Asia residential sector delivered energy consumption by country, 2010-2040 (quadrillion Btu)



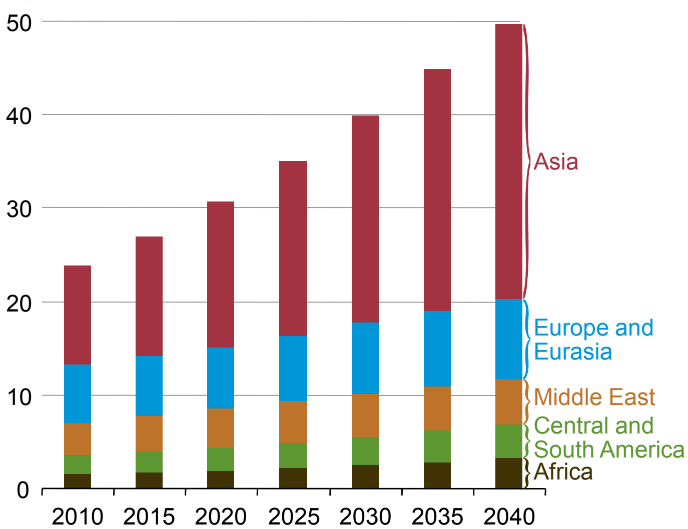
residential energy consumption per capita in South Korea was similar to that in Japan. However, its per-capita residential energy consumption is 15 percent higher than Japan's in 2040, partly due to faster growth in South Korea's GDP per capita over the period.

In the *IEO2013* Reference case, residential delivered energy consumption in Australia and New Zealand combined grows by an average of 1.1 percent per year. Natural gas and electricity meet the increase in total residential energy demand, growing by 1.5 percent and 1.0 percent per year, respectively. The increases in electricity and natural gas use result mainly from increased use of electric appliances and natural gas space heating [*303*].

Non-OECD

Delivered residential energy in the non-OECD region, which accounted for 46 percent of the world's total delivered residential energy consumption in 2010, grows to 51 percent of the world's total in 2020 and 61 percent in 2040 as a result of generally faster economic and population growth than in the OECD. Total non-OECD residential delivered energy consumption increases from 24 quadrillion Btu in 2010 to 50 quadrillion Btu in 2040, an average increase of 2.5 percent per year (Figure 103). Growth in electricity consumption, which rises from 7 quadrillion Btu in 2010 to 23 quadrillion Btu in 2040, is the main source of the increase in residential energy consumption. Electricity grows from 29 percent to 47 percent of non-OECD residential energy, with many emerging economies building out their electric infrastructure, transitioning from traditional fuels[42] to modern energy sources, and improving standards of living for residents.

Figure 103. Non-OECD residential sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)



Non-OECD Asia

In the non-OECD Asia nations, particularly China and India (Figure 104), growth in population, income, and urbanization drives increases in residential energy consumption. In the *IEO2013* Reference case, China and India account for about 31 percent of the world's residential energy consumption in 2040, up from 16 percent in 2010. In non-OECD Asia as a whole, residential delivered energy use grows from 11 quadrillion Btu in 2010 to 30 quadrillion Btu in 2040, an average rate of 3.5 percent per year (Figure 105).

The importance of China in world residential delivered energy consumption continues to grow. In 2010, China's residential energy consumption was 60 percent of residential energy consumption in the United States, but in 2040 it is almost twice as high as in the United States, as China becomes the world's largest residential energy consumer. In 2040, residential energy consumption in China accounts for about 24 percent of total world residential delivered energy use.

Figure 104. Average annual change in non-OECD residential sector delivered energy consumption by region, 2010-2040 (percent per year)

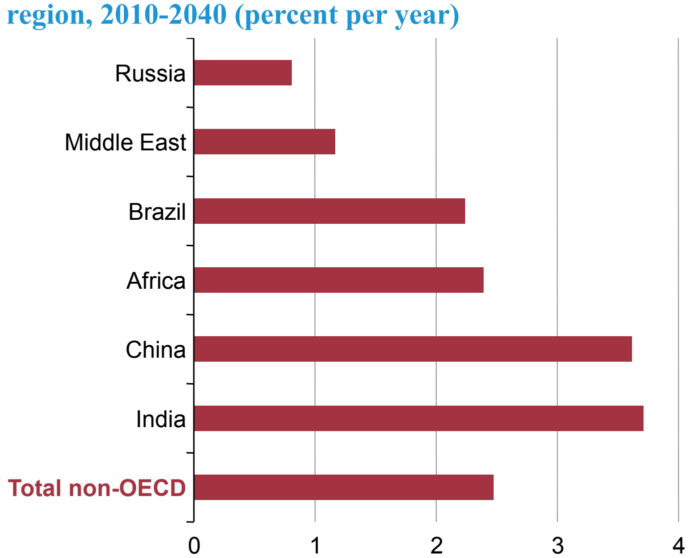
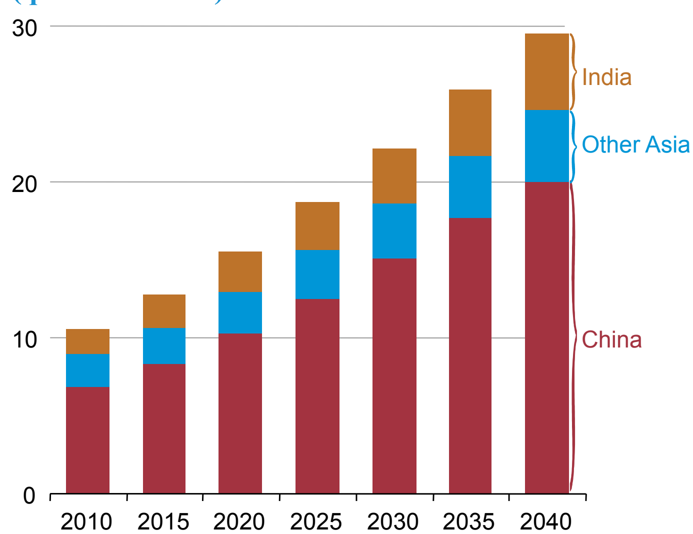


Figure 105. Non-OECD Asia residential sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)



[42]Traditional fuels include fuelwood, charcoal, animal dung, and agricultural residues in stoves with very low efficiencies.

Energy use in China grows by an average of 3.6 percent per year from 2010 to 2040 in the *IEO2013* Reference case, from 6.9 quadrillion Btu in 2010 to 20.0 quadrillion Btu in 2040. In 2010, the residential sector accounted for nearly 10 percent of China's total delivered energy consumption. In 2040, its share is 14 percent.

The rapid growth in China's energy consumption is mainly a result of strong economic growth and urbanization, as lifestyle and energy use patterns vary widely between urban and rural populations [*304*]. China's population peaks in 2026 and thereafter declines through 2040. According to the United Nations, nearly three-fourths of the Chinese population will live in urban areas by 2040 [*305*]. China's demand for energy services increases as per capita incomes and quality of life improve, accompanied by an increase in urban population and increased access to modern fuels in rural areas. Over the projection period, China's residential energy use per capita grows by 3.6 percent per year, from about 5 million Btu per person to 15 million Btu per person, or more than one-half of U.S. energy use per capita in 2040.

China's residential fuel mix shifts toward electricity and natural gas over the period from 2010 to 2040. In the *IEO2013* Reference case, residential natural gas consumption grows faster than electricity consumption in China, as natural gas prices decline and China's central government promotes natural gas as a preferred energy source [*306*]. Natural gas consumption grows by 7.2 percent per year and electricity consumption by 5.7 percent per year, while consumption of liquid fuels and coal declines by 1.0 percent and 0.2 percent per year, respectively. By 2017, electricity becomes the major energy source, and in 2040 it accounts for 46 percent of residential delivered energy consumption. Natural gas accounts for 35 percent at that point.

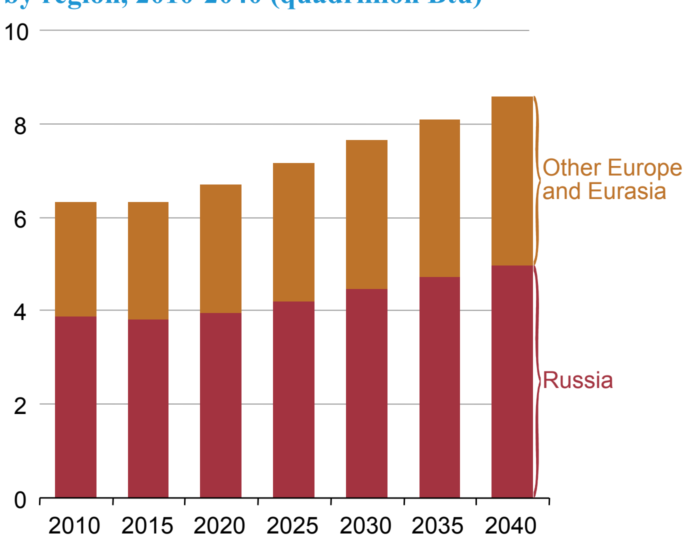
Since the 1980s, the Chinese government has engaged in promoting energy efficiency in residential buildings. It will continue to promote building energy efficiency during the 12th Five-Year Plan (2011-2015). Even with the strong emphasis on improving building energy efficiency, the country's residential delivered energy consumption grows strongly due to various factors, including fast economic growth, improved standards of living, and annual additions of new buildings to house the expanding urbanized population [*307*].

In India, economic growth and population growth have been the two key factors leading to growth in energy consumption [*308*]. Urban areas, which accounted for 31 percent of India's population in 2010, account for 46 percent of the population in 2040 [*309*]. India has the world's most rapid rate of economic growth in the *IEO2013* Reference case, at 6.1 percent per year. Further, India's population grows faster than China's, and India becomes the world's most populous country by 2021. Despite faster growth in GDP and population, growth in India's residential energy consumption resembles that of China, increasing by 3.7 percent per year, from 1.7 quadrillion Btu in 2010 to 5.0 quadrillion Btu in 2040.

The government of India has been engaged in various energy efficiency programs for household appliances and buildings, particularly since 2002, with the establishment of the Bureau of Energy Efficiency [*310*]. Further improvements in the energy efficiency of residential buildings and equipment will affect India's residential sector energy consumption, although again, similarly to China, residential sector delivered energy consumption continues to increase as a result of improving standards of living and rising urbanization.

From 2010 to 2040, India's residential sector fuel mix changes from mainly liquids to electricity, most of which is used for appliances. In 2008, lighting and refrigeration accounted for nearly 50 percent, and space cooling (fans and air conditioners) accounted for 24 percent of total residential electricity consumption [*311*]. As incomes increase and more people have access to electricity, the ownership of electricity-using appliances also increases [*312*]. Residential electricity demand in India, which accounted for 35 percent of the country's total residential delivered energy consumption in 2010, increases to 76 percent in 2040. Electricity use grows more rapidly than total residential delivered energy consumption, averaging 6.4 percent per year as compared with total residential energy consumption growth of 3.7 percent per year.

Figure 106. Non-OECD Europe and Eurasia residential sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)



Non-OECD Europe and Eurasia

The residential sector in non-OECD Europe and Eurasia accounted for about 27 percent of total non-OECD residential delivered energy consumption in 2010, and its share declines to 17 percent in 2040. Residential delivered energy consumption in non-OECD Europe and Eurasia grows from 6.3 quadrillion Btu in 2010 to 8.6 quadrillion Btu in 2040 (Figure 106), an average of 1.0 percent per year. Increased urbanization and GDP growth of about 3.8 percent per year contribute to the increase in residential delivered energy consumption over the projection period [*313*]. Russia has non-OECD Europe and Eurasia's largest economy and consumes the largest amount of energy in the residential sector, accounting for about 58 percent of total residential delivered energy consumption in the region in 2040.

Russia has the highest residential energy consumption per capita among the non-OECD countries. The country's total residential energy demand grows by 0.8 percent per year in the *IEO2013* Reference case. Inefficient heating systems and energy price subsidies, along with the cold climate in much of the country, are some of the factors causing higher per capita consumption in Russia [*314*]. The Russian government, acknowledging that considerable energy savings would be possible with improved energy efficiency of residential buildings, passed an Energy Efficiency Law in November 2009 that included mandated metering in newly commissioned buildings and various other provisions aimed at measuring building efficiency [*315*]. Further, a study by the International Finance Corporation estimated that about 60 percent of Russia's multifamily apartment buildings (which account for approximately 70 percent of its total housing stock on a square footage basis) are in urgent need of capital repair [*316*]. There is considerable uncertainty about the extent to which Russia's existing efficiency law will result in substantial improvements in consumption. Some efficiency improvements occur in the Reference case, but strong economic growth that results in higher living standards and increased demand for energy-consuming appliances and devices offsets the savings, resulting in growing residential energy use through 2040.

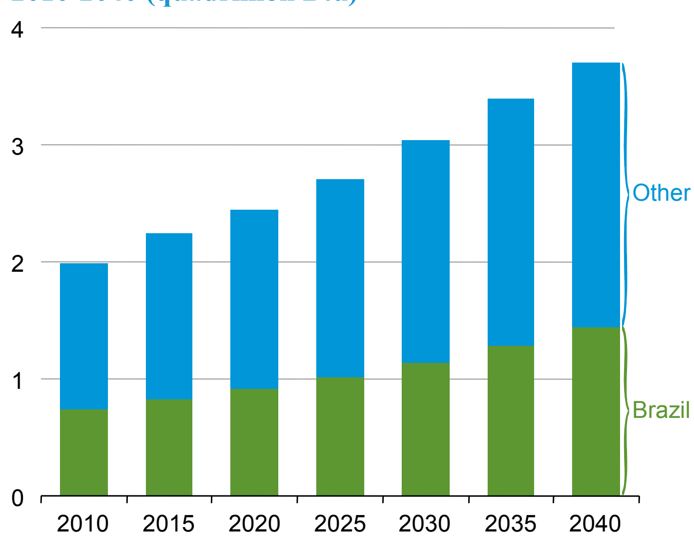
Outside of Russia, residential energy consumption in non-OECD Europe and Eurasia increases by 1.3 percent per year, from 2.4 quadrillion Btu in 2010 to 3.6 quadrillion Btu in 2040, with a rapid increase in economic development accompanied by higher GDP per capita. As the standard of living improves, energy consumption per capita increases by an average of 1.2 percent per year from 2010 to 2040. The growth is attributed mainly to increases in consumption of electricity and natural gas, as the fuels combine for about 89 percent of total residential delivered energy consumption in 2010 and 94 percent in 2040.

Middle East

The countries of the Middle East accounted for about 6.4 percent of total world residential delivered energy consumption in 2010. In 2010, the region made up less than 4 percent of the world population, but its population growth averages 1.5 percent per year from 2010 to 2040. There are wide differences in income across the countries of the Middle East, but the overall economy grows by an average of 2.2 percent per year over the projection period. Residential energy consumption in the region grows at an annual average rate of 1.2 percent, from 3.4 quadrillion Btu in 2010 to 4.8 quadrillion Btu in 2040. The electricity share of the fuel mix increases from 34 percent to 41 percent, as households shift away from other fuel sources, particularly liquids. The increase in electricity demand results from increased use of electric appliances, particularly for space cooling. Despite a slight decline in its share of the overall fuel mix, natural gas remains the dominant fuel of choice in the residential sector through 2040.

Although residential energy use per capita in the Middle East declines by an average of 0.3 percent per year, from 16 million Btu per person in 2010 to 15 million Btu in 2040, it remains higher than the world average. Low prices, high energy subsidies, and the absence of stringent building codes and energy efficiency standards contribute to the relatively high intensity of residential energy use [*317*]. However, with continued strong growth in demand for energy in the residential sector, several countries in the region have begun to look at ways to improve energy efficiency. If successful, such measures could slow the future rate of growth in residential energy use. In 2010, Saudi Arabia established the Saudi Energy Efficiency Center, with one of its primary roles being to develop energy conservation policies. Saudi Arabia's household electricity use has grown rapidly, averaging nearly 7 percent per year since the 1990s [*318*].

Figure 107. Central and South America residential sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)



Africa

Residential delivered energy consumption in Africa grows by an average 2.4 percent per year from 2010 to 2040 in the *IEO2013* Reference case. Much of Africa still is not connected to a power grid and relies heavily on biomass as an energy source. In 2010, the region accounted for 15 percent of the total world population but only 3 percent of total world residential energy consumption. In 2040, Africa's shares of world population and energy consumption grow to 20 percent and 4 percent, respectively.

Central and South America

In non-OECD Central and South America, residential energy consumption grows from 2.0 quadrillion Btu in 2010 to 3.7 quadrillion Btu in 2040, accounting for about 7 percent of total non-OECD residential energy consumption in 2040 (Figure 107). In Brazil, the region's largest economy, residential energy use grows by 2.2 percent per year from 2010 to 2040 in the Reference case. Brazil's residential sector fuel mix shifts away from liquids and increasingly to electricity and natural gas, but while the natural gas share grows, electricity remains the largest source of energy in 2040, followed by liquids. Electricity's share of total residential energy consumption in Brazil grows from 58 percent in 2010 to 73 percent in 2040, while the natural gas share grows from 1 percent in 2010 to nearly 6 percent in 2040, and the liquids share declines from 41 percent to 21 percent. Many of the government policies to improve energy efficiency are targeted at lighting (such as programs to eliminate incandescent light bulbs) or appliances (through minimum energy efficiency standards adopted in 2007 for refrigeration and air-conditioning devices).

Commercial energy consumption

The commercial sector brings together categories of stationary energy use associated with profit-seeking and nonprofit enterprises that provide services, including those for public administration. The sector focuses on energy consumed by heating and cooling systems, lights, water heaters, and other equipment in the buildings where businesses, institutions, and other organizations are located. Examples of commercial sector buildings include schools, retail stores, restaurants, hotels, hospitals, office buildings, and leisure and recreational facilities. Some nonbuilding energy use is included in the commercial sector, where it contributes to such public services as traffic lights and water and sewer systems. In the *IEO2013* Reference case, total world delivered commercial sector energy consumption grows at an average annual rate of 1.8 percent from 2010 to 2040, making it the fastest-growing demand sector (Table 17).

The non-OECD region leads the growth of commercial delivered energy consumption, accounting for about 30 percent of global commercial energy consumption in 2010 and growing to a 46-percent share in 2040, mainly as a result of population and economic growth. Generally, the need for services (health, education, leisure, and government, among others) increases as populations grow and economic growth increases the capacity of enterprises to provide those services. The non-OECD region contained more than 80 percent of the world's population in 2010, and its population growth rate is almost twice that of the OECD through the projection. The non-OECD countries accounted for slightly less than one-half of the world's GDP (on a purchasing power parity basis) in 2010, and their share increases to about 66 percent in 2040.

Dynamics within the overall economic and population growth trends that affect commercial delivered energy consumption include employment rates, productivity, and the amount of commercial activity that occurs as a part of total economic activity. Some other broad factors are important as well, including climate, availability of resources, and the efficiency of energy consumption. In the commercial sector, the energy efficiencies of building shells and commercial equipment generally are determined by management decisions during the construction and operation of commercial buildings and enterprises. Those decisions can be guided by national energy policies and laws.

Figure 108. World commercial sector delivered energy consumption by energy source, 2010-2040 (quadrillion Btu)

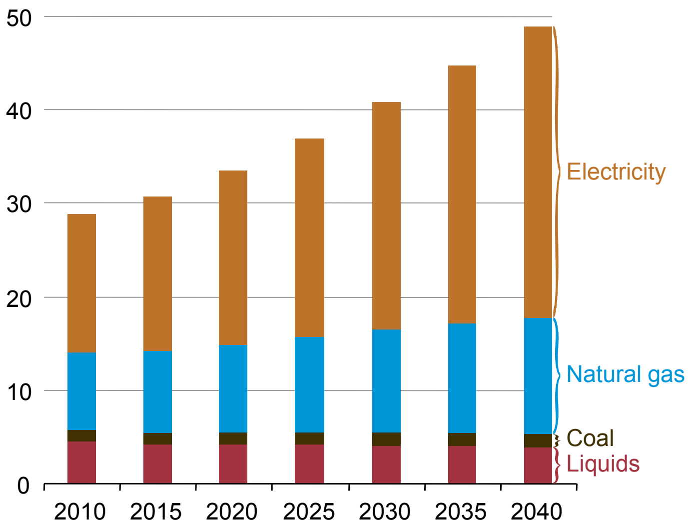


Table 17. Commercial sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD	**20.2**	**20.9**	**22.0**	**23.2**	**24.4**	**25.5**	**26.5**	**0.9**
Americas	9.8	10.1	10.5	10.9	11.5	12.0	12.6	0.8
Europe	6.5	6.9	7.4	7.8	8.3	8.6	9.0	1.1
Asia	3.9	3.9	4.2	4.4	4.6	4.8	5.0	0.8
Non-OECD	**8.8**	**9.9**	**11.7**	**13.9**	**16.5**	**19.4**	**22.5**	**3.2**
Europe and Eurasia	2.2	2.3	2.5	2.8	3.1	3.5	3.8	1.8
Asia	4.2	4.9	6.0	7.4	9.1	11.0	13.1	3.9
Middle East	1.0	1.1	1.3	1.5	1.7	1.9	2.0	2.4
Africa	0.4	0.5	0.6	0.7	0.8	1.0	1.2	3.5
Central and South America	1.0	1.1	1.3	1.5	1.8	2.0	2.4	3.1
World	**28.9**	**30.8**	**33.6**	**37.1**	**40.9**	**44.8**	**49.0**	**1.8**

Electricity is increasingly the preferred energy source in the commercial sector (Figure 108). In 2010, electricity accounted for about 51 percent of world commercial energy use, and its share grows to nearly 64 percent in 2040. OECD electricity use grows from 10.4 quadrillion Btu in 2010 to 15.7 quadrillion Btu in 2040, while non-OECD electricity use grows from 4.3 quadrillion Btu in 2010 to 15.4 quadrillion Btu in 2040. Electricity and natural gas taken together remain the most prominent fuels in the commercial sector, accounting for about 80 percent of total world fuel consumption in 2010 and 89 percent in 2040.

OECD

OECD Americas

In the OECD Americas, energy use in the U.S. commercial sector was more than 8 times Canada's and more than 40 times Mexico/Chile's in 2010 (Figure 109). However, from 2010 to 2040 commercial energy consumption in the United States grows at about one-third the rate of Canada's commercial sector energy use and about one-seventh the rate of Mexico/Chile's. U.S. commercial energy use remains much higher than Canada's and Mexico/Chile's in 2040 and the largest in the world through the projection. Commercial energy consumption is similarly proportioned in the United States and Canada relative to the energy demand in other sectors (residential, industrial, and transportation), remaining between 10 percent and 14 percent of total delivered energy consumption for the entire projection period. In Mexico/Chile, the commercial sector share of total delivered energy consumption is much smaller, at 3 percent of total energy demand in 2010 and 5 percent in 2040.

In the United States, federal efficiency standards, which help to foster technological improvements in end-use equipment, act to limit growth in delivered energy consumption compared with growth in commercial floorspace [*319*]. Efficiency improvements in the United States are expected for lighting, refrigeration, space cooling, and space heating, as a result of the Energy Independence and Security Act of 2007 (EISA2007) and the Energy Policy Act of 2005.

Electricity is the most common commercial energy source in the OECD Americas, accounting for about one-half of commercial energy consumption in 2010. The electricity share grows to more than 80 percent in 2040 in Mexico/Chile but remains below 63 percent in the United States and Canada. The United States and Canada also get roughly one-third of their commercial energy from natural gas throughout the projection period, compared with less than 8 percent in Mexico\Chile, where access to natural gas resources is limited [*320*]. Although Mexico/Chile used liquid fuels to meet more than one-third of their combined commercial delivered energy consumption in 2010, much of that energy demand switches to electricity by 2040 in response to sustained high oil prices.

OECD Europe

In 2010, the economy of OECD Europe was slightly larger than the U.S. economy but consumed 24 percent less commercial energy. Many countries in OECD Europe have instituted regulations and policies aimed at increasing energy efficiency in commercial buildings. Implementation of those rules, along with relatively slow growth in GDP and population, results in slow growth in energy consumption in OECD Europe through 2040. OECD Europe's total commercial energy consumption grows from 6.5 quadrillion Btu in 2010 to 9.0 quadrillion Btu in 2040, an average of 1.1 percent per year (Figure 110). Natural gas maintains a one-third share of energy use in the region's commercial sector through the projection, while most new consumption comes from expanded electricity use.

Figure 109. OECD Americas commercial sector delivered energy consumption by country, 2010 and 2040 (quadrillion Btu)

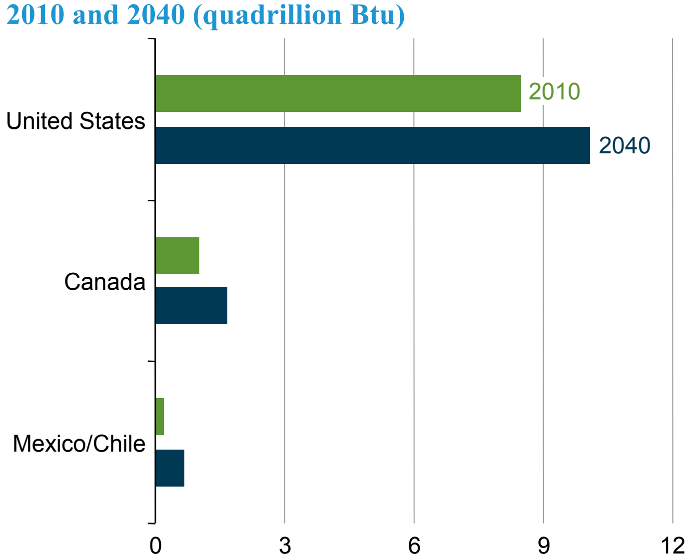
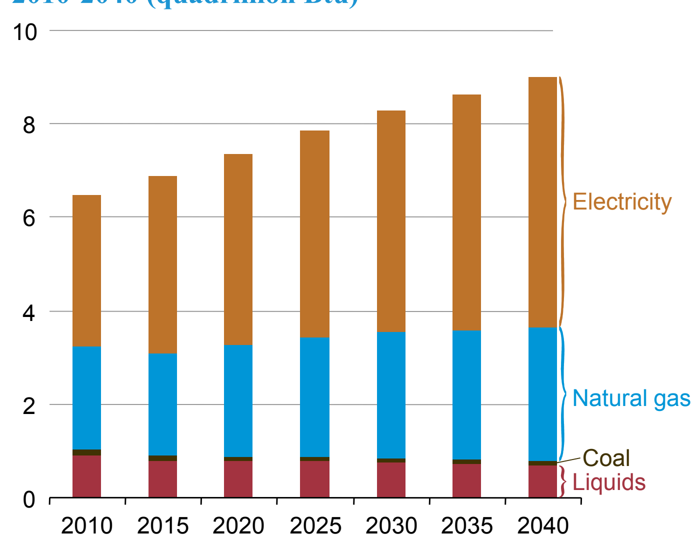


Figure 110. OECD Europe commercial sector delivered energy consumption by energy source, 2010-2040 (quadrillion Btu)



The October 2012 enactment of the European Union's Energy Efficiency Directive improves energy efficiency in the buildings sector [*321*]. In addition, a number of individual countries in OECD Europe have introduced initiatives to improve energy efficiency in the commercial sector. For example, the Netherlands strengthened its building standards in 2009, requiring newly constructed or renovated nonresidential buildings to be 40 percent more energy efficient than previous standards [*322*].

OECD Asia

In OECD Asia, Japan had the highest level of commercial delivered energy consumption in 2010, at 2.7 quadrillion Btu; however, Japan also has the lowest growth rate of commercial energy consumption from 2010 to 2040 at 0.3 percent per year, reaching 3.0 quadrillion Btu in 2040 (Figure 111). Commercial sector delivered energy consumption increases by 2.1 percent per year in South Korea and by 1.2 percent per year in Australia/New Zealand. In 2010, South Korea's commercial sector energy consumption was equal to only about 30 percent of Japan's, but it is about 50 percent of Japan's in 2040, as a result of South Korea's rapid GDP growth and Japan's continued efforts to conserve energy [*323*].

In 2010, about 46 percent of Japan's commercial energy consumption was met by electricity, with the other half split almost equally between natural gas and liquids. In 2040, electricity use is about 27 percent higher, natural gas use is about 12 percent higher, and liquids use is more than 23 percent lower. In comparison, electricity provided a larger share of commercial energy consumption in South Korea in 2010, and the use of both electricity and natural gas grow more rapidly from 2010 to 2040 than in Japan. In Australia/New Zealand, the electricity share of commercial energy consumption was the region's highest in 2010 at 73 percent—and the second highest globally behind the Central and South America region. From 2010 to 2040, most of the growth in Australia/New Zealand's commercial energy use is fueled by electricity and nearly all of the remainder by natural gas.

Non-OECD

Non-OECD Asia

With strong economic growth fueling rising standards of living and growing demand for services, non-OECD Asia has the world's fastest growth in commercial energy consumption from 2010 to 2040, at 3.9 percent per year (Figure 112). Non-OECD Asia accounted for 14 percent of the world's commercial sector delivered energy consumption in 2010, but its share grows to 18 percent in 2020 and 27 percent in 2040 in the *IEO2013* Reference case. China's commercial sector consumed about 2.5 quadrillion Btu in 2010, which was almost twice the level of any other country in the non-OECD. In India, which has the world's highest economic growth rate in the *IEO2013* Reference case, commercial sector energy consumption grows at an average rate of 5.4 percent per year, which is also the world's highest.

In both China and India, the commercial sector share of total delivered energy consumption remains between 2 percent and 6 percent throughout the 2010-2040 period. India's commercial sector is fueled mostly by electricity and coal, with the electricity share growing from about 59 percent in 2010 to 80 percent in 2040. In China, where 43 percent of commercial sector energy consumption was met by liquids in 2010, electricity use for commercial activity grows rapidly, reaching 58 percent of the country's total commercial sector energy consumption in 2040. Consumption of liquids in the commercial sector drops by 0.7 percent per year in China over the projection period, while the use of natural gas and electricity rises dramatically, with growth rates averaging 7.1 percent and 6.5 percent per year, respectively. In 2010, more than 21 percent of commercial sector energy consumption in China was met by coal, making it one of only a few countries, along with India, using significant amounts of coal in the commercial sector.

Figure 111. OECD Asia commercial sector delivered energy consumption by country, 2010-2040 (quadrillion Btu)

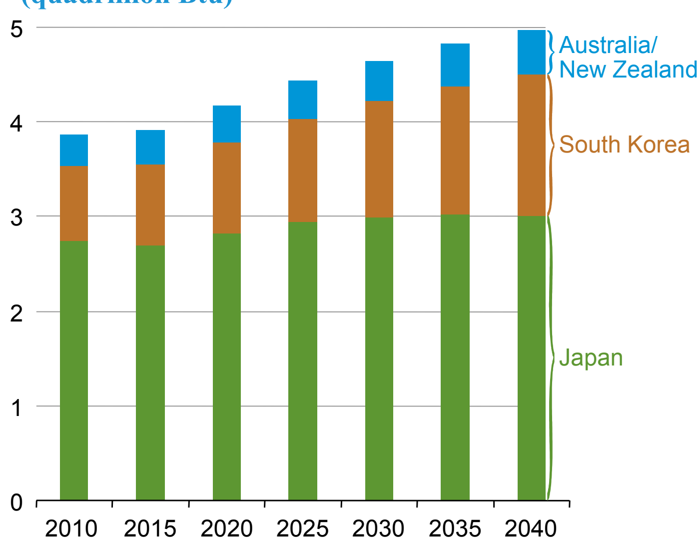
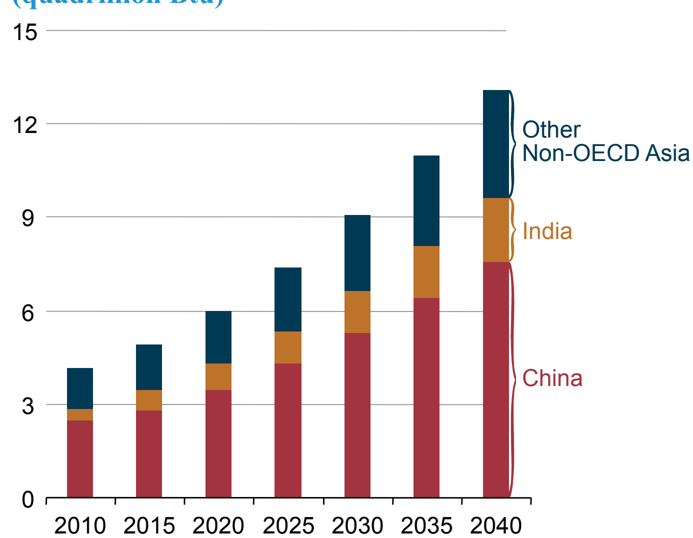


Figure 112. Non-OECD Asia commercial sector delivered energy consumption by country, 2010-2040 (quadrillion Btu)



Unlike the increase in India, coal use in China's commercial sector is virtually unchanged from 2010 to 2040, although the coal share of total commercial sector energy use declines to 7 percent.

Non-OECD Europe and Eurasia

In non-OECD Europe and Eurasia, Russia consumes the second-largest amount of energy in the commercial sector among all non-OECD countries in 2010, but its commercial energy consumption grows by an average of only 1.6 percent per year from 2010 to 2040 in the Reference case. Russia's economic growth rate is the second slowest in the non-OECD region, after the Middle East.

The commercial sector accounted for about 6 percent of Russia's total delivered energy consumption in 2010, the largest share among all non-OECD countries. Most of the energy consumed in Russia's commercial sector comes from electricity and natural gas. In 2010, coal accounted for slightly less than 14 percent of Russia's commercial energy consumption, and liquids accounted for about 8 percent. Both of those shares are smaller in 2040, as use of the two fuels declines in the Reference case, while electricity use and natural gas use increase on average by 2.8 percent and 0.7 percent per year, respectively (Figure 113). In 2040, about 65 percent of Russia's commercial energy consumption is supplied by electricity and about 26 percent by natural gas.

Middle East

Commercial sector delivered energy consumption in the Middle East doubles in the *IEO2013* Reference case, from 1.0 quadrillion Btu in 2010 to 2.0 quadrillion Btu in 2040. The Middle East currently has the second-highest energy intensity in the non-OECD region (after Russia) in terms of commercial energy consumption. The region's energy intensity remains high as the availability of inexpensive, subsidized oil and natural gas discourages efforts to conserve energy [*324*]. Electricity, natural gas, and liquids account for all commercial energy consumption in the Middle East region through 2040 (Figure 114).

Africa

In the *IEO2013* Reference case, Africa's economic growth averages 4.6 percent per year from 2010 to 2040—a full percentage point higher than the world average of 3.6 percent per year. To date, however, Africa continues to use relatively little energy in its commercial sector, which accounts for 3 percent of total delivered energy consumption in 2010 and about 5 percent of the total in 2040. The share in 2010 represents the second-smallest share among all country groups in 2010; and the share in 2040 is the smallest. Many of Africa's sub-Saharan nations rely on nonmarketed, traditional fuels for commercial activities [*325*]. In the countries that have developed national energy infrastructures, most of the activity in their commercial sectors is powered by electricity.

Although a significant portion of Africa's population does not have access to national electric power grids, in some countries, such as South Africa, there is beginning to be an interest in constructing more energy-efficient buildings, particularly in the public sector. In 2011, South Africa released new regulations as part of its South African Bureau of Standards SANS 10400 XA standards, which include a mandate for all new building construction to meet minimum requirements for insulation in order to minimize energy use for space conditioning [*326*]. The program is geared toward improving the penetration of energy-saving equipment and construction techniques over the next decade.

In addition to electricity, Africa's commercial sector consumes significant amounts of liquids (about 20 percent of commercial energy consumption in 2010) and coal (about 10 percent of commercial energy consumption in 2010) but a minimal amount of natural gas. The switch to electricity from liquids and coal is evident in the Reference case, with electricity supplying more than 80 percent of the energy consumed in the commercial sector in 2040, up from 68 percent in 2010.

Figure 113. Russia commercial sector delivered energy consumption by energy source, 2010-2040 (quadrillion Btu)

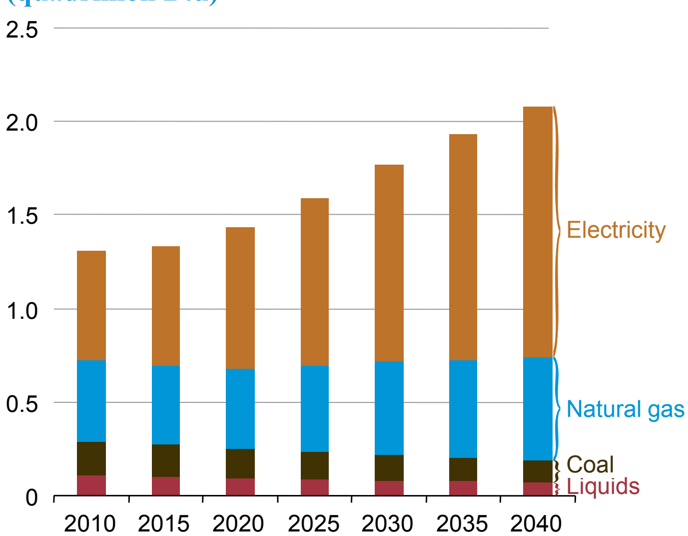
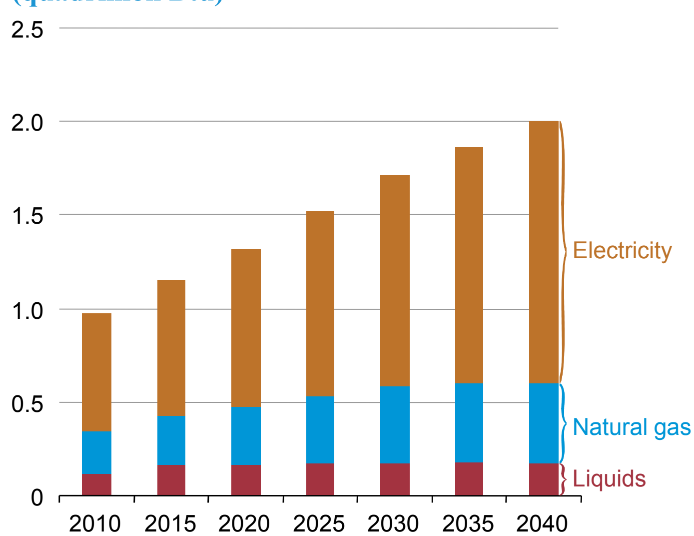


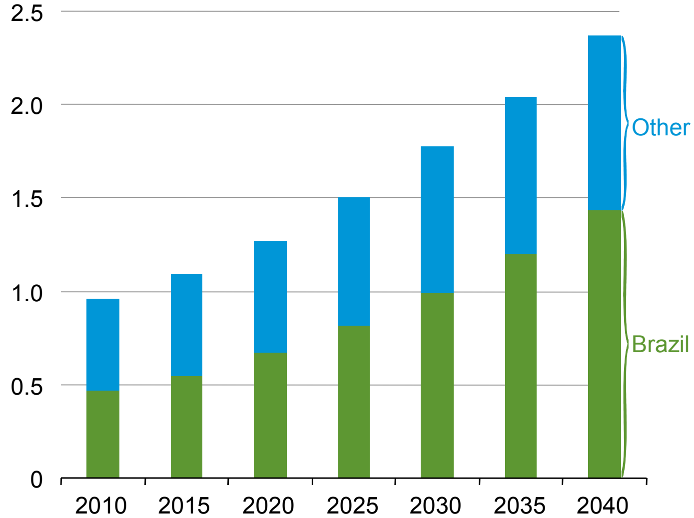
Figure 114. Middle East commercial sector delivered energy consumption by energy source, 2010-2040 (quadrillion Btu)



Central and South America

Commercial sector delivered energy consumption in Central and South America is relatively small compared with the rest of the world. The region's commercial energy consumption amounted to only about 3 percent of the world commercial total in 2010. In the *IEO2013* Reference case, Central and South America's commercial sector energy consumption increases rapidly, by an average of 3.1 percent per year from 2010 to 2040, compared with the world average increase of 1.8 percent per year. The increase is driven largely by a high annual economic growth of 3.3 percent during the period.

Figure 115. Central and South America commercial sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)



Brazil is Central and South America's largest economy and largest commercial sector energy consumer. In 2010, Brazil's commercial sector consumed almost 0.5 quadrillion Btu of energy, nearly equal to the commercial energy use of the rest of Central and South America combined (Figure 115). Brazil's commercial sector is powered almost entirely by electricity, which makes up more than 90 percent of commercial energy consumption in 2010. For some time, Brazil's government has been concerned about overreliance on electricity. In 2001, after a severe drought caused electricity shortages and a national energy emergency, the government enacted the Law of Energy Efficiency [*327*], and in 2009 it released energy efficiency rules for commercial buildings in an effort to improve energy efficiency. The goal of the initiative is to manage growth in energy consumption through improvements in commercial building shells, heating and cooling systems, and lighting.

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Chapter 7

Industrial sector energy consumption

Overview

The industrial sector uses more delivered energy[43] than any other end-use sector, consuming about one-half of the world's total delivered energy. The industrial sector comprises a diverse set of industries, including manufacturing (food, paper, chemicals, refining, iron and steel, nonferrous metals, nonmetallic minerals, and others) and nonmanufacturing (agriculture, mining, and construction). The mix and intensity of fuels consumed in the industrial sector vary across regions and countries, depending on the level and mix of economic activity and technological development, among other factors. Energy is consumed in the industrial sector for a wide range of purposes, such as processing, assembly, producing steam, cogeneration, heating, air conditioning, and lighting in buildings. Industrial sector energy consumption also includes natural gas and petroleum products (naphtha and natural gas liquids) used as feedstocks to produce non-energy products, such as fertilizers for agriculture and petrochemicals for the manufacture of plastics.

Energy consumption worldwide by the industrial sector in the *IEO2013* Reference case is expected to grow from 200 quadrillion Btu in 2010 to 307 quadrillion Btu in 2040, increasing by an average of 1.4 percent per year (Table 18). The industrial sector accounted for a majority of the decline in energy consumption during the global economic recession that began in 2008 and lingered into 2010, primarily because of substantial cutbacks in manufacturing that were more pronounced than the impacts on other sectors [*328*]. In the *IEO2013* Reference case, over the long term growth in industrial energy consumption begins to level off as most developing countries reach the height of their industrialization (Figure 116).

Most of the long-term growth in industrial sector delivered energy consumption occurs in the non-OECD countries. From 2010 to 2040, industrial energy consumption in non-OECD countries grows by an average of 2.3 percent per year, compared with 0.4 percent per year in the OECD (Table 18). The non-OECD countries, which accounted for 64 percent of world total delivered energy in the industrial sector in 2010, grows to account for 72 percent of world total delivered energy consumption in the industrial sector in 2040 (Figure 117).

Table 18. World industrial sector delivered energy consumption by region and energy source, 2010-2040 (quadrillion Btu)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD	**71.9**	**72.9**	**77.5**	**80.4**	**82.2**	**84.4**	**87.1**	**0.6**
Petroleum and other liquids[a]	27.4	27.5	29.3	30.3	31.0	31.7	32.6	0.6
Natural gas	19.4	20.2	21.7	22.7	23.5	24.3	25.2	0.9
Coal	8.7	8.7	9.0	9.2	9.2	9.2	9.2	0.2
Electricity	11.0	11.3	12.0	12.4	12.6	12.9	13.2	0.6
Renewables[b]	5.3	5.2	5.5	5.7	6.0	6.3	7.0	0.9
Non-OECD	**128.1**	**148.5**	**169.2**	**186.0**	**201.3**	**213.5**	**219.8**	**1.8**
Petroleum and other liquids[a]	29.8	34.1	37.1	39.8	43.2	46.5	49.5	1.7
Natural gas	26.1	28.7	32.6	36.3	40.0	43.6	46.6	2.0
Coal	44.2	53.0	61.1	67.0	71.0	72.6	70.4	1.6
Electricity	18.2	22.9	27.4	30.9	33.9	36.1	36.8	2.4
Renewables[b]	9.9	9.8	10.9	12.0	13.3	14.8	16.6	1.7
World	**200.0**	**221.4**	**246.7**	**266.4**	**283.5**	**297.9**	**306.9**	**1.4**
Petroleum and other liquids[a]	57.2	61.6	66.4	70.1	74.2	78.2	82.1	1.2
Natural gas	45.5	48.8	54.3	59.0	63.4	67.8	71.7	1.5
Coal	52.9	61.7	70.1	76.2	80.2	81.9	79.6	1.4
Electricity	29.2	34.2	39.4	43.3	46.5	49.0	50.0	1.8
Renewables[b]	15.2	15.0	16.5	17.7	19.2	21.1	23.5	1.5

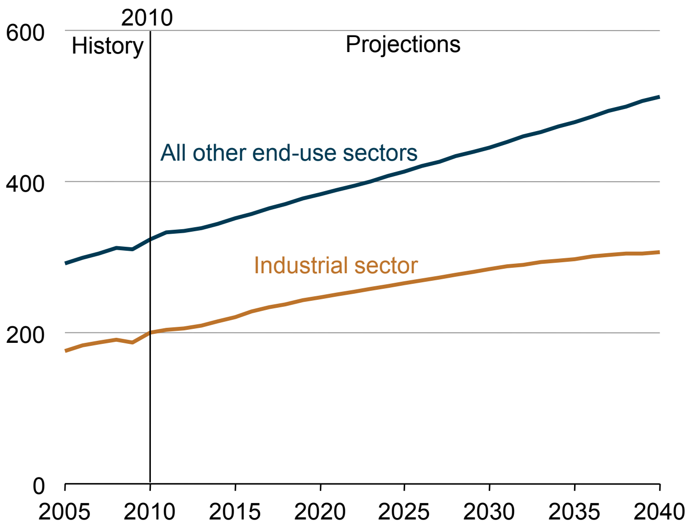
[a]*Other liquids* here refers to natural gas liquids and those derived from the Fischer-Tropsch process.
[b]Includes biomass used for combined heat and power operations as well as biomass for process heat.

[43]Delivered energy is measured as the heat content of energy at the site of use. It includes the heat content of electricity (3,412 Btu per kilowatthour) but does not include the conversion losses that occur at electricity sector generation plants. Delivered energy also includes fuels (natural gas, coal, liquids, and renewables) used for combined heat and power facilities (cogeneration) in the industrial sector.

While liquids consumption, which includes both oil-based products and natural gas liquids used for both feedstocks and fuel, in the industrial sector increases at an average annual rate of 1.2 percent from 2010 to 2040 (Figure 118), the liquids share of total delivered energy consumption in the industrial sector declines over the same period. In contrast, industrial sector electricity consumption grows by an average of 1.8 percent per year over the projection period, but its share of total consumption rises from 14.6 percent in 2010 to 16.3 percent in 2040. Natural gas consumption and coal consumption in the industrial sector increase by annual average rates of 1.5 percent and 1.4 percent, respectively, in the *IEO2013* Reference case. The industrial sector fuel mix differs between the OECD and non-OECD countries. In 2010, liquids made up 38 percent of industrial sector energy consumption in OECD countries, compared with 23 percent in non-OECD countries, and coal represented 12 percent of OECD industrial sector energy consumption, compared with 34 percent of non-OECD industrial sector energy consumption.

There are some small shifts in the industrial sector fuel mix in both OECD and non-OECD countries over the 2010 to 2040 projection period (Figures 119 and 120). Both liquids and coal are slowly displaced by growing industrial sector consumption of natural gas, electricity, and renewable energy sources (largely biomass). As a result, the liquids share of OECD industrial sector delivered energy consumption falls slightly, from 38 percent in 2010 to 37 percent in 2040, while the natural gas share increases from 27 percent to 29 percent. In the non-OECD countries there is also a slight shift away from liquids and coal consumption in the industrial sector, with natural gas and electricity showing small gains in their respective shares of total industrial sector delivered energy consumption.

Figure 116. World industrial sector and all other delivered end-use energy consumption, 2005-2040 (quadrillion Btu)



In 2010, the global industrial sector consumed 15 quadrillion Btu of renewable energy for non-electricity uses, representing about 7.6 percent of total industrial sector delivered energy consumption [*329*]. From 2010 to 2040, renewable energy consumption in the industrial sector grows by an average of 1.5 percent per year. Biomass currently provides the vast majority of renewable energy consumed in the industrial sector and continues to do so throughout the projection period, largely because of its role in the paper and pulp industry.

Industrial sector delivered energy consumption in each OECD and non-OECD country varies as a function of total industrial sector output and the energy intensity (measured as energy consumed per unit of output) of the mix of industries. The five most energy-intensive industries (chemicals, pulp and paper, iron and steel, refining, and nonmetallic minerals) consume about one-half of the energy used in the industrial sector. For years, the energy-intensive industries have focused on reducing energy consumption, which represents a large portion of their production costs [*330*]. Enterprises can reduce energy consumption in a number of ways, including

Figure 117. OECD and non-OECD industrial sector delivered energy consumption, 2010-2040 (quadrillion Btu)

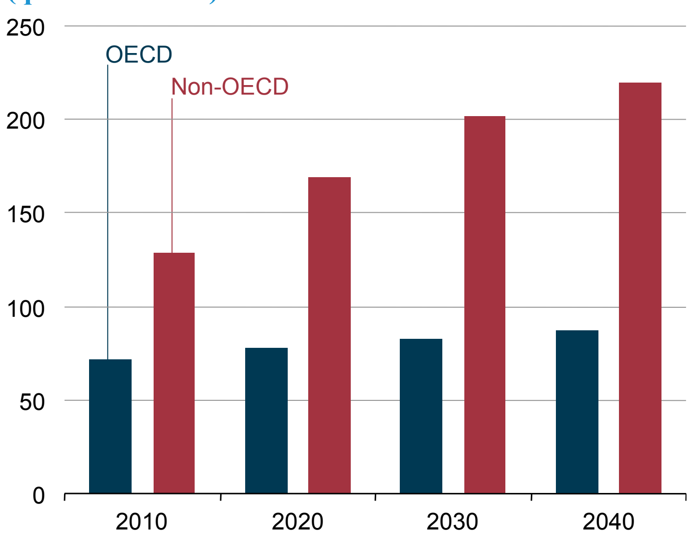
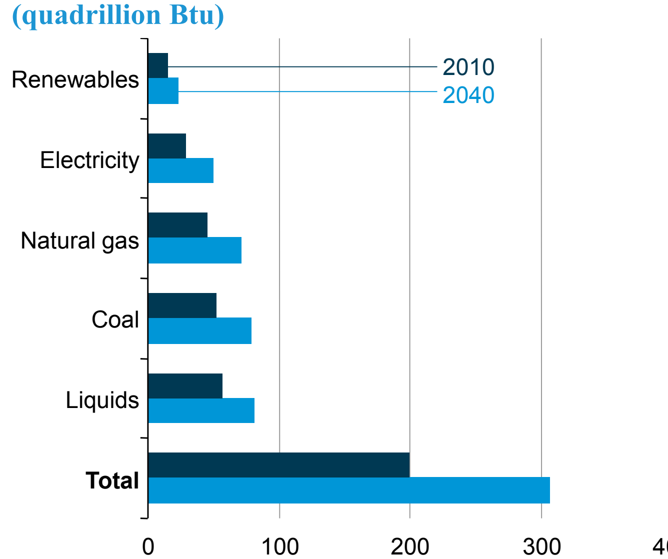


Figure 118. World industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)



improving industrial sector processes to reduce energy waste and to recover energy lost (often process heat), increasing the use of cogeneration capacity, and recycling materials and fuel inputs to reduce input costs and improve efficiency.

The development trajectories of individual countries play a major role in the rate of growth of industrial sector delivered energy consumption. When economies initially begin to develop, industrial sector energy consumption rises as manufacturing output makes up a rapidly growing portion of GDP, as is occurring in many non-OECD economies, most notably China. When developing countries achieve higher levels of economic development, their economies tend to become more service-oriented, and their industrial sector energy consumption levels off, as can be seen in most OECD countries.

Energy-intensive industries

The chemicals, pulp and paper, iron and steel, refining, and nonmetallic minerals industries account for about one-half of all energy used in the industrial sector (Figure 121). Consequently, the quantity and fuel mix of future industrial sector delivered energy consumption will be determined largely by energy consumption in those five industries. In addition, the same industries emit large quantities of carbon dioxide, related to both their energy consumption (combustion emissions) and their production processes (process emissions).

The largest industrial sector consumer of delivered energy is the chemical industry, which accounted for 19 percent of the global total in 2010. Energy inputs represent a large portion of the chemical industry's operating costs and an even higher percentage—up to 85 percent [*331*]—in the petrochemical subsector, which uses large amounts of energy products as feedstocks. Petrochemical feedstocks (liquefied petroleum gas [LPG], naphtha, and natural gas) accounted for roughly 60 percent of the energy consumed in the chemicals sector in 2010. Intermediate petrochemical products, or building blocks, which go into products such as plastics, require a fixed amount of hydrocarbon feedstock as input. For any given amount of chemical output, depending on the fundamental chemical process of production, a fixed amount of feedstock is required, which greatly reduces opportunities for decreasing fuel consumption in the absence of any major shifts toward recycling and bio-based chemicals [*332*].

By volume, the most important building block in the petrochemical sector is ethylene, which can be produced from various feedstocks. In Europe and Asia, ethylene is produced primarily from naphtha, which is refined from crude oil. In North America (the United States, Canada, and Mexico) and the Middle East, where domestic supplies of natural gas are

Figure 119. OECD industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)

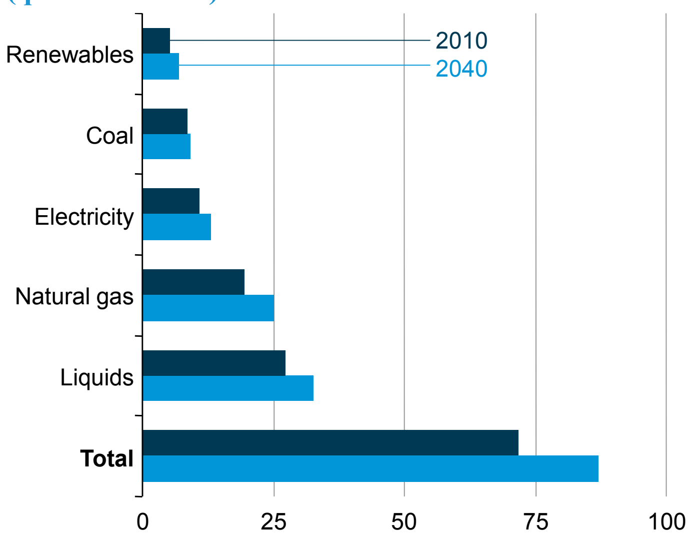


Figure 120. Non-OECD industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)

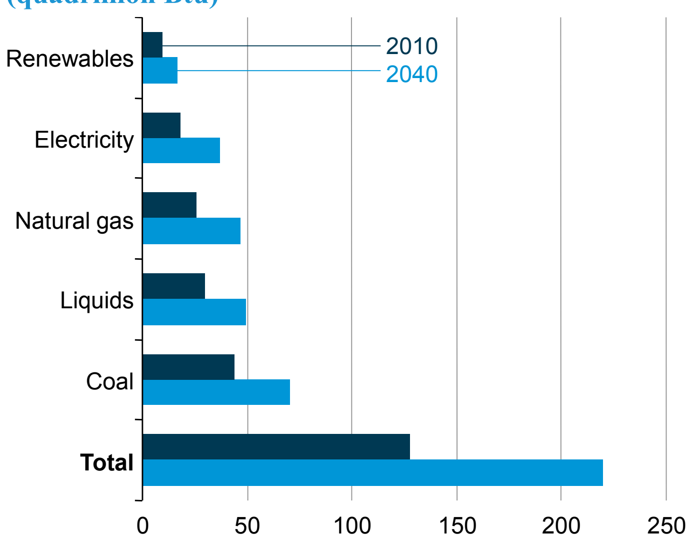
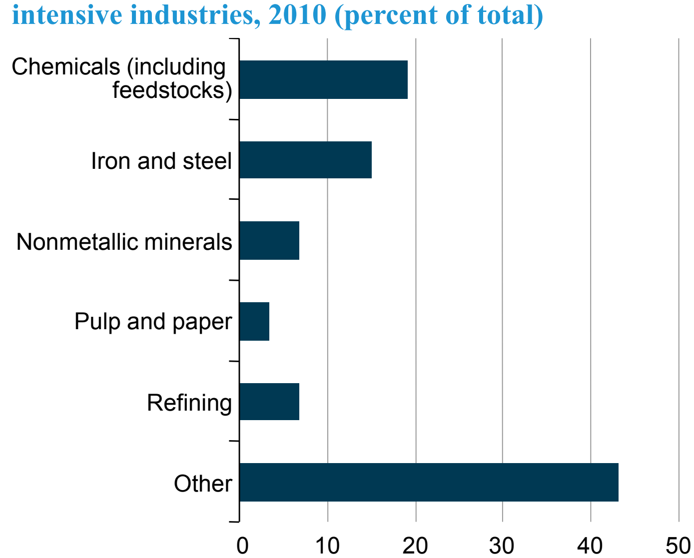


Figure 121. Shares of total world industrial sector delivered energy consumption by major energy-intensive industries, 2010 (percent of total)



Note: Other industries include remaining (non-energy-intensive) manufacturing industries, as well as all nonmanufacturing industrial sectors (agriculture, construction, and mining).

more abundant, ethylene is produced from ethane, which typically is obtained from natural gas reservoirs. Because petrochemical feedstocks represent such a large share of industrial sector energy consumption, patterns of feedstock use play a substantial role in determining the industrial sector fuel mix in each region.

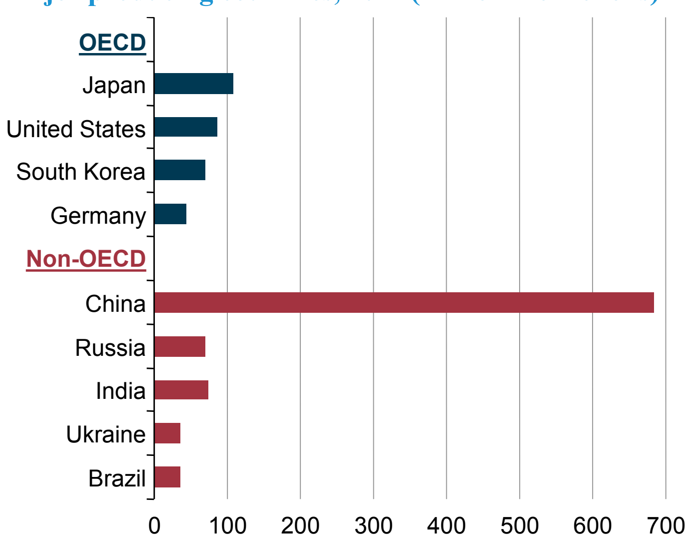
Most of the expansion of petrochemical production and consumption in recent years took place in non-OECD Asia and the Middle East. The combination of high energy prices in 2008 and the global recession in 2009 that reduced demand in client industries, such as construction, had a significant impact on the chemical industry. Demand for petrochemicals bounced back in 2009, however, when crude oil prices declined significantly from their 2008 highs. With the exception of Japan, petrochemical production is expected to grow steadily over the next few years. With the recent growth in U.S. supplies of domestic shale gas and, concurrently, natural gas liquids (NGL), especially ethane and propane, the United States has ramped up its production of ethylene, propylene, and other petrochemicals. In addition, feedstock consumption has shifted from naphtha to ethane, as owners of flexible-feed hydrocarbon processors (crackers) have opted for less expensive ethane over petroleum-based naphtha feedstock, the price of which is closely linked to oil prices [*333*]. Ethylene production in Canada also increases, with plans to ship growing ethane supply from the U.S. Marcellus shale formation to Canadian crackers in Sarnia, Ontario, by way of the Mariner West pipeline [*334*].

Petrochemical production in North America accelerates over the next 10 years, while chemical production in Europe remains relatively flat. Markets in Asia, the Middle East, and Latin America (including Mexico) largely outperform the global trend over the next five years, with growth led by China, where the petrochemical operations of domestic firms such as Sinopec and PetroChina have expanded rapidly, and there has been an influx of petrochemical sector investment from multinational firms, such as ExxonMobil. China also is starting to exploit its own abundant coal resources as feedstock for basic petrochemicals (olefins and methanol) [*335*]. Saudi Arabia is leading the Middle East with a large buildup of chemical plants to produce basic petrochemicals such as ethylene, propylene, and their immediate derivatives.

The second-largest user of energy in the world industrial sector is the iron and steel industry, which accounted for 15 percent of industrial sector delivered energy consumption in 2010. Energy represents roughly 15 percent of production costs in the iron and steel industry [*336*]. The amount of energy consumed in the production of steel depends on the process used. In the blast furnace process, super-heated oxygen is blown into a furnace containing iron ore and coke. The iron ore is reduced (meaning that oxygen molecules in the ore bond with the carbon), leaving pure molten iron and carbon dioxide [*337*]. Coal consumption and heat generation make the process highly energy-intensive. In addition, it requires metallurgical, or coking, coal which is more costly than steam coal because of its lower ash and sulfur content. Two-thirds of global steel production uses the blast furnace process, and in China—by far the world's largest producer—90 percent of steel production employs the blast furnace method. In Japan, the world's second-largest steel producer, 77 percent of production comes from blast furnaces [*338*].

The other major type of steel production process uses electric arc furnaces to produce steel by melting scrap metal with an electric current. The only countries that make most of their steel with electric arc furnaces are the United States (60 percent in 2011) and India (61 percent in 2011) [*339*]. The process is more energy-efficient and produces less carbon dioxide than the blast furnace process but depends on a reliable supply of scrap steel. As a supplement to scrap steel in an electric arc furnace, direct reduced iron (DRI) can be used. DRI is much less energy-intensive than the blast furnace process (and requires only natural gas as opposed to coking coal, although thermal coal may be used), but the iron must be used in an electric arc furnace immediately after production. India is by far the world leader in the use of DRI, followed by Iran, Mexico, Saudi Arabia, and Russia [*340*]. DRI currently accounts for only 6 percent of world iron production, but because of expanding supplies of cheap natural gas (in the United States and, potentially, other regions that may be able to exploit shale gas resources), that percentage is likely to grow.

Figure 122. OECD and non-OECD steel production by major producing countries, 2011 (million metric tons)



Over the past decade, there has been a major expansion of steel consumption in non-OECD countries, especially in Asia, with a corresponding increase in global production. Fueled by demand from the construction and manufacturing sectors, China provides almost one-half of the world total—more than the seven next-largest steel-producing nations combined (Figure 122). China's rapidly growing construction industry helped to stabilize its steel industry throughout the global economic downturn. In the medium term, world demand for steel grows steadily, spurred by infrastructure projects in non-OECD countries, with corresponding growth in energy consumption for steel production. Over the long term, however, the growth of energy consumption in the steel industry slows, as increasing inventories of scrap iron drive down the price of inputs for the electric arc process, and the fuel mix shifts from coal to electricity.

The third-largest energy-consuming industry is nonmetallic minerals, which includes cement, glass, brick, and ceramics. Production of those materials, which requires a substantial amount of heat, accounted for 7 percent of global industrial sector delivered energy consumption in 2010. The most significant nonmetallic minerals industry is cement production, which accounts for 85 percent of energy consumption in the nonmetallic minerals industry. Although the cement industry has improved energy efficiency over the years by switching from the wet kiln production process to the dry kiln process, which requires less heat, energy costs still constitute 20 to 40 percent of the total cost of cement production.

The demand base for cement—the vast majority of which is used for construction—is less diversified than that for steel. Consequently, the impact of the 2008-2010 economic downturn on the cement industry was severe. The most significant growth in cement production over the next few years will be in the non-OECD, where construction continues to boom. China is the largest cement producer by a wide margin, churning out 58 percent of global production in 2011 [*341*]. Because the production of cement generates carbon dioxide directly, the industry has responded to pressure to address climate change impacts by focusing considerable attention on reducing fossil fuel use and improving energy efficiency. In the future, the energy efficiency of cement production will increase as a result of continued improvements in kiln technology, the use of recycled materials and waste for heating fuels (known as co-processing), and increased use of additives to reduce the amount of clinker (the primary ingredient in marketed cement) needed to produce a given amount of cement [*342*]. However, cheap fossil fuels (especially petroleum coke) are now being used by cement manufacturers in China and India, where relatively weak regulations on sulfur content partially offset the environmental benefits of improved kiln technology.

Pulp and paper production, which accounted for about 3 percent of global industrial sector delivered energy consumption in 2010, remains at about the same percentage through 2040. Paper manufacturing is an energy-intensive process, but paper mills typically generate about one-half of the energy they use through cogeneration, primarily with black liquor and biomass from wood waste. In some cases, integrated paper mills generate more electricity than they need and are able to sell their excess power to the grid. As is the case in other industries, recycling significantly reduces the energy intensity of production in the paper sector. The production of recycled paper produces more carbon dioxide, however, because the energy used in the process comes from fossil fuels rather than biomass [*343*].

Electronic media and digital file storage may cause global demand for paper to contract over time. Such trends have been observed in North America, for example, where reduced demand for newsprint and an aging capital stock have led the paper industry to reduce capacity [*344*]. For much of the rest of the world, however, output from the paper industry expands steadily in the *IEO2013* Reference case, in part because of growing needs for a variety of paper products in non-OECD Asia, including paperboard for packaging and materials for diapers and toilet paper.

Production of nonferrous metals, which include aluminum, copper, lead, and zinc, accounted for 2 percent of industrial sector delivered energy consumption in 2010, mostly for aluminum production. Although aluminum is one of the more widely recycled materials, two-thirds of the aluminum industry's output still comes from primary production [*345*]. Energy accounts for about 30 percent of the total cost of primary aluminum manufacturing and is the second most expensive input after the raw material, alumina. The impact of the 2008-2009 global recession on downstream economic sectors, such as construction and automobile manufacturing, reduced aluminum demand globally, but the trend was far less severe in non-OECD countries. Although some analysts expect a greater portion of OECD aluminum production to be exported to non-OECD countries in the future [*346*], non-OECD countries still will increase their market share of global aluminum production.

To guard against electricity outages and fluctuations in electric power prices, many aluminum producers have turned to hydropower, going so far as to locate plants in areas where they can operate captive hydroelectric facilities. For example, Norway, which has considerable hydroelectric resources, hosts seven aluminum smelters. In 2010, more than one-half of the electricity used in Norway's primary aluminum production came from hydropower [*347*].

Aluminum production from recycled materials uses only one-twentieth the energy of primary production [*348*]. Although aluminum recycling is encouraged by the aluminum industry and many governments, it is unlikely that the share of aluminum made from recycled product will increase appreciably in the future because most aluminum is used in the construction and manufacturing sectors and remains in place for a long time. Because three-fourths of the aluminum ever produced still is in use [*349*], it is expected that the aluminum industry will continue to consume large amounts of electricity.

Regional industrial energy outlooks

OECD countries

The OECD has transitioned in recent decades from manufacturing to more service-oriented economic activity. Partially as a result of this transition, industrial sector delivered energy consumption in OECD countries grows more slowly than commercial sector delivered energy consumption from 2010 to 2040 in the *IEO2013* Reference case, at an average rate of 0.6 percent per year in the industrial sector, compared to 0.9 percent per year in the commercial sector. In addition to the shift away from manufacturing to services, slow growth in OECD industrial sector delivered energy consumption can be attributed to relatively slow growth in overall economic output. OECD gross domestic product (as measured in purchasing power parity terms) grows by 2.2 percent per year on average from 2010 to 2040 in the *IEO2013* Reference case, but the industrial sector's 52-percent share of global economic output in 2010 falls to about 34 percent in 2040. As discussed above, the relative fuel mix for this region changes only slightly over the projection period.

OECD Americas

The industrial sector in the United States consumes more energy than the industrial sector of any other OECD country, a position that is maintained through 2040 in the *IEO2013* Reference case. The growth in U.S. industrial sector delivered energy consumption is small, however, increasing at an average annual rate of 0.6 percent, from 24 quadrillion Btu in 2010 to 28 quadrillion Btu in 2040. The industrial sector's share of total U.S. delivered energy consumption remains at approximately 25 percent through 2040.

Although oil prices rise steadily in the *IEO2013* Reference case, liquids consumption in the U.S. industrial sector increases slightly through 2025, with the growth in production of bulk chemicals consuming an increasing volume of natural gas liquids. Low natural gas prices resulting from the strong growth in shale gas production support more rapid growth in natural gas consumption than liquids consumption in the U.S. industrial sector. The U.S. industrial sector's consumption of renewable fuels, such as waste and biomass, grows at a faster rate than the consumption of any other energy source in the Reference case, with the renewable share of U.S. industrial sector delivered energy consumption rising from 10 percent in 2010 to 13 percent in 2040 (Figure 123).

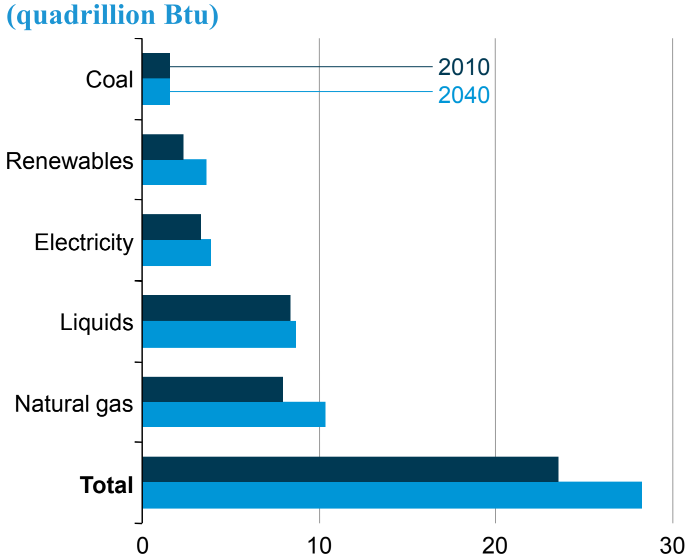
The projected growth in U.S. industrial sector delivered energy consumption is moderated by legislation aimed at reducing the energy intensity of industrial processes. For example, the U.S. Department of Energy supports reductions in energy consumption through its Advanced Manufacturing Office, guided by the Energy Policy Act of 2005, which is working toward a 25-percent reduction in the energy intensity of U.S. industrial sector production by 2017 [*350*]. The Energy Independence and Security Act of 2007 also addresses energy-intensive industries, providing incentive programs for additional waste heat recovery and supporting research, development, and demonstration for efficiency-increasing technologies [*351*].

Although there is no comprehensive set of federal rules in place to limit greenhouse gas emissions from the industrial sector in the United States, in 2012 California introduced a cap-and-trade policy (California Assembly Bill 32) aimed at reducing emissions [*352*]. In addition, the U.S. Environmental Protection Agency implemented an extension of the National Emissions Standards for Hazardous Air Pollutants for industrial sector boilers and process heaters (Boiler MACT). Each rule has a modest effect on industrial sector delivered energy consumption in the Reference case [*353*].

In Canada, industrial sector energy consumption grows by an average of 1.3 percent per year in the Reference case and accounts for just over one-half of Canada's total delivered energy consumption over the projection period. Industrial sector energy efficiency in Canada has been increasing at an average rate of about 1.5 percent per year in recent decades, largely reflecting provisions in Canada's Energy Efficiency Act of 1992 [*354*]. The government increased those efforts in 2007, releasing its Regulatory Framework for Industrial Greenhouse Gas Emissions, which calls for a 20-percent reduction in greenhouse gas emissions by 2020. The plan stipulates that industrial enterprises must reduce the emissions intensity of their production by 18 percent between 2006 and 2010, and by 2 percent per year thereafter. The plan exempts fixed-process emissions from industrial processes in which carbon dioxide is a basic chemical byproduct of production. Therefore, most of the abatement must come from increased energy efficiency and fuel switching [*355*].

Mexico and Chile's combined economy grows by 3.7 percent per year from 2010 to 2040 in the Reference case, which is the highest economic growth rate among all OECD countries. At 2.6 percent, Mexico and Chile also have the highest average annual rate of growth in OECD industrial sector delivered energy consumption, which increases from 3.4 quadrillion Btu in 2010 to 7.5 quadrillion Btu in 2040. Petroleum and other liquids and natural gas account for the largest share of industrial sector delivered energy consumption in Mexico and Chile through 2040 (Figure 124).

Figure 123. U.S. industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)



Chile, added to the OECD in 2010, is the world's largest producer of copper, and the mining industry accounts for 16 percent of total fuel consumption in the country's industrial sector. In 2005, Chile's National Energy Efficiency Programme was passed. Together with the Chilean Economic Development Agency, the National Energy Efficiency Programme created an Energy Efficiency Pre-Investment Programme that provides public resource monies to all but the largest companies to hire consultants or conduct audits to develop plans for improving energy efficiency [*356*].

Mexico's industrial sector continues to consume liquids and natural gas for most of its energy needs. In December 2009, the Mexican government introduced its Special Climate Change Program 2009-2012, which included many initiatives for the industrial sector, such as requiring the increased use of cogeneration and improvement of the operational efficiency of Petróleos Mexicanos (the state-owned oil company) and other Mexican industrial sector enterprises [*357*].

OECD Europe

In the *IEO2013* Reference case, OECD Europe continues its transition to a service economy, with commercial sector energy consumption growing by 1.1 percent per year while industrial sector energy consumption grows by a slower 0.3 percent per year. Energy and environmental policies significantly influence the trends in industrial sector energy consumption in OECD Europe. In December 2010, the European Parliament passed the 20-20-20 plan, which targets a 20-percent reduction in greenhouse gas emissions, a 20-percent improvement in energy efficiency, and a 20-percent share for renewables in the fuel mix of European Union member countries by 2020 [*358*]. In debates on the plan, representatives of energy-intensive industries voiced concern about the price of carbon allocations. They argued that fully auctioning carbon dioxide permits to heavy industrial sector enterprises exposed to global competition would simply drive industrial sector production away from Europe and slow carbon abatement efforts at the global level [*359*]. The resulting compromise was an agreement that 100 percent of carbon allowances would be given free of charge to industries that are exposed to such carbon leakage, provided that they adhere to benchmark requirements for using the cleanest available technology [*360*]. As a result, the impact of the 20-20-20 plan on industrial sector emissions in the European Union is limited relative to its original intention.

OECD Asia

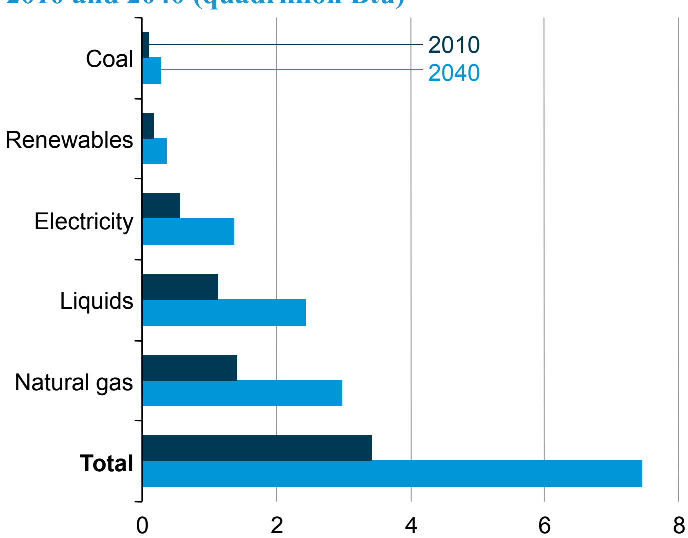
In OECD Asia, which includes Japan, South Korea, and Australia/New Zealand, short-term trends in industrial sector delivered energy consumption are likely to be tempered by events unfolding in Japan. Japan is the largest economy in OECD Asia and the largest industrial sector energy consumer.

Along with slow economic growth, a major factor behind Japan's slow growth in industrial sector energy consumption is increasing efficiency. The energy intensity of Japan's industrial sector is among the lowest in the world. Since 1970, Japan has reduced the energy intensity (in terms of energy per unit of gross output) of its manufacturing sector by 50 percent, mostly through efficiency improvements, along with a structural shift toward lighter manufacturing [*361*]. An amended version of Japan's Energy Conservation Law went into effect in April 2009, introducing efficiency benchmarks for energy-intensive industries, including cement and steel [*362*]. There have also been efficiency gains in industrial sector electricity use, motivated by the national consensus to conserve electricity in the wake of Fukushima [*363*].

South Korea, which experienced rapid industrial sector development during the later decades of the 20th century, also is beginning to make a transition to a service-oriented economy. In the *IEO2013* Reference case, South Korea's GDP grows by an average of 3.3 percent per year. The largest consumer of industrial sector energy in South Korea is the chemicals industry, and remains so through 2040 according to the Reference case projections. Liquids consumption, primarily naphtha for feedstock use, maintains the largest share of South Korea's industrial sector energy consumption through 2040. In addition, South Korea currently is the sixth-largest steel producer in the world. A large portion of its steel (39 percent in 2011) is produced by electric arc furnaces [*364*]. Steel production triples from 2010 to 2040, resulting in significant increases in consumption of both electricity and coal.

In Australia and New Zealand, industrial sector delivered energy consumption grows by 0.8 percent per year in the Reference case, from 2.3 quadrillion Btu in 2010 to 2.9 quadrillion Btu in 2040, while the industrial sector share of total delivered energy consumption does not change materially. As a result of growing natural gas production in Australia [*365*], natural gas fuels much of the growth in the region's industrial sector energy consumption, and the natural gas share of industrial sector delivered energy consumption rises from 36 percent in 2010 to 44 percent in 2040.

Figure 124. Mexico and Chile industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)



Non-OECD countries

Non-OECD industrial sector delivered energy consumption grows at an average annual rate of 1.8 percent in the *IEO2013* Reference case—almost three times the OECD average. The industrial sector in non-OECD countries accounted for about 63 percent of total non-OECD delivered energy consumption in 2010, but the share declines to 58 percent in 2040 as energy-intensive industries become more energy-efficient and the non-OECD economies become more service-oriented. With non-OECD economies expanding at an average annual rate of 4.5 percent in the Reference case, much faster than the OECD, their share of total global output increases from 35 percent in 2010 to 66 percent in 2040.

Non-OECD Asia

Non-OECD Asia will be a major center of global economic growth in the coming decades. In the Reference case, the economies of non-OECD Asia, led by China, expand by an average of 5.4 percent per year, and industrial sector delivered energy consumption increases across the region. Industrial sector delivered energy consumption in China increases by 77 percent from 2010 to 2040, at an average annual growth rate of 1.9 percent.

The industrial sector, which accounted for 74 percent of China's total delivered energy consumption in 2010, still accounts for about two-thirds of total delivered energy consumption in China in 2040. After the beginning of economic reform in 1979, China's GDP growth averaged 9.8 percent per year through 2007 [*366*]. With strong economic growth through 2015 and beyond, China accounts for more than one-fourth of total global GDP growth from 2010 to 2040 in the *IEO2013* Reference case.

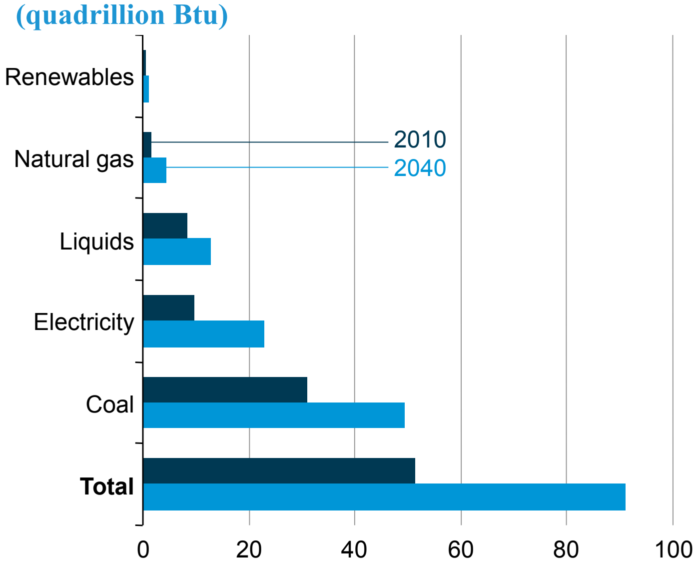
In addition to the impact of strong economic growth, continued rapid increases in industrial sector energy consumption can be explained in part by the structure of China's economy. Although the energy intensity of production in individual industries has improved over time, heavy industry still constitutes a major portion of China's total output. Energy consumption in China directly reflects the composition of its economy, where the iron and steel, nonmetallic minerals, and chemical industries together account for more than one-half of the country's industrial sector energy consumption over the 2010-2040 projection period. Those industries provide inputs to China's export and construction sectors, which continue to expand in the Reference case. The potential for structural change in the Chinese economy represents a major source of uncertainty in *IEO2013*.

China's industrial sector fuel mix changes somewhat over the projection period, due in part to increases in light manufacturing. Despite its abundant coal reserves, direct consumption of coal in China's industrial sector grows by an average of only 1.6 percent per year in the Reference case, while industrial sector consumption of electricity (most of which is from coal-fired power plants) grows by 2.9 percent per year (Figure 125). As a result, coal's share of the industrial sector fuel mix falls from 60 percent in 2010 to 54 percent in 2040, while electricity's share increases from 19 percent to 25 percent. The drop in coal share partly reflects the slower growth in steel output compared with other industries, in particular the non-energy-intensive industries. Natural gas consumption in the industrial sector grows by 3.2 percent per year on average from 2010 to 2040—faster than the consumption of any other fuel—but represents only 5.0 percent of China's total industrial sector fuel mix in 2040. Renewable energy does not play a material role in China's industrial sector energy consumption in the *IEO2013* Reference case.

In addition to its primary focus on economic development, the Chinese government has introduced policy initiatives aimed at improving industrial sector energy efficiency. The 12th Five Year Economic Plan, approved in 2011 [*367*], includes a goal of reducing energy intensity by 16 percent and carbon emissions per unit of GDP by 17 percent between 2011 and 2015.

In August 2010, the Chinese government announced that 2,087 steel mills, cement works, and other energy-intensive factories would be required to close by September 30, 2010, solely to meet its energy intensity reduction goal. The closure of the factories did not have a large effect on industrial sector energy consumption, because many of the targeted factories were old and inefficient and were operated at low utilization rates. The *IEO2013* Reference case assumes that China will continue to update its factories and become less energy-intensive [*368*]. The government is seeking further reductions in energy intensity, by 40 to 45 percent in 2020 relative to 2005. In the *IEO2013* Reference case, based on projected gross output and total projected industrial energy consumption, China achieves a 1.5-percent average annual improvement from 2010 to 2020 in energy intensity and a 2.6-percent average annual improvement from 2010 to 2040.

Figure 125. China industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)



India has the world's highest rate of GDP growth in the *IEO2013* Reference case, averaging 6.1 percent per year from 2010 to 2040, which leads to an average increase of 1.5 percent per year in industrial sector delivered energy consumption. Although India's 2010 to 2040 economic growth rate is faster than China's, its levels of GDP and energy consumption continue to be dwarfed by those of China throughout the projection period. Much of India's economic growth over the next few decades is driven by light manufacturing and services rather than heavy industry. As a result, the industrial sector share of total energy consumption in India falls from 46 percent in 2010 to 32 percent in 2040, and commercial sector energy consumption grows more than twice as fast as industrial sector energy consumption. Those changes are accompanied by a shift in the industrial sector fuel mix. Consumption of petroleum and other liquids in the industrial sector grows more rapidly than coal consumption, and natural gas consumption nearly doubles (Figure 126).

India has reduced the energy intensity of production in its industrial sector over the past 20 years. Most of its steel production comes from electric arc furnaces, and as in the rest of the world, most of its cement production uses dry kiln technology [*369*]. A major reason for the reduction in industrial energy intensity is India's public policy, which provides subsidized fuel to citizens and farmers but requires industry to pay higher prices for fuel. These market interventions have spurred industry to reduce energy costs, and India is now one of the world's lower-cost producers of both aluminum and steel [*370*] as well as the world's largest producer of pig iron, which can be used in place of scrap metal in electric arc furnaces [*371*].

The quality of India's indigenous coal supplies has contributed to the steel industry's efforts to reduce its energy consumption. India's metallurgical coal is low quality, forcing steel producers to import supplies [*372*]. As a result, producers have invested heavily in improving the efficiency of their capital stock in order to reduce the use of relatively expensive imported coal.

The Indian government has facilitated further reductions in industrial sector energy consumption over the past decade by mandating industrial sector energy audits in the Energy Conservation Act of 2001 and requiring specific consumption decreases for heavy industry as part of the 2010 National Action Plan on Climate Change. Under the 2001 Act, the central government is able to target designated consumers—including paper, steel, aluminum, and some chemical industries—for reductions in energy consumption [*373*]. The new plan also calls for fiscal and tax incentives to promote efficiency and creates an energy-efficiency financing platform and a trading market for energy savings certificates, wherein firms that have exceeded their required savings levels will be able to sell the certificates to firms that have not [*374*]. Those measures contribute to a reduction in India's projected industrial sector energy intensity in the Reference case, which averages 2.5 percent per year from 2010 to 2040.

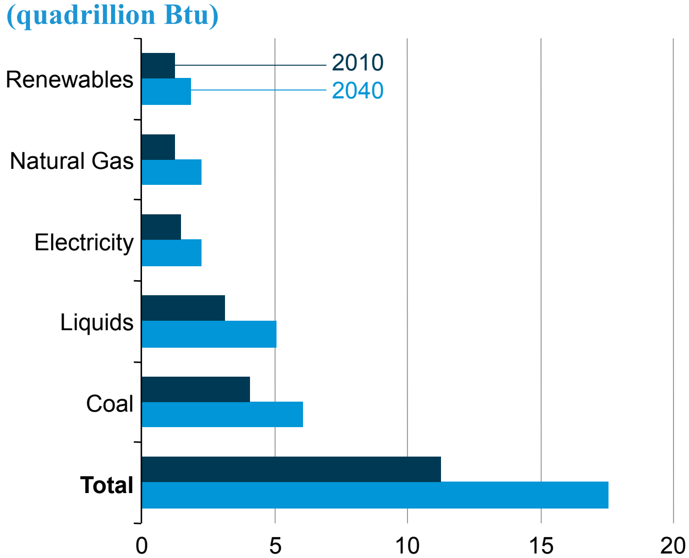
Outside of China and India, industrial sector energy consumption trends in the countries of non-OECD Asia follow diverse trajectories in the *IEO2013* Reference case. Mature economies, such as Taiwan, Hong Kong, and Singapore, follow patterns similar to those in the OECD countries—transitioning from energy-intensive industries to activities with higher added value. Much of the growth in commercial sector energy consumption occurs in those countries. Other economies in the region, notably Vietnam, expand manufacturing and increase industrial sector energy consumption.

Non-OECD Europe and Eurasia

Industrial sector delivered energy consumption in Russia is shaped largely by the country's role as a major energy producer. Russia's economy grows by an average of 2.8 percent per year from 2010 to 2040 in the *IEO2013* Reference case, with the industrial sector accounting for almost 40 percent of the country's total energy consumption throughout the projection period. The energy intensity of Russia's economy is the highest in the world, and although it declines in the Reference case, Russia remains among the world's least energy-efficient economies through 2040, due in part to its continued reliance on blast furnace technology. The energy intensity of Russia's industrial sector (as measured by industrial sector energy consumed per unit of GDP) is almost twice the world average. The relative inefficiency of Russian industry can be attributed to the continued use of Soviet-era capital stock and abundant and inexpensive domestic energy supplies. In the Reference case, natural gas—one of Russia's more abundant domestic fuels—accounts for more than 40 percent of industrial sector energy consumption. The share of electricity, most of which is provided by nuclear and natural gas-fired generation, increases through 2040, when it accounts for 17 percent of industrial sector energy consumption.

Industrial sector energy consumption in other parts of non-OECD Europe and Eurasia is relatively constant through 2040. The iron and steel sector constitutes the largest single energy-consuming industry in the region, which consists primarily of states that were once part of the Soviet Union. Ukraine is the region's largest—and the world's eighth-largest—steel producer. More than one-quarter of Ukraine's steel production industry uses open hearth furnaces, the least energy-efficient steelmaking process [*375*, *376*]. As in Russia, energy intensity in the other countries of non-OECD Europe and Eurasia remains high, and the region continues to be one of the world's least energy-efficient through 2040.

Figure 126. India industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)



Central and South America

Brazil's industrial sector energy consumption grows by an average of 1.7 percent per year from 2010 to 2040 in the *IEO2013* Reference case, while its GDP expands by 3.4 percent per year. Industrial sector energy consumption accounted for 60 percent of Brazil's total delivered energy consumption in 2010 and remains at roughly that share through 2040. A large share of delivered energy consumption in Brazil's industrial sector (more than 40 percent in 2010) comes from renewable sources, with biomass often the fuel of choice for heat generation in the industrial sector. In addition, many of Brazil's steel producers use charcoal (a wood-based renewable) instead of coking coal in the production process, and the government plans to support that practice as part of its National Plan on Climate Change [*377*]. The effects of the government's push to use renewable charcoal are seen to be minor, however, and coal consumption in the industrial sector—primarily for steelmaking—grows faster than the consumption of any other fuel (Figure 127).

Compared to Brazil , economic output in the remaining countries of Central and South America grows more slowly, averaging 3.3 percent per year, and industrial sector delivered energy consumption in those countries increases from 6.0 quadrillion Btu in 2010 to 7.3 quadrillion Btu in 2040. Chemicals and refining account for the largest shares of industrial sector energy consumption in the Central and South America region in the *IEO2013* Reference case. Natural gas displaces some liquids consumption in the industrial sector energy mix, fueled by growth in the region's domestic natural gas production. In 2010, liquids and natural gas accounted for 34 percent and 44 percent of industrial sector energy consumption, respectively. From 2010 to 2040, industrial sector natural gas consumption increases by an average of 0.7 percent per year, while liquids consumption increases by 0.5 percent per year. As a result, the natural gas share of industrial sector energy consumption increases to 45 percent in 2040, and the liquids share falls to 32 percent.

Other Non-OECD regions

Industrial sector energy consumption in the Middle East grows on average by 2.5 percent per year from 2010 to 2040 in the *IEO2013* Reference case. The largest energy-consuming industry in the Middle East is the chemical industry [*378*]. High world crude oil and natural gas prices have spurred new investment in the region's petrochemical industry, where companies can rely on low-cost feedstocks, and the trend continues despite the current global slump in demand for chemicals. Numerous petrochemical mega-projects currently are under construction in Saudi Arabia, Qatar, Kuwait, the United Arab Emirates, and Iran, although many faced considerable delays from 2009 to 2011 as a result of the global economic downturn [*379*]. Construction activity is now back on track, and the Middle East is becoming a major manufacturer of the olefin building blocks that constitute a large share of global petrochemical output, with the region's ethylene capacity doubling from 2009 to 2012 [*380*]. Because of the availability of relatively cheap fossil fuels and the heavy emphasis on developing the domestic petrochemical and refining sectors, liquids and natural gas maintain at least a 95-percent combined share of the Middle East's industrial sector fuel mix through 2040 (Figure 128).

Although 15 percent of the world's population in 2010 lived in Africa, the continent's industrial sector energy consumption that year was only 4.2 percent of the world industrial total, and its share increases only modestly in the Reference case. Africa's total industrial sector energy consumption grows on average by 2.3 percent per year from 2010 to 2040 in the *IEO2013* Reference case. Africa's total GDP grows at an average rate of 4.6 percent per year over the projection period, but a substantial portion of the increase comes from the production of commodities. Although commodity extraction is an energy-intensive process, it does not support the expansion of industrial sector energy consumption on the same scale as the development of a widespread manufacturing base. Without a substantial departure from historical patterns of economic activity, low levels of industrial sector energy consumption in Africa continue through 2040 in the *IEO2013* Reference case.

Figure 127. Brazil industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)

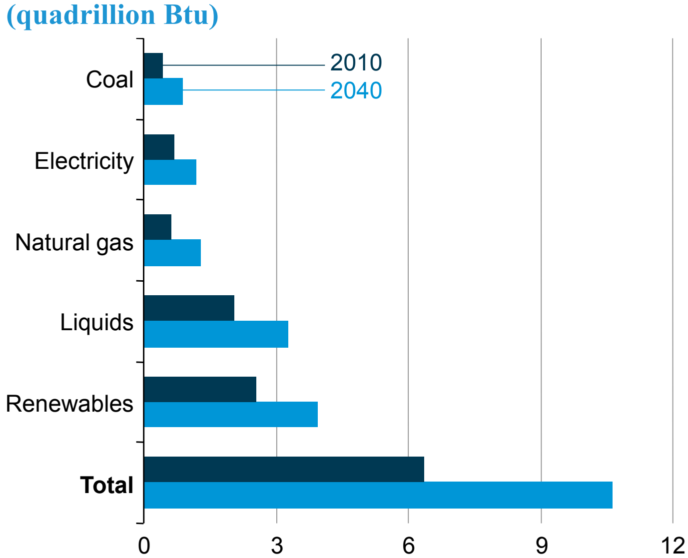
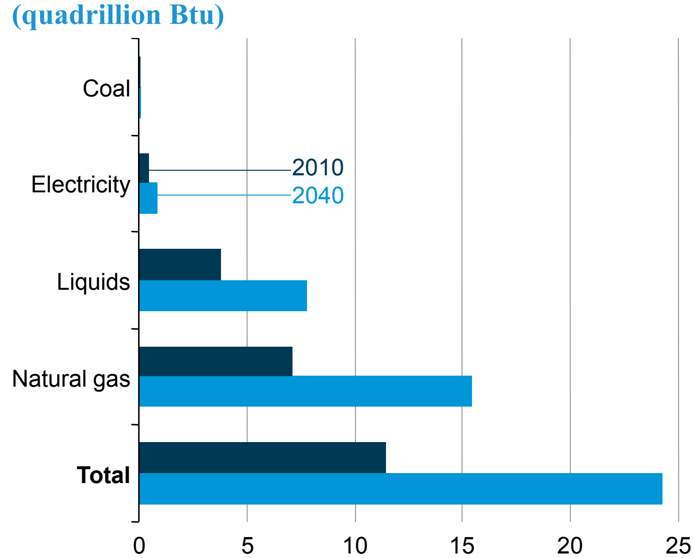


Figure 128. Middle East industrial sector delivered energy consumption by energy source, 2010 and 2040 (quadrillion Btu)



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Chapter 8

Transportation sector energy consumption

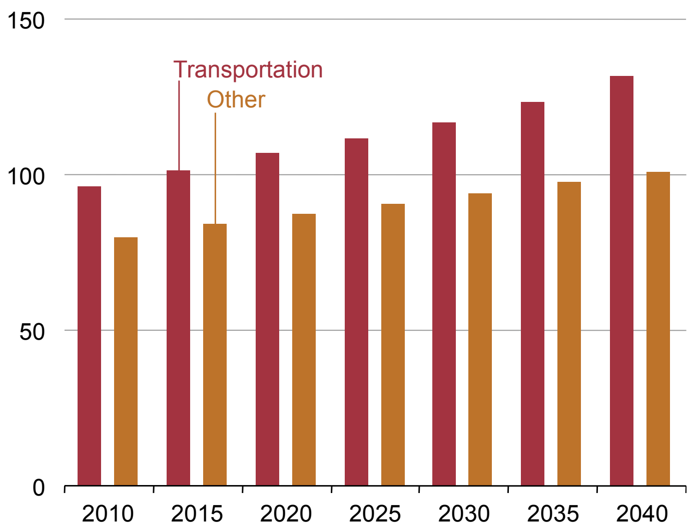
Overview

Energy use in the transportation sector includes energy consumed in moving people and goods by road, rail, air, water, and pipeline. Transportation systems are essential for trade and economic competitiveness in an increasingly globalized world, as well as for enhancing standards of living. Trade and economic activity are the most significant factors determining demand for freight transportation. A more complex set of determinants—including travel behavior, land use patterns, and urbanization—affect demand for passenger transportation, along with macroeconomic and fuel market impacts.

In the *IEO2013* Reference case, world energy consumption in the transportation sector increases by an average of 1.1 percent per year (Table 19). Petroleum and other liquid fuels are the most important component of transportation sector energy use throughout the projection. The transportation sector accounts for the largest share (63 percent) of the total growth in world consumption of petroleum and other liquid fuels from 2010 to 2040 (Figure 129), increasing by 36 quadrillion Btu as compared with an increase of 25 quadrillion Btu in the industrial sector and declines in all other end-use sectors.

Most of the growth in transportation energy use occurs in the non-OECD nations, where high projected economic and population growth, combined with relatively immature transportation sectors, leads to strong growth in demand for transport-related energy use. Non-OECD transportation sector energy consumption increases by an average of 2.2 percent per year from 2010 to 2040 (Table 19). In contrast, OECD transportation sector energy use declines over the projection period, as a result of relatively slow economic growth, improvements in energy efficiency, and stable or declining population levels. Total OECD energy consumption for transportation decreases by an average of 0.1 percent per year, from 58 quadrillion Btu in 2010 to 56 quadrillion Btu in 2040.

Figure 129. World liquids consumption by end-use sector, 2010-2040 (quadrillion Btu)



In the *IEO2013* Reference case, non-OECD demand for transportation energy use nearly doubles, from 43.1 quadrillion Btu in 2010 to 83.9 quadrillion Btu in 2040. The fast-paced growth in non-OECD transportation energy demand is a result of strong economic growth that leads to rising standards of living and corresponding increases in demand for personal and commercial travel. There is, however, a great deal of uncertainty associated with long-term projections for transportation sector energy consumption, particularly among the developing non-OECD regions. Because of the rapid economic growth in non-OECD regions, there is greater flexibility in future capital investment, infrastructure development, and other elements of transportation systems than in the OECD regions. Consequently, there is a wider range of potential outcomes for transportation energy consumption in the non-OECD regions.

Table 19. World transportation sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)

Region	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD	**57.9**	**56.0**	**55.9**	**54.8**	**54.5**	**54.8**	**55.5**	**-0.1**
Americas	32.7	32.5	32.5	32.0	31.7	32.0	32.9	0.0
Europe	18.0	16.3	16.2	15.8	15.7	15.8	15.7	-0.5
Asia	7.1	7.2	7.1	7.0	7.0	7.0	7.0	-0.1
Non-OECD	**43.1**	**50.3**	**56.4**	**62.3**	**68.3**	**75.6**	**83.9**	**2.2**
Europe and Eurasia	6.7	8.0	8.5	8.9	9.5	10.1	10.6	1.5
Asia	19.9	23.5	28.0	32.5	37.0	42.6	49.2	3.1
Middle East	6.0	7.4	8.1	8.3	8.6	9.0	9.5	1.5
Africa	3.8	4.0	4.1	4.4	4.5	4.6	4.8	0.8
Central and South America	6.6	7.3	7.7	8.1	8.8	9.3	9.8	1.3
World	**101.0**	**106.2**	**112.2**	**117.0**	**122.8**	**130.4**	**139.5**	**1.1**

In the *IEO2013* Reference case, the fastest growth in transportation sector energy consumption per capita from 2010 to 2040 occurs in China and India, with average annual increases of 4.1 and 4.6 percent, respectively, while transportation energy use per capita in the United States and OECD Europe declines (Figure 130). In both China and India, however, total transportation energy use per capita remains much lower than in the OECD regions. If transportation energy use per capita in China and India were to evolve as it has in the United States and OECD Europe, the world outlook for transportation energy use would be considerably different from the *IEO2013* Reference case projections.

Liquid fuels account for most of the transportation energy consumption in the non-OECD countries throughout the projection. From 92 percent of total non-OECD transportation energy use in 2010, the liquid fuels share increases to 94 percent in 2040, growing from 40 quadrillion Btu in 2010 to 79 quadrillion Btu in 2040 while consumption of all other transportation energy sources increases from 3.5 quadrillion Btu in 2010 to 5.0 quadrillion Btu in 2040. Accordingly, the non-OECD share of world demand for transportation liquids grows to 60 percent in 2040 (Figure 131). China, the largest transportation energy consumer among the non-OECD regions, leads the growth in world demand for transportation fuels, with its transportation energy use increasing from 9.0 quadrillion Btu in 2010 to 26.6 quadrillion Btu in 2040. In 2010, China's transportation energy use was only one-third of that in the United States; by 2040, it consumes nearly as much energy for transportation as the United States.

Leading factors in the projected increase in transportation energy demand include steadily increasing motorization levels in the non-OECD countries and strong growth in freight transport resulting from increasing economic activity in both the developing and mature economies. In the non-OECD countries, income growth and demand for personal mobility, combined with rapid urbanization, have the greatest impact on growth in passenger transport. For freight transportation, trucking is expected to lead the growth in non-OECD demand for transportation fuels. In addition, as international trade increases, the volumes of freight transported by air and marine modes are expected to increase over the projection period.

Improvement in energy efficiency is the key factor affecting projected transportation demand in the OECD economies. With adaptation of more stringent fuel economy standards in the United States and the harmonization of standards with Canada and Mexico, the OECD Americas experience virtually no growth in transportation energy use. Declines in consumption in the United States and Canada are offset by increases in Mexico and Chile. Energy efficiency improvements also lead to declining transportation energy use in OECD Europe and in Japan, where new technologies and improved energy efficiencies reduce demand for liquids across all transportation modes in the long term.

A key uncertainty is the effectiveness of the government policies in shaping transportation demand in the coming decades. Governments are likely to address environmental, mobility, and other geopolitical concerns through the promotion of new energy-efficient technologies, alternative-fuel vehicles and nonpetroleum fuels, land use planning, and viable alternatives to light-duty vehicle travel.

OECD countries

In 2010, OECD countries accounted for 57 percent of the world's total demand for transportation fuels, but their share declines to 40 percent in 2040 in the *IEO2013* Reference case. Demand for transportation fuels in the OECD economies declines by 0.1 percent per year in the projection, from 57.9 quadrillion Btu in 2010 to 55.5 quadrillion Btu in 2040 (Figure 132).

Figure 130. Transportation sector energy consumption per person in selected regions, 2010 and 2040 (million Btu)

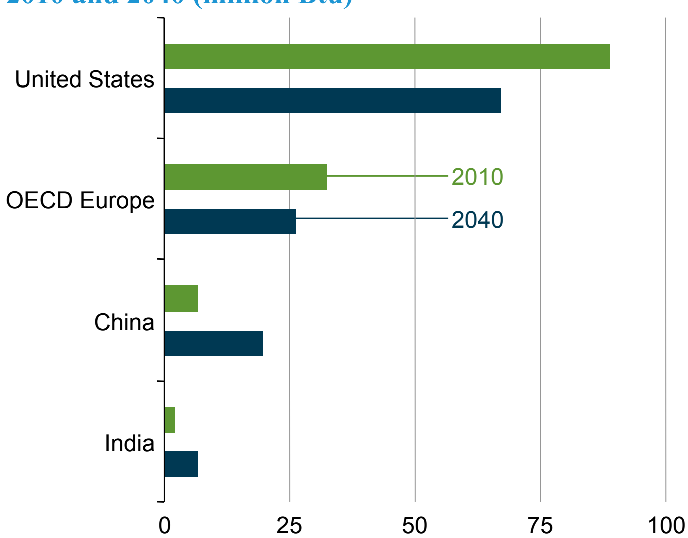
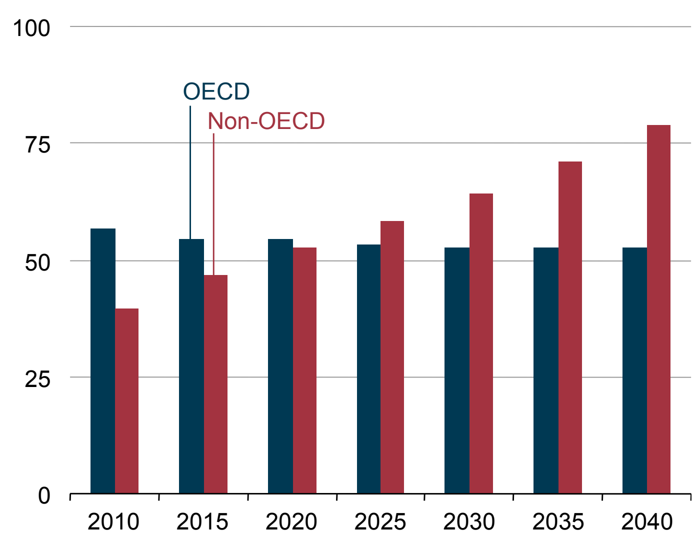


Figure 131. World transportation sector liquids consumption, 2010-2040 (quadrillion Btu)



OECD Americas

Demand for transportation fuels in the OECD Americas is essentially flat throughout the projection, due to the combination of declining demand in the United States and Canada and only moderate demand growth in Mexico and Chile (Figure 133). From about 32 percent of the world's total demand for transport fuels in 2010, the OECD Americas share declines to about 24 percent in 2040, primarily as a result of more stringent environmental regulations and progress toward the harmonization of vehicle fuel economy standards in the United States, Canada, and Mexico.

United States

The United States is the largest consumer of transportation energy in the world. From about 27 percent of the world total in 2010, its share declines to 19 percent in 2040 in the Reference case. Projected U.S. energy consumption for transportation is 27.1 quadrillion Btu in 2040, slightly lower than the 2010 total of 27.5 quadrillion Btu. In comparison, U.S. demand for transportation energy increased at an average rate of 1.1 percent from 1975 to 2010 [*381*].

U.S. light-duty vehicle energy demand declines from 16.5 quadrillion Btu in 2010 to 14.9 quadrillion Btu in 2020 and 13.0 quadrillion Btu in 2040, higher fuel economy offsets modest growth in vehicle miles traveled. The *IEO2013* Reference case assumes the adoption of greenhouse gas emission and corporate average fuel economy (CAFE) standards proposed by the U.S. Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) for model years 2012 through 2025 [*382*]. The average fuel economy of new light-duty vehicles in the United States (including credits for alternative-fuel vehicles and banked credits) rises from 31.8 miles per gallon in 2010 to 47.3 miles per gallon in 2025 and 49.0 miles per gallon in 2040 as additional fuel-saving technologies are adopted. Vehicle-miles traveled per licensed driver increase from 12,600 miles in 2010 to 13,300 miles in 2040, however, somewhat offsetting the impact of higher vehicle fuel economy. Growth in light-duty vehicle travel, primarily as a result of rising real disposable incomes and lower costs of driving per mile, is tempered by slow recovery of employment rates and lower vehicle ownership rates relative to historic averages.

U.S. energy demand for heavy-duty vehicles (including tractor trailers, buses, vocational vehicles, and heavy-duty pickups and vans) increases the fastest among transportation modes, from 5.1 quadrillion Btu in 2010 to 6.3 quadrillion Btu in 2020 and 7.6 quadrillion Btu in 2040. The increase in energy demand for heavy-duty vehicles results from higher industrial output and more high-value goods being carried by freight trucks, offset partially by increased heavy-duty vehicle fuel economy. The *IEO2013* Reference case includes the heavy-duty engine and vehicle fuel efficiency and greenhouse gas emissions standards for heavy-duty vehicles issued jointly by the EPA and NHTSA starting in model year 2014 [*383*].

Aircraft energy demand increases from 2.5 quadrillion Btu in 2010 to 2.9 quadrillion Btu in 2040. Increases in personal air travel are offset by gains in aircraft fuel efficiency, while air freight movement grows as exports increase. Energy consumption for marine and rail travel increases as industrial output rises. Pipeline energy use also rises moderately, as robust increases in natural gas production more than offset the fact that production is closer to end-use markets.

Canada

As in the United States, the transportation sector in Canada is characterized by well-developed infrastructure and high per capita motor vehicle ownership rates. Historically, the transportation sector has been the major source of liquids demand growth in Canada. However, in recent years the Canadian government has been tightening greenhouse gas emissions standards for road

Figure 132. OECD transportation sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)

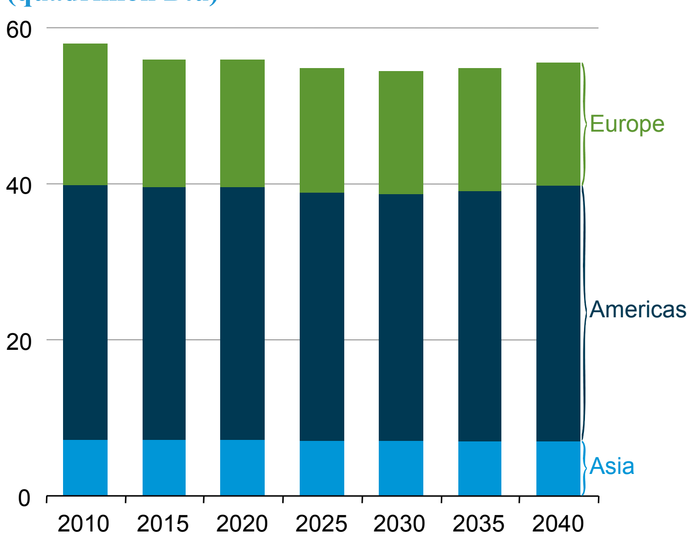
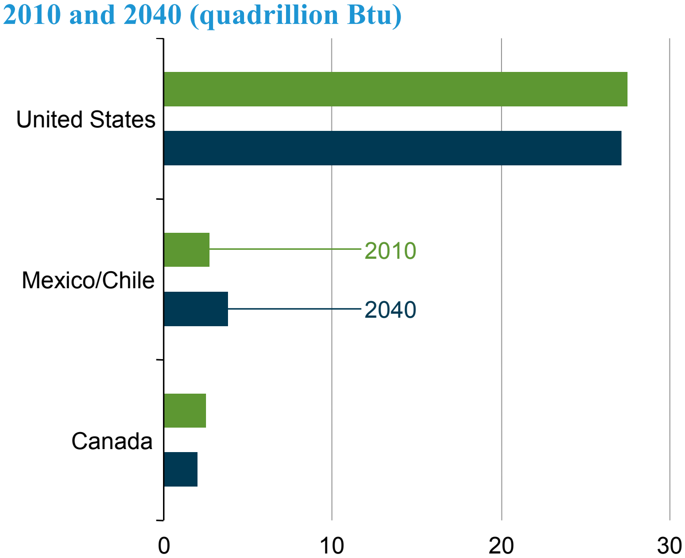


Figure 133. OECD Americas transportation sector delivered energy consumption by country, 2010 and 2040 (quadrillion Btu)



vehicles and aligning them with the national fuel economy standards of the United States, which are expected to curb the growth in demand for petroleum fuels in the long term. In the *IEO2013* Reference case, total transportation energy use in Canada declines by an average of 0.8 percent annually, from 2.5 quadrillion Btu in 2010 to 2.3 quadrillion Btu in 2020 and 2.0 quadrillion Btu in 2040.

The transportation sector in Canada is the largest source of that nation's greenhouse gas emissions, currently accounting for approximately 27 percent of the total [*384*]. Canada is taking action to reduce the transportation sector's environmental impact. In 2012, the government proposed new, more stringent greenhouse gas emissions regulations for passenger vehicles and light trucks in model years 2017 to 2025, extending regulations already in place for model years 2011 to 2016 that require fuel efficiency of 6.6 liters per 100 kilometers (35.5 miles per gallon) for vehicles manufactured in 2016 [*385*]. The new standards are expected to reduce greenhouse gas emissions from 2025 model year vehicles by 50 percent relative to 2008 levels.

In addition to the new emissions regulations for passenger vehicles, the Canadian government has proposed regulations for heavy-duty vehicles in model years 2014-2018 that would reduce greenhouse gas emissions by up to 23 percent compared with 2010 model year vehicles [*386*]. Final regulations for heavy-duty vehicles will be published before the end of 2013.

As part of its Renewable Fuels Strategy, Canada has adopted regulations that require renewable energy contents of at least 5 percent in gasoline starting in December 2010 and 2 percent in diesel fuel and distillate heating oil starting in July 2011 [*387*]. The initiatives are part of Canada's commitment to reducing total greenhouse gas emissions in 2020 by 17 percent from 2005 levels.

Mexico/Chile

In Mexico and Chile, strong economic growth averaging 3.7 percent per year results in a robust increase in transportation energy demand, from 2.7 quadrillion Btu in 2010 to 3.8 quadrillion Btu in 2040. The combined transportation energy use of Mexico and Chile grows by an average of 1.2 percent annually, as compared with an average decline in transportation energy consumption of 0.1 percent per year for the OECD region as a whole. The growth in Mexico and Chile's transportation demand is primarily in the road sector, which currently has relatively low ownership rates per capita as compared with other OECD markets and considerable potential for growth as per capita incomes rise, trade with North American and Latin American countries increase, and standards of living improve.

Although the *IEO2013* Reference case projects relatively strong growth in transportation energy demand in Mexico and Chile, both countries are promoting policies that encourage energy efficiency and the use of cleaner fuels. For instance, Mexico has been tightening vehicle emissions standards in recent years. In July 2012, the Mexican government proposed carbon dioxide emissions standards for passenger vehicles (including cars, pickup trucks, and sport utility vehicles), mandating an average fuel economy of 35 miles per gallon for new vehicles in 2016 [*388*]. The proposed regulations, which were altered after legal challenges from automakers, are intended to be the final step in harmonizing passenger vehicle fuel economy and greenhouse gas emissions standards throughout North America. In the near term, however, the benefit of more stringent emissions regulations for new vehicles may be offset by imports of used vehicles (more than 10 years old) from the United States. Since liberalization of trade between Mexico and the United States as a result of the 1994 North American Free Trade Agreement, an estimated 11 million used vehicles have been imported into Mexico [*389*]. Some import restrictions on used vehicles have been introduced recently, but more expensive fuel-efficient vehicles are likely to take a back seat to cheaper and more widely available used vehicles.

Chile relies on petroleum imports for more than 95 percent of its transportation demand and has some of the highest fuel prices in Central and South American countries, which should encourage penetration of alternative-fuel vehicles [*390*]. The Chilean government is working on a series of initiatives to promote the adoption of alternative-fuel vehicles for personal and public uses. In 2008, the General Treasury of Chile adopted a hybrid vehicle law, which allows a refund of the annual vehicle registration costs for hybrid vehicles for 4 years. Sales of hybrid vehicles have been slow, however, with only 400 hybrid vehicles registered between 2008 and 2010 [*391*]. Some municipalities have changed their administrative fleets to hybrid and battery-operated electric vehicles, and in 2011 the first charging station in Latin America was established in Santiago. Growth in the use of alternative-fuel vehicles is likely to be gradual and will require continued commitment on the part of the government.

The Chilean government continues efforts to repair and rebuild infrastructure damaged during a massive 2010 earthquake. Through public-private partnerships, Chile plans to invest $14 billion in infrastructure projects through 2014, including $568 million by 2020 to rehabilitate 81 bridges, up to $1 billion for upgrades to ports, an estimated $5 billion for road and highway projects, $500 million for expansion of the Santiago international airport, $2.7 billion for expansion of the Santiago metro, and $3 billion for a freight rail tunnel through the Andes at the Los Libertadores Pass to link Chile and Argentina [*392*]. Two other rail projects include the Arica-La Paz rail line and the Empresa de Ferrocarriles del Estado.

OECD Europe

Demand for transportation fuels in OECD Europe declines in the Reference case at an average annual rate of 0.5 percent. The decrease in the region's transportation energy use results from increases in fuel efficiency that outweigh increases in highway travel. These projections contrast with those in EIA's *International Energy Outlook 2011*, which showed no change in OECD Europe's consumption of transportation fuels from 2008 to 2035 in the Reference case. The difference between the current and previous *IEO* projections stem from lower economic growth, a lower correlation between economic activity and highway travel, and higher projected fuel efficiency increases, as mandated by the latest European Union directive published in 2012 [*393*]. The 2012 directive requires that new cars emit no more than an average of 130 grams of carbon dioxide per kilometer by 2015 and that vans emit no more than 175 grams of carbon dioxide by 2017. By 2020, the limit on carbon emissions reduces to 95 grams per kilometer for cars and 147 grams per kilometer for vans.[44] These mandates compare with an estimated average of 136 grams per kilometer for new cars in 2011. The directive, which is one of several policies designed to improve vehicle efficiency and increase the use of clean transportation fuels, leads to higher projected fuel economy (see box on page 146).

In addition to the European policy measures aimed at curbing emissions, many OECD European countries have levied both energy and emissions taxes on motor vehicles to encourage fuel conservation, resulting in retail prices that are substantially higher than those in the United States. Taxes on fuel consumption vary widely among the countries of OECD Europe, but they have traditionally favored diesel fuel, which has contributed to an increasing share for diesel fuel in the light-duty vehicle market (50 percent in 2009 in Btu terms) and an increase in aggregate fuel efficiency. Diesel generally is 20 to 30 percent more efficient than motor gasoline in an equivalent vehicle.

Highway travel in OECD Europe grows slowly in the Reference case, despite continued economic growth, largely as a result of demographics. The region's total population grows by only 0.3 percent per year from 2010 to 2040, and as the average age increases, the number of licensed drivers and the average amount of highway travel per capita decline. The demographic shift contributes to the weakening of the link between aggregate income and fuel consumption. In its promotion of fuel efficiency increases and more stringent greenhouse gas emissions standards, the European Union has called for a decoupling of fuel consumption from underlying economic activity as a means of promoting economic growth. In addition, the promotion of alternative transportation options, such as bicycle rental schemes in major cities, contributes to the decline in highway travel.

OECD Asia

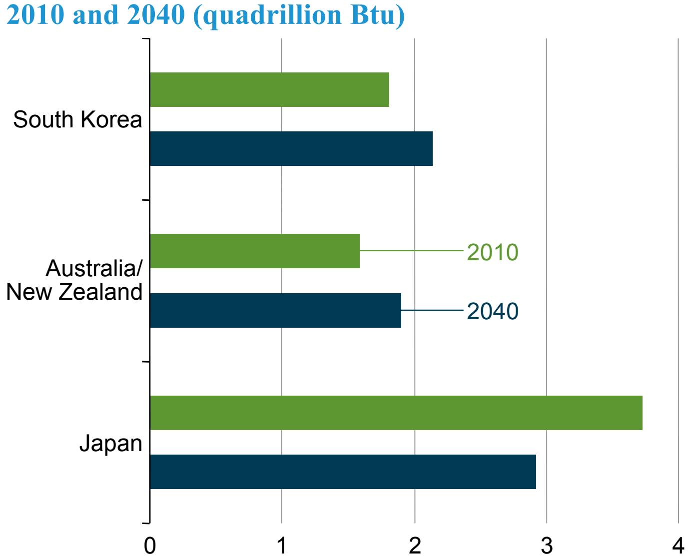
In the OECD Asia region, with a fully established transportation infrastructure, high motorization levels, expected population declines, and continuous improvements in transportation energy efficiency, transportation energy demand remains essentially flat at around 7 quadrillion Btu from 2010 to 2040 in the *IEO2013* Reference case (Figure 134).

Transportation energy use in Japan declines by an average of 0.8 percent per year in the Reference case, from 3.7 quadrillion Btu in 2010 to 3.4 quadrillion Btu in 2020 and 2.9 quadrillion Btu in 2040. The main factor contributing to the decline is Japan's changing demographics, with population decreases averaging 0.4 percent per year from 2010 to 2040 and the number of people in the main vehicle-buying group, 20-60 years old, also declining. In addition, high motorization levels, a mature and fully established transportation infrastructure, high fuel costs, high urbanization levels with wide availability of mass transit, environmental concerns, and further efficiency improvements in all transportation sectors also contribute to the decrease in future transportation energy use.

Although vehicle sales in Japan declined sharply after the devastating earthquake and tsunami in March 2011, they rebounded in 2012—particularly sales of fuel-efficient vehicles, aided by government subsidies (about $770 dollars for small vehicles with engine displacement of 660 cubic centimeters or less and about $1,100 dollars for others) that ran through September 2012, when subsidy funds were depleted [*394*]. Sales of hybrid vehicles were particularly strong in recent years, due to government incentives and declining prices. Toyota Prius has been the best-selling vehicle in Japan for four consecutive years since 2009, with 2012 sales of 317,675 cars nearly 26 percent higher than in 2011 [*395*].

As part of the Green Growth Strategy launched in 2012, the Japanese government has set 2020 targets for 50 percent of new car sales to be environmentally friendly vehicles (including zero-emission electric, fuel cell, and highly fuel-efficient hybrids), and for mass public transportation to be available to 70 percent of the population [*396*, *397*]. For the transportation industry, the strategy is focused on promoting next-generation green vehicles and storage batteries [*398*]. The government plans to support the development of battery storage technologies, with a goal of doubling the maximum driving range of electric vehicles to 200 kilometers (124 miles) on a single charge by 2020 [*399*]. To promote the use of electric vehicles, the government plans to build 2 million regular charging stations across Japan for electric and plug-in

Figure 134. OECD Asia transportation sector delivered energy consumption by country, 2010 and 2040 (quadrillion Btu)



[44]In terms of vehicle efficiencies: 130 grams of carbon dioxide (CO_2) per kilometer is equivalent to vehicle efficiencies of 42.0 miles per gallon (mpg) for motor-gasoline-fueled vehicles or 48.0 mpg for diesel-fueled vehicles; 95 grams CO_2 per kilometer is equivalent to 57.4 mpg for motor-gasoline-fueled vehicles or 65.3 miles per gallon for diesel-fueled vehicles; 147 grams CO_2 per kilometer is equivalent to 37.4 mpg for motor-gasoline-fueled vehicles or 42.8 miles per gallon for diesel-fueled vehicles; and 175 grams per kilometer is equivalent to 31.4 mpg for motor-gasoline-fueled vehicles or 35.6 miles per gallon for diesel-fueled vehicles.

Legislating fuel efficiency in OECD Europe

Over the past few years, several measures adopted by the European Union (EU) and by individual countries have contributed to higher fleetwide fuel efficiencies. The measures generally focus on taxation and emissions regulations as means of increasing fuel efficiencies and reducing greenhouse gas emissions.

The 20-20-20 initiative [*400*], adopted by the European Commission in 2009 and codified in the 2012 Directive, calls for a 20-percent improvement in total primary energy efficiency and a 20-percent reduction in total greenhouse gas emissions from 1990 to 2020, as well as an increase in the renewables share of energy consumption to 20 percent. Although the targets pertain to total energy usage, they affect the transportation sector as evidenced by recent regulations calling for lower greenhouse gas emissions. In addition, in March 2011 the EU adopted a European 2050 Roadmap framework that would reduce total greenhouse gas emissions from 1990 levels by 40 percent in 2030, 60 percent in 2040, and 80 percent in 2050 [*401*]. According to the Roadmap, most of the reduction in greenhouse gas emissions in the transportation sector would occur after 2030 with increased use of fuel cell and electric vehicles.

The adoption of emissions standards for road-related vehicles is a cornerstone of EU road transportation policy. The tightening of carbon dioxide emissions standards is a means by which increases in the fuel economy of new vehicles and other environmental goals would be achieved in accordance with the 20-20-20 initiative goals. In 2007, new passenger cars in the EU emitted an estimated 160 grams of carbon dioxide per kilometer (comparable to 34.0 miles per gallon for motor gasoline and 38.9 miles per gallon for diesel). The corresponding estimate for 2011 was 135.7 grams per kilometer (39.7 miles per gallon for motor gasoline cars and 45.4 miles per gallon for diesel cars). The EU is in the process of adopting new, more stringent standards that are likely to be ratified in 2013. The proposed 2015 standard is 130 grams per kilometer (42.0 miles per gallon for gasoline-powered cars and 48.0 miles per gallon for diesel-fueled cars) [*402*]. For 2020, the EU has proposed an average carbon dioxide emissions limit of 95 grams per kilometer that also is likely to be approved in 2013. As a result, new cars would, on average, be required to achieve CAFE standards of 57.4 miles per gallon for motor-gasoline-fueled cars and 65.3 miles per gallon for diesel-fueled cars. The EU also has proposed standards for other light-duty vehicles that would result in substantial increases in fuel efficiency for new vehicles. In 2011, new vehicles emitted an average of 181 grams of carbon dioxide. In 2017, the proposed carbon dioxide limit would be 175 grams per kilometer (31.4 miles per gallon for motor-gasoline-powered vehicles and 35.6 miles per gallon for diesel-powered vehicles). In 2020, the proposed carbon dioxide limit would be 147 grams per kilometer (37.4 miles per gallon for motor-gasoline-fueled vehicles and 42.8 miles per gallon for diesel-fueled vehicles).

In addition, the EU since 2009 has required the use of diesel particulate filters (DPFs) on the exhaust systems of all new light-duty vehicles and will require them on heavy-duty vehicles in 2013 now that ultra-low-sulfur diesel (defined as 10 parts per million by weight in the EU) is widely available in Europe. Several major cities, including London, already have mandated DPFs for heavy-duty vehicles. The implementation of phases 3 and 4 of London's Low Emissions Zone in 2012 has led to thousands of trucks, coaches, and smaller commercial vehicles being retrofitted with DPFs, as well as older vehicles being replaced by new ones. Moreover, the limit on diesel emissions from new vehicles is scheduled to be lowered in September 2014 in accordance with EU regulations. For example, permissible nitrogen oxide emissions for passenger cars and most light commercial vehicles were 500 milligrams per liter in 2000 before being reduced to 250 milligrams in 2005 and 180 milligrams in 2009. The September 2014 standard is 80 milligrams [*403*].

Excise taxes on motor fuel, on the other hand, are primarily the purview of individual countries and vary widely. Most countries tax motor gasoline more heavily than diesel to encourage the consumption of diesel fuel as a means of achieving higher aggregate fuel efficiencies. (The United Kingdom is a notable exception, with tax rates for gasoline and diesel fuel being the same.) Most European countries adopted tax rates favorable to diesel in the wake of the 1979 Iranian Revolution, which led to a tripling of crude oil prices. However, several countries as well as the EU currently are considering schemes to increase emissions-related taxes on diesel (either at the pump or on purchased vehicles in the form of a registration tax) in light of findings by the World Health Organization in 2012 that diesel fumes contain carcinogens. If adopted, the measures would constitute a reversal of policies designed to encourage diesel fuel consumption. In April 2011, the EU Commission put forward a proposal to change fuel taxation policies, with member states required to tax transportation fuels on the basis of both energy content and carbon and particulate emissions, starting in 2023 [*404*]. However, the European Parliament's rejection of that measure in 2012 suggests that such changes in the motor fuel tax regime would have to take place at the national level, at least in the short run.

hybrid vehicles and to install 5,000 rapid-charging stations along major routes [*405*]. To promote the use of fuel cell vehicles, targeted for launch in 2015, 13 Japanese automakers and energy companies plan to build around 100 hydrogen refueling stations in four major metropolitan areas (Tokyo, Nagoya, Osaka and Fukuoka) by 2015 [*406*].

South Korea's transportation energy use grows by an average of 0.6 percent per year in the *IEO2013* Reference case, from 1.8 quadrillion Btu in 2010 to 2.1 quadrillion Btu in 2040, due to relatively strong GDP growth (3.3 percent per year) and continuous focus on energy efficiency improvements in transportation. As part of South Korea's efforts to reduce greenhouse gas emissions, the government enacted fuel economy standards in 2006 for domestic cars and in 2009 for imported cars. The fuel economy standards, which apply to vehicles with engine displacement of less than 1,600 cubic centimeters, required a 16.5-percent improvement in fuel efficiency, from 26 miles per gallon in 2008 to 34 miles per gallon by 2012 [*407*]. In 2012, the Ministry of the Environment announced that it would start regulating greenhouse gas emissions from new vehicles to meet an emissions standard of 140 grams per kilometer (39.5 miles per gallon) by 2015. The new standards will be implemented in stages, with 30 percent of new domestically manufactured or imported vehicles required to meet the standards in 2012, followed by 60 percent of new vehicles in 2013, 80 percent in 2014, and all new vehicles by 2015.

To promote the use of electric vehicles, in 2011 South Korea's government announced a tax subsidy of up to 4.2 million won, or about $3,850, for purchases of electric vehicles and allocated about $25.3 million for purchases of 1,000 electric vehicles by public organizations in 2013 [*408*]. Currently, there are around 600 charging stations in South Korea, which is low in comparison with Japan and the European Union countries, where charging stations number in the tens of thousands. More charging infrastructure and greater government involvement will be required in order to scale up usage of electric and plug-in hybrid vehicles in South Korea in the future.

Transportation energy use in Australia and New Zealand grows by an average 0.6 percent per year in the *IEO2013* Reference case, based on relatively moderate population growth and average annual GDP growth of 2.2 percent from 2010 to 2040. In the past, transportation demand growth in Australia has been led by road freight, which doubled from 1,031 million metric tons in 1985 to 2,092 million metric tons in 2010, when it accounted for 71 percent of all goods moved, followed by rail transportation at 28 percent of all goods moved [*409*].

Non-OECD countries

In the *IEO2013* Reference case, the annual average growth rate for transportation energy consumption in the non-OECD countries is 2.2 percent from 2010 through 2040, led by strong growth in non-OECD Asia at 3.1 percent annually. The use of liquids in the non-OECD transportation sector nearly doubles from 40 quadrillion Btu in 2010 to 79 quadrillion Btu in 2040 (Figure 135). In 2010, non-OECD countries accounted for 43 percent of the world's transportation energy use. In 2040 their share is projected to be 60 percent in the Reference case.

Non-OECD Asia

Non-OECD Asia's share of world transportation liquids consumption increases from 20 percent in 2010 to 36 percent in 2040, exceeding transportation energy demand in the OECD Americas by 2025. Robust demand growth in the region is led by rising per-capita incomes and increasing motorization and urbanization of the large and growing populations. In the long term, major uncertainties in the projection center around the expected rate of motorization, vehicle fuel efficiencies, government policies, fuel subsidies, penetration of alternative vehicle technologies, and the pace of urbanization, including the availability of public transport and mass transit systems.

China

China is the major source of transportation liquids demand growth worldwide, and it remains so in the *IEO2013* Reference case (Figure 136). From 2010 to 2040, China's GDP grows by an average of 5.7 percent per year, while energy demand in the transportation sector grows by 3.7 percent annually, from 9.0 quadrillion Btu in 2010 to 14.9 quadrillion Btu in 2020 and 26.6 quadrillion Btu in 2040. China's transportation liquids consumption currently accounts for about 9 percent of total world liquids consumed for transportation, but its share increases to 20 percent in 2040. China becomes the world's second-largest consumer of transportation fuels, overtaking OECD Europe by 2025 and trailing slightly behind the United States at 26.6 quadrillion Btu in 2040. The strong growth in transportation liquids demand in China is a result primarily of growing personal mobility, as per capita

Figure 135. Non-OECD transportation sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)

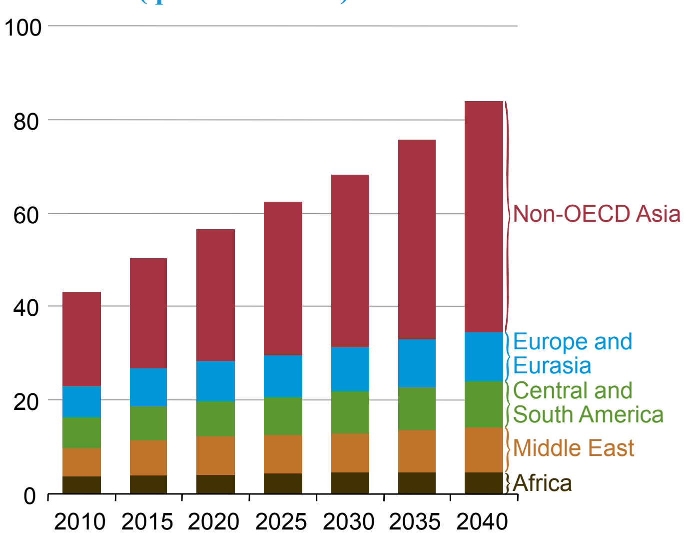
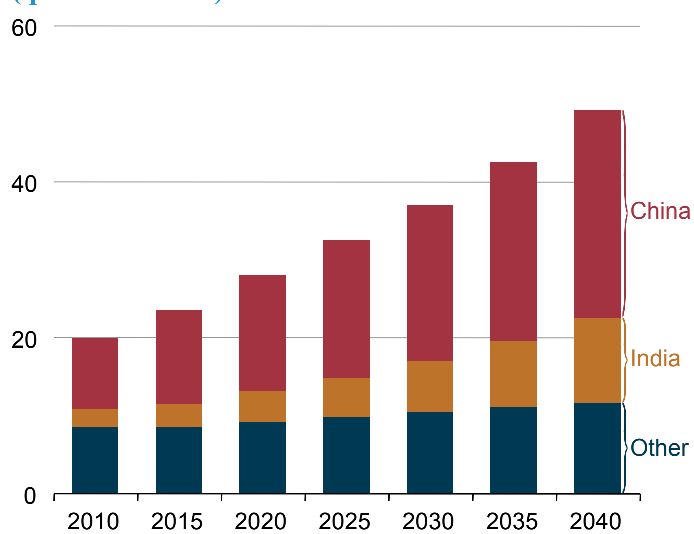


Figure 136. Non-OECD Asia transportation sector delivered energy consumption by country, 2010-2040 (quadrillion Btu)



incomes rise and there is an abundance of relatively affordable personal vehicle choices. In the long term, however, a wide variety of factors plays into the overall demand for transportation energy in China, leading to substantial uncertainty about the ultimate growth rates and levels of consumption.

Since 2009, China has been the world's largest automotive market, aided by government subsidies introduced to stimulate demand during the 2008-2009 global financial crisis. Economic stimulus measures are estimated to have increased vehicle sales by 46 percent in 2009 and 32 percent in 2010 [*410*]. The number of light-duty vehicles grew by an average of 24 percent per year from 2000 to 2008, with the total number of vehicles almost quadrupling from 22.3 million vehicles in 2000 to 86 million vehicles in 2008 [*411*].

China's 2011 motorization level is estimated at 58 motor vehicles per 1,000 people, which is low in comparison with the estimated averages of 135 vehicles per 1,000 people worldwide, 797 vehicles per 1,000 people in the United States, and 363 vehicles per 1,000 people in South Korea [*412*]. Although China's passenger transportation energy use per capita triples in the *IEO2013* Reference case, it is only about one-half the level of South Korea, and below the levels of many other OECD countries, in 2040.

Road infrastructure in China has undergone major expansion since the 1990s, contributing to China's economic growth. From 1998 to 2008, growth in the combined length of China's highways averaged 11.3 percent per year, while growth in expressways averaged 21.4 percent per year [*413*]. The national highway mileage reached 2.5 million miles in 2011, of which 1.6 million miles were paved, an increase of 1.7 percent over 2010 [*414*]. Some 249,000 miles of local and township roads were also improved. The expansion of roadways was funded by an investment of more than $40 billion annually, one-third of which was allocated to the National Expressway Network (NEN). The current NEN expansion plan includes 7 corridors radiating from Beijing, 9 north-south corridors, and 18 east-west corridors, designed to maximize transportation interconnectivity among cities.

China is also pursuing large-scale plans for expansion of high-speed rail and mass transit networks. The Chinese government has stated that expansion of the rail infrastructure is intended to address the challenges posed by rapid urbanization and motorization, while integrating and modernizing underdeveloped rural provinces in the central and western parts of the country. At the end of 2012, China had about 61,000 miles of railways in operation, the second-longest network in the world, and almost 6,000 miles of high-speed rail lines, the world's longest [*415*]. According to the 12th Five-Year Plan (2011-2015) for the Railway Industry, eight high-speed railway networks will be completed in China by 2015, with planned investment of more than $79 billion annually in 2013, 2014, and 2015 to reach the target [*416*]. In 2013 alone, China's Railway Ministry plans to invest about $103 billion in new rail construction, build 3,231 miles of new railways, and begin service on more than 10 major new lines, including the Tianjin-Baoding railway, the Ningbo-Hangzhou high-speed railway, the Xiamen-Shenzhen railway, and the Chongqing-Lizhou railway. By 2015, high speed rail is set to increase to about 11,000 miles and railways to nearly 75,000 miles.

In addition to expanding rail networks, China is expanding urban railways, subways, and light rail in response to the rapid urbanization taking place across the country. In September 2012, the National Development and Reform Commission approved 25 urban rail projects worth $127 billion, in cities including Shijiazhuang, Taiyuan, Lanzhou, Guangzhou, and Xiamen [*417*]. In addition, 60 subway projects already are underway in more than 20 cities [*418*]. In 2012, the Beijing metro system opened a new 44-mile line, bringing the total mileage of the metro tracks to 275 miles and making it the world's largest metro system [*419*]. Also in 2012, three Chinese cities—Hangzhou, Suzhou, and Kunming—opened metro lines, bringing the total number of Chinese cities with a metro system to 18. As of 2012, more than 30 Chinese cities had urban rail systems under construction, and China plans to add 1,553 miles of metro lines during the 12th Five-Year Plan. Forty Chinese cities will have subway systems by 2020, bringing the total track length to 4,350 miles, or 4.3 times the current length [*420*]. In the *IEO2013* Reference case, China's passenger rail system tempers the growth in demand for personal motor vehicles.

Demand for passenger vehicles in China grows in response to increasing per-capita incomes and modernization of lifestyles, which are associated with greater mobility. For four consecutive years since 2009, China has overtaken the United States as the world's largest vehicle market, with total vehicle sales (including buses and trucks) of 18.1 million units in 2010, 18.5 million units in 2011, and an estimated 19 million units in December 2012 [*421*] despite withdrawal of government stimulus measures, which ended in 2010. China's demand for personal vehicles continues to expand rapidly through the medium term, although it is tempered somewhat by various government policies focused on constraining further explosive growth in personal vehicle ownership.

In its 12th Five-Year Plan, the Chinese Government committed to reducing energy intensity by 16 percent between 2011 and 2015, building on the previous target of 20 percent between 2006 and 2010 [*422*]. To curb greenhouse gas emissions from the transportation sector, the Chinese government has been tightening greenhouse gas emissions standards. China applied the Euro 3 standard to new cars sold nationwide, the Euro 4 standard in Shanghai and Guangzhou, and the Euro 5 standard in Beijing, starting in February 2013 [*423*]. The government imposed a new vehicle tax based on engine size in 2012 and also plans to liberalize petroleum prices and bring them into better alignment with world oil prices. Also, government policies are in place to expand the use of alternative fuel or new energy vehicles in China to help reduce the impact of increased motorization on the environment (see box on page 149).

In response to serious air pollution and traffic congestion, several Chinese cities began capping the number of new vehicles allowed to register and obtain license plates. In Beijing, one of the most polluted cities in the world, municipal authorities have capped the number of new vehicle registrations at 240,000 per year since 2010. The city administers a lottery that gives new car buyers an opportunity to win a car license free of charge, and only about 2 percent of participants are granted licenses. The number of participants in the January 2013 lottery exceeded 1.4 million, with only 20,000 license permits issued to the city's residents [*424*].

Prospects for new energy vehicles in China

In addition to vehicle control policies in China's largest cities, the government is actively promoting the use of alternative vehicles. Support for the development of new energy vehicles (NEVs)[45] and the capabilities of China's domestic automobile industry to mass produce such vehicles are the key components of China's 12th five-year plan, which identifies the alternative vehicle industry as one of seven strategic emerging industries. The government plans to invest an estimated $15 billion in alternative-energy vehicles over the next 10 years [*425*]. The national target for cumulative production and sales of pure electric and plug-in hybrid vehicles is 500,000 units by 2015, and the target for NEVs is 5 million units by 2020 [*426*]. Under the new energy vehicle industrial plan for 2012 to 2020, released in 2012, average passenger car fuel economy is targeted to increase to 34 miles per gallon by 2015 and 47 miles per gallon by 2020, while the fuel economy of energy-efficient vehicles is targeted to increase to 40 miles per gallon or more by 2015 and 52.3 miles per gallon by 2020 [*427*].

To meet NEV growth targets, boost consumer demand, and make alternative vehicles more affordable, the Chinese government has been offering numerous financial incentives, including some $4 billion allocated for energy-saving products, primarily NEVs and household appliances [*428*]. In addition, an annual subsidy of about $313.5 million has been allocated to support the manufacturing of NEVs starting in 2012. For electric vehicles, subsidies from the central government often are matched by local subsidies. For example, in Beijing, the central government subsidy of approximately $9,400 is matched by a subsidy of the same amount from the city of Beijing [*429*]. Many other cities also offer considerable subsidies. The Shenzhen government offers one of the highest subsidies for electric vehicles in the country—about $18,812 per passenger vehicle [*430*], reducing the price of such vehicles by more than one-half. In addition to financial incentives, some cities offer other incentives, including free license plates for NEVs. For example, Shanghai offers free license plates for 20,000 electric vehicles starting in 2013 [*431*], Guangzhou offers 12,000 free plates allocated by lottery [*432*], and Beijing offers electric vehicles an exemption from the vehicle license lottery [*433*].

Any large-scale transition to electrification of the Chinese vehicle fleet will take time, as well as a concerted effort by the Chinese government, before mass adoption of alternative-fuel vehicle technologies becomes a reality. Sales of alternative-fuel vehicles to date have been minimal. Only 8,159 NEVs and hybrid vehicles were sold in 2011, and 6,019 NEVs, including 2,661 electric and 3,358 hybrid vehicles, were sold in the first 8 months of 2012 [*434*]. Development of charging infrastructure also has been lagging behind government targets: of the 400,000 charging stations planned for completion by 2015, only 16,000 had been constructed through 2011 [*435*].

Some of the reasons for low sales of NEVs are high vehicle costs despite government subsidies, inadequate charging infrastructure, limited driving range in comparison with conventional vehicles, supply constraints and fragmentation (at present only one vehicle, Roewe E50, is mass produced domestically), lack of a national industry standard for EV charging connectors, consumer education and acceptance of the new technology, and vehicle safety issues, among others.

Shanghai started implementing restrictions on vehicle registrations in 1994, using a monthly vehicle license auction to grant car registration rights to the highest bidders. The price of a vehicle license plate can be as high as $12,000, equivalent to the price of a family economy car [*436*].

Along with Beijing and Shanghai, Guiyang and Guangzhou have implemented vehicle registration restrictions, and other cities may soon follow suit [*437*]. In addition to controlling the number of new vehicle registrations, many cities limit the number of vehicles driving on the roads through travel restrictions based on vehicle license plate numbers. Such restrictions currently are in place in seven cities—Beijing, Changchun, Chengdu, Guiyang, Hangzhou, Lanzhou, and Nanchang—and other cities may soon join. Restrictions on vehicle registrations and travel, if adopted nationwide, could affect the pace and extent of growth in personal vehicle ownership in China over the long term.

India

India's transportation energy use grows at the fastest rate in the world in the *IEO2013* Reference case, averaging 5.1 percent per year, compared with the world average of 1.1 percent per year. Transportation energy use more than quadruples, from 2.4 quadrillion Btu in 2010 to 10.9 quadrillion Btu in 2040, as India's economy and population continue to grow and develop and demand for passenger and freight transportation increases. The road sector leads the expansion of transportation energy use, with passenger energy use per capita and demand for personal transportation growing rapidly. While two- and three-wheel vehicles currently make up most of India's vehicle fleet (72 percent of the total), demand for larger four-wheel passenger vehicles increases considerably as per capita incomes rise [*438*]. In the next decades, robust GDP growth, urbanizing population, and rising per capita income are expected to continue to drive strong sales growth in the Indian automotive market. The country's demographics, with 600 million people younger than 25 years old, offer some of the best prospects for automobile market expansion in the world.

In the *IEO2013* Reference case, India's demand for personal transportation is expected to continue expanding rapidly from 2010 to 2040. The number of registered motor vehicles in India increased more than fivefold from 21 million in 1991 to 115 million in 2009 [*439*]. Currently, the transportation sector accounts for almost 10 percent of India's carbon dioxide equivalent emissions from all

[45]The Chinese government introduced policies in 2010 to boost the development of what it called "new energy vehicles," which include electric vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, and fuel cell electric vehicles.

energy sources, with the largest share coming from road transport. Under current policies and market conditions, transportation emissions will also increase dramatically from 2010 to 2040.

Although India's 11th five-year plan (2007-2012) did not explicitly provide development goals for the transportation sector beyond improving road access in rural areas, *An Approach to the Twelfth Five Year Plan* [*440*] released by the Government of India Planning Commission in October 2011 extensively addresses mode shifting from road to rail and inland waterways for freight traffic, as well as greater development of public transport. According to the document, transportation sector development will continue to focus on expanding and modernizing roadways between cities and in rural areas, modernizing and improving railway infrastructure and service, expanding minor port development for international trade, and modernizing air traffic monitoring. In addition, the National Action Plan on Climate Change sets a number of transportation development goals focused on curbing the growth of carbon dioxide emissions from the transportation sector through the National Urban Transport Policy (NUTP) [*441*].

The NUTP, launched in 2006, emphasizes development of extensive public transport systems and nonmotorized transport modes as an alternative to rapid expansion of personal vehicle usage. Public transit currently accounts for less than 25 percent of urban transport in India [*442*]. India's rapid urbanization has increased demand for urban transport systems. It is expected that more than 50 percent of the population of India may reside in urban areas by 2025, a substantial increase from 34 percent in 2011 [*443*]. The NUTP has implemented the expansion of several urban mass transit systems, such as the Metro Rail Transportation System in Delhi, Bangalore's Metro Bus project, and bus rapid transit systems in 10 other cities. The Maharashtra state government recently announced that it will impose a congestion tax to discourage use of private vehicles in cities where it has created sufficient public transport capacity [*444*].

Petroleum fuels continue to dominate India's transportation energy mix over the long term, accounting for 85 percent of the total transportation fuels mix; however, the government continues to focus on increasing the share of alternative fuels. In 2010, India established a 5-percent mandatory ethanol blending standard in 20 states and started selling blended fuel in 14 of the program's states while increasing the regulated prices for ethanol [*445*]. Supply variability in sugar production and availability of sugarcane remain key challenges to the policy's success. It is doubtful that India can meet its 20-percent blending target by 2017, given current ethanol production levels and the need for additional government incentives to stimulate continued growth. At present, commercial production of biodiesel in India is insignificant [*446*]. The government's plan to reach a 20-percent share of biodiesel in diesel fuel by fiscal year 2011-2012 (April-March) was complicated by the lack of availability of high-yield drought-tolerant jatropha seeds, which are favored for producing biodiesel in India.

The Indian government has been establishing progressively more stringent emissions standards for the transportation sector. Since 2010, gasoline sold in India's 13 largest cities has been required to meet Euro 4 emissions standards, while Euro 3 standards are applied in all other areas of the country [*447*]. India's emissions reduction policies also are focused on consumer incentives, such as vehicle registration fees based on engine size, regulation of carbon dioxide emissions, and sales incentives for more fuel-efficient vehicles [*448*].

India currently has the third-largest rail network in the world, carrying 23 million passengers and 2.65 million metric tons of freight daily on about 19,000 trains [*449*]. However, the rail shares of freight and passenger transportation have declined as the road transport shares have increased. At present, road transportation accounts for 90 percent of India's passenger movement and 65 percent of its freight transport [*450*]. Indian railways have added only 1,087 miles of new lines since 2006, as compared with 2,486 miles of railways and 6,214 miles of high-speed rail network added by China over the same period [*451*]. To achieve India's low-carbon growth strategy, greater use of railroads will be essential in combating greenhouse gas emissions and meeting the goals of sustainable transport. To that end, the Indian government has proposed a five-pronged strategy to modernize the railways, with a total required investment of $67 billion [*452*].

A particular focus is placed on raising funds through public private partnerships (PPPs), with a targeted investment of about $42 billion over the next 5 years [*453*]. India's 12th five-year plan (2013-2017) emphasizes the importance of PPPs in the development of transportation infrastructure. Currently there are 1,017 active PPP projects in the country, which is the world's second-largest number of active PPP projects (after China) and the second-largest total investment in PPP projects (after Brazil) [*454*]. Success in securing the needed investments will be crucial for improving the operation of India's railways and achieving the government's sustainable transportation goals.

India's road sector, which has accounted for around 90 percent of its total transportation energy use over the past 10 years, is the second-largest road network in the world after the United States [*455*, *456*]. The 12th five-year plan targets an investment of $1 trillion for infrastructure projects, including $42 billion for roads, with a goal of raising at least $300 billion from private funds [*457*, *458*]. India plans to double its 43,496 miles of national interstate highway roads in the next 5 years and increase the overall road network to 3.1 million miles in the next decade. Specifically, the Indian government's planning commission intends to use the funds to upgrade and expand state highway networks; upgrade roads in Delhi and other large cities; execute national highway projects connecting the freight corridors that run from north to south and from east to west to the interiors; and set up related highway infrastructure, such as toll booths, warehousing facilities, and connector and feeder lanes [*459*]. Development of the country's infrastructure is one of the key priorities for India's government, as the country's rapidly growing economy has been placing significant demand on its transportation system, and existing bottlenecks in both urban and rural infrastructure have been impeding the country's competitiveness. Expansion of transportation infrastructure will be essential for India's future economic growth.

Other non-OECD Asia

In the other countries of non-OECD Asia (excluding China and India), transportation energy use grows from 8.5 quadrillion Btu in 2010 to 11.7 quadrillion Btu in 2040 in the *IEO2013* Reference case. As in the case of India and China, the key reason for robust growth in transportation energy demand is increasing motorization supported by major investments in infrastructure to accommodate growth.

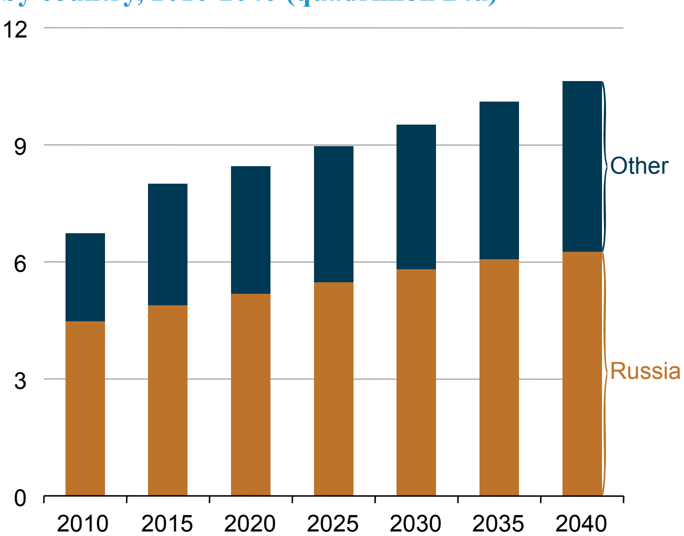
Transportation infrastructure in many non-OECD Asia countries is underdeveloped and will require major investment to support economic growth, provide greater internal integration between regions, and increase international competitiveness. Governments in many non-OECD Asia countries have been actively promoting participation of the private sector and foreign investors in infrastructure projects through PPPs, which in many countries are vital for successful implementation of infrastructure programs.

Indonesia's government has developed several plans to address transportation infrastructure shortages in the country. In 2010, the government launched a medium-term development plan, which allocated $140 billion for infrastructure projects between 2010 and 2014, including plans to build 14 new airports, in addition to modest expansion of rail (53 miles) and improvement of existing road capacity (1,625 miles) [*460*]. The plan was complemented in 2011 by a master plan for acceleration and economic development, which targets an investment of $1 trillion in infrastructure projects over a 15-year period, with several PPP tenders designed to raise $700 billion in private financing [*461*]. Under the plan, 17 new projects were launched in 2011, including a $1.5 billion railway project connecting coal mines and plantations at Bangkuang to ports at Puruk Cahu in Umbulan, East Java [*462*]. Several more tenders for transportation project will be launched in 2013, using PPP investments, including $870 million to revitalize the Malioboro rail station in Yogyakarta; $435 million for monorail in Makassar; a $177 million Jakarta Integrated Urban Transport Club; and a $196 million toll road to connect Benoa Harbor, Ngurah Rai International Airport, and the Nusa Dua tourist area with a water supply in Maros, among others [*463*]. In the long term, investment and expansion of the transportation infrastructure, a large growing population with a relatively young demographic profile, increasing per capita incomes, and improving living standards will lead to rapidly growing motorization levels.

Malaysia has one of the most developed transportation infrastructures in non-OECD Asia. Over the years, Malaysia has made considerable investments in expanding and maintaining its transportation networks to accommodate economic expansion and the growing mobility needs of its population. Government policies, including the New Economic Model are focused on transforming the country into a high-income economy by 2020 [*464*]. Malaysia's expected increases in per capita incomes will lead to further increases in motorization levels, even though the country already has one of the highest levels of automobile ownership among the non-OECD nations, at 361 vehicles per 1,000 people, compared with 40 vehicles per 1,000 people in Indonesia and 157 vehicles per 1,000 people in Thailand [*465*].

Malaysia is becoming a hub for energy-efficient vehicles, aided by government incentives that include excise duty exemptions on the vehicles and a wide range and availability of alternative vehicle choices. A recent trend in sales of energy-efficient vehicles indicates the country's potential for becoming one of the leading consumers of alternative vehicles: in the first half of 2012, sales of hybrid vehicles reached record highs, with 6,209 vehicles sold, after already strong sales of 8,334 hybrid vehicles in 2011, up from 328 vehicles sold in 2010 [*466*]. Nevertheless, penetration of hybrid vehicles in the country's total fleet remains comparatively modest. Malaysia is one of Asia's most highly-motorized countries, with more than 21 million registered vehicles on the road by the end of 2010 [*467*].

Figure 137. Non-OECD Europe and Eurasia transportation sector delivered energy consumption by country, 2010-2040 (quadrillion Btu)



Non-OECD Europe and Eurasia

In the *IEO2013* Reference case, transportation sector energy use in non-OECD Europe and Eurasia grows at an annual average rate of 1.5 percent, from 6.7 quadrillion Btu in 2010 to 8.5 quadrillion Btu in 2020 and 10.6 quadrillion Btu in 2040 (Figure 137). Growth in the transportation sector is led by increases in private vehicle ownership, particularly in the countries of the Former Soviet Union, where rising per capita incomes, higher levels of economic activity, and improvement in standards of living lead to higher demand for personal motorized vehicles. Strong regional GDP growth and virtually flat population growth (less than 0.1 percent per year) lead to more demand for personal transportation, with increases in transportation energy consumption per capita averaging 1.6 percent per year from 2010 to 2040 in the Reference case.

In the region's largest economy, Russia, transportation energy consumption increases by 1.1 percent per year on average, from 4.5 quadrillion Btu in 2010 to 6.2 quadrillion Btu in 2040, despite a population decline averaging 0.2 percent per year.

The growth in transportation energy consumption is a result primarily of expanding ownership of private vehicles and growth in freight transportation.

From 2003 through 2008, sales of light-duty vehicles in Russia registered strong growth; however, during the 2008-2009 global recession and a severe economic downturn in Russia, vehicle sales fell sharply, by 49 percent in 2009 [*468*]. To promote vehicle sales and aid the ailing domestic auto sector, in 2010 the Russia's government implemented a scrappage program that offered discount certificates of around $1,665 per vehicle to consumers replacing a vehicle more than 10 years old with a new vehicle. The government allocated $1 billion for the program and issued 500,000 discount certificates, before ending it early due to the depletion of funds [*469*]. The scrappage program acted as a highly effective stimulus for the passenger car market, contributing to a robust recovery in light-duty vehicle sales, which posted a 30-percent increase to 1.9 million units in 2010. Through November 2012, sales of passenger cars and light commercial vehicles were up by 12 percent from their 2011 levels [*470*]. With personal incomes growing and economic conditions and living standards improving, passenger car sales in Russia are likely to continue robust growth over the long term, from comparatively low vehicle ownership rates in the past (271 vehicles per 1,000 people in 2007) [*471*].

Middle East

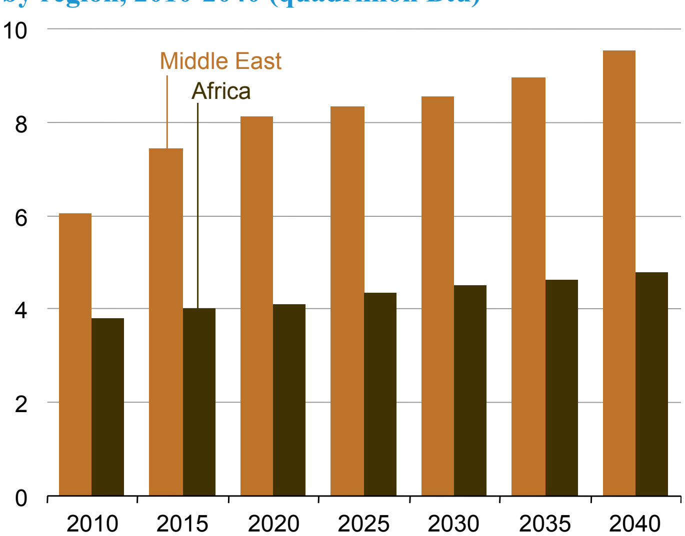
Transportation energy consumption in the Middle East grows by an average of 1.5 percent per year in the *IEO2013* Reference case, to 9.5 quadrillion Btu in 2040 (Figure 138). Although the Middle East has a relatively small population, population growth and continued urbanization are expected to result in increased demand for transportation. Sustained economic expansion and continuous end-user subsidies, which are unlikely to be completely eliminated in some countries in the region, will support strong growth in transportation fuel demand through the medium term. Investments in the road sector in the Middle East are expected to be significant, matching the increase in motorization levels and demand for road transport in the long term.

Strong growth in transportation fuels consumption in the Middle East is based on expansionary fiscal policies and considerable fuel subsidies for end users across the region, which have discouraged conservation and improvements in energy efficiency. Even a gradual removal of such subsidies has proven to be difficult, particularly in light of the 2011 Arab Spring uprisings. Before 2011, several countries in the region, which already have some of the highest retail prices among the Gulf Cooperation Council (GCC) countries[46] were considering a partial removal of fuel subsidies, but they have since decided to keep them in place.

Iran's attempt to remove fuel subsidies provides an insight into the challenges faced by Middle Eastern governments in addressing the problem of fuel subsidies. Iran was the first Middle Eastern country to implement a partial removal of fuel subsidies, beginning in 2010. Even before the Arab Spring, Iran had sought to reform its extremely costly subsidy system for some time, but concerns remained that significant subsidy reform could trigger civil unrest, as happened briefly in 2007 when fuel rationing was initially enacted. In 2010, the Iranian government in its fifth development plan (2010-2015) enacted a subsidy reform law, which called for an increase in the price of petroleum products of up to 95 percent of freight-on-board prices in the Persian Gulf [*472*]. The subsidy cut had an immediate impact on fuel consumption, with demand for gasoline falling by about 6 percent from 2010 to 2011. However, gasoline demand rebounded in 2012 to pre-Reform levels despite higher end-use prices. In November 2012, the Iranian Parliament rejected implementation of the second phase of the subsidy reform.

High world oil prices have increased revenues in many of the oil-exporting countries of the Middle East, and as a result several transportation infrastructure projects, including mass transit projects, have been launched. In the GCC countries, railways have been identified as a preferred mode of transportation for the future, capable of meeting the challenges of rapid urbanization and growth in freight transport. Some $106 billion has been allocated for railway and metro construction projects in GCC countries through 2014 [*473*]. One of the most ambitious projects is to develop a 1,200-mile rail network from Kuwait to Oman, linking all six GCC countries. The GCC rail network is part of a wider GCC economic strategy to build a closely integrated regional community that will stimulate trade and provide efficiencies in transport. Moreover, rail networks will allow Bahrain, Kuwait, and Qatar, which lack direct access to markets outside the Gulf region, to transport goods to international markets without passing though the Straits of Hormuz [*474*].

Figure 138. Non-OECD Middle East and Africa transportation sector delivered energy consumption by region, 2010-2040 (quadrillion Btu)



Africa

Transportation energy consumption in Africa grows by 0.8 percent per year, from 3.8 quadrillion Btu in 2010 to 4.8 quadrillion Btu in 2040 in the *IEO2013* Reference case (Figure 138). Transportation infrastructure in most of the African countries is underdeveloped and will require major investment

[46]Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

to bring it to the levels necessary to support economic growth. The African road network includes 1.1 million miles, with low density relative to the population and low average traffic levels [*475*]. There is only limited investment in road maintenance, and road freight transport remains expensive and fragmented. Most of Africa's 260 airports have sufficient runway capacity, but some of the larger airports have terminal capacity shortages. In general, railroads are underutilized and poorly maintained. Most ports are small, and only a few highly specialized ports meet international standards.

African transportation infrastructure needs significant additional investment to address shortages and maintenance problems and to effectively integrate Africa with the global economy. Transportation infrastructure projects in Africa are typically financed through some form of assistance from international lending agencies. Private investment has been limited, in part due to a lack of enabling legislative frameworks [*476*]. In recent years, the number of projects financed by the World Bank has declined [*477*], with total investment in Africa's transportation sector totaling $851 million in 2011, including $716 million for three new projects and the remainder for existing projects. The three new projects include building seaports in Nigeria and Togo, and a cross-border highway project linking Zimbabwe and South Africa at the Beitbridge Border Post, the major cross border point between South Africa and Zimbabwe.

Central and South America

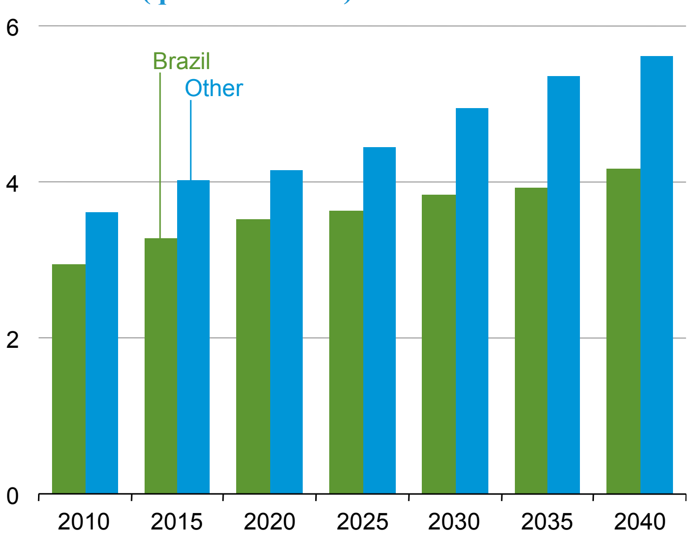
Transportation energy consumption in Central and South America grows by an average of 1.3 percent per year in the Reference case, from 6.6 quadrillion Btu in 2010 to 9.8 quadrillion Btu in 2040 (Figure 139), based on relatively strong regional GDP growth (3.3 percent per year) and population growth (0.7 percent per year) from 2010 to 2040. The region's demographics (28 percent of the population was younger than age 14 in 2011) and increasing intra- and interregional trade support growth in the transportation sector in the long term [*478*]. The region is highly urbanized (79 percent in 2011), and continues to develop mass transit and urban highway and rail networks. Currently, the region spends about 2 percent of aggregate GDP annually on transportation infrastructure; however, some estimates indicate that 4 to 6 percent would be required to support sustained growth in the long term [*479*].

Brazil's consumption of transportation fuels grows by 1.2 percent per year on average, from 2.9 quadrillion Btu in 2010 to 4.2 quadrillion Btu in 2040, in the Reference case. In recent years, after achieving economic stability, Brazil has had strong growth in its transportation sector. The country experienced only mild effects from the 2008-2009 global economic recession, and demand for transportation fuels continued to grow with the expanding road and air travel sectors and increasing demand for transportation of freight and agricultural commodities. From 2002 to 2011, Brazil's automotive market grew by 145 percent and became the fifth-largest market in the world, with 3.63 million vehicles (including cars, vans, trucks, and buses) sold in 2011 [*480*]. In May 2012, the government initiated a stimulus program that led to an all-time record of 405,000 cars and light commercial vehicles sold in August 2012 [*481*]. The key element of the stimulus program was a cut in the industrial product tax, which contributed to an average 10-percent reduction in vehicle prices to consumers.

Brazilian transportation infrastructure suffers from underinvestment, with only 14 percent of the roads paved. However, some improvements were made in ports and railways as a result of privatization in the 1990s [*482*, *483*]. Infrastructure spending in Brazil as a share of GDP has been declining over the past 40 years, averaging 5.4 percent of GDP during the 1970s, 3.6 percent in the 1980s, 2.3 percent in the 1990s, and 2.1 percent in the 2000s [*484*]. Factors that could support infrastructure growth in Brazil in the coming decade include the Growth Acceleration Program (launched in 2007), the development of pre-salt oil reserves, and the hosting of two major international sporting events—the World Cup in 2014 and the Summer Olympics in 2016.

The Growth Acceleration Program envisions thousands of infrastructure projects across the country. The Brazilian National Development Bank estimates investments of $37 billion on railways and sanitation, as well as $25 billion on ports, highways, and airports in the 2010-2013 period and a further $2.47 billion after 2014 [*485*]. The program allocated funds for the construction of new railway lines and the expansion of the current network (Transnordestina, Norte-Sul, and Ferronorte-Rondonopolis), as well as plans to build a high-speed rail line between Sao Paulo and Rio de Janeiro [*486*]. For ports, the program allocated funds to build new facilities and implement upgrades to existing ones. For highways, funding was provided for maintenance of the current network and the grant of new concessions to the private sector. And for airports, funds were allocated for the implementation of upgrades to alleviate congestion at heavily used passenger terminals. In preparation for the 2014 World Cup games, Brazil is planning nearly 300 miles of rapid transit bus corridors serving the 12 World Cup cities. Federal, state, and local governments already have committed nearly $6.5 billion in urban transit investments, with additional investments to come from the private sector [*487*].

Figure 139. Non-OECD Central and South America transportation sector delivered energy consumption, 2010-2040 (quadrillion Btu)



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Chapter 9

Energy-related carbon dioxide emissions

Overview

Energy-related carbon dioxide emissions—those emissions produced through the combustion of liquid fuels, natural gas, and coal—account for much of the world's anthropogenic greenhouse gas emissions. As a result, energy consumption is an important component of the global climate change debate. In the *IEO2013* Reference case, which does not assume new policies to limit greenhouse gas emissions, world energy-related carbon dioxide emissions[47] increase from 31.2 billion metric tons in 2010 to 36.4 billion metric tons in 2020 and 45.5 billion metric tons in 2040. Much of the growth in emissions is attributed to the developing non-OECD nations that continue to rely heavily on fossil fuels to meet fast-paced growth in energy demand. Non-OECD carbon dioxide emissions total 31.6 billion metric tons in 2040, or 69 percent of the world total. In comparison, OECD emissions total 13.9 billion metric tons in 2040—31 percent of the world total (Table 20 and Figure 140).

Near-term events can have a substantial impact on year-to-year changes in energy use and the corresponding carbon dioxide emissions. For instance, recent years have seen fluctuations in economic growth and, as a result, energy demand and emissions. During the 2008-2009 global economic recession, world energy consumption contracted, and as a result total world carbon dioxide emissions in 2009 were about 1 percent lower than in 2008. In 2010, as the world economy rebounded—especially among the emerging economies—total emissions increased by about 5.1 percent. In the longer term, conservation, improved technology, and increased use of energy sources with low or no emissions moderate the growth of energy-related carbon dioxide emissions in the Reference case.

The *IEO2013* Reference case projections are, to the extent possible, based on existing laws and policies. Projections for carbon dioxide emissions could change significantly if new laws and policies aimed at reducing greenhouse gas emissions were implemented in the future. For example, emissions cap-and-trade programs, fees, and credits for meeting energy efficiency standards could facilitate global efforts to curb emissions that contribute to global warming. In addition, beyond energy-related carbon dioxide, other greenhouse gases (such as methane) and other activities that influence carbon dioxide levels (such as deforestation) contribute to anthropogenic influences on the climate but are not included in the *IEO2013* Reference case projections.

Figure 140. World energy-related carbon dioxide emissions, 1990-2040 (billion metric tons)

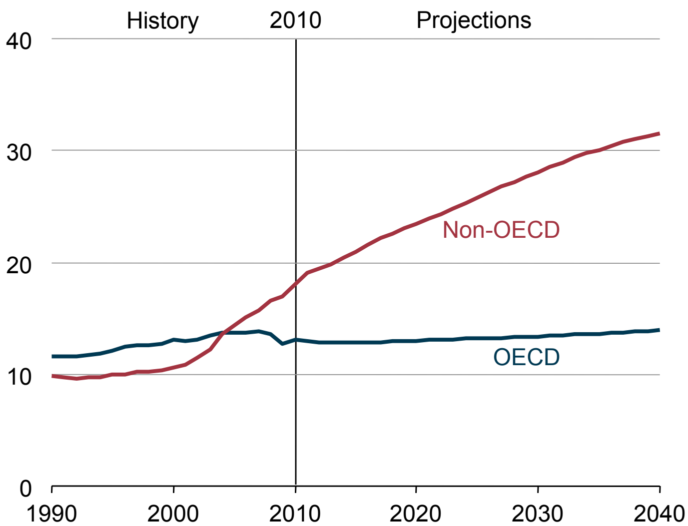


Table 20. OECD and non-OECD energy-related carbon dioxide emissions by fuel type, 1990-2040 (billion metric tons)

Region/country	1990	2010	2020	2030	2040	Average annual percent change, 2010-2040
OECD	**11.6**	**13.1**	**13.0**	**13.4**	**13.9**	**0.2**
Liquid fuels	5.5	5.8	5.7	5.6	5.7	-0.1
Natural gas	2.0	3.0	3.4	3.7	4.1	1.1
Coal	4.1	4.2	4.0	4.0	4.0	-0.2
Non-OECD	**9.8**	**18.1**	**23.4**	**28.1**	**31.6**	**1.9**
Liquid fuels	3.6	5.4	6.6	7.7	9.0	1.7
Natural gas	2.0	3.2	3.8	4.9	6.0	2.2
Coal	4.2	9.6	13.0	15.5	16.6	1.8
World total	**21.5**	**31.2**	**36.4**	**41.5**	**45.5**	**1.3**

Note: Historical estimates are as of November 15, 2012, and do not include revisions made to the series after that date.

[47]In *IEO2013*, energy-related carbon dioxide emissions are defined as emissions related to the combustion of fossil fuels (liquid fuels, natural gas, and coal). Emissions from the flaring of natural gas are not included.

Emissions by fuel

Carbon dioxide emissions from the use of liquid fuels, natural gas, and coal all increase in the *IEO2013* Reference case, but the relative contributions of the individual fuels shift over time (Figure 141). Carbon dioxide emissions from liquid fuels consumption accounted for 43 percent of the world total in 1990 and 36 percent in 2010, and in the Reference case they are 34 percent of the 2020 total and 32 percent of the 2040 total. Emissions from coal use accounted for 39 percent of total emissions in 1990 and 44 percent in 2010, and their share increases to 47 percent in 2020 and 2030 before dropping slightly to 45 percent in 2040. Coal, the most carbon-intensive fossil fuel, became the leading source of world energy-related carbon dioxide emissions in 2004 and remains the leading source through 2040. Carbon dioxide emissions from natural gas increase from 19 percent of the total in 1990 to 22 percent in 2040.

Emissions from coal use show the largest increment in the Reference case, from about 14 billion metric tons in 2010 to 21 billion metric tons in 2040 (Figure 142). Coal is the largest contributor to emissions growth in the non-OECD economies, accounting for 52 percent of the increase in non-OECD carbon dioxide emissions from 2010 to 2040. For the entire world, coal-related carbon dioxide emissions grow by an average of 1.3 percent per year from 2010 to 2040, with 1.8-percent average annual increases in the non-OECD countries accounting for all of the growth. For the OECD countries, coal-related emissions decline by an average of 0.2 percent per year from 2010 to 2040.

Energy-related carbon dioxide emissions from natural gas use increase in both the OECD and non-OECD countries, by average annual rates of 1.1 percent and 2.2 percent, respectively. In percentage terms, world natural gas consumption grows more rapidly than consumption of coal or liquid fuels from 2010 to 2040 and accounts for 30 percent of world fossil fuel use in 2040. However, because of its relatively low carbon intensity, the natural gas share of energy-related carbon dioxide emissions in 2040 is only 22 percent.

Carbon dioxide emissions from the consumption of liquid fuels worldwide show the slowest growth, averaging 0.9 percent per year, resulting in an increment of 3.5 billion metric tons in liquids-related carbon dioxide emission from 2010 to 2040. As is the case for coal, carbon dioxide emissions related to liquid fuels decline in the OECD countries (by an average of 0.1 percent per year) but increase in non-OECD countries, where growing demand for transportation and industrial uses of liquid fuels contributes to an average growth rate of 1.7 percent per year. As a result, the OECD share of carbon dioxide emissions from liquid fuels declines from 52 percent in 2010 to 39 percent in 2040.

Emissions by region

World energy-related carbon dioxide emissions increase at an average annual rate of 1.3 percent from 2010 to 2040 in the *IEO2013* Reference case, with much of the overall increase occurring in the non-OECD nations (see Table 21 on page 162). OECD emissions increase by 0.2 percent per year on average, while non-OECD emissions increase by an average of 1.9 percent per year.

In the OECD regions, the United States continues to be the largest source of energy-related carbon dioxide emissions through 2040, followed by OECD Europe and Japan. Those three OECD regions accounted for 84 percent of total OECD emissions in 2010. Carbon dioxide emissions in the United States and OECD Europe grow only slightly, and in Japan they decline over the long term (see box on page 161). Thus, total emissions from the three largest OECD emitters increase by only 91 million metric tons over the 30-year period. For the other OECD countries combined, carbon dioxide emissions increase by a total of 727 million metric tons from 2010 to 2040.

Figure 141. World energy-related carbon dioxide emissions by fuel type, 1990-2040 (billion metric tons)

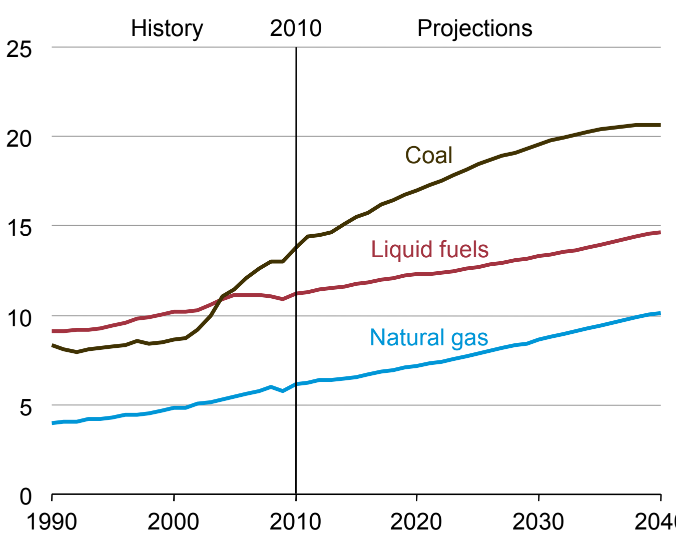
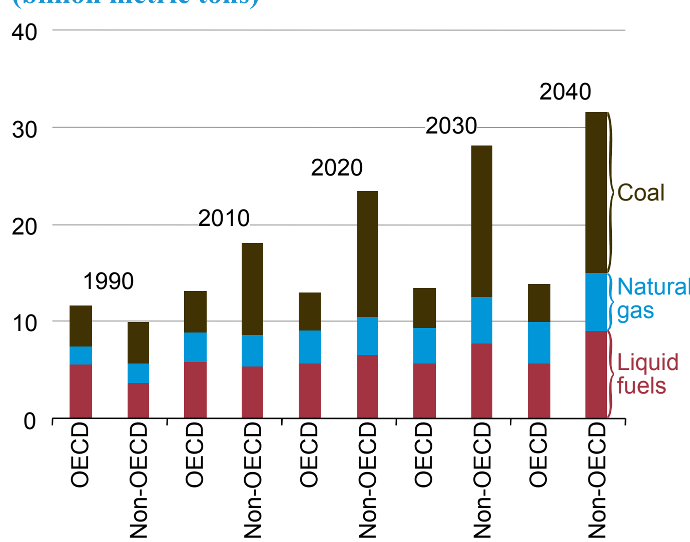


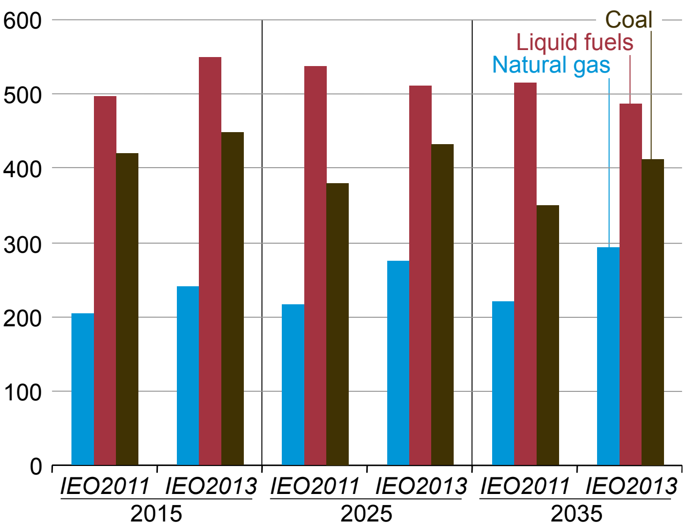
Figure 142. OECD and non-OECD energy-related carbon dioxide emissions by fuel type, 1990-2040 (billion metric tons)



Effect of nuclear plant shutdowns on Japan's carbon dioxide emissions

Japan's energy-related carbon dioxide emissions decline in the *IEO2013* Reference case by an average of 0.1 percent per year from 2010 to 2040. The 2040 total of 1.1 billion metric tons is 2.2 percent less than the 2010 total. In the *IEO2011* Reference case, Japan's emissions declined by 0.4 percent annually from 2008 to 2035. However, following the March 2011 disaster at the Fukushima Daiichi nuclear facility, the country's nuclear power plants were shut down over a period extending to May 2012, and the resulting loss of nuclear electricity generation was replaced with generation from plants using coal, oil, and natural gas. While the *IEO2013* Reference case anticipates that many of the reactors will be restarted, the projections for nuclear generation in Japan are lower than the *IEO2011* estimates. Nuclear generation in 2035 is 50 percent lower in the *IEO2013* Reference case than was projected in *IEO2011*, natural gas-fired generation in 2020 is 107 billion kilowatthours higher, and coal-fired generation is 44 billion kilowatthours higher.

Figure 143. Japan projected energy-related carbon dioxide emissions by fuel type, 2015-2035, in the *IEO2011* and *IEO2013* Reference cases (million metric tons)

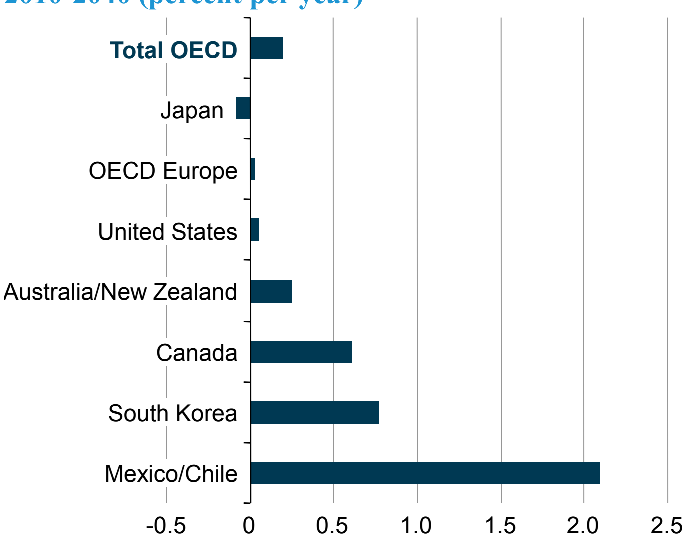


From 2008 to 2035, the growth rates of Japan's population and GDP are similar in *IEO2013* and *IEO2011*. However, Japan's total projected electricity generation is lower in this year's outlook, by 29 billion kilowatthours in 2020 and 67 billion kilowatthours in 2035, reflecting conservation efforts undertaken after the events at Fukushima forced the closure of all of the nation's nuclear reactors. Long-term conservation efforts help to offset some of the increase in emissions in the *IEO2013* projection.

Total carbon dioxide emissions in Japan decline in the *IEO2013* Reference case, from 1,243 million metric tons in 2015 to 1,223 million metric tons in 2025 and 1,194 million metric tons in 2035, but at a slightly lower rate than in *IEO2011*, where they were projected to be 1,136 million metric tons and 1,087 million metric tons in 2025 and 2035, respectively. Emissions from coal and natural gas combustion are higher in all years from 2015 to 2035 in the *IEO2013* Reference case (Figure 143). For liquid fuels there is a spike in 2015 emissions, followed by declines in the subsequent years as oil-fired electricity generation that was brought on line to compensate for lost nuclear generation is displaced by increases in generation from coal and natural gas.

In the *IEO2013* Reference case, the fastest rate of increase in carbon dioxide emissions in the OECD region is for Mexico/Chile, at 2.1 percent per year on average from 2010 to 2040, followed by South Korea at 0.8 percent per year (Figure 144). Mexico and Chile in combination have the highest economic growth rate in the OECD over the 2010-2040 period, averaging 3.7 percent per year, and South Korea's GDP growth averages 3.3 percent per year. For the OECD region as a whole, GDP growth averages 2.2 percent per year.

Figure 144. Average annual increases in OECD energy-related carbon dioxide emissions by region, 2010-2040 (percent per year)



The non-OECD countries together account for 94 percent of the total increase in world carbon dioxide emissions from 2010 to 2040, and non-OECD Asia alone accounts for 71 percent of the total increase. China's emissions grow by an average of 2.1 percent per year (Figure 145) and account for 69 percent of the increase for non-OECD Asia and 49 percent of the total world increase in carbon dioxide emissions. India's emissions increase by 2.3 percent per year, and emissions in the rest of non-OECD Asia increase by an average of 1.9 percent per year. The increases in non-OECD Asia, particularly China, are led by coal-related carbon dioxide emissions, and emissions from natural gas and liquid fuels use also increase substantially (Figure 146).

Non-OECD Europe and Eurasia has the slowest growth in carbon dioxide emissions among the non-OECD regions, at 1.0 percent per year in the *IEO2013* Reference case. Natural gas is the region's leading source of emissions from fossil fuel use, accounting for 51 percent of total carbon dioxide emissions in Russia in 2010 and 36 percent in the other non-OECD

Figure 145. Average annual increases in non-OECD energy-related carbon dioxide emissions by region, 2010-2040 (percent per year)

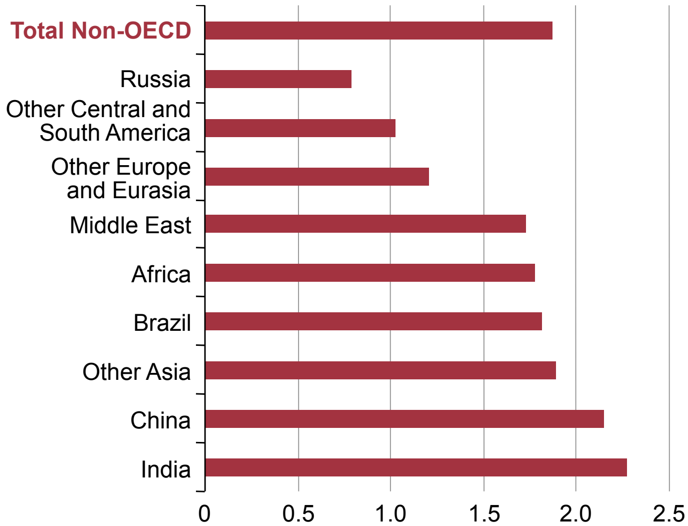


Figure 146. Increases in energy-related carbon dioxide emissions by fuel type for non-OECD regions with the largest increases, 2010-2040 (billion metric tons)

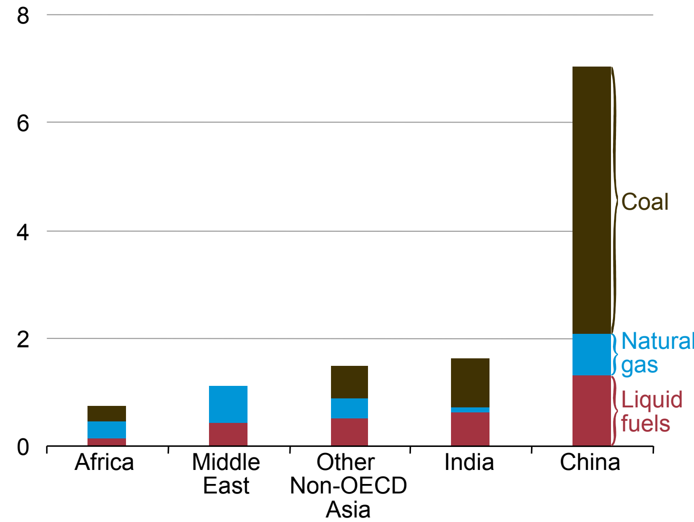


Table 21. World carbon dioxide emissions by region and country in the Reference case, 1990-2040 (million metric tons)

Region/Country	1990	2010	2020	2030	2040	Average annual percent change 1990-2010	Average annual percent change 2010-2040
OECD							
OECD Americas	**5,832**	**6,657**	**6,627**	**6,880**	**7,283**	**0.7**	**0.3**
United States	5,032	5,608	5,454	5,523	5,691	0.5	0.0
Canada	466	546	574	609	654	0.8	0.6
Mexico/Chile	334	503	599	748	937	2.1	2.1
OECD Europe	**4,195**	**4,223**	**4,097**	**4,151**	**4,257**	**0.0**	**0.0**
OECD Asia	**1,585**	**2,200**	**2,296**	**2,340**	**2,358**	**1.7**	**0.2**
Japan	1,047	1,176	1,220	1,215	1,150	0.6	-0.1
South Korea	242	581	627	666	730	4.5	0.8
Australia/New Zealand	296	443	449	460	478	2.0	0.3
Total OECD	**11,612**	**13,079**	**13,020**	**13,373**	**13,897**	**0.6**	**0.2**
Non-OECD							
Non-OECD Europe and Eurasia	**4,199**	**2,645**	**2,898**	**3,249**	**3,526**	**-2.3**	**1.0**
Russia	2,368	1,595	1,749	1,945	2,018	-2.0	0.8
Other	1,831	1,050	1,149	1,304	1,508	-2.7	1.2
Non-OECD Asia	**3,652**	**11,538**	**15,812**	**19,392**	**21,668**	**5.9**	**2.1**
China	2,270	7,885	11,532	14,028	14,911	6.4	2.1
India	569	1,695	2,109	2,693	3,326	5.6	2.3
Other	814	1,958	2,171	2,671	3,431	4.5	1.9
Middle East	**669**	**1,649**	**2,126**	**2,419**	**2,756**	**4.6**	**1.7**
Africa	**657**	**1,070**	**1,224**	**1,474**	**1,815**	**2.5**	**1.8**
Central and South America	**663**	**1,202**	**1,366**	**1,556**	**1,793**	**3.0**	**1.3**
Brazil	235	450	547	632	771	3.3	1.8
Other	428	752	819	924	1,022	2.9	1.0
Total non-OECD	**9,840**	**18,104**	**23,426**	**28,092**	**31,558**	**3.1**	**1.9**
World total	**21,452**	**31,183**	**36,446**	**41,464**	**45,453**	**1.9**	**1.3**

Europe and Eurasia nations. Total carbon dioxide emissions in non-OECD Europe and Eurasia increase from 2.6 billion metric tons in 2010 to 3.5 billion metric tons in 2040.

Measures of trends and comparisons of energy-related carbon dioxide emissions

Many factors influence national levels of carbon dioxide emissions, as reflected in the relationships among a country's economy, its energy demand, and the fuel mix used to meet that demand. Three measures provide useful insights for the analysis of trends in energy-related emissions:

1. The *energy intensity of economic activity* is a measure of energy consumption per unit of economic activity as measured by GDP. It relates changes in energy consumption to changes in economic output. Increased energy use and economic growth generally occur together, although the degree to which they are linked varies across regions and stages of economic development.

   Energy intensity can be indicative of the energy efficiency of an economy's capital stock (vehicles, appliances, manufacturing equipment, power plants, etc.). For example, if an old power plant is replaced with a more thermally efficient unit, then it is possible to supply the same amount of electricity with a lower level of primary energy use, thereby decreasing energy intensity. If the sector that consumes the electricity also achieves gains in energy efficiency (for example, through more efficient refrigerators), then there is an additional reduction in energy intensity to meet the same level of energy service demand.

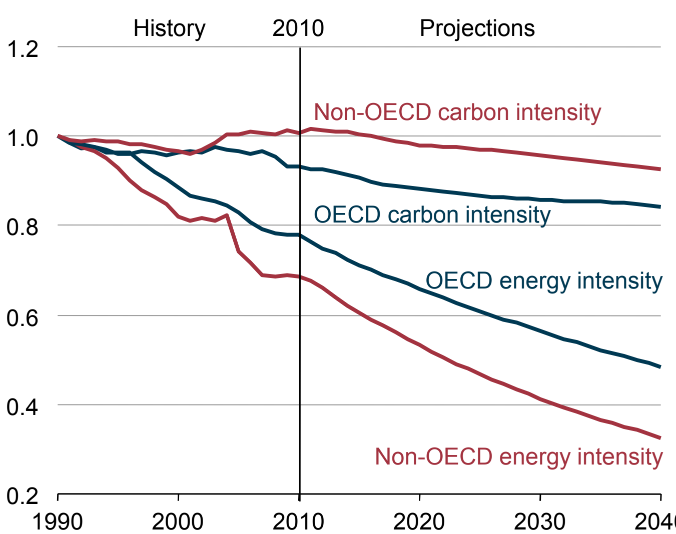
   Energy intensity is acutely affected by structural changes within an economy—in particular, the relative shares of its output sectors (manufacturing versus service, for example). Higher concentrations of energy-intensive industries, such as oil and gas extraction, yield higher overall energy intensities, whereas countries with proportionately larger service sectors tend to have lower energy intensities. For example, the Middle East had a relatively high energy intensity of 12.1 thousand Btu per dollar of GDP in 2010, in part because of the important role played by hydrocarbon production (an energy-intensive activity) and exports in most Middle East economies. On a worldwide basis, shifting energy-intensive industries such as steel production from one country to another does little to lower global energy demand and related emissions unless the countries to which the industries are shifted possess more efficient industrial capacity than the original country or substitute labor for energy.

2. The *carbon intensity of energy supply* is a measure of the amount of carbon dioxide associated with each unit of energy used. It directly links changes in carbon dioxide emissions levels with changes in energy usage. Carbon emissions vary by energy source, with coal being the most carbon-intensive fuel, followed by oil and natural gas. Nuclear power and some renewable energy sources (i.e., solar and wind) do not directly generate carbon dioxide emissions. Consequently, changes in the fuel mix alter overall carbon intensity. Over time, declining carbon intensity can offset increasing energy consumption to some extent. If energy consumption increases and carbon intensity declines by an equivalent factor, carbon dioxide emissions will remain constant. A decline in carbon intensity can indicate a shift away from fossil fuels, a shift toward less carbon-intensive fossil fuels, or both.

   Carbon intensities, like energy intensities, do not necessarily remain constant over time. However, carbon intensities historically have varied less than energy intensities (Figure 147) because they reflect the energy endowment of a country or region or are dependent on major shifts in energy technologies, such as the introduction of nuclear power, that occur relatively slowly over time.

3. The *carbon intensity of economic output* is a measure of carbon dioxide emissions per dollar of GDP (CO_2/GDP), which can be calculated by multiplying the carbon intensity of energy supply (CO_2/E) by the energy intensity of economy activity (E/GDP). The carbon intensity of economic output is commonly used in analysis of changes in carbon dioxide emissions, and it is sometimes used as a stand-alone measure for tracking progress in relative emissions reductions.

Figure 147. OECD and non-OECD energy intensity and carbon intensity, 1990-2040 (index, 1990 = 1.0)



Historically, carbon intensity of economic output has declined over time (Figure 148), and it continues to decline worldwide from 2010 to 2040 in the Reference case. In the non-OECD countries, where national and regional economies are growing more rapidly than in the OECD countries, the rate of decline in carbon intensity of economic output is slower than the rate of economic growth, leading to net increases in emissions over time. For the world as a whole, if the carbon intensity of economic output declines faster than the world economy grows, emissions will decline over time.

The Kaya decomposition of emissions trends

The Kaya Identity provides an approach to the interpretation of historical trends and future projections of energy-related carbon dioxide emissions. It can be used to decompose total carbon dioxide emissions as the product of individual factors that explicitly link energy-related carbon dioxide emissions to energy consumption, the level of economic output as measured by GDP, and population size.

The Kaya Identity expresses total carbon dioxide emissions as the product of (1) carbon intensity of energy supply (CO_2/E), (2) energy intensity of economic activity (*E/GDP*), (3) economic output per capita, and (4) population:

$$CO_2 = (CO_2 / E) \times (E / GDP) \times (GDP / POP) \times POP \; .$$

Using 2010 data as an example, world energy-related carbon dioxide emissions totaled 31.2 billion metric tons in 2010, world energy consumption totaled 524 quadrillion Btu, world GDP totaled $70.5 trillion, and the world population was 6,880 million. Using those figures in the Kaya equation yields the following: 59.5 metric tons of carbon dioxide per billion Btu of energy (CO_2/E), 7,400 Btu of energy per dollar of GDP (*E/GDP*), and $10,247 of income per person (*GDP/POP*). Appendix H delineates the Kaya factors for all *IEO* regions over the *IEO2013* projection period.

Of the four Kaya components, policymakers generally focus on developing programs that can change, in various energy-consuming sectors, the energy intensity of economic output (*E/GDP*) and carbon dioxide intensity of the energy supply (CO_2/E). Reducing growth in output per capita may have a mitigating influence on emissions, but governments generally pursue policies to increase rather than reduce output per capita in order to advance objectives other than greenhouse gas mitigation.

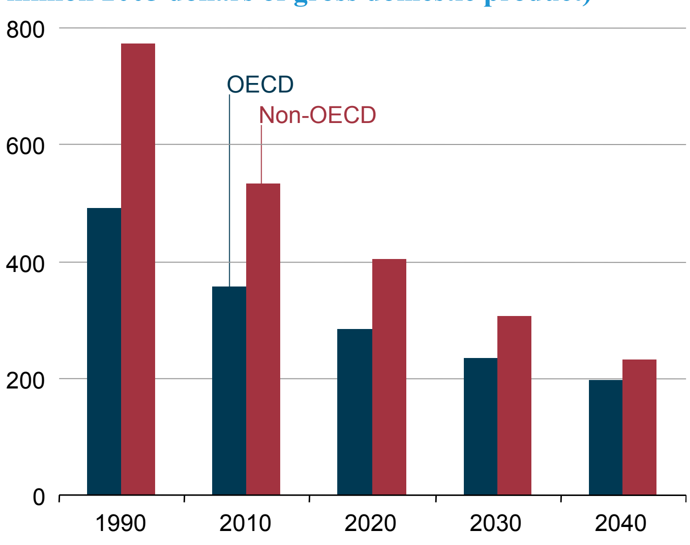
Policies related to energy intensity of GDP typically involve improvements in energy efficiency. However, the measure is also sensitive to shifts in the energy-intensive portion of a country's trade balance, and improvements may simply reflect a greater reliance on imports of manufactured goods, which may decrease one country's energy intensity but, if the country producing the imported goods is less energy efficient, could lead to a worldwide increase in energy consumption and related carbon dioxide emissions. Policies related to the carbon dioxide intensity of energy supply typically focus on promotion of low-carbon or zero-carbon sources of energy.

Conveniently, the percentage rate of change in carbon dioxide emission levels approximates the sum of the percentage rate of change across the four Kaya components. Table 22 shows the average rate of change of total carbon dioxide emissions and each individual Kaya component for the projection period from 2010 to 2040 in the *IEO2013* Reference case. The most significant factor for the growth of energy-related carbon dioxide emissions is economic output per capita. The average annual growth rate of output per capita for non-OECD countries (3.8 percent from 2010 to 2040) in particular dominates all other Kaya components in the 30-year projection. For OECD countries, on the other hand, the 1.8-percent average annual increase in output per capita is nearly offset by the 1.6-percent annual decline in energy intensity.

Population growth is another important determinant in the rate of emissions change. However, as mentioned above, the population effect is less pronounced than the effect of output per capita. For non-OECD countries, increases in output per capita coupled with population growth overwhelm improvements in energy intensity and carbon intensity, yielding 1.9-percent average annual growth in emissions. The projection horizon shows OECD growth in output per capita and growth in population mostly balanced by improvements in energy intensity and carbon intensity, yielding average emissions growth of 0.2 percent per year.

Over the 2010-2040 period, the energy intensity of economic output declines in all the *IEO2013* regions. The trend is particularly pronounced in the non-OECD countries, where energy intensity of output decreases on average by 2.5 percent per year, compared with 1.6 percent per year in the OECD countries. Worldwide, the largest declines in energy intensity of output are projected for India, at 3.2 percent per year, while declines in other non-OECD Europe and Eurasia nations and in China both average 2.9 percent annually. However, output per capita increases by averages of more than 5 percent per year in and India and China and by 4 percent per year in the other non-OECD Europe and Eurasia nations.

Figure 148. OECD and non-OECD carbon intensities, 1990-2040 (metric tons carbon dioxide emitted per million 2005 dollars of gross domestic product)



The carbon intensity of energy supply also is projected to decline in all the *IEO2013* regions from 2010 to 2040. In the OECD region, the largest decline in carbon intensity of energy supply is for South Korea (0.5 percent per year), and several countries and regions—Australia/New Zealand, Canada, Mexico/Chile, and OECD Europe—have annual decreases in carbon intensity that average 0.4 percent. In the non-OECD economies, both China and India have 0.5-percent average annual declines in carbon intensity. Decreases or only moderate increases in the consumption of liquid fuels and coal (the most carbon-intensive fuels) in those regions, combined with increases in consumption of renewable energy, nuclear power (except for Australia/New Zealand), and natural gas (the least carbon-intensive fossil fuel), reduce the carbon intensity of the energy supply. For the OECD region as a whole, the average rate of decline in carbon intensity of energy supply over the 2010-2040 period is 0.3 percent per year, the same as the non-OECD average.

Table 22. Average annual changes in Kaya factors by region and country in the Reference case, 2010-2040 (percent per year)

Region/Country	Carbon intensity of energy supply *(CO_2/E)*	Energy intensity of economic activity *(E/GDP)*	Income per person *(GDP/POP)*	Population *(POP)*	Carbon dioxide emissions
OECD					
OECD Americas	-0.3	-2.1	1.9	0.8	0.3
United States	-0.3	-2.3	1.8	0.9	0.0
Canada	-0.4	-1.1	1.2	1.0	0.6
Mexico/Chile	-0.4	-1.1	2.9	0.7	2.1
OECD Europe	-0.4	-1.3	1.6	0.3	0.0
OECD Asia	-0.3	-1.0	1.7	-0.1	0.2
Japan	-0.1	-0.6	1.0	-0.4	-0.1
South Korea	-0.5	-1.9	3.2	0.1	0.8
Australia/New Zealand	-0.4	-1.5	1.3	0.9	0.3
Total OECD	**-0.3**	**-1.6**	**1.8**	**0.4**	**0.2**
Non-OECD					
Non-OECD Europe and Eurasia	-0.2	-2.5	3.8	0.0	1.0
Russia	-0.3	-1.7	3.0	-0.2	0.8
Other	-0.2	-2.9	4.3	0.1	1.2
Non-OECD Asia	-0.4	-2.7	4.8	0.6	2.1
China	-0.5	-2.9	5.7	0.0	2.1
India	-0.5	-3.2	5.1	1.0	2.3
Other	-0.2	-2.1	3.3	0.9	1.9
Middle East	-0.2	-0.3	0.7	1.5	1.7
Africa	-0.3	-2.4	2.7	1.8	1.8
Central and South America	-0.3	-1.6	2.5	0.7	1.3
Brazil	-0.3	-1.3	2.9	0.5	1.8
Other	-0.1	-2.0	2.3	0.9	1.0
Total non-OECD	**-0.3**	**-2.5**	**3.8**	**0.9**	**1.9**
Total world	**-0.2**	**-2.1**	**2.8**	**0.8**	**1.3**

Data Sources

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Table 13. OECD and non-OECD net electricity generation by energy source, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 80. Growth in world total electricity generation and total delivered energy consumption, 1990-2040: ***History:*** *Generation:* EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. *Delivered energy consumption:* Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 81. OECD and non-OECD net electricity generation, 1990-2040: ***History:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 82. Non-OECD net electricity generation by region, 1990-2040: ***History:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 83. World net electricity generation by fuel, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 84. World net electricity generation from nuclear power by region, 2010-2040: ***2010:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Table 14. OECD and non-OECD net renewable electricity generation by energy source, 2010-2040: ***2010:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 85. OECD Americas net electricity generation by country, 2010-2040: ***2010:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013) National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Figure 86. OECD Americas net electricity generation by fuel, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013) National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Figure 87. OECD Europe net electricity generation by fuel, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 88. OECD Asia net electricity generation by country, 2010-2040: ***2010:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 89. Gross electricity generation by Japan's ten general electric utilities, April-December 2010, 2011, and 2012: EIA, Office of Electricity, Coal, Nuclear and Renewables Analysis, based on Bloomberg L.P.

Figure 90. Total net electricity generation in Japan by fuel, 2010-2040: ***2010:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 91. Non-OECD Europe and Eurasia net electricity generation by region, 2010-2040: ***2010:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 92. Non-OECD Asia net electricity generation by fuel, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 93. Middle East net electricity generation by fuel, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 94. Africa net electricity generation by fuel, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 95. Brazil and Other Central and South America net electricity generation, 2010-2040: ***2010:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 96. Brazil net electricity generation by fuel, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

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Figure 97. World buildings sector delivered energy consumption, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Table 15. Residential sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Table 16. Per capita residential sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and IHS Global Insight, *World Overview* (Lexington, MA: fourth quarter 2012). ***Projections:*** EIA, World Energy Projection System Plus (2013); and IHS Global Insight, *World Overview* (Lexington, MA: various issues).

Figure 98. World residential sector delivered energy consumption by energy source, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 99. Average annual change in OECD residential sector energy consumption, 2010-2040: EIA, World Energy Projection System Plus (2013).

Figure 100. OECD Americas residential sector delivered energy consumption by country, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Figure 101. OECD Europe residential sector delivered energy consumption by energy source, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 102. OECD Asia residential sector delivered energy consumption by country, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 103. Non-OECD residential sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 104. Average annual change in non-OECD residential sector delivered energy consumption by region, 2010-2040: EIA, World Energy Projection System Plus (2013).

Figure 105. Non-OECD Asia residential sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 106. Non-OECD Europe and Eurasia residential sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 107. Central and South America residential sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Table 17. Commercial sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 108. World commercial sector delivered energy consumption by energy source, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 109. OECD Americas commercial sector delivered energy consumption by country, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Figure 110. OECD Europe commercial sector delivered energy consumption by energy source, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 111. OECD Asia commercial sector delivered energy consumption by country, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 112. Non-OECD Asia commercial sector delivered energy consumption by country, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 113. Russia commercial sector delivered energy consumption by energy source, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 114. Middle East commercial sector delivered energy consumption by energy source, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 115. Central and South America commercial sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

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Table 18. World industrial sector delivered energy consumption by region and energy source, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 116. World industrial sector and all other delivered end-use energy consumption, 2005-2040: ***History:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 117. OECD and non-OECD industrial sector delivered energy consumption, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 118. World industrial sector delivered energy consumption by energy source, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 119. OECD industrial sector delivered energy consumption by energy source, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 120. Non-OECD industrial sector delivered energy consumption by energy source, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 121. Shares of total world industrial sector delivered energy consumption by major energy-intensive industries, 2010: International Energy Agency Data Services, *World Energy Balances* (2012), www.iea.org (subscription site).

Figure 122. OECD and non-OECD steel production by major producing countries, 2011: World Steel Assocation, "Steel Statistical Yearbook 2012" (October 2012), www.worldsteel.org.

Figure 123. U.S. industrial sector delivered energy consumption by energy source, 2010 and 2040: EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Figure 124. Mexico and Chile industrial sector delivered energy consumption by energy source, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 125. China industrial sector delivered energy consumption by energy source, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 126. India industrial sector delivered energy consumption by energy source, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 127. Brazil industrial sector delivered energy consumption by energy source, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 128. Middle East industrial sector delivered energy consumption by energy source, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "OECD and Non-OECD Energy Balances" (2012), data.iea.org (subscription site). ***2040:*** EIA, World Energy Projection System Plus (2013).

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Table 19. World transportation sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 129. World liquids consumption by end-use sector, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 130. Transportation sector energy consumption per person in selected regions, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; and IHS Global Insight, *World Overview* (Lexington, MA: fourth quarter 2012). ***2040:*** EIA, World Energy Projection System Plus (2013); IHS Global Insight, *World Overview* (Lexington, MA: fourth quarter 2012); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013) National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Figure 131. World transportation sector liquids consumption, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 132. OECD transportation sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Figure 133. OECD Americas transportation sector delivered energy consumption by country, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Figure 134. OECD Asia transportation sector delivered energy consumption by country, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 135. Non-OECD transportation sector delivered energy consumption by region, 2010 and 2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 136. Non-OECD Asia transportation sector delivered energy consumption by country, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 137. Non-OECD Europe and Eurasia transportation sector delivered energy consumption by country, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 138. Non-OECD Middle East and Africa transportation sector delivered energy consumption by region, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 139. Non-OECD Central and South America transportation sector delivered energy consumption, 2010-2040: ***2010:*** Derived from EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013).

Chapter 9. Energy-related carbon dioxide emissions

Table 20. OECD and non-OECD energy-related carbon dioxide emissions by fuel type, 1990-2040: ***History:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 140. World energy-related carbon dioxide emissions, 1990-2040: ***History:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 141. World energy-related carbon dioxide emissions by fuel type, 1990-2040: ***History:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 142. OECD and non-OECD energy-related carbon dioxide emissions by fuel type, 1990-2040: ***History:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Table 21. World carbon dioxide emissions by region and country in the Reference case, 1990-2040: ***History:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***Projections:*** EIA, World Energy Projection System Plus (2013).

Figure 143. Japan projected energy-related carbon dioxide emissions by fuel type, 2015-2035, in the *IEO2011* and *IEO2013* Reference cases: EIA, *International Energy Outlook 2011*, DOE/EIA-0484(September 2011); and EIA, World Energy Projection System Plus (2013).

Figure 144. Average annual increases in OECD energy-related carbon dioxide emissions by region, 2010-2040: EIA, World Energy Projection System Plus (2013).

Figure 145. Average annual increases in non-OECD energy-related carbon dioxide emissions by region, 2010-2040: EIA, World Energy Projection System Plus (2013).

Figure 146. Increases in energy-related carbon dioxide emissions by fuel type for non-OECD regions with the largest increases, 2010-2040: Calculated using: ***2010:*** EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013).

Figure 147. OECD and non-OECD energy intensity and carbon intensity, 1990-2040: Calculated using: ***1990:*** EIA, International Energy Statistics database (as of November 2012); and IHS Global Insight, *World Overview* (Lexington, MA: fourth quarter 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013); and derived from Oxford Economics Model (October 2012).

Figure 148. OECD and non-OECD carbon intensities, 1990-2040: Calculated using: ***1990:*** EIA, International Energy Statistics database (as of November 2012); and IHS Global Insight, *World Overview* (Lexington, MA: fourth quarter 2012), www.eia.gov/ies. ***2040:*** EIA, World Energy Projection System Plus (2013); and derived from Oxford Economics Model (October 2012).

Table 22. Average annual changes in Kaya factors by region and country in the Reference case, 2010-2040: Calculated using: EIA, International Energy Statistics database (as of November 2012), www.eia.gov/ies; IHS Global Insight, *World Overview* (Lexington, MA: fourth quarter 2012); Oxford Economics Model (October 2012); and EIA, World Energy Projection System Plus (2013).

Appendix A

Reference case projections

- ***World energy consumption***
- ***Gross domestic product***
- ***Carbon dioxide emissions***
- ***World population***

Table A1. World total primary energy consumption by region, Reference case, 2009-2040
(quadrillion Btu)

Region	History 2009	History 2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**117.0**	**120.2**	**121.3**	**126.1**	**129.7**	**132.9**	**137.2**	**143.6**	**0.6**
United States[a]	94.9	97.9	97.3	100.5	101.8	102.3	103.9	107.2	0.3
Canada	13.7	13.5	14.2	14.8	15.6	16.5	17.3	18.2	1.0
Mexico/Chile	8.4	8.8	9.9	10.9	12.3	14.1	16.0	18.2	2.5
OECD Europe	**80.0**	**82.5**	**82.1**	**85.5**	**88.6**	**90.9**	**92.8**	**94.6**	**0.5**
OECD Asia	**37.7**	**39.6**	**40.6**	**43.0**	**44.3**	**45.4**	**46.1**	**46.4**	**0.5**
Japan	21.0	22.1	21.7	22.5	23.0	23.0	22.9	22.2	0.0
South Korea	10.1	10.8	11.8	13.0	13.8	14.7	15.3	15.9	1.3
Australia/NewZealand	6.7	6.7	7.0	7.4	7.5	7.7	8.0	8.2	0.7
Total OECD	**234.7**	**242.3**	**244.1**	**254.6**	**262.7**	**269.2**	**276.1**	**284.6**	**0.5**
Non-OECD									
Non-OECD Europe and Eurasia	**43.7**	**47.2**	**49.8**	**53.3**	**56.8**	**60.8**	**64.6**	**67.1**	**1.2**
Russia	27.0	29.6	31.0	33.3	35.7	38.0	39.9	40.5	1.0
Other	16.7	17.6	18.9	20.0	21.1	22.8	24.7	26.6	1.4
Non-OECD Asia	**148.1**	**159.0**	**194.3**	**230.3**	**261.6**	**290.4**	**317.2**	**337.5**	**2.5**
China	93.1	101.2	132.2	159.0	180.9	198.9	213.3	219.9	2.6
India	23.1	24.4	27.5	32.1	37.2	42.6	48.7	55.0	2.7
Other	31.8	33.4	34.6	39.2	43.5	48.9	55.2	62.6	2.1
Middle East	**26.6**	**27.8**	**33.1**	**36.6**	**39.5**	**42.5**	**45.7**	**48.8**	**1.9**
Africa	**18.4**	**18.9**	**19.6**	**21.9**	**24.4**	**27.4**	**31.0**	**35.0**	**2.1**
Central and South America	**26.9**	**28.7**	**31.0**	**33.2**	**35.5**	**38.8**	**42.5**	**46.6**	**1.6**
Brazil	12.7	13.7	14.9	16.5	17.8	19.9	22.3	25.4	2.1
Other	14.3	15.0	16.1	16.7	17.6	19.0	20.2	21.3	1.2
Total Non-OECD	**263.7**	**281.7**	**327.9**	**375.3**	**417.7**	**460.0**	**501.0**	**535.1**	**2.2**
Total World	**498.4**	**523.9**	**572.0**	**629.8**	**680.4**	**729.2**	**777.1**	**819.6**	**1.5**

[a]Includes the 50 States and the District of Columbia.
Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A2. World total energy consumption by region and fuel, Reference case, 2009-2040
(quadrillion Btu)

	History		Projections						Average annual percent change, 2010-2040
Region	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas									
Liquids	45.5	46.4	45.9	46.4	46.0	45.8	46.1	47.0	0.0
Natural gas	28.9	29.9	32.0	34.1	35.9	37.7	40.1	42.3	1.2
Coal	21.3	22.5	19.9	20.3	21.1	21.5	21.9	22.2	0.0
Nuclear	9.4	9.5	9.8	10.3	10.9	11.1	10.8	11.2	0.6
Other	11.9	11.9	13.7	15.0	15.9	16.8	18.3	20.8	1.9
Total	**117.0**	**120.2**	**121.3**	**126.1**	**129.7**	**132.9**	**137.2**	**143.6**	**0.6**
OECD Europe									
Liquids	30.8	30.6	27.9	28.4	28.4	28.7	28.9	29.1	-0.2
Natural gas	19.3	20.4	20.3	21.0	21.4	22.7	23.9	25.2	0.7
Coal	11.9	12.2	12.2	11.9	11.6	11.3	11.0	10.7	-0.4
Nuclear	8.6	8.9	9.2	9.6	10.8	11.0	11.1	11.1	0.7
Other	9.4	10.4	12.6	14.7	16.4	17.2	17.9	18.5	2.0
Total	**80.0**	**82.5**	**82.1**	**85.5**	**88.6**	**90.9**	**92.8**	**94.6**	**0.5**
OECD Asia									
Liquids	15.5	15.8	16.8	16.6	16.6	16.5	16.4	16.1	0.1
Natural gas	6.6	7.2	7.7	8.3	9.1	9.6	10.2	10.7	1.3
Coal	9.4	10.1	10.2	10.1	10.0	9.9	9.9	9.7	-0.1
Nuclear	4.1	4.2	3.0	4.5	5.0	5.6	5.7	5.9	1.1
Other	2.1	2.3	2.9	3.4	3.7	3.8	3.9	4.0	1.8
Total	**37.7**	**39.6**	**40.6**	**43.0**	**44.3**	**45.4**	**46.1**	**46.4**	**0.5**
Total OECD									
Liquids	91.8	92.8	90.6	91.4	91.0	90.9	91.4	92.3	0.0
Natural gas	54.8	57.5	60.1	63.4	66.3	70.0	74.2	78.2	1.0
Coal	42.5	44.8	42.2	42.3	42.8	42.7	42.8	42.7	-0.2
Nuclear	22.1	22.6	22.0	24.4	26.6	27.7	27.6	28.1	0.7
Other	23.4	24.6	29.2	33.0	35.9	37.8	40.1	43.3	1.9
Total	**234.7**	**242.3**	**244.1**	**254.6**	**262.7**	**269.2**	**276.1**	**284.6**	**0.5**
Non-OECD									
Non-OECD Europe and Eurasia									
Liquids	9.7	9.7	11.7	11.9	12.2	12.9	13.5	14.0	1.2
Natural gas	20.2	22.3	22.0	23.6	25.5	27.5	29.3	30.5	1.0
Coal	7.7	8.9	8.9	9.5	10.0	10.4	10.7	10.8	0.6
Nuclear	3.0	3.0	3.7	4.5	5.1	5.7	6.3	6.7	2.7
Other	3.1	3.2	3.5	3.8	4.0	4.3	4.7	5.1	1.5
Total	**43.7**	**47.2**	**49.8**	**53.3**	**56.8**	**60.8**	**64.6**	**67.1**	**1.2**
Non-OECD Asia									
Liquids	37.9	40.6	46.2	53.2	59.7	65.6	72.6	80.1	2.3
Natural gas	12.6	14.2	16.4	19.8	23.8	28.4	33.3	37.4	3.3
Coal	83.7	88.4	107.7	122.0	136.1	147.1	154.7	156.8	1.9
Nuclear	1.3	1.4	4.2	8.1	10.9	13.8	16.6	19.4	9.2
Other	12.6	14.4	19.8	27.2	31.2	35.5	40.0	43.7	3.8
Total	**148.1**	**159.0**	**194.3**	**230.3**	**261.6**	**290.4**	**317.2**	**337.5**	**2.5**

See notes at end ot table.

(continued on page 181)

Table A2. World total energy consumption by region and fuel, Reference case, 2009-2040 (continued)
(quadrillion Btu)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
Middle East									
Liquids	13.4	13.8	16.5	17.2	17.6	18.3	19.2	20.4	1.3
Natural gas	12.9	13.7	16.2	18.4	20.5	22.5	24.3	26.3	2.2
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.6
Nuclear	0.0	0.0	0.1	0.4	0.7	1.0	1.2	1.2	--
Other	0.1	0.2	0.3	0.5	0.6	0.7	0.9	0.9	5.6
Total	**26.6**	**27.8**	**33.1**	**36.6**	**39.5**	**42.5**	**45.7**	**48.8**	**1.9**
Africa									
Liquids	6.6	6.9	7.2	7.3	7.7	8.1	8.6	9.1	1.0
Natural gas	3.6	3.7	3.9	4.5	5.2	6.2	7.6	9.3	3.1
Coal	4.4	4.4	4.6	5.2	5.8	6.3	6.9	7.5	1.8
Nuclear	0.1	0.1	0.2	0.2	0.4	0.7	0.9	0.9	6.8
Other	3.7	3.9	3.8	4.7	5.2	6.0	7.0	8.2	2.5
Total	**18.4**	**18.9**	**19.6**	**21.9**	**24.4**	**27.4**	**31.0**	**35.0**	**2.1**
Central and South America									
Liquids	11.8	12.3	13.3	13.6	14.0	14.9	15.8	16.7	1.0
Natural gas	4.6	5.3	5.8	6.4	7.1	7.9	8.7	9.6	2.0
Coal	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.6	2.0
Nuclear	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.8	4.4
Other	9.7	10.0	10.7	11.8	12.6	14.0	15.8	17.9	2.0
Total	**26.9**	**28.7**	**31.0**	**33.2**	**35.5**	**38.8**	**42.5**	**46.6**	**1.6**
Total Non-OECD									
Liquids	79.5	83.3	94.9	103.3	111.1	119.9	129.7	140.3	1.8
Natural gas	53.9	59.3	64.1	72.6	82.1	92.5	103.2	113.1	2.2
Coal	96.6	102.6	122.4	138.0	153.2	165.2	173.9	176.8	1.8
Nuclear	4.6	4.7	8.4	13.5	17.7	21.8	25.9	29.0	6.2
Other	29.2	31.7	38.1	48.0	53.6	60.5	68.4	75.8	3.0
Total	**263.7**	**281.7**	**327.9**	**375.3**	**417.7**	**460.0**	**501.0**	**535.1**	**2.2**
Total World									
Liquids	171.3	176.1	185.5	194.7	202.1	210.9	221.1	232.6	0.9
Natural gas	108.7	116.8	124.2	136.0	148.5	162.6	177.4	191.3	1.7
Coal	139.1	147.4	164.6	180.3	196.0	207.9	216.7	219.5	1.3
Nuclear	26.7	27.3	30.4	37.9	44.3	49.5	53.5	57.2	2.5
Other	52.6	56.2	67.3	81.0	89.5	98.3	108.5	119.1	2.5
Total	**498.4**	**523.9**	**572.0**	**629.8**	**680.4**	**729.2**	**777.1**	**819.6**	**1.5**

Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A3. World gross domestic product (GDP) by region expressed in purchasing power parity, Reference case, 2009-2040
(billion 2005 dollars)

	History		Projections						Average annual percent change,
Region	2009	2010	2015	2020	2025	2030	2035	2040	2010-2040
OECD									
OECD Americas	**15,498**	**15,929**	**18,079**	**20,833**	**23,589**	**26,663**	**30,250**	**34,441**	**2.6**
United States[a]	12,758	13,063	14,679	16,859	18,985	21,355	24,095	27,277	2.5
Canada	1,165	1,202	1,349	1,519	1,684	1,850	2,053	2,285	2.2
Mexico/Chile	1,575	1,664	2,050	2,455	2,921	3,458	4,102	4,879	3.7
OECD Europe	**14,262**	**14,618**	**15,589**	**17,353**	**19,224**	**21,002**	**22,939**	**25,080**	**1.8**
OECD Asia	**5,791**	**6,062**	**6,723**	**7,386**	**8,019**	**8,563**	**9,139**	**9,720**	**1.6**
Japan	3,776	3,948	4,215	4,424	4,608	4,687	4,741	4,716	0.6
South Korea	1,244	1,323	1,598	1,951	2,295	2,642	3,024	3,467	3.3
Australia/NewZealand	771	790	910	1,011	1,116	1,234	1,374	1,537	2.2
Total OECD	**35,551**	**36,609**	**40,391**	**45,572**	**50,832**	**56,227**	**62,328**	**69,241**	**2.1**
Non-OECD									
Non-OECD Europe and Eurasia	**4,346**	**4,502**	**5,463**	**6,841**	**8,323**	**9,918**	**11,749**	**13,681**	**3.8**
Russia	1,938	2,022	2,433	2,965	3,474	3,911	4,338	4,618	2.8
Other	2,408	2,480	3,030	3,876	4,850	6,007	7,411	9,063	4.4
Non-OECD Asia	**16,628**	**18,206**	**25,623**	**34,632**	**45,417**	**58,549**	**73,472**	**89,127**	**5.4**
China	8,299	9,167	13,715	18,906	25,203	32,829	40,977	48,404	5.7
India	3,364	3,661	5,112	7,277	9,894	13,124	17,046	21,731	6.1
Other	4,965	5,379	6,796	8,449	10,320	12,597	15,449	18,991	4.3
Middle East	**2,263**	**2,292**	**2,781**	**3,316**	**3,662**	**3,967**	**4,241**	**4,427**	**2.2**
Africa	**3,780**	**3,963**	**4,868**	**6,165**	**7,732**	**9,725**	**12,224**	**15,348**	**4.6**
Central and South America	**4,623**	**4,927**	**6,016**	**7,194**	**8,398**	**9,711**	**11,207**	**12,954**	**3.3**
Brazil	1,833	1,971	2,365	2,860	3,319	3,859	4,522	5,328	3.4
Other	2,790	2,955	3,651	4,334	5,079	5,853	6,685	7,626	3.2
Total Non-OECD	**31,640**	**33,889**	**44,750**	**58,147**	**73,532**	**91,870**	**112,893**	**135,537**	**4.7**
Total World	**67,192**	**70,498**	**85,141**	**103,719**	**124,364**	**148,097**	**175,221**	**204,779**	**3.6**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: Derived from Oxford Economic Model (October 2012), www.oxfordeconomics.com (subscription site); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Table A4. World gross domestic product (GDP) by region expressed in market exchange rates, Reference case, 2009-2040
(billion 2005 dollars)

Region	History 2009	History 2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**14,941**	**15,341**	**17,353**	**19,963**	**22,555**	**25,441**	**28,803**	**32,722**	**2.6**
United States[a]	12,758	13,063	14,679	16,859	18,985	21,355	24,095	27,277	2.5
Canada	1,167	1,204	1,351	1,521	1,686	1,853	2,057	2,289	2.2
Mexico/Chile	1,016	1,073	1,322	1,583	1,884	2,233	2,651	3,156	3.7
OECD Europe	**15,313**	**15,678**	**16,655**	**18,441**	**20,319**	**22,073**	**23,992**	**26,147**	**1.7**
OECD Asia	**6,334**	**6,619**	**7,286**	**7,927**	**8,537**	**9,039**	**9,565**	**10,072**	**1.4**
Japan	4,443	4,646	4,960	5,206	5,422	5,515	5,579	5,549	0.6
South Korea	958	1,019	1,231	1,503	1,768	2,035	2,330	2,671	3.3
Australia/NewZealand	933	954	1,095	1,219	1,347	1,489	1,656	1,852	2.2
Total OECD	**36,589**	**37,638**	**41,294**	**46,332**	**51,411**	**56,553**	**62,360**	**68,941**	**2.0**
Non-OECD									
Non-OECD Europe and Eurasia	**1,527**	**1,568**	**1,866**	**2,305**	**2,732**	**3,139**	**3,558**	**3,919**	**3.1**
Russia	870	908	1,092	1,331	1,560	1,756	1,948	2,074	2.8
Other	657	660	773	973	1,172	1,383	1,610	1,846	3.5
Non-OECD Asia	**6,605**	**7,232**	**10,178**	**13,744**	**18,011**	**23,192**	**29,045**	**35,116**	**5.4**
China	3,477	3,840	5,746	7,921	10,559	13,753	17,167	20,279	5.7
India	1,115	1,214	1,696	2,415	3,283	4,355	5,657	7,212	6.1
Other	2,012	2,178	2,736	3,409	4,169	5,083	6,222	7,625	4.3
Middle East	**1,173**	**1,241**	**1,589**	**1,954**	**2,360**	**2,802**	**3,269**	**3,742**	**3.7**
Africa	**1,661**	**1,733**	**2,108**	**2,652**	**3,298**	**4,119**	**5,147**	**6,431**	**4.5**
Central and South America	**2,210**	**2,322**	**2,776**	**3,337**	**3,877**	**4,463**	**5,136**	**5,918**	**3.2**
Brazil	1,019	1,096	1,315	1,590	1,846	2,146	2,515	2,963	3.4
Other	1,191	1,226	1,461	1,746	2,031	2,317	2,621	2,955	3.0
Total Non-OECD	**13,176**	**14,096**	**18,517**	**23,992**	**30,277**	**37,714**	**46,156**	**55,126**	**4.7**
Total World	**49,764**	**51,734**	**59,810**	**70,323**	**81,688**	**94,268**	**108,515**	**124,066**	**3.0**

[a]Includes the 50 States and the District of Columbia.
Notes: Totals may not equal sum of components due to independent rounding.
Sources: Derived from Oxford Economic Model (October 2012), www.oxfordeconomics.com (subscription site); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Table A5. World liquids consumption by region, Reference case, 2009-2040
(million barrels per day)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**23.1**	**23.5**	**23.9**	**24.3**	**24.1**	**23.9**	**24.0**	**24.5**	**0.1**
United States[a]	18.6	18.9	19.1	19.5	19.2	18.7	18.6	18.6	0.0
Canada	2.2	2.2	2.3	2.2	2.2	2.2	2.2	2.3	0.1
Mexico/Chile	2.4	2.4	2.5	2.6	2.8	3.1	3.3	3.6	1.3
OECD Europe	**15.0**	**14.8**	**13.5**	**13.7**	**13.7**	**13.8**	**14.0**	**14.1**	**-0.2**
OECD Asia	**7.7**	**7.7**	**8.2**	**8.1**	**8.1**	**8.1**	**8.0**	**7.9**	**0.1**
Japan	4.4	4.4	4.6	4.4	4.3	4.2	4.1	3.9	-0.4
South Korea	2.2	2.3	2.4	2.5	2.6	2.6	2.7	2.7	0.6
Australia/NewZealand	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.3	0.5
Total OECD	**45.8**	**46.0**	**45.6**	**46.2**	**46.0**	**45.8**	**46.0**	**46.4**	**0.0**
Non-OECD									
Non-OECD Europe and Eurasia	**4.8**	**4.8**	**5.8**	**5.9**	**6.0**	**6.4**	**6.7**	**6.9**	**1.2**
Russia	2.9	3.0	3.4	3.5	3.6	3.8	3.9	3.9	0.9
Other	1.8	1.8	2.4	2.4	2.4	2.6	2.8	3.0	1.7
Non-OECD Asia	**18.4**	**19.8**	**22.5**	**25.9**	**29.1**	**32.0**	**35.4**	**39.0**	**2.3**
China	8.5	9.3	11.6	13.6	15.4	16.6	18.2	19.8	2.5
India	3.1	3.3	3.7	4.4	5.1	6.1	7.1	8.2	3.1
Other	6.7	7.2	7.2	7.9	8.6	9.3	10.1	11.0	1.4
Middle East	**6.5**	**6.7**	**8.1**	**8.4**	**8.6**	**8.9**	**9.4**	**9.9**	**1.3**
Africa	**3.3**	**3.4**	**3.5**	**3.6**	**3.8**	**4.0**	**4.2**	**4.5**	**1.0**
Central and South America	**5.7**	**6.0**	**6.5**	**6.6**	**6.8**	**7.3**	**7.7**	**8.2**	**1.0**
Brazil	2.5	2.6	2.8	3.0	3.1	3.3	3.5	3.8	1.2
Other	3.3	3.4	3.6	3.7	3.8	4.0	4.2	4.4	0.9
Total Non-OECD	**38.7**	**40.7**	**46.4**	**50.5**	**54.3**	**58.6**	**63.4**	**68.6**	**1.8**
Total World	**84.5**	**86.7**	**92.0**	**96.6**	**100.3**	**104.5**	**109.4**	**115.0**	**0.9**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013,* DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A6. World natural gas consumption by region, Reference case, 2009-2040
(trillion cubic feet)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**28.2**	**29.2**	**31.3**	**33.4**	**35.1**	**37.0**	**39.4**	**41.6**	**1.2**
United States[a]	22.9	23.8	25.3	26.3	26.9	27.6	28.7	29.5	0.7
Canada	3.1	2.9	3.1	3.6	4.0	4.3	4.6	4.9	1.7
Mexico/Chile	2.2	2.5	2.9	3.5	4.3	5.1	6.1	7.2	3.6
OECD Europe	**18.8**	**19.8**	**19.7**	**20.4**	**20.8**	**22.1**	**23.2**	**24.5**	**0.7**
OECD Asia	**6.1**	**6.7**	**7.2**	**7.8**	**8.5**	**9.0**	**9.5**	**9.9**	**1.3**
Japan	3.7	3.8	4.3	4.6	4.9	5.1	5.2	5.2	1.0
South Korea	1.2	1.5	1.5	1.7	1.9	2.0	2.3	2.5	1.7
Australia/NewZealand	1.3	1.3	1.4	1.5	1.7	1.8	2.0	2.2	1.7
Total OECD	**53.2**	**55.6**	**58.2**	**61.5**	**64.4**	**68.0**	**72.1**	**76.0**	**1.0**
Non-OECD									
Non-OECD Europe and Eurasia	**19.8**	**21.8**	**21.4**	**23.1**	**24.9**	**26.9**	**28.6**	**29.8**	**1.0**
Russia	13.5	15.0	14.8	15.8	17.0	18.2	19.1	19.3	0.9
Other	6.3	6.9	6.7	7.2	7.9	8.7	9.5	10.5	1.4
Non-OECD Asia	**12.3**	**13.9**	**15.9**	**19.2**	**23.0**	**27.6**	**32.2**	**36.3**	**3.3**
China	3.1	3.8	5.6	7.8	10.3	13.0	15.6	17.5	5.3
India	1.9	2.3	2.3	2.7	3.0	3.4	3.8	4.1	2.0
Other	7.3	7.8	8.0	8.8	9.8	11.2	12.8	14.6	2.1
Middle East	**12.4**	**13.1**	**15.5**	**17.6**	**19.7**	**21.6**	**23.3**	**25.2**	**2.2**
Africa	**3.4**	**3.6**	**3.7**	**4.2**	**4.9**	**5.9**	**7.2**	**8.8**	**3.1**
Central and South America	**4.3**	**4.9**	**5.4**	**5.9**	**6.6**	**7.3**	**8.1**	**8.9**	**2.0**
Brazil	0.7	0.9	1.1	1.4	1.8	2.0	2.4	2.8	3.9
Other	3.6	4.0	4.2	4.5	4.9	5.3	5.7	6.1	1.4
Total Non-OECD	**52.1**	**57.3**	**61.9**	**70.0**	**79.2**	**89.2**	**99.5**	**109.0**	**2.2**
Total World	**105.3**	**113.0**	**120.1**	**131.5**	**143.6**	**157.2**	**171.6**	**185.0**	**1.7**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013,* DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A7. World coal consumption by region, Reference case, 2009-2040
(quadrillion Btu)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**21.3**	**22.5**	**19.9**	**20.3**	**21.1**	**21.5**	**21.9**	**22.2**	**0.0**
United States[a]	19.6	20.8	18.2	18.6	19.3	19.7	20.1	20.4	-0.1
Canada	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	-0.3
Mexico/Chile	0.5	0.6	0.7	0.7	0.7	0.8	0.8	0.8	1.2
OECD Europe	**11.9**	**12.2**	**12.2**	**11.9**	**11.6**	**11.3**	**11.0**	**10.7**	**-0.4**
OECD Asia	**9.4**	**10.1**	**10.2**	**10.1**	**10.0**	**9.9**	**9.9**	**9.7**	**-0.1**
Japan	4.2	4.8	4.9	4.8	4.7	4.6	4.5	4.3	-0.4
South Korea	2.7	3.0	3.0	3.1	3.2	3.2	3.4	3.5	0.5
Australia/NewZealand	2.4	2.3	2.2	2.2	2.1	2.1	2.0	2.0	-0.6
Total OECD	**42.5**	**44.8**	**42.2**	**42.3**	**42.8**	**42.7**	**42.8**	**42.7**	**-0.2**
Non-OECD									
Non-OECD Europe and Eurasia	**7.7**	**8.9**	**8.9**	**9.5**	**10.0**	**10.4**	**10.7**	**10.8**	**0.6**
Russia	3.7	4.8	4.9	5.2	5.5	5.6	5.7	5.6	0.5
Other	4.0	4.2	4.1	4.3	4.5	4.8	5.0	5.2	0.8
Non-OECD Asia	**83.7**	**88.4**	**107.7**	**122.0**	**136.1**	**147.1**	**154.7**	**156.8**	**1.9**
China	65.1	69.4	87.4	99.6	110.8	118.9	123.2	121.5	1.9
India	12.2	12.6	13.7	15.4	17.2	18.9	20.8	22.4	1.9
Other	6.4	6.4	6.6	7.1	8.0	9.2	10.8	13.0	2.4
Middle East	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**1.6**
Africa	**4.4**	**4.4**	**4.6**	**5.2**	**5.8**	**6.3**	**6.9**	**7.5**	**1.8**
Central and South America	**0.7**	**0.9**	**1.0**	**1.1**	**1.2**	**1.3**	**1.4**	**1.6**	**2.0**
Brazil	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.1	2.7
Other	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.8
Total Non-OECD	**96.6**	**102.6**	**122.4**	**138.0**	**153.2**	**165.2**	**173.9**	**176.8**	**1.8**
Total World	**139.1**	**147.4**	**164.6**	**180.3**	**196.0**	**207.9**	**216.7**	**219.5**	**1.3**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013,* DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A8. World nuclear energy consumption by region, Reference case, 2009-2040
(billion kilowatthours)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**894**	**899**	**932**	**978**	**1,032**	**1,054**	**1,030**	**1,066**	**0.6**
United States[a]	799	807	820	885	912	908	875	903	0.4
Canada	86	86	99	81	99	117	118	118	1.0
Mexico/Chile	10	6	12	12	21	29	37	46	7.3
OECD Europe	**840**	**867**	**892**	**929**	**1,045**	**1,065**	**1,077**	**1,073**	**0.7**
OECD Asia	**406**	**415**	**301**	**447**	**490**	**551**	**557**	**576**	**1.1**
Japan	266	274	103	192	200	206	209	209	-0.9
South Korea	140	141	198	255	291	346	348	367	3.2
Australia/NewZealand	0	0	0	0	0	0	0	0	--
Total OECD	**2,140**	**2,181**	**2,124**	**2,354**	**2,567**	**2,670**	**2,664**	**2,715**	**0.7**
Non-OECD									
Non-OECD Europe and Eurasia	**272**	**274**	**344**	**414**	**475**	**533**	**592**	**630**	**2.8**
Russia	155	162	197	250	294	336	379	416	3.2
Other	117	112	147	164	181	196	213	213	2.2
Non-OECD Asia	**123**	**132**	**401**	**776**	**1,052**	**1,327**	**1,600**	**1,868**	**9.2**
China	67	70	298	610	780	946	1,116	1,289	10.2
India	14	19	49	69	146	223	309	396	10.6
Other	42	42	54	97	126	158	175	182	5.0
Middle East	**0**	**0**	**6**	**43**	**71**	**94**	**113**	**113**	**--**
Africa	**13**	**13**	**15**	**15**	**39**	**64**	**89**	**89**	**6.7**
Central and South America	**20**	**20**	**26**	**36**	**52**	**67**	**77**	**77**	**4.5**
Brazil	12	14	14	23	39	54	55	55	4.7
Other	8	7	13	13	13	13	22	22	4.1
Total Non-OECD	**428**	**439**	**792**	**1,284**	**1,688**	**2,085**	**2,471**	**2,777**	**6.3**
Total World	**2,568**	**2,620**	**2,917**	**3,638**	**4,255**	**4,755**	**5,134**	**5,492**	**2.5**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013,* DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A9. World consumption of hydroelectricity and other renewable energy by region, Reference case, 2009-2040
(quadrillion Btu)

	History		Projections						Average annual
Region	2009	2010	2015	2020	2025	2030	2035	2040	percent change, 2010-2040
OECD									
OECD Americas	**11.9**	**11.9**	**13.7**	**15.0**	**15.9**	**16.8**	**18.3**	**20.8**	**1.9**
United States[a]	6.9	7.0	8.1	8.9	9.3	9.6	10.3	11.9	1.8
Canada	4.2	4.0	4.5	4.8	5.1	5.5	5.9	6.4	1.6
Mexico/Chile	0.8	0.9	1.2	1.3	1.5	1.7	2.1	2.4	3.5
OECD Europe	**9.4**	**10.4**	**12.6**	**14.7**	**16.4**	**17.2**	**17.9**	**18.5**	**2.0**
OECD Asia	**2.1**	**2.3**	**2.9**	**3.4**	**3.7**	**3.8**	**3.9**	**4.0**	**1.8**
Japan	1.3	1.5	1.7	1.9	2.1	2.2	2.3	2.3	1.5
South Korea	0.1	0.1	0.2	0.3	0.3	0.3	0.3	0.4	3.0
Australia/NewZealand	0.7	0.7	1.0	1.2	1.2	1.3	1.3	1.4	2.3
Total OECD	**23.4**	**24.6**	**29.2**	**33.0**	**35.9**	**37.8**	**40.1**	**43.3**	**1.9**
Non-OECD									
Non-OECD Europe and Eurasia	**3.1**	**3.2**	**3.5**	**3.8**	**4.0**	**4.3**	**4.7**	**5.1**	**1.5**
Russia	1.8	1.8	1.9	2.1	2.3	2.5	2.7	2.8	1.6
Other	1.2	1.5	1.5	1.7	1.7	1.8	2.0	2.2	1.3
Non-OECD Asia	**12.6**	**14.4**	**19.8**	**27.2**	**31.2**	**35.5**	**40.0**	**43.7**	**3.8**
China	6.6	8.0	12.0	17.1	19.8	22.5	24.9	26.2	4.0
India	2.4	2.6	3.3	4.4	4.8	5.5	6.4	7.4	3.6
Other	3.6	3.7	4.5	5.8	6.5	7.5	8.7	10.1	3.4
Middle East	**0.1**	**0.2**	**0.3**	**0.5**	**0.6**	**0.7**	**0.9**	**0.9**	**5.6**
Africa	**3.7**	**3.9**	**3.8**	**4.7**	**5.2**	**6.0**	**7.0**	**8.2**	**2.5**
Central and South America	**9.7**	**10.0**	**10.7**	**11.8**	**12.6**	**14.0**	**15.8**	**17.9**	**2.0**
Brazil	6.4	6.8	7.1	7.9	8.5	9.6	11.1	13.0	2.2
Other	3.3	3.2	3.6	3.9	4.1	4.4	4.6	5.0	1.4
Total Non-OECD	**29.2**	**31.7**	**38.1**	**48.0**	**53.6**	**60.5**	**68.4**	**75.8**	**3.0**
Total World	**52.6**	**56.2**	**67.3**	**81.0**	**89.5**	**98.3**	**108.5**	**119.1**	**2.5**

[a]Includes the 50 States and the District of Columbia.

Notes: Totals may not equal sum of components due to independent rounding. U.S. totals include net electricity imports, methanol, and liquid hydrogen. Other renewable energy includes wind, geothermal, solar, biomass, waste, and tide/wave/ocean.

Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A10. World carbon dioxide emissions by region, Reference case, 2009-2040
(million metric tons carbon dioxide)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**6,448**	**6,657**	**6,480**	**6,627**	**6,762**	**6,880**	**7,070**	**7,283**	**0.3**
United States[a]	5,418	5,608	5,381	5,454	5,501	5,523	5,607	5,691	0.0
Canada	548	546	551	574	593	609	628	654	0.6
Mexico/Chile	482	503	548	599	668	748	835	937	2.1
OECD Europe	**4,147**	**4,223**	**4,054**	**4,097**	**4,097**	**4,151**	**4,202**	**4,257**	**0.0**
OECD Asia	**2,085**	**2,200**	**2,287**	**2,296**	**2,329**	**2,341**	**2,365**	**2,358**	**0.2**
Japan	1,105	1,176	1,243	1,220	1,223	1,215	1,194	1,150	-0.1
South Korea	531	581	600	627	653	666	703	730	0.8
Australia/NewZealand	449	443	444	449	452	460	468	478	0.3
Total OECD	**12,680**	**13,079**	**12,821**	**13,020**	**13,188**	**13,373**	**13,637**	**13,897**	**0.2**
Non-OECD									
Non-OECD Europe and Eurasia	**2,421**	**2,645**	**2,750**	**2,898**	**3,065**	**3,250**	**3,420**	**3,526**	**1.0**
Russia	1,414	1,595	1,650	1,749	1,853	1,945	2,019	2,018	0.8
Other	1,007	1,050	1,100	1,149	1,212	1,304	1,401	1,508	1.2
Non-OECD Asia	**10,841**	**11,538**	**13,859**	**15,812**	**17,740**	**19,392**	**20,795**	**21,668**	**2.1**
China	7,347	7,885	10,022	11,532	12,951	14,028	14,771	14,911	2.1
India	1,621	1,695	1,856	2,109	2,397	2,693	3,009	3,326	2.3
Other	1,873	1,958	1,981	2,171	2,392	2,671	3,016	3,431	1.9
Middle East	**1,583**	**1,649**	**1,959**	**2,126**	**2,264**	**2,419**	**2,580**	**2,756**	**1.7**
Africa	**1,047**	**1,070**	**1,123**	**1,224**	**1,343**	**1,474**	**1,626**	**1,815**	**1.8**
Central and South America	**1,112**	**1,202**	**1,306**	**1,366**	**1,441**	**1,556**	**1,669**	**1,793**	**1.3**
Brazil	409	450	506	547	584	632	691	771	1.8
Other	703	752	800	819	857	924	978	1,022	1.0
Total Non-OECD	**17,004**	**18,104**	**20,996**	**23,426**	**25,853**	**28,092**	**30,090**	**31,558**	**1.9**
Total World	**29,684**	**31,183**	**33,817**	**36,446**	**39,041**	**41,464**	**43,727**	**45,455**	**1.3**

[a]Includes the 50 States and the District of Columbia.
Note: The U.S. numbers include carbon dioxide emissions from electricity generation using nonbiogenic municipal solid waste and geothermal energy.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies.
Projections: EIA, *Annual Energy Outlook 2013,* DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A11. World carbon dioxide emissions from liquids use by region, Reference case, 2009-2040
(million metric tons carbon dioxide)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**2,906**	**2,950**	**2,891**	**2,892**	**2,858**	**2,842**	**2,864**	**2,929**	**0.0**
United States[a]	2,320	2,357	2,277	2,270	2,218	2,169	2,156	2,175	-0.3
Canada	272	280	287	279	274	274	277	287	0.1
Mexico/Chile	314	313	327	344	366	399	431	468	1.3
OECD Europe	**1,998**	**1,989**	**1,811**	**1,842**	**1,847**	**1,860**	**1,876**	**1,890**	**-0.2**
OECD Asia	**874**	**889**	**943**	**931**	**926**	**923**	**915**	**899**	**0.0**
Japan	511	519	552	524	514	502	489	462	-0.4
South Korea	211	217	232	245	250	254	256	260	0.6
Australia/NewZealand	152	153	160	162	163	166	170	176	0.5
Total OECD	**5,779**	**5,827**	**5,646**	**5,665**	**5,630**	**5,624**	**5,656**	**5,718**	**-0.1**
Non-OECD									
Non-OECD Europe and Eurasia	**623**	**624**	**756**	**765**	**783**	**831**	**873**	**908**	**1.3**
Russia	334	338	387	397	409	428	439	438	0.9
Other	289	286	369	368	375	403	434	470	1.7
Non-OECD Asia	**2,345**	**2,512**	**2,853**	**3,281**	**3,677**	**4,046**	**4,474**	**4,938**	**2.3**
China	1,060	1,155	1,444	1,688	1,905	2,061	2,255	2,454	2.5
India	393	408	462	546	644	759	885	1,030	3.1
Other	893	948	948	1,046	1,128	1,225	1,334	1,453	1.4
Middle East	**887**	**909**	**1,088**	**1,135**	**1,158**	**1,206**	**1,269**	**1,342**	**1.3**
Africa	**451**	**467**	**488**	**500**	**525**	**554**	**587**	**623**	**1.0**
Central and South America	**805**	**842**	**907**	**929**	**955**	**1,020**	**1,077**	**1,142**	**1.0**
Brazil	337	356	386	406	418	446	473	516	1.2
Other	467	485	521	523	537	574	604	626	0.9
Total Non-OECD	**5,110**	**5,353**	**6,092**	**6,610**	**7,098**	**7,658**	**8,280**	**8,953**	**1.7**
Total World	**10,889**	**11,181**	**11,738**	**12,275**	**12,728**	**13,282**	**13,936**	**14,671**	**0.9**

[a]Includes the 50 States and the District of Columbia.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013,* DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A12. World carbon dioxide emissions from natural gas use by region, Reference case, 2009-2040
(million metric tons carbon dioxide)

	History		Projections						Average annual percent change,
Region	2009	2010	2015	2020	2025	2030	2035	2040	2010-2040
OECD									
OECD Americas	**1,511**	**1,563**	**1,686**	**1,793**	**1,888**	**1,987**	**2,114**	**2,233**	**1.2**
United States[a]	1,222	1,266	1,357	1,404	1,431	1,468	1,528	1,570	0.7
Canada	170	162	171	199	223	240	255	271	1.7
Mexico/Chile	119	135	158	190	234	279	331	392	3.6
OECD Europe	**1,024**	**1,082**	**1,086**	**1,123**	**1,144**	**1,215**	**1,277**	**1,348**	**0.7**
OECD Asia	**347**	**377**	**408**	**438**	**478**	**505**	**539**	**561**	**1.3**
Japan	205	215	242	257	276	288	293	293	1.0
South Korea	72	90	91	98	110	117	136	148	1.7
Australia/NewZealand	70	71	75	83	91	101	110	119	1.7
Total OECD	**2,882**	**3,022**	**3,180**	**3,353**	**3,510**	**3,707**	**3,930**	**4,142**	**1.1**
Non-OECD									
Non-OECD Europe and Eurasia	**1,078**	**1,190**	**1,144**	**1,230**	**1,329**	**1,433**	**1,526**	**1,589**	**1.0**
Russia	735	814	796	854	919	980	1,030	1,043	0.8
Other	343	376	348	377	410	453	497	546	1.3
Non-OECD Asia	**667**	**755**	**871**	**1,051**	**1,265**	**1,514**	**1,772**	**1,993**	**3.3**
China	173	209	315	435	576	731	876	981	5.3
India	104	126	129	146	165	185	208	228	2.0
Other	390	420	428	470	524	598	688	784	2.1
Middle East	**691**	**734**	**865**	**984**	**1,099**	**1,205**	**1,302**	**1,405**	**2.2**
Africa	**193**	**202**	**209**	**241**	**280**	**336**	**409**	**501**	**3.1**
Central and South America	**241**	**280**	**305**	**336**	**376**	**415**	**460**	**506**	**2.0**
Brazil	37	49	63	79	98	109	131	157	3.9
Other	205	231	242	257	279	306	329	349	1.4
Total Non-OECD	**2,870**	**3,162**	**3,394**	**3,842**	**4,349**	**4,903**	**5,469**	**5,995**	**2.2**
Total World	**5,752**	**6,183**	**6,574**	**7,195**	**7,858**	**8,610**	**9,399**	**10,137**	**1.7**

[a]Includes the 50 States and the District of Columbia.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013,* DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A13. World carbon dioxide emissions from coal use by region, Reference case, 2009-2040
(million metric tons carbon dioxide)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**2,031**	**2,144**	**1,891**	**1,930**	**2,005**	**2,040**	**2,080**	**2,109**	**-0.1**
United States[a]	1,876	1,985	1,735	1,769	1,841	1,874	1,912	1,936	-0.1
Canada	106	104	93	96	96	95	95	96	-0.3
Mexico/Chile	49	55	63	65	68	70	73	77	1.2
OECD Europe	**1,125**	**1,153**	**1,157**	**1,133**	**1,106**	**1,077**	**1,049**	**1,019**	**-0.4**
OECD Asia	**864**	**934**	**936**	**927**	**925**	**913**	**911**	**898**	**-0.1**
Japan	389	442	450	440	433	425	413	394	-0.4
South Korea	248	274	278	284	294	296	311	322	0.5
Australia/NewZealand	227	218	209	203	198	193	187	182	-0.6
Total OECD	**4,020**	**4,230**	**3,984**	**3,990**	**4,036**	**4,030**	**4,040**	**4,026**	**-0.2**
Non-OECD									
Non-OECD Europe and Eurasia	**720**	**831**	**850**	**903**	**952**	**986**	**1,021**	**1,028**	**0.7**
Russia	345	442	468	498	525	537	551	537	0.7
Other	375	389	382	405	427	449	470	491	0.8
Non-OECD Asia	**7,829**	**8,272**	**10,134**	**11,480**	**12,798**	**13,833**	**14,549**	**14,738**	**1.9**
China	6,114	6,520	8,263	9,409	10,471	11,235	11,639	11,476	1.9
India	1,125	1,162	1,266	1,417	1,588	1,749	1,917	2,067	1.9
Other	591	590	605	654	740	848	994	1,194	2.4
Middle East	**5**	**6**	**6**	**7**	**8**	**8**	**9**	**9**	**1.6**
Africa	**403**	**401**	**426**	**483**	**538**	**584**	**631**	**691**	**1.8**
Central and South America	**66**	**80**	**94**	**101**	**110**	**120**	**132**	**145**	**2.0**
Brazil	35	44	57	63	69	77	87	99	2.7
Other	31	36	37	39	41	43	45	46	0.8
Total Non-OECD	**9,023**	**9,590**	**11,510**	**12,974**	**14,406**	**15,531**	**16,341**	**16,610**	**1.8**
Total World	**13,043**	**13,820**	**15,494**	**16,965**	**18,443**	**19,561**	**20,381**	**20,636**	**1.3**

[a]Includes the 50 States and the District of Columbia.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013,* DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table A14. World population by region, Reference case, 2009-2040
(millions)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**470**	**475**	**499**	**523**	**547**	**569**	**591**	**612**	**0.8**
United States[a]	308	310	325	340	356	372	388	404	0.9
Canada	34	34	36	38	40	42	44	46	1.0
Mexico/Chile	129	131	138	144	150	155	159	162	0.7
OECD Europe	**553**	**556**	**570**	**580**	**588**	**594**	**598**	**601**	**0.3**
OECD Asia	**202**	**203**	**204**	**205**	**204**	**203**	**201**	**199**	**-0.1**
Japan	128	128	127	125	122	119	117	114	-0.4
South Korea	48	48	49	50	50	50	50	49	0.1
Australia/NewZealand	26	27	28	30	32	33	34	35	0.9
Total OECD	**1,226**	**1,234**	**1,273**	**1,307**	**1,339**	**1,366**	**1,390**	**1,411**	**0.4**
Non-OECD									
Non-OECD Europe and Eurasia	**338**	**338**	**342**	**342**	**342**	**340**	**337**	**334**	**0.0**
Russia	141	140	142	141	139	136	134	131	-0.2
Other	197	198	199	201	203	203	203	202	0.1
Non-OECD Asia	**3,595**	**3,631**	**3,813**	**3,975**	**4,116**	**4,233**	**4,325**	**4,391**	**0.6**
China	1,335	1,341	1,370	1,388	1,395	1,393	1,381	1,361	0.0
India	1,208	1,225	1,308	1,387	1,459	1,523	1,580	1,627	1.0
Other	1,052	1,066	1,135	1,201	1,262	1,316	1,363	1,403	0.9
Middle East	**204**	**208**	**229**	**250**	**269**	**288**	**305**	**321**	**1.5**
Africa	**987**	**1,009**	**1,123**	**1,242**	**1,363**	**1,487**	**1,615**	**1,747**	**1.8**
Central and South America	**454**	**459**	**485**	**508**	**529**	**547**	**562**	**574**	**0.7**
Brazil	193	195	203	210	216	220	223	224	0.5
Other	261	264	281	297	313	326	339	349	0.9
Total Non-OECD	**5,578**	**5,646**	**5,991**	**6,317**	**6,619**	**6,894**	**7,143**	**7,366**	**0.9**
Total World	**6,804**	**6,880**	**7,264**	**7,624**	**7,958**	**8,260**	**8,533**	**8,777**	**0.8**

[a]Includes the 50 States and the District of Columbia.
Sources: **United States:** U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo. **Other countries:** IHS Global Insight, *World Overview* (Lexington, MA: various issues).

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Appendix B

High Economic Growth case projections

- *World energy consumption*
- *Gross domestic product*

Table B1. World total primary energy consumption by region, High Economic Growth case, 2009-2040
(quadrillion Btu)

	History		Projections						Average annual percent change, 2010-2040
Region	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**117.0**	**120.2**	**122.0**	**129.8**	**134.8**	**139.5**	**146.0**	**155.6**	**0.9**
United States[a]	94.9	97.9	97.9	104.2	106.8	108.7	112.5	118.9	0.6
Canada	13.7	13.5	14.2	14.7	15.6	16.5	17.2	18.2	1.0
Mexico/Chile	8.4	8.8	9.8	10.9	12.4	14.3	16.3	18.6	2.5
OECD Europe	**80.0**	**82.5**	**82.2**	**85.7**	**88.9**	**91.3**	**93.4**	**95.4**	**0.5**
OECD Asia	**37.7**	**39.6**	**40.0**	**42.1**	**43.5**	**44.8**	**45.9**	**46.8**	**0.6**
Japan	21.0	22.1	21.3	21.9	22.3	22.5	22.6	22.4	0.0
South Korea	10.1	10.8	11.8	12.9	13.8	14.8	15.6	16.6	1.4
Australia/NewZealand	6.7	6.7	6.9	7.3	7.4	7.6	7.7	7.9	0.6
Total OECD	**234.7**	**242.3**	**244.2**	**257.6**	**267.2**	**275.6**	**285.4**	**297.9**	**0.7**
Non-OECD									
Non-OECD Europe and Eurasia	**43.7**	**47.2**	**49.8**	**53.2**	**56.8**	**61.0**	**65.3**	**68.6**	**1.3**
Russia	27.0	29.6	30.9	33.2	35.6	38.0	40.2	41.5	1.1
Other	16.7	17.6	18.9	20.0	21.2	23.1	25.1	27.2	1.5
Non-OECD Asia	**148.1**	**159.0**	**195.1**	**238.0**	**283.5**	**333.6**	**389.5**	**440.2**	**3.5**
China	93.1	101.2	132.7	165.3	199.2	235.3	274.1	305.0	3.7
India	23.1	24.4	27.8	33.3	40.1	48.1	58.1	69.6	3.6
Other	31.8	33.4	34.6	39.4	44.2	50.1	57.3	65.6	2.3
Middle East	**26.6**	**27.8**	**34.9**	**39.3**	**43.2**	**47.5**	**52.1**	**57.3**	**2.4**
Africa	**18.4**	**18.9**	**19.6**	**21.9**	**24.5**	**27.6**	**31.2**	**35.3**	**2.1**
Central and South America	**26.9**	**28.7**	**31.0**	**33.2**	**35.6**	**39.0**	**42.8**	**47.1**	**1.7**
Brazil	12.7	13.7	14.9	16.5	18.0	20.0	22.6	25.8	2.1
Other	14.3	15.0	16.1	16.7	17.6	19.0	20.2	21.3	1.2
Total Non-OECD	**263.7**	**281.7**	**330.4**	**385.7**	**443.6**	**508.7**	**580.9**	**648.5**	**2.8**
Total World	**498.4**	**523.9**	**574.6**	**643.2**	**710.7**	**784.3**	**866.2**	**946.4**	**2.0**

[a]Includes the 50 States and the District of Columbia.
Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run HIGHMACRO.D110912A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table B2. World total energy consumption by region and fuel, High Economic Growth case, 2009-2040
(quadrillion Btu)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
OECD									
OECD Americas									
Liquids	45.5	46.4	46.3	47.9	48.2	48.4	49.4	51.1	0.3
Natural gas	28.9	29.9	32.1	34.8	37.2	39.5	42.0	44.1	1.3
Coal	21.3	22.5	19.7	21.5	22.4	22.7	23.2	23.9	0.2
Nuclear	9.4	9.5	9.8	10.3	10.9	11.2	11.6	13.2	1.1
Other	11.9	11.9	14.0	15.3	16.2	17.7	19.9	23.3	2.3
Total	**117.0**	**120.2**	**122.0**	**129.8**	**134.8**	**139.5**	**146.0**	**155.6**	**0.9**
OECD Europe									
Liquids	30.8	30.6	28.0	28.5	28.6	28.8	29.2	29.5	-0.1
Natural gas	19.3	20.4	20.3	21.1	21.5	22.8	24.0	25.4	0.7
Coal	11.9	12.2	12.2	11.9	11.6	11.4	11.1	10.8	-0.4
Nuclear	8.6	8.9	9.2	9.6	10.8	11.0	11.1	11.1	0.7
Other	9.4	10.4	12.6	14.7	16.4	17.3	18.0	18.7	2.0
Total	**80.0**	**82.5**	**82.2**	**85.7**	**88.9**	**91.3**	**93.4**	**95.4**	**0.5**
OECD Asia									
Liquids	15.5	15.8	16.6	16.2	16.2	16.3	16.4	16.4	0.1
Natural gas	6.6	7.2	7.6	8.1	8.8	9.4	10.0	10.5	1.3
Coal	9.4	10.1	10.1	9.9	9.9	9.8	9.9	10.0	0.0
Nuclear	4.1	4.2	3.0	4.5	5.0	5.6	5.7	5.9	1.1
Other	2.1	2.3	2.8	3.4	3.6	3.7	3.9	4.0	1.8
Total	**37.7**	**39.6**	**40.0**	**42.1**	**43.5**	**44.8**	**45.9**	**46.8**	**0.6**
Total OECD									
Liquids	91.8	92.8	90.8	92.6	92.9	93.6	95.0	97.0	0.1
Natural gas	54.8	57.5	60.0	63.9	67.5	71.7	76.1	80.0	1.1
Coal	42.5	44.8	42.0	43.3	43.9	43.8	44.2	44.7	0.0
Nuclear	22.1	22.6	22.0	24.4	26.6	27.8	28.3	30.2	1.0
Other	23.4	24.6	29.4	33.4	36.3	38.7	41.8	46.0	2.1
Total	**234.7**	**242.3**	**244.2**	**257.6**	**267.2**	**275.6**	**285.4**	**297.9**	**0.7**
Non-OECD									
Non-OECD Europe and Eurasia									
Liquids	9.7	9.7	11.8	11.9	12.2	13.0	13.6	14.2	1.3
Natural gas	20.2	22.3	21.9	23.5	25.4	27.4	29.4	31.0	1.1
Coal	7.7	8.9	9.0	9.6	10.2	10.6	11.1	11.5	0.8
Nuclear	3.0	3.0	3.7	4.5	5.1	5.7	6.3	6.7	2.7
Other	3.1	3.2	3.5	3.8	4.0	4.3	4.8	5.2	1.6
Total	**43.7**	**47.2**	**49.8**	**53.2**	**56.8**	**61.0**	**65.3**	**68.6**	**1.3**
Non-OECD Asia									
Liquids	37.9	40.6	46.5	54.7	63.4	72.7	84.1	97.1	2.9
Natural gas	12.6	14.2	16.4	20.1	24.9	30.8	37.3	43.0	3.8
Coal	83.7	88.4	108.3	127.8	152.8	180.1	209.0	231.6	3.3
Nuclear	1.3	1.4	4.2	8.1	10.9	13.8	16.6	19.4	9.2
Other	12.6	14.4	19.8	27.3	31.5	36.2	42.5	49.1	4.2
Total	**148.1**	**159.0**	**195.1**	**238.0**	**283.5**	**333.6**	**389.5**	**440.2**	**3.5**

See notes at end ot table.

(continued on page 199)

Table B2. World total energy consumption by region and fuel, High Economic Growth case, 2009-2040 (continued)
(quadrillion Btu)

	History		Projections						Average annual percent change, 2010-2040
Region	2009	2010	2015	2020	2025	2030	2035	2040	
Middle East									
Liquids	13.4	13.8	16.6	17.8	18.7	20.1	21.7	23.7	1.8
Natural gas	12.9	13.7	17.8	20.5	23.1	25.7	28.2	31.4	2.8
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.3
Nuclear	0.0	0.0	0.1	0.4	0.7	1.0	1.2	1.2	0.0
Other	0.1	0.2	0.3	0.5	0.6	0.7	0.9	1.0	5.7
Total	**26.6**	**27.8**	**34.9**	**39.3**	**43.2**	**47.5**	**52.1**	**57.3**	**2.4**
Africa									
Liquids	6.6	6.9	7.2	7.4	7.8	8.2	8.8	9.3	1.0
Natural gas	3.6	3.7	3.9	4.4	5.2	6.1	7.4	9.0	3.0
Coal	4.4	4.4	4.6	5.3	5.9	6.5	7.1	7.8	2.0
Nuclear	0.1	0.1	0.2	0.2	0.4	0.7	0.9	0.9	6.8
Other	3.7	3.9	3.8	4.7	5.2	6.0	7.0	8.2	2.5
Total	**18.4**	**18.9**	**19.6**	**21.9**	**24.5**	**27.6**	**31.2**	**35.3**	**2.1**
Central and South America									
Liquids	11.8	12.3	13.3	13.6	14.1	15.1	16.0	17.1	1.1
Natural gas	4.6	5.3	5.7	6.3	7.1	7.9	8.7	9.6	2.0
Coal	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.9
Nuclear	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.8	4.4
Other	9.7	10.0	10.7	11.8	12.6	14.1	15.8	18.0	2.0
Total	**26.9**	**28.7**	**31.0**	**33.2**	**35.6**	**39.0**	**42.8**	**47.1**	**1.7**
Total Non-OECD									
Liquids	79.5	83.3	95.3	105.4	116.2	129.1	144.2	161.5	2.2
Natural gas	53.9	59.3	65.7	74.8	85.6	97.9	111.1	124.0	2.5
Coal	96.6	102.6	122.9	143.8	170.2	198.6	228.7	252.5	3.0
Nuclear	4.6	4.7	8.4	13.5	17.7	21.8	25.9	29.0	6.2
Other	29.2	31.7	38.1	48.1	53.9	61.3	71.0	81.5	3.2
Total	**263.7**	**281.7**	**330.4**	**385.7**	**443.6**	**508.7**	**580.9**	**648.5**	**2.8**
Total World									
Liquids	171.3	176.1	186.1	198.0	209.2	222.6	239.2	258.5	1.3
Natural gas	108.7	116.8	125.7	138.7	153.1	169.6	187.1	204.0	1.9
Coal	139.1	147.4	164.9	187.1	214.1	242.5	272.9	297.3	2.4
Nuclear	26.7	27.3	30.4	37.9	44.3	49.6	54.2	59.2	2.6
Other	52.6	56.2	67.5	81.5	90.1	99.9	112.8	127.4	2.8
Total	**498.4**	**523.9**	**574.6**	**643.2**	**710.7**	**784.3**	**866.2**	**946.4**	**2.0**

Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run HIGHMACRO.D110912A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table B3. World gross domestic product (GDP) by region expressed in purchasing power parity, High Economic Growth case, 2009-2040
(billion 2005 dollars)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**15,498**	**15,929**	**18,217**	**21,735**	**25,023**	**28,578**	**32,822**	**37,787**	**2.9**
United States[a]	12,758	13,063	14,815	17,754	20,397	23,232	26,609	30,552	2.9
Canada	1,165	1,202	1,349	1,519	1,685	1,854	2,061	2,300	2.2
Mexico/Chile	1,575	1,664	2,052	2,462	2,940	3,492	4,152	4,935	3.7
OECD Europe	**14,262**	**14,618**	**15,609**	**17,427**	**19,378**	**21,243**	**23,287**	**25,560**	**1.9**
OECD Asia	**5,791**	**6,062**	**6,727**	**7,399**	**8,056**	**8,626**	**9,227**	**9,830**	**1.6**
Japan	3,776	3,948	4,218	4,434	4,634	4,729	4,799	4,801	0.7
South Korea	1,244	1,323	1,599	1,952	2,303	2,657	3,049	3,496	3.3
Australia/NewZealand	771	790	910	1,013	1,120	1,239	1,378	1,534	2.2
Total OECD	**35,551**	**36,609**	**40,553**	**46,560**	**52,457**	**58,447**	**65,336**	**73,178**	**2.3**
Non-OECD									
Non-OECD Europe and Eurasia	**4,346**	**4,502**	**5,468**	**6,872**	**8,397**	**10,048**	**11,951**	**13,994**	**3.9**
Russia	1,938	2,022	2,436	2,989	3,533	4,018	4,505	4,872	3.0
Other	2,408	2,480	3,033	3,884	4,864	6,030	7,445	9,122	4.4
Non-OECD Asia	**16,628**	**18,206**	**25,766**	**35,753**	**48,418**	**64,691**	**84,284**	**105,934**	**6.0**
China	8,299	9,167	13,795	19,659	27,277	37,123	48,462	59,583	6.4
India	3,364	3,661	5,155	7,510	10,483	14,300	19,135	25,184	6.6
Other	4,965	5,379	6,816	8,584	10,658	13,268	16,687	21,167	4.7
Middle East	**2,263**	**2,292**	**2,783**	**3,346**	**3,747**	**4,139**	**4,534**	**4,896**	**2.6**
Africa	**3,780**	**3,963**	**4,872**	**6,196**	**7,820**	**9,908**	**12,563**	**15,934**	**4.7**
Central and South America	**4,623**	**4,927**	**6,021**	**7,228**	**8,489**	**9,895**	**11,524**	**13,461**	**3.4**
Brazil	1,833	1,971	2,367	2,881	3,381	3,989	4,755	5,709	3.6
Other	2,790	2,955	3,654	4,348	5,108	5,905	6,769	7,752	3.3
Total Non-OECD	**31,640**	**33,889**	**44,911**	**59,395**	**76,871**	**98,681**	**124,856**	**154,219**	**5.2**
Total World	**67,192**	**70,498**	**85,464**	**105,955**	**129,327**	**157,127**	**190,191**	**227,397**	**4.0**

[a]Includes the 50 States and the District of Columbia.

Notes: Totals may not equal sum of components due to independent rounding. GDP growth rates for non-OECD Europe and Eurasia (excluding Russia), China, India, Africa, and Central and South America (excluding Brazil) were adjusted based on the analyst's judgment.

Sources: Derived from Oxford Economic Model (October 2012), www.oxfordeconomics.com (subscription site); and U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); and AEO2013 National Energy Modeling System, run HIGHMACRO.D110912A, www.eia.gov/aeo.

Appendix C

Low Economic Growth case projections

- *World energy consumption*
- *Gross domestic product*

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Table C1. World total primary energy consumption by region, Low Economic Growth case, 2009-2040
(quadrillion Btu)

	History		Projections						Average annual percent change,
Region	2009	2010	2015	2020	2025	2030	2035	2040	2010-2040
OECD									
OECD Americas	**117.0**	**120.2**	**119.9**	**122.1**	**124.1**	**125.9**	**129.0**	**133.9**	**0.4**
United States[a]	94.9	97.9	95.9	96.4	96.1	95.3	95.7	97.3	0.0
Canada	13.7	13.5	14.2	14.7	15.6	16.5	17.3	18.2	1.0
Mexico/Chile	8.4	8.8	9.8	10.9	12.3	14.1	16.0	18.3	2.5
OECD Europe	**80.0**	**82.5**	**82.1**	**85.3**	**88.0**	**90.1**	**91.6**	**93.0**	**0.4**
OECD Asia	**37.7**	**39.6**	**40.3**	**42.7**	**43.9**	**44.6**	**45.0**	**45.0**	**0.4**
Japan	21.0	22.1	21.6	22.5	22.8	22.6	22.2	21.4	-0.1
South Korea	10.1	10.8	11.8	12.9	13.7	14.5	15.1	15.8	1.3
Australia/NewZealand	6.7	6.7	6.9	7.2	7.3	7.5	7.7	7.9	0.6
Total OECD	**234.7**	**242.3**	**242.3**	**250.1**	**256.0**	**260.5**	**265.6**	**271.9**	**0.4**
Non-OECD									
Non-OECD Europe and Eurasia	**43.7**	**47.2**	**49.8**	**52.9**	**55.9**	**59.3**	**62.5**	**64.6**	**1.1**
Russia	27.0	29.6	30.9	32.9	34.7	36.3	37.6	37.7	0.8
Other	16.7	17.6	18.9	20.0	21.2	23.0	24.9	27.0	1.4
Non-OECD Asia	**148.1**	**159.0**	**192.8**	**223.1**	**246.1**	**264.8**	**279.4**	**282.1**	**1.9**
China	93.1	101.2	131.9	155.4	171.6	182.1	187.3	179.9	1.9
India	23.1	24.4	26.6	29.3	32.6	36.7	41.7	47.2	2.2
Other	31.8	33.4	34.4	38.4	41.9	45.9	50.4	55.0	1.7
Middle East	**26.6**	**27.8**	**32.6**	**35.1**	**37.1**	**38.9**	**40.6**	**41.8**	**1.4**
Africa	**18.4**	**18.9**	**19.6**	**21.5**	**23.4**	**25.6**	**27.9**	**30.0**	**1.6**
Central and South America	**26.9**	**28.7**	**30.9**	**32.9**	**34.7**	**37.3**	**39.9**	**42.6**	**1.3**
Brazil	12.7	13.7	14.9	16.3	17.3	18.8	20.4	22.4	1.6
Other	14.3	15.0	16.1	16.6	17.3	18.5	19.5	20.3	1.0
Total Non-OECD	**263.7**	**281.7**	**325.8**	**365.6**	**397.2**	**425.8**	**450.2**	**461.2**	**1.7**
Total World	**498.4**	**523.9**	**568.1**	**615.7**	**653.2**	**686.4**	**715.9**	**733.1**	**1.1**

[a]Includes the 50 States and the District of Columbia.
Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run LOWMACRO.D110912A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table C2. World total energy consumption by region and fuel, Low Economic Growth case, 2009-2040
(quadrillion Btu)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas									
Liquids	45.5	46.4	45.4	44.8	43.7	42.7	42.6	43.2	-0.2
Natural gas	28.9	29.9	31.9	33.4	34.7	35.9	38.0	40.4	1.0
Coal	21.3	22.5	19.2	18.9	19.4	19.9	20.3	20.6	-0.3
Nuclear	9.4	9.5	9.8	10.2	10.8	11.0	10.7	10.7	0.4
Other	11.9	11.9	13.7	14.7	15.5	16.4	17.4	19.0	1.6
Total	**117.0**	**120.2**	**119.9**	**122.1**	**124.1**	**125.9**	**129.0**	**133.9**	**0.4**
OECD Europe									
Liquids	30.8	30.6	27.9	28.3	28.2	28.2	28.3	28.3	-0.3
Natural gas	19.3	20.4	20.3	21.0	21.4	22.5	23.6	24.8	0.7
Coal	11.9	12.2	12.1	11.9	11.6	11.3	11.0	10.6	-0.5
Nuclear	8.6	8.9	9.2	9.6	10.8	11.0	11.1	11.1	0.7
Other	9.4	10.4	12.6	14.6	16.1	17.1	17.7	18.2	1.9
Total	**80.0**	**82.5**	**82.1**	**85.3**	**88.0**	**90.1**	**91.6**	**93.0**	**0.4**
OECD Asia									
Liquids	15.5	15.8	16.8	16.6	16.4	16.2	16.0	15.6	0.0
Natural gas	6.6	7.2	7.7	8.2	8.9	9.3	9.9	10.3	1.2
Coal	9.4	10.1	10.1	10.0	9.9	9.7	9.6	9.3	-0.3
Nuclear	4.1	4.2	3.0	4.5	5.0	5.6	5.7	5.9	1.1
Other	2.1	2.3	2.8	3.4	3.7	3.7	3.9	3.9	1.8
Total	**37.7**	**39.6**	**40.3**	**42.7**	**43.9**	**44.6**	**45.0**	**45.0**	**0.4**
Total OECD									
Liquids	91.8	92.8	90.0	89.7	88.2	87.1	86.9	87.1	-0.2
Natural gas	54.8	57.5	59.8	62.6	65.0	67.8	71.6	75.5	0.9
Coal	42.5	44.8	41.4	40.8	40.9	40.9	40.9	40.5	-0.3
Nuclear	22.1	22.6	22.0	24.3	26.5	27.6	27.4	27.6	0.7
Other	23.4	24.6	29.1	32.7	35.3	37.2	38.9	41.2	1.7
Total	**234.7**	**242.3**	**242.3**	**250.1**	**256.0**	**260.5**	**265.6**	**271.9**	**0.4**
Non-OECD									
Non-OECD Europe and Eurasia									
Liquids	9.7	9.7	11.7	11.8	12.0	12.6	13.1	13.5	1.1
Natural gas	20.2	22.3	22.0	23.5	25.2	26.9	28.5	29.5	0.9
Coal	7.7	8.9	8.9	9.3	9.6	9.8	10.0	10.0	0.4
Nuclear	3.0	3.0	3.7	4.5	5.1	5.7	6.3	6.7	2.7
Other	3.1	3.2	3.5	3.8	4.0	4.2	4.6	4.9	1.4
Total	**43.7**	**47.2**	**49.8**	**52.9**	**55.9**	**59.3**	**62.5**	**64.6**	**1.1**
Non-OECD Asia									
Liquids	37.9	40.6	45.9	51.3	55.5	58.8	62.3	65.6	1.6
Natural gas	12.6	14.2	16.2	19.1	22.6	26.5	30.5	33.6	2.9
Coal	83.7	88.4	106.8	117.7	126.4	131.0	131.6	124.3	1.1
Nuclear	1.3	1.4	4.2	8.1	10.9	13.8	16.6	18.5	9.1
Other	12.6	14.4	19.7	27.0	30.7	34.8	38.3	40.2	3.5
Total	**148.1**	**159.0**	**192.8**	**223.1**	**246.1**	**264.8**	**279.4**	**282.1**	**1.9**

See notes at end ot table.

(continued on page 205)

Table C2. World total energy consumption by region and fuel, Low Economic Growth case, 2009-2040 (continued)
(quadrillion Btu)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
Middle East									
Liquids	13.4	13.8	16.4	16.7	16.6	16.8	17.0	17.2	0.7
Natural gas	12.9	13.7	15.8	17.4	19.1	20.5	21.5	22.5	1.7
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.9
Nuclear	0.0	0.0	0.1	0.4	0.7	1.0	1.2	1.2	--
Other	0.1	0.2	0.3	0.5	0.6	0.6	0.9	0.9	5.4
Total	**26.6**	**27.8**	**32.6**	**35.1**	**37.1**	**38.9**	**40.6**	**41.8**	**1.4**
Africa									
Liquids	6.6	6.9	7.2	7.3	7.5	7.8	8.0	8.2	0.6
Natural gas	3.6	3.7	3.9	4.4	5.0	5.9	6.9	8.1	2.6
Coal	4.4	4.4	4.6	5.1	5.5	5.7	5.8	5.9	1.0
Nuclear	0.1	0.1	0.2	0.2	0.4	0.7	0.9	0.9	6.8
Other	3.7	3.9	3.8	4.6	5.0	5.6	6.2	6.9	2.0
Total	**18.4**	**18.9**	**19.6**	**21.5**	**23.4**	**25.6**	**27.9**	**30.0**	**1.6**
Central and South America									
Liquids	11.8	12.3	13.2	13.4	13.6	14.3	14.8	15.3	0.7
Natural gas	4.6	5.3	5.7	6.2	6.9	7.5	8.1	8.7	1.7
Coal	0.7	0.9	1.0	1.1	1.2	1.2	1.3	1.4	1.5
Nuclear	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.8	4.4
Other	9.7	10.0	10.7	11.7	12.4	13.5	14.8	16.4	1.7
Total	**26.9**	**28.7**	**30.9**	**32.9**	**34.7**	**37.3**	**39.9**	**42.6**	**1.3**
Total Non-OECD									
Liquids	79.5	83.3	94.4	100.5	105.3	110.3	115.3	119.8	1.2
Natural gas	53.9	59.3	63.5	70.7	78.7	87.2	95.4	102.5	1.8
Coal	96.6	102.6	121.4	133.3	142.7	147.8	148.8	141.7	1.1
Nuclear	4.6	4.7	8.4	13.5	17.7	21.8	25.9	28.1	6.1
Other	29.2	31.7	38.0	47.6	52.7	58.8	64.8	69.2	2.6
Total	**263.7**	**281.7**	**325.8**	**365.6**	**397.2**	**425.8**	**450.2**	**461.2**	**1.7**
Total World									
Liquids	171.3	176.1	184.5	190.2	193.5	197.4	202.1	206.9	0.5
Natural gas	108.7	116.8	123.3	133.3	143.7	154.9	167.0	177.9	1.4
Coal	139.1	147.4	162.8	174.1	183.7	188.6	189.7	182.2	0.7
Nuclear	26.7	27.3	30.4	37.8	44.2	49.4	53.3	55.7	2.4
Other	52.6	56.2	67.1	80.4	88.0	95.9	103.8	110.4	2.3
Total	**498.4**	**523.9**	**568.1**	**615.7**	**653.2**	**686.4**	**715.9**	**733.1**	**1.1**

Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run LOWMACRO.D110912A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table C3. World gross domestic product (GDP) by region expressed in purchasing power parity, Low Economic Growth case, 2009-2040
(billion 2005 dollars)

	History		Projections						Average annual percent change, 2010-2040
Region	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**15,498**	**15,929**	**17,783**	**19,679**	**21,675**	**23,949**	**26,819**	**30,292**	**2.2**
United States[a]	12,758	13,063	14,387	15,717	17,103	18,703	20,767	23,283	1.9
Canada	1,165	1,202	1,348	1,517	1,679	1,841	2,036	2,251	2.1
Mexico/Chile	1,575	1,664	2,048	2,445	2,893	3,405	4,016	4,759	3.6
OECD Europe	**14,262**	**14,618**	**15,541**	**17,180**	**18,874**	**20,455**	**22,142**	**23,956**	**1.7**
OECD Asia	**5,791**	**6,062**	**6,714**	**7,357**	**7,937**	**8,425**	**8,943**	**9,463**	**1.5**
Japan	3,776	3,948	4,208	4,400	4,547	4,585	4,596	4,501	0.4
South Korea	1,244	1,323	1,596	1,947	2,280	2,616	2,989	3,435	3.2
Australia/NewZealand	771	790	910	1,010	1,111	1,223	1,359	1,527	2.2
Total OECD	**35,551**	**36,609**	**40,038**	**44,215**	**48,486**	**52,829**	**57,904**	**63,711**	**1.9**
Non-OECD									
Non-OECD Europe and Eurasia	**4,346**	**4,502**	**5,451**	**6,782**	**8,192**	**9,688**	**11,397**	**13,153**	**3.6**
Russia	1,938	2,022	2,426	2,922	3,371	3,728	4,054	4,201	2.5
Other	2,408	2,480	3,025	3,860	4,821	5,961	7,343	8,953	4.4
Non-OECD Asia	**16,628**	**18,206**	**25,393**	**33,035**	**41,412**	**50,860**	**60,762**	**70,340**	**4.6**
China	8,299	9,167	13,587	17,807	22,399	27,424	32,168	35,880	4.7
India	3,364	3,661	5,045	6,934	9,066	11,548	14,376	17,505	5.4
Other	4,965	5,379	6,761	8,294	9,946	11,888	14,219	16,955	3.9
Middle East	**2,263**	**2,292**	**2,775**	**3,263**	**3,508**	**3,653**	**3,712**	**3,622**	**1.5**
Africa	**3,780**	**3,963**	**4,861**	**6,113**	**7,596**	**9,450**	**11,738**	**14,541**	**4.4**
Central and South America	**4,623**	**4,927**	**6,004**	**7,132**	**8,249**	**9,425**	**10,723**	**12,173**	**3.1**
Brazil	1,833	1,971	2,359	2,824	3,221	3,660	4,170	4,740	3.0
Other	2,790	2,955	3,644	4,307	5,028	5,765	6,553	7,433	3.1
Total Non-OECD	**31,640**	**33,889**	**44,483**	**56,325**	**68,956**	**83,077**	**98,332**	**113,828**	**4.1**
Total World	**67,192**	**70,498**	**84,522**	**100,540**	**117,442**	**135,906**	**156,236**	**177,539**	**3.1**

[a]Includes the 50 States and the District of Columbia.
Notes: Totals may not equal sum of components due to independent rounding. GDP growth rates for non-OECD Europe and Eurasia (excluding Russia), China, India, Africa, and Central and South America (excluding Brazil) were adjusted based on the analyst's judgment.
Sources: Derived from Oxford Economic Model (October 2012), www.oxfordeconomics.com (subscription site); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run LOWMACRO.D110912A, www.eia.gov/aeo.

Appendix D

High Oil Price case projections

- *World energy consumption*
- *Gross domestic product*

Table D1. World total primary energy consumption by region, High Oil Price case, 2009-2040
(quadrillion Btu)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**117.0**	**120.2**	**119.5**	**124.2**	**128.2**	**131.8**	**136.7**	**144.7**	**0.6**
United States[a]	94.9	97.9	96.0	99.4	100.9	101.4	103.0	107.3	0.3
Canada	13.7	13.5	13.9	14.3	15.3	16.4	17.6	19.0	1.1
Mexico/Chile	8.4	8.8	9.6	10.5	12.0	14.0	16.1	18.5	2.5
OECD Europe	**80.0**	**82.5**	**80.5**	**83.3**	**86.3**	**88.6**	**90.5**	**92.3**	**0.4**
OECD Asia	**37.7**	**39.6**	**39.3**	**41.1**	**42.4**	**43.5**	**44.3**	**44.5**	**0.4**
Japan	21.0	22.1	21.0	21.6	21.9	22.0	21.8	21.0	-0.2
South Korea	10.1	10.8	11.5	12.5	13.3	14.2	14.9	15.7	1.3
Australia/NewZealand	6.7	6.7	6.8	7.0	7.2	7.3	7.5	7.8	0.5
Total OECD	**234.7**	**242.3**	**239.2**	**248.6**	**256.9**	**263.9**	**271.5**	**281.5**	**0.5**
Non-OECD									
Non-OECD Europe and Eurasia	**43.7**	**47.2**	**49.2**	**51.7**	**55.2**	**59.3**	**63.4**	**66.6**	**1.2**
Russia	27.0	29.6	30.5	32.0	34.3	36.6	38.7	39.9	1.0
Other	16.7	17.6	18.7	19.7	20.9	22.7	24.6	26.6	1.4
Non-OECD Asia	**148.1**	**159.0**	**188.1**	**226.2**	**266.8**	**313.9**	**366.1**	**413.6**	**3.2**
China	93.1	101.2	126.8	156.0	185.5	218.7	254.2	282.5	3.5
India	23.1	24.4	27.2	31.9	38.3	46.1	55.6	66.7	3.4
Other	31.8	33.4	34.1	38.3	43.0	49.1	56.2	64.4	2.2
Middle East	**26.6**	**27.8**	**31.8**	**35.5**	**38.7**	**42.6**	**46.5**	**51.3**	**2.1**
Africa	**18.4**	**18.9**	**19.0**	**20.7**	**23.3**	**26.6**	**30.3**	**34.5**	**2.0**
Central and South America	**26.9**	**28.7**	**30.1**	**31.6**	**33.8**	**37.4**	**41.3**	**46.0**	**1.6**
Brazil	12.7	13.7	14.4	15.5	16.9	19.1	21.8	25.3	2.1
Other	14.3	15.0	15.7	16.1	16.9	18.3	19.5	20.7	1.1
Total Non-OECD	**263.7**	**281.7**	**318.1**	**365.7**	**417.8**	**479.7**	**547.5**	**612.0**	**2.6**
Total World	**498.4**	**523.9**	**557.3**	**614.3**	**674.7**	**743.5**	**819.0**	**893.5**	**1.8**

[a]Includes the 50 States and the District of Columbia.
Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run HIGHPRICE.D110912A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table D2. World total energy consumption by region and fuel, High Oil Price case, 2009-2040
(quadrillion Btu)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
OECD									
OECD Americas									
Liquids	45.5	46.4	45.0	44.8	44.1	43.6	43.8	45.0	-0.1
Natural gas	28.9	29.9	31.9	34.0	36.2	38.4	40.7	43.0	1.2
Coal	21.3	22.5	19.3	20.2	21.1	21.7	22.2	22.6	0.0
Nuclear	9.4	9.5	9.8	10.3	10.9	11.1	11.1	12.4	0.9
Other	11.9	11.9	13.6	15.0	15.9	17.0	18.9	21.8	2.0
Total	**117.0**	**120.2**	**119.5**	**124.2**	**128.2**	**131.8**	**136.7**	**144.7**	**0.6**
OECD Europe									
Liquids	30.8	30.6	27.3	27.1	27.1	27.3	27.6	27.8	-0.3
Natural gas	19.3	20.4	19.9	20.4	20.8	22.1	23.2	24.5	0.6
Coal	11.9	12.2	11.9	11.6	11.3	11.0	10.7	10.4	-0.5
Nuclear	8.6	8.9	9.2	9.6	10.8	11.0	11.1	11.1	0.7
Other	9.4	10.4	12.3	14.6	16.4	17.2	17.9	18.5	2.0
Total	**80.0**	**82.5**	**80.5**	**83.3**	**86.3**	**88.6**	**90.5**	**92.3**	**0.4**
OECD Asia									
Liquids	15.5	15.8	16.4	15.7	15.5	15.5	15.5	15.2	-0.1
Natural gas	6.6	7.2	7.4	7.9	8.6	9.1	9.7	10.1	1.2
Coal	9.4	10.1	9.9	9.8	9.7	9.5	9.5	9.4	-0.2
Nuclear	4.1	4.2	2.9	4.5	5.0	5.6	5.7	5.9	1.1
Other	2.1	2.3	2.7	3.2	3.6	3.7	3.9	4.0	1.8
Total	**37.7**	**39.6**	**39.3**	**41.1**	**42.4**	**43.5**	**44.3**	**44.5**	**0.4**
Total OECD									
Liquids	91.8	92.8	88.6	87.6	86.7	86.4	86.9	87.9	-0.2
Natural gas	54.8	57.5	59.2	62.3	65.6	69.6	73.6	77.6	1.0
Coal	42.5	44.8	41.0	41.5	42.1	42.2	42.3	42.4	-0.2
Nuclear	22.1	22.6	21.9	24.4	26.6	27.7	27.9	29.3	0.9
Other	23.4	24.6	28.5	32.8	35.9	38.0	40.7	44.3	2.0
Total	**234.7**	**242.3**	**239.2**	**248.6**	**256.9**	**263.9**	**271.5**	**281.5**	**0.5**
Non-OECD									
Non-OECD Europe and Eurasia									
Liquids	9.7	9.7	11.6	11.4	11.7	12.4	13.0	13.6	1.1
Natural gas	20.2	22.3	21.8	23.1	25.0	27.1	29.1	30.6	1.1
Coal	7.7	8.9	8.7	8.9	9.4	9.7	10.2	10.4	0.5
Nuclear	3.0	3.0	3.7	4.5	5.1	5.7	6.3	6.7	2.7
Other	3.1	3.2	3.4	3.8	4.0	4.3	4.8	5.2	1.6
Total	**43.7**	**47.2**	**49.2**	**51.7**	**55.2**	**59.3**	**63.4**	**66.6**	**1.2**
Non-OECD Asia									
Liquids	37.9	40.6	45.5	52.2	60.2	69.2	80.2	92.6	2.8
Natural gas	12.6	14.2	16.1	19.8	24.9	31.2	37.9	43.8	3.8
Coal	83.7	88.4	102.6	118.9	139.6	163.6	188.9	208.8	2.9
Nuclear	1.3	1.4	4.2	8.1	10.9	13.8	16.6	19.4	9.3
Other	12.6	14.4	19.7	27.2	31.3	36.1	42.4	49.0	4.2
Total	**148.1**	**159.0**	**188.1**	**226.2**	**266.8**	**313.9**	**366.1**	**413.6**	**3.2**

See notes at end ot table.

(continued on page 211)

Table D2. World total energy consumption by region and fuel, High Oil Price case, 2009-2040 (continued)
(quadrillion Btu)

	History		Projections						Average annual percent change,
Region	2009	2010	2015	2020	2025	2030	2035	2040	2010-2040
Middle East									
Liquids	13.4	13.8	16.1	16.7	17.2	18.3	19.6	21.5	1.5
Natural gas	12.9	13.7	15.2	17.8	20.1	22.6	24.7	27.5	2.3
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.0
Nuclear	0.0	0.0	0.1	0.4	0.7	1.0	1.2	1.2	--
Other	0.1	0.2	0.3	0.5	0.6	0.7	0.9	1.0	5.7
Total	**26.6**	**27.8**	**31.8**	**35.5**	**38.7**	**42.6**	**46.5**	**51.3**	**2.1**
Africa									
Liquids	6.6	6.9	7.0	7.0	7.4	7.9	8.4	9.0	0.9
Natural gas	3.6	3.7	3.7	4.2	5.1	6.2	7.5	9.2	3.0
Coal	4.4	4.4	4.5	4.9	5.4	5.9	6.5	7.1	1.7
Nuclear	0.1	0.1	0.1	0.2	0.4	0.7	0.9	0.9	6.8
Other	3.7	3.9	3.6	4.4	5.0	5.9	7.0	8.2	2.5
Total	**18.4**	**18.9**	**19.0**	**20.7**	**23.3**	**26.6**	**30.3**	**34.5**	**2.0**
Central and South America									
Liquids	11.8	12.3	12.9	12.9	13.2	14.3	15.3	16.4	1.0
Natural gas	4.6	5.3	5.5	5.8	6.5	7.3	8.1	9.0	1.8
Coal	0.7	0.9	0.9	1.0	1.1	1.1	1.3	1.4	1.6
Nuclear	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.8	4.4
Other	9.7	10.0	10.4	11.6	12.4	14.0	15.9	18.3	2.0
Total	**26.9**	**28.7**	**30.1**	**31.6**	**33.8**	**37.4**	**41.3**	**46.0**	**1.6**
Total Non-OECD									
Liquids	79.5	83.3	93.2	100.1	109.6	122.1	136.6	153.3	2.1
Natural gas	53.9	59.3	62.3	70.7	81.6	94.2	107.3	120.2	2.4
Coal	96.6	102.6	116.8	133.8	155.5	180.5	206.9	227.9	2.7
Nuclear	4.6	4.7	8.4	13.5	17.7	21.8	25.9	29.0	6.2
Other	29.2	31.7	37.5	47.5	53.4	60.9	70.9	81.6	3.2
Total	**263.7**	**281.7**	**318.1**	**365.7**	**417.8**	**479.7**	**547.5**	**612.0**	**2.6**
Total World									
Liquids	171.3	176.1	181.8	187.7	196.3	208.6	223.5	241.2	1.1
Natural gas	108.7	116.8	121.4	133.1	147.2	163.9	181.0	197.8	1.8
Coal	139.1	147.4	157.8	175.3	197.6	222.7	249.2	270.2	2.0
Nuclear	26.7	27.3	30.3	37.9	44.3	49.5	53.8	58.4	2.6
Other	52.6	56.2	66.0	80.3	89.3	98.9	111.6	126.0	2.7
Total	**498.4**	**523.9**	**557.3**	**614.3**	**674.7**	**743.5**	**819.0**	**893.5**	**1.8**

Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run HIGHPRICE.D110912A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table D3. World gross domestic product (GDP) by region expressed in purchasing power parity, High Oil Price case, 2009-2040
(billion 2005 dollars)

	History		Projections						Average annual
Region	2009	2010	2015	2020	2025	2030	2035	2040	percent change, 2010-2040
OECD									
OECD Americas	**15,498**	**15,929**	**17,914**	**20,777**	**23,647**	**26,726**	**30,368**	**34,751**	**2.6**
United States[a]	12,758	13,063	14,519	16,803	19,017	21,301	23,998	27,270	2.5
Canada	1,165	1,202	1,351	1,524	1,701	1,897	2,148	2,445	2.4
Mexico/Chile	1,575	1,664	2,045	2,450	2,930	3,528	4,223	5,036	3.8
OECD Europe	**14,262**	**14,618**	**15,438**	**17,237**	**19,137**	**20,931**	**22,891**	**25,037**	**1.8**
OECD Asia	**5,791**	**6,062**	**6,712**	**7,357**	**7,970**	**8,577**	**9,184**	**9,707**	**1.6**
Japan	3,776	3,948	4,211	4,407	4,567	4,696	4,768	4,687	0.6
South Korea	1,244	1,323	1,591	1,935	2,279	2,634	3,020	3,452	3.2
Australia/NewZealand	771	790	910	1,015	1,123	1,248	1,397	1,568	2.3
Total OECD	**35,551**	**36,609**	**40,064**	**45,371**	**50,754**	**56,234**	**62,443**	**69,494**	**2.2**
Non-OECD									
Non-OECD Europe and Eurasia	**4,346**	**4,502**	**5,435**	**6,811**	**8,344**	**9,984**	**11,895**	**13,891**	**3.8**
Russia	1,938	2,022	2,455	2,944	3,496	3,975	4,450	4,788	2.9
Other	2,408	2,480	2,980	3,867	4,847	6,009	7,445	9,103	4.4
Non-OECD Asia	**16,628**	**18,206**	**25,484**	**35,168**	**47,473**	**63,673**	**82,990**	**104,043**	**6.0**
China	8,299	9,167	13,632	19,376	26,746	36,624	47,941	58,908	6.4
India	3,364	3,661	5,106	7,392	10,308	14,058	18,791	24,711	6.6
Other	4,965	5,379	6,747	8,400	10,419	12,992	16,257	20,424	4.5
Middle East	**2,263**	**2,292**	**2,785**	**3,234**	**3,637**	**4,074**	**4,445**	**4,830**	**2.5**
Africa	**3,780**	**3,963**	**4,814**	**6,096**	**7,726**	**9,831**	**12,470**	**15,810**	**4.7**
Central and South America	**4,623**	**4,927**	**5,949**	**7,078**	**8,293**	**9,700**	**11,355**	**13,327**	**3.4**
Brazil	1,833	1,971	2,346	2,804	3,288	3,927	4,743	5,761	3.6
Other	2,790	2,955	3,602	4,274	5,005	5,773	6,612	7,566	3.2
Total Non-OECD	**31,640**	**33,889**	**44,467**	**58,386**	**75,473**	**97,262**	**123,155**	**151,900**	**5.1**
Total World	**67,192**	**70,498**	**84,531**	**103,758**	**126,227**	**153,496**	**185,598**	**221,394**	**3.9**

[a]Includes the 50 States and the District of Columbia.
Notes: Totals may not equal sum of components due to independent rounding.
Sources: Derived from Oxford Economic Model (October 2012), www.oxfordeconomics.com (subscription site); U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); and AEO2013 National Energy Modeling System, run HIGHPRICE.D110912A, www.eia.gov/aeo.

Table D4. World liquids consumption by region, High Oil Price case, 2009-2040
(million barrels per day)

Region	History 2009	History 2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**23.1**	**23.5**	**23.4**	**23.5**	**23.2**	**22.9**	**22.9**	**23.5**	**0.0**
United States[a]	18.6	18.9	18.7	18.8	18.4	17.7	17.4	17.5	-0.3
Canada	2.2	2.2	2.2	2.1	2.1	2.1	2.2	2.4	0.2
Mexico/Chile	2.4	2.4	2.5	2.5	2.7	3.0	3.3	3.6	1.4
OECD Europe	**15.0**	**14.8**	**13.2**	**13.1**	**13.1**	**13.2**	**13.3**	**13.4**	**-0.3**
OECD Asia	**7.7**	**7.7**	**8.0**	**7.7**	**7.6**	**7.6**	**7.6**	**7.4**	**-0.1**
Japan	4.4	4.4	4.5	4.2	4.0	3.9	3.8	3.6	-0.7
South Korea	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	0.5
Australia/NewZealand	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	0.3
Total OECD	**45.8**	**46.0**	**44.6**	**44.3**	**43.8**	**43.6**	**43.8**	**44.3**	**-0.1**
Non-OECD									
Non-OECD Europe and Eurasia	**4.8**	**4.8**	**5.7**	**5.6**	**5.8**	**6.1**	**6.4**	**6.7**	**1.1**
Russia	2.9	3.0	3.4	3.3	3.4	3.6	3.7	3.7	0.8
Other	1.8	1.8	2.3	2.3	2.3	2.5	2.7	3.0	1.7
Non-OECD Asia	**18.4**	**19.8**	**22.2**	**25.4**	**29.3**	**33.7**	**39.1**	**45.2**	**2.8**
China	8.5	9.3	11.4	13.4	15.7	17.9	20.8	23.9	3.2
India	3.1	3.3	3.6	4.3	5.3	6.5	8.1	10.0	3.8
Other	6.7	7.2	7.1	7.7	8.4	9.3	10.2	11.3	1.5
Middle East	**6.5**	**6.7**	**7.9**	**8.1**	**8.4**	**9.0**	**9.6**	**10.5**	**1.5**
Africa	**3.3**	**3.4**	**3.5**	**3.4**	**3.6**	**3.9**	**4.2**	**4.5**	**0.9**
Central and South America	**5.7**	**6.0**	**6.3**	**6.3**	**6.5**	**7.0**	**7.5**	**8.0**	**1.0**
Brazil	2.5	2.6	2.8	2.8	2.9	3.1	3.4	3.8	1.3
Other	3.3	3.4	3.6	3.5	3.6	3.8	4.1	4.2	0.7
Total Non-OECD	**38.7**	**40.7**	**45.5**	**48.9**	**53.6**	**59.7**	**66.7**	**74.9**	**2.1**
Total World	**84.5**	**86.7**	**90.1**	**93.2**	**97.4**	**103.3**	**110.6**	**119.2**	**1.1**

[a]Includes the 50 States and the District of Columbia.
Notes: Totals may not equal sum of components due to independent rounding. GDP growth rates for non-OECD Europe and Eurasia (excluding Russia), China, India, Africa, and Central and South America (excluding Brazil) were adjusted based on the analyst's judgment.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies.
Projections: EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run HIGHPRICE.D110912A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Appendix E
Low Oil Price case projections

- *World energy consumption*
- *Gross domestic product*

Table E1. World total primary energy consumption by region, Low Oil Price case, 2009-2040
(quadrillion Btu)

	History		Projections						Average annual percent change,
Region	2009	2010	2015	2020	2025	2030	2035	2040	2010-2040
OECD									
OECD Americas	**117.0**	**120.2**	**122.3**	**128.2**	**132.1**	**135.5**	**140.0**	**146.7**	**0.7**
United States[a]	94.9	97.9	97.9	101.6	102.9	103.6	105.3	108.8	0.4
Canada	13.7	13.5	14.4	15.2	16.2	17.1	17.8	18.6	1.1
Mexico/Chile	8.4	8.8	10.0	11.4	12.9	14.8	16.8	19.3	2.7
OECD Europe	**80.0**	**82.5**	**83.1**	**88.0**	**91.8**	**94.7**	**97.4**	**100.0**	**0.6**
OECD Asia	**37.7**	**39.6**	**41.1**	**44.7**	**46.6**	**47.9**	**49.0**	**49.7**	**0.8**
Japan	21.0	22.1	22.0	23.6	24.3	24.4	24.4	23.9	0.3
South Korea	10.1	10.8	12.1	13.6	14.7	15.7	16.5	17.4	1.6
Australia/NewZealand	6.7	6.7	7.0	7.5	7.6	7.9	8.1	8.4	0.8
Total OECD	**234.7**	**242.3**	**246.6**	**260.9**	**270.5**	**278.1**	**286.4**	**296.4**	**0.7**
Non-OECD									
Non-OECD Europe and Eurasia	**43.7**	**47.2**	**50.1**	**54.1**	**57.8**	**61.8**	**65.7**	**68.5**	**1.2**
Russia	27.0	29.6	31.1	33.9	36.3	38.4	40.2	40.8	1.1
Other	16.7	17.6	19.0	20.2	21.5	23.4	25.5	27.7	1.5
Non-OECD Asia	**148.1**	**159.0**	**198.0**	**238.8**	**271.9**	**300.2**	**324.5**	**334.2**	**2.5**
China	93.1	101.2	135.4	166.0	189.6	207.1	219.1	215.9	2.6
India	23.1	24.4	27.9	33.1	38.7	44.8	51.9	59.2	3.0
Other	31.8	33.4	34.7	39.6	43.6	48.3	53.5	59.1	1.9
Middle East	**26.6**	**27.8**	**33.2**	**37.3**	**40.5**	**43.1**	**46.2**	**48.8**	**1.9**
Africa	**18.4**	**18.9**	**19.9**	**22.6**	**24.9**	**27.2**	**29.7**	**32.2**	**1.8**
Central and South America	**26.9**	**28.7**	**31.5**	**34.5**	**36.9**	**40.2**	**43.4**	**46.9**	**1.6**
Brazil	12.7	13.7	15.2	17.2	18.6	20.5	22.5	24.9	2.0
Other	14.3	15.0	16.3	17.3	18.2	19.7	20.9	22.0	1.3
Total Non-OECD	**263.7**	**281.7**	**332.7**	**387.2**	**431.8**	**472.5**	**509.6**	**530.6**	**2.1**
Total World	**498.4**	**523.9**	**579.2**	**648.1**	**702.3**	**750.6**	**795.9**	**827.0**	**1.5**

[a]Includes the 50 States and the District of Columbia.
Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run LOWPRICE.D031213A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table E2. World total energy consumption by region and fuel, Low Oil Price case, 2009-2040
(quadrillion Btu)

Region	History 2009	History 2010	Projections 2015	Projections 2020	Projections 2025	Projections 2030	Projections 2035	Projections 2040	Average annual percent change, 2010-2040
OECD									
OECD Americas									
Liquids	45.5	46.4	46.5	48.1	48.1	48.4	49.4	51.5	0.3
Natural gas	28.9	29.9	32.0	34.1	36.0	37.8	39.7	41.7	1.1
Coal	21.3	22.5	20.2	20.8	21.2	21.5	22.0	22.4	0.0
Nuclear	9.4	9.5	9.8	10.3	10.9	11.1	10.8	10.9	0.5
Other	11.9	11.9	13.8	14.9	15.9	16.8	18.1	20.3	1.8
Total	**117.0**	**120.2**	**122.3**	**128.2**	**132.1**	**135.5**	**140.0**	**146.7**	**0.7**
OECD Europe									
Liquids	30.8	30.6	28.4	30.0	30.5	31.2	32.0	32.7	0.2
Natural gas	19.3	20.4	20.6	21.6	22.0	23.5	24.9	26.4	0.9
Coal	11.9	12.2	12.3	12.2	11.9	11.7	11.4	11.1	-0.3
Nuclear	8.6	8.9	9.2	9.6	10.8	11.0	11.1	11.1	0.7
Other	9.4	10.4	12.6	14.7	16.5	17.3	18.0	18.7	2.0
Total	**80.0**	**82.5**	**83.1**	**88.0**	**91.8**	**94.7**	**97.4**	**100.0**	**0.6**
OECD Asia									
Liquids	15.5	15.8	17.1	17.8	18.1	18.3	18.5	18.5	0.5
Natural gas	6.6	7.2	7.8	8.6	9.4	10.0	10.7	11.1	1.5
Coal	9.4	10.1	10.2	10.3	10.4	10.3	10.3	10.2	0.0
Nuclear	4.1	4.2	3.0	4.5	5.0	5.6	5.7	5.9	1.1
Other	2.1	2.3	2.9	3.4	3.7	3.8	3.9	4.0	1.8
Total	**37.7**	**39.6**	**41.1**	**44.7**	**46.6**	**47.9**	**49.0**	**49.7**	**0.8**
Total OECD									
Liquids	91.8	92.8	91.9	95.9	96.8	97.9	99.9	102.7	0.3
Natural gas	54.8	57.5	60.4	64.3	67.5	71.3	75.2	79.2	1.1
Coal	42.5	44.8	42.8	43.3	43.5	43.4	43.7	43.7	-0.1
Nuclear	22.1	22.6	22.0	24.4	26.6	27.7	27.6	27.8	0.7
Other	23.4	24.6	29.4	33.1	36.1	37.9	40.1	43.0	1.9
Total	**234.7**	**242.3**	**246.6**	**260.9**	**270.5**	**278.1**	**286.4**	**296.4**	**0.7**
Non-OECD									
Non-OECD Europe and Eurasia									
Liquids	9.7	9.7	11.9	12.8	13.3	14.2	15.0	15.7	1.6
Natural gas	20.2	22.3	22.0	23.5	25.3	27.2	29.0	30.3	1.0
Coal	7.7	8.9	9.0	9.5	10.0	10.3	10.7	10.7	0.6
Nuclear	3.0	3.0	3.7	4.5	5.1	5.7	6.3	6.7	2.7
Other	3.1	3.2	3.5	3.8	4.0	4.3	4.7	5.0	1.5
Total	**43.7**	**47.2**	**50.1**	**54.1**	**57.8**	**61.8**	**65.7**	**68.5**	**1.2**
Non-OECD Asia									
Liquids	37.9	40.6	46.7	54.7	61.3	66.7	72.9	79.4	2.3
Natural gas	12.6	14.2	16.5	19.9	23.6	27.8	32.1	35.4	3.1
Coal	83.7	88.4	110.8	128.9	144.9	156.4	163.3	158.4	2.0
Nuclear	1.3	1.4	4.2	8.1	10.9	13.8	16.6	18.8	9.1
Other	12.6	14.4	19.8	27.3	31.2	35.5	39.6	42.2	3.7
Total	**148.1**	**159.0**	**198.0**	**238.8**	**271.9**	**300.2**	**324.5**	**334.2**	**2.5**

See notes at end ot table.

(continued on page 219)

Table E2. World total energy consumption by region and fuel, Low Oil Price case, 2009-2040 (continued)
(quadrillion Btu)

	History		Projections						Average annual percent change, 2010-2040
Region	2009	2010	2015	2020	2025	2030	2035	2040	
Middle East									
Liquids	13.4	13.8	16.5	17.7	18.2	18.7	19.6	20.5	1.3
Natural gas	12.9	13.7	16.2	18.6	20.9	22.7	24.4	26.2	2.2
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.4
Nuclear	0.0	0.0	0.1	0.4	0.7	1.0	1.2	1.2	--
Other	0.1	0.2	0.3	0.5	0.6	0.7	0.9	0.9	5.5
Total	**26.6**	**27.8**	**33.2**	**37.3**	**40.5**	**43.1**	**46.2**	**48.8**	**1.9**
Africa									
Liquids	6.6	6.9	7.3	7.7	8.1	8.4	8.8	9.2	1.0
Natural gas	3.6	3.7	3.9	4.6	5.2	6.0	6.9	8.2	2.6
Coal	4.4	4.4	4.7	5.5	6.0	6.3	6.6	6.8	1.5
Nuclear	0.1	0.1	0.2	0.2	0.4	0.7	0.9	0.9	6.8
Other	3.7	3.9	3.9	4.8	5.2	5.8	6.5	7.2	2.1
Total	**18.4**	**18.9**	**19.9**	**22.6**	**24.9**	**27.2**	**29.7**	**32.2**	**1.8**
Central and South America									
Liquids	11.8	12.3	13.4	14.3	14.9	15.9	16.7	17.6	1.2
Natural gas	4.6	5.3	5.9	6.7	7.5	8.2	8.9	9.7	2.0
Coal	0.7	0.9	1.1	1.2	1.3	1.4	1.6	1.7	2.1
Nuclear	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.8	4.4
Other	9.7	10.0	10.8	11.9	12.7	13.9	15.4	17.1	1.8
Total	**26.9**	**28.7**	**31.5**	**34.5**	**36.9**	**40.2**	**43.4**	**46.9**	**1.6**
Total Non-OECD									
Liquids	79.5	83.3	95.9	107.2	115.7	124.0	133.1	142.4	1.8
Natural gas	53.9	59.3	64.4	73.2	82.4	91.9	101.5	109.7	2.1
Coal	96.6	102.6	125.6	145.2	162.3	174.6	182.1	177.7	1.8
Nuclear	4.6	4.7	8.4	13.5	17.7	21.8	25.9	28.4	6.2
Other	29.2	31.7	38.3	48.2	53.7	60.2	67.0	72.4	2.8
Total	**263.7**	**281.7**	**332.7**	**387.2**	**431.8**	**472.5**	**509.6**	**530.6**	**2.1**
Total World									
Liquids	171.3	176.1	187.8	203.0	212.5	221.9	232.9	245.1	1.1
Natural gas	108.7	116.8	124.8	137.5	149.9	163.2	176.7	188.9	1.6
Coal	139.1	147.4	168.4	188.5	205.9	218.0	225.9	221.4	1.4
Nuclear	26.7	27.3	30.4	37.9	44.3	49.5	53.4	56.2	2.4
Other	52.6	56.2	67.8	81.3	89.7	98.0	107.1	115.4	2.4
Total	**498.4**	**523.9**	**579.2**	**648.1**	**702.3**	**750.6**	**795.9**	**827.0**	**1.5**

Notes: Energy totals include net imports of coal coke and electricity generated from biomass in the United States. Totals may not equal sum of components due to independent rounding. The electricity portion of the national fuel consumption values consists of generation for domestic use plus an adjustment for electricity trade based on a fuel's share of total generation in the exporting country.

Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run LOWPRICE.D031213A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table E3. World gross domestic product (GDP) by region expressed in purchasing power parity, Low Oil Price case, 2009-2040
(billion 2005 dollars)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**15,498**	**15,929**	**18,156**	**20,912**	**23,616**	**26,683**	**30,239**	**34,405**	**2.6**
United States[a]	12,758	13,063	14,756	16,932	19,022	21,437	24,216	27,460	2.5
Canada	1,165	1,202	1,348	1,519	1,677	1,830	2,007	2,192	2.0
Mexico/Chile	1,575	1,664	2,052	2,461	2,917	3,417	4,017	4,753	3.6
OECD Europe	**14,262**	**14,618**	**15,665**	**17,467**	**19,331**	**21,122**	**23,077**	**25,229**	**1.8**
OECD Asia	**5,791**	**6,062**	**6,728**	**7,416**	**8,045**	**8,556**	**9,130**	**9,734**	**1.6**
Japan	3,776	3,948	4,216	4,449	4,637	4,690	4,747	4,742	0.6
South Korea	1,244	1,323	1,602	1,958	2,297	2,640	3,020	3,465	3.3
Australia/NewZealand	771	790	910	1,009	1,112	1,226	1,363	1,528	2.2
Total OECD	**35,551**	**36,609**	**40,550**	**45,795**	**50,993**	**56,361**	**62,447**	**69,368**	**2.2**
Non-OECD									
Non-OECD Europe and Eurasia	**4,346**	**4,502**	**5,453**	**6,814**	**8,263**	**9,829**	**11,570**	**13,371**	**3.7**
Russia	1,938	2,022	2,405	2,925	3,406	3,818	4,186	4,373	2.6
Other	2,408	2,480	3,048	3,889	4,858	6,011	7,384	8,998	4.4
Non-OECD Asia	**16,628**	**18,206**	**25,604**	**33,845**	**43,182**	**53,708**	**65,052**	**76,332**	**4.9**
China	8,299	9,167	13,711	18,300	23,573	29,313	34,971	39,665	5.0
India	3,364	3,661	5,086	7,105	9,406	12,124	15,278	18,848	5.6
Other	4,965	5,379	6,808	8,439	10,203	12,270	14,803	17,818	4.1
Middle East	**2,263**	**2,292**	**2,774**	**3,374**	**3,716**	**3,921**	**4,115**	**4,145**	**2.0**
Africa	**3,780**	**3,963**	**4,891**	**6,213**	**7,731**	**9,623**	**11,965**	**14,870**	**4.5**
Central and South America	**4,623**	**4,927**	**6,047**	**7,263**	**8,479**	**9,736**	**11,114**	**12,663**	**3.2**
Brazil	1,833	1,971	2,371	2,886	3,337	3,807	4,343	4,950	3.1
Other	2,790	2,955	3,676	4,377	5,142	5,929	6,771	7,713	3.2
Total Non-OECD	**31,640**	**33,889**	**44,769**	**57,509**	**71,371**	**86,817**	**103,816**	**121,382**	**4.3**
Total World	**67,192**	**70,498**	**85,319**	**103,305**	**122,363**	**143,177**	**166,262**	**190,750**	**3.4**

[a]Includes the 50 States and the District of Columbia.
Notes: Totals may not equal sum of components due to independent rounding.
Sources: Derived from Oxford Economic Model (October 2012), www.oxfordeconomics.com (subscription site); and U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); and AEO2013 National Energy Modeling System, run LOWPRICE.D031213A, www.eia.gov/aeo.

Table E4. World liquids consumption by region, Low Oil Price case, 2009-2040
(million barrels per day)

Region	History 2009	History 2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**23.1**	**23.5**	**24.2**	**25.1**	**25.2**	**25.2**	**25.7**	**26.7**	**0.4**
United States[a]	18.6	18.9	19.4	20.0	19.8	19.6	19.7	20.2	0.2
Canada	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.5	0.4
Mexico/Chile	2.4	2.4	2.5	2.8	3.0	3.3	3.6	4.0	1.7
OECD Europe	**15.0**	**14.8**	**13.7**	**14.5**	**14.7**	**15.1**	**15.4**	**15.8**	**0.2**
OECD Asia	**7.7**	**7.7**	**8.3**	**8.7**	**8.9**	**8.9**	**9.0**	**9.1**	**0.5**
Japan	4.4	4.4	4.7	4.8	4.8	4.7	4.6	4.5	0.1
South Korea	2.2	2.3	2.5	2.7	2.9	3.0	3.1	3.2	1.2
Australia/NewZealand	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	0.8
Total OECD	**45.8**	**46.0**	**46.2**	**48.3**	**48.8**	**49.2**	**50.2**	**51.5**	**0.4**
Non-OECD									
Non-OECD Europe and Eurasia	**4.8**	**4.8**	**5.9**	**6.3**	**6.6**	**7.0**	**7.4**	**7.7**	**1.6**
Russia	2.9	3.0	3.5	3.8	3.9	4.1	4.3	4.3	1.2
Other	1.8	1.8	2.4	2.5	2.6	2.9	3.1	3.4	2.2
Non-OECD Asia	**18.4**	**19.8**	**22.8**	**26.6**	**29.8**	**32.5**	**35.5**	**38.7**	**2.3**
China	8.5	9.3	11.7	13.9	15.5	16.5	17.7	18.8	2.4
India	3.1	3.3	3.8	4.6	5.5	6.5	7.6	8.9	3.4
Other	6.7	7.2	7.3	8.2	8.8	9.5	10.2	11.0	1.4
Middle East	**6.5**	**6.7**	**8.1**	**8.6**	**8.9**	**9.2**	**9.6**	**10.0**	**1.3**
Africa	**3.3**	**3.4**	**3.6**	**3.8**	**4.0**	**4.2**	**4.3**	**4.5**	**1.0**
Central and South America	**5.7**	**6.0**	**6.6**	**7.0**	**7.3**	**7.8**	**8.2**	**8.6**	**1.2**
Brazil	2.5	2.6	2.9	3.2	3.3	3.5	3.6	3.9	1.3
Other	3.3	3.4	3.7	3.8	4.0	4.3	4.5	4.7	1.1
Total Non-OECD	**38.7**	**40.7**	**46.9**	**52.4**	**56.6**	**60.6**	**65.0**	**69.6**	**1.8**
Total World	**84.5**	**86.7**	**93.1**	**100.7**	**105.3**	**109.9**	**115.2**	**121.1**	**1.1**

[a]Includes the 50 States and the District of Columbia.
Notes: Totals may not equal sum of components due to independent rounding. GDP growth rates for non-OECD Europe and Eurasia (excluding Russia), China, India, Africa, and Central and South America (excluding Brazil) were adjusted based on the analyst's judgment.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run LOWPRICE.D031213A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Appendix F

Reference case projections by end-use sector and country grouping

Table F1. Total world delivered energy consumption by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	9.5	9.5	9.1	8.9	8.7	8.5	8.3	-0.4
Natural gas	19.9	20.8	22.6	24.8	27.1	29.0	30.8	1.5
Coal	4.6	4.4	4.5	4.5	4.4	4.4	4.3	-0.3
Electricity	17.6	20.1	23.1	26.4	30.0	33.9	38.0	2.6
Total	**52.0**	**55.1**	**59.8**	**65.0**	**70.8**	**76.3**	**81.8**	**1.5**
Commercial								
Liquids	4.5	4.2	4.2	4.2	4.1	4.0	3.9	-0.4
Natural gas	8.4	8.8	9.4	10.2	11.1	11.8	12.4	1.3
Coal	1.2	1.2	1.2	1.3	1.3	1.4	1.4	0.5
Electricity	14.8	16.5	18.6	21.3	24.3	27.5	31.1	2.5
Total	**28.9**	**30.8**	**33.6**	**37.1**	**40.9**	**44.8**	**49.0**	**1.8**
Industrial								
Liquids	57.2	61.6	66.4	70.1	74.2	78.2	82.1	1.2
Natural gas	45.5	48.8	54.3	59.0	63.4	67.8	71.7	1.5
Coal	52.9	61.7	70.1	76.2	80.2	81.9	79.6	1.4
Electricity	29.2	34.2	39.4	43.3	46.5	49.0	50.0	1.8
Total	**200.0**	**221.4**	**246.7**	**266.4**	**283.5**	**297.9**	**306.9**	**1.4**
Transportation								
Liquids	96.1	101.4	107.1	111.5	116.7	123.5	131.7	1.1
Natural gas	3.8	3.7	3.9	4.2	4.7	5.3	6.0	1.6
Coal	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-10.3
Electricity	1.0	1.1	1.2	1.3	1.4	1.5	1.7	1.8
Total	**101.0**	**106.2**	**112.2**	**117.0**	**122.8**	**130.4**	**139.5**	**1.1**
All end-use sectors								
Liquids	167.3	176.7	186.8	194.6	203.7	214.3	226.1	1.0
Natural gas	77.6	82.1	90.3	98.3	106.3	114.0	121.0	1.5
Coal	58.8	67.3	75.8	82.0	86.0	87.6	85.3	1.2
Electricity	62.6	71.8	82.4	92.4	102.2	111.9	120.7	2.2
Delivered energy	**382.0**	**413.6**	**452.3**	**485.5**	**518.0**	**549.5**	**577.1**	**1.4**
Electricity-related losses	141.9	158.4	177.6	194.9	211.2	227.7	242.5	1.8
Total	**523.9**	**572.0**	**629.8**	**680.4**	**729.2**	**777.1**	**819.6**	**1.5**
Electric power[a]								
Liquids	8.8	8.8	7.9	7.5	7.2	6.8	6.5	-1.0
Natural gas	39.2	42.1	45.7	50.2	56.3	63.5	70.3	2.0
Coal	88.6	97.2	104.5	114.0	121.9	129.1	134.2	1.4
Nuclear	27.3	30.4	37.9	44.3	49.5	53.5	57.2	2.5
Total	**204.5**	**230.2**	**259.9**	**287.2**	**313.4**	**339.6**	**363.2**	**1.9**
Total energy consumption								
Liquids	176.1	185.5	194.7	202.1	210.9	221.1	232.6	0.9
Natural gas	116.8	124.2	136.0	148.5	162.6	177.4	191.3	1.7
Coal	147.4	164.6	180.3	196.0	207.9	216.7	219.5	1.3
Nuclear	27.3	30.4	37.9	44.3	49.5	53.5	57.2	2.5
Total	**523.9**	**572.0**	**629.8**	**680.4**	**729.2**	**777.1**	**819.6**	**1.5**

[a]Fuel inputs used in the production of electricity and heat at central-station generators.

Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table F2. Total OECD delivered energy consumption by end-use sector and fuel, 2010-2040
(quadrillion Btu)

		Projections						Average annual percent change,
Sector/fuel	2010	2015	2020	2025	2030	2035	2040	2010-2040
Residential								
Liquids	4.3	4.0	3.9	3.8	3.7	3.5	3.4	-0.8
Natural gas	12.0	11.9	12.2	12.5	12.8	12.9	12.9	0.3
Coal	0.8	0.8	0.7	0.7	0.7	0.6	0.6	-1.4
Electricity	10.6	11.1	11.7	12.5	13.2	13.9	14.6	1.1
Total	**28.2**	**28.1**	**29.0**	**29.9**	**30.8**	**31.3**	**32.0**	**0.4**
Commercial								
Liquids	2.6	2.4	2.4	2.3	2.3	2.2	2.2	-0.7
Natural gas	6.8	7.0	7.3	7.6	8.0	8.2	8.4	0.7
Coal	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-0.9
Electricity	10.4	11.2	12.0	12.9	13.9	14.8	15.7	1.4
Total	**20.2**	**20.9**	**22.0**	**23.2**	**24.4**	**25.5**	**26.5**	**0.9**
Industrial								
Liquids	27.4	27.5	29.3	30.3	31.0	31.7	32.6	0.6
Natural gas	19.4	20.2	21.7	22.7	23.5	24.3	25.2	0.9
Coal	8.7	8.7	9.0	9.2	9.2	9.2	9.2	0.2
Electricity	11.0	11.3	12.0	12.4	12.6	12.9	13.2	0.6
Total	**71.9**	**72.9**	**77.5**	**80.4**	**82.2**	**84.4**	**87.1**	**0.6**
Transportation								
Liquids	56.5	54.6	54.4	53.2	52.6	52.6	52.8	-0.2
Natural gas	1.0	1.0	1.1	1.1	1.3	1.7	2.2	2.7
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
Electricity	0.4	0.4	0.4	0.5	0.5	0.5	0.6	1.3
Total	**57.9**	**56.0**	**55.9**	**54.8**	**54.5**	**54.8**	**55.5**	**-0.1**
All end-use sectors								
Liquids	90.9	88.5	89.9	89.6	89.5	90.0	91.0	0.0
Natural gas	39.2	40.1	42.3	44.1	45.6	47.0	48.6	0.7
Coal	9.8	9.7	9.9	10.1	10.1	10.0	9.9	0.1
Electricity	32.4	33.9	36.1	38.3	40.2	42.1	44.1	1.0
Delivered energy	**178.1**	**177.9**	**184.3**	**188.3**	**191.9**	**196.0**	**201.2**	**0.4**
Electricity-related losses	64.1	66.2	70.2	74.4	77.3	80.1	83.4	0.9
Total	**242.2**	**244.1**	**254.6**	**262.7**	**269.2**	**276.1**	**284.6**	**0.5**
Electric power[a]								
Liquids	1.9	2.1	1.5	1.5	1.4	1.3	1.3	-1.2
Natural gas	18.3	20.0	21.1	22.3	24.5	27.3	29.6	1.6
Coal	35.1	32.5	32.4	32.7	32.7	32.8	32.7	-0.2
Nuclear	22.6	22.0	24.4	26.6	27.7	27.6	28.1	0.7
Total	**96.5**	**100.1**	**106.4**	**112.6**	**117.5**	**122.2**	**127.5**	**0.9**
Total energy consumption								
Liquids	92.8	90.6	91.4	91.0	90.9	91.4	92.3	0.0
Natural gas	57.5	60.1	63.4	66.3	70.0	74.2	78.2	1.0
Coal	44.8	42.2	42.3	42.8	42.7	42.8	42.7	-0.2
Nuclear	22.6	22.0	24.4	26.6	27.7	27.6	28.1	0.7
Total	**242.2**	**244.1**	**254.6**	**262.7**	**269.2**	**276.1**	**284.6**	**0.5**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table F3. Delivered energy consumption in the United States by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	1.1	1.1	1.0	1.0	0.9	0.9	0.9	-1.0
Natural gas	4.9	4.8	4.6	4.5	4.5	4.3	4.2	-0.5
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.6
Electricity	4.9	4.7	4.8	5.1	5.4	5.7	6.0	0.7
Total	**11.4**	**11.0**	**11.0**	**11.0**	**11.2**	**11.4**	**11.6**	**0.1**
Commercial								
Liquids	0.7	0.7	0.7	0.6	0.6	0.6	0.6	-0.3
Natural gas	3.2	3.4	3.4	3.4	3.5	3.6	3.7	0.5
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.7
Electricity	4.5	4.5	4.7	5.0	5.2	5.5	5.7	0.8
Total	**8.6**	**8.8**	**8.9**	**9.2**	**9.5**	**9.9**	**10.2**	**0.6**
Industrial								
Liquids	8.4	8.2	8.7	8.7	8.6	8.6	8.7	0.1
Natural gas	8.0	8.7	9.6	9.8	9.9	10.1	10.4	0.9
Coal	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.0
Electricity	3.3	3.6	4.0	4.0	4.0	3.9	3.9	0.6
Total	**23.6**	**24.5**	**26.3**	**26.9**	**26.9**	**27.3**	**28.2**	**0.6**
Transportation								
Liquids	26.8	26.4	26.4	25.8	25.2	25.0	25.2	-0.2
Natural gas	0.7	0.8	0.8	0.8	1.0	1.4	1.8	3.2
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.1	0.1	3.8
Total	**27.5**	**27.1**	**27.2**	**26.7**	**26.2**	**26.4**	**27.1**	**-0.1**
All end-use sectors								
Liquids	37.0	36.4	36.8	36.1	35.4	35.2	35.4	-0.1
Natural gas	16.8	17.6	18.4	18.7	18.9	19.4	20.1	0.6
Coal	1.7	1.7	1.6	1.7	1.6	1.6	1.7	0.0
Electricity	12.8	12.8	13.5	14.1	14.6	15.1	15.7	0.7
Delivered energy	**71.1**	**71.3**	**73.5**	**73.8**	**73.9**	**74.9**	**77.2**	**0.3**
Electricity-related losses	26.9	25.9	27.0	27.9	28.4	29.0	30.0	0.4
Total	**97.9**	**97.3**	**100.5**	**101.8**	**102.3**	**103.9**	**107.2**	**0.3**
Electric power[a]								
Liquids	0.4	0.2	0.2	0.2	0.2	0.2	0.2	-2.4
Natural gas	7.6	8.3	8.4	8.6	9.1	9.6	9.7	0.8
Coal	19.1	16.5	16.9	17.7	18.1	18.5	18.7	-0.1
Nuclear	8.4	8.6	9.2	9.5	9.5	9.1	9.4	0.4
Total	**39.7**	**38.8**	**40.6**	**42.1**	**43.0**	**44.1**	**45.7**	**0.5**
Total energy consumption								
Liquids	37.4	36.6	37.0	36.3	35.6	35.3	35.6	-0.2
Natural gas	24.3	25.9	26.8	27.3	28.0	29.1	29.8	0.7
Coal	20.8	18.2	18.6	19.3	19.7	20.1	20.4	-0.1
Nuclear	8.4	8.6	9.2	9.5	9.5	9.1	9.4	0.4
Total	**97.9**	**97.3**	**100.5**	**101.8**	**102.3**	**103.9**	**107.2**	**0.3**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table F4. Delivered energy consumption in Canada by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Natural gas	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.4
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.5
Electricity	0.5	0.6	0.6	0.7	0.7	0.8	0.8	1.4
Total	**1.1**	**1.2**	**1.2**	**1.3**	**1.4**	**1.4**	**1.5**	**0.8**
Commercial								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.3
Natural gas	0.4	0.4	0.4	0.5	0.5	0.5	0.5	1.1
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.5	0.6	0.7	0.7	0.8	0.9	1.0	2.3
Total	**1.0**	**1.1**	**1.2**	**1.3**	**1.4**	**1.6**	**1.7**	**1.7**
Industrial								
Liquids	1.7	1.9	1.9	2.0	2.1	2.3	2.4	1.2
Natural gas	1.7	1.9	2.0	2.2	2.4	2.5	2.6	1.4
Coal	0.2	0.2	0.2	0.3	0.3	0.3	0.3	1.4
Electricity	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.3
Total	**4.7**	**5.1**	**5.4**	**5.8**	**6.2**	**6.6**	**6.9**	**1.3**
Transportation								
Liquids	2.4	2.3	2.2	2.0	1.9	1.8	1.8	-1.0
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.9
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**2.5**	**2.5**	**2.3**	**2.1**	**2.0**	**2.0**	**2.0**	**-0.8**
All end-use sectors								
Liquids	4.3	4.4	4.3	4.2	4.2	4.3	4.4	0.1
Natural gas	2.7	2.9	3.1	3.4	3.6	3.7	3.8	1.2
Coal	0.2	0.2	0.2	0.3	0.3	0.3	0.3	1.4
Electricity	1.7	1.8	2.0	2.2	2.4	2.6	2.8	1.7
Delivered energy	**9.4**	**9.8**	**10.1**	**10.6**	**11.1**	**11.5**	**12.0**	**0.9**
Electricity-related losses	4.1	4.4	4.6	5.0	5.4	5.8	6.2	1.4
Total	**13.5**	**14.2**	**14.8**	**15.6**	**16.5**	**17.3**	**18.2**	**1.0**
Electric power[a]								
Liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Natural gas	0.3	0.3	0.6	0.8	0.8	1.0	1.2	4.6
Coal	0.9	0.8	0.8	0.8	0.8	0.7	0.7	-0.7
Nuclear	1.0	1.1	0.9	1.1	1.3	1.3	1.3	1.0
Total	**5.8**	**6.2**	**6.7**	**7.2**	**7.8**	**8.4**	**9.0**	**1.5**
Total energy consumption								
Liquids	4.3	4.5	4.3	4.3	4.3	4.3	4.5	0.1
Natural gas	3.0	3.2	3.7	4.1	4.5	4.7	5.0	1.7
Coal	1.1	1.0	1.0	1.0	1.0	1.0	1.0	-0.3
Nuclear	1.0	1.1	0.9	1.1	1.3	1.3	1.3	1.0
Total	**13.5**	**14.2**	**14.8**	**15.6**	**16.5**	**17.3**	**18.2**	**1.0**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F5. Delivered energy consumption in Mexico and Chile by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	3.4
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
Electricity	0.2	0.3	0.4	0.5	0.5	0.6	0.7	4.0
Total	**0.6**	**0.7**	**0.8**	**0.8**	**1.0**	**1.1**	**1.2**	**2.4**
Commercial								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
Natural gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.1	0.2	0.2	0.3	0.4	0.5	0.6	5.5
Total	**0.2**	**0.3**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**4.0**
Industrial								
Liquids	1.1	1.2	1.4	1.6	1.8	2.1	2.4	2.6
Natural gas	1.4	1.5	1.7	1.9	2.2	2.6	3.0	2.5
Coal	0.1	0.1	0.2	0.2	0.2	0.2	0.3	3.1
Electricity	0.6	0.6	0.7	0.8	1.0	1.2	1.4	3.0
Total	**3.4**	**3.8**	**4.2**	**4.8**	**5.6**	**6.4**	**7.5**	**2.6**
Transportation								
Liquids	2.7	2.9	3.0	3.1	3.4	3.6	3.8	1.2
Natural gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**2.7**	**2.9**	**3.0**	**3.1**	**3.4**	**3.6**	**3.8**	**1.2**
All end-use sectors								
Liquids	4.2	4.5	4.7	5.1	5.6	6.1	6.7	1.5
Natural gas	1.5	1.6	1.8	2.1	2.4	2.7	3.2	2.5
Coal	0.1	0.1	0.2	0.2	0.2	0.2	0.3	3.1
Electricity	0.9	1.1	1.4	1.6	1.9	2.3	2.7	3.7
Delivered energy	**6.9**	**7.6**	**8.3**	**9.2**	**10.4**	**11.7**	**13.2**	**2.2**
Electricity-related losses	1.8	2.3	2.6	3.1	3.7	4.3	5.0	3.4
Total	**8.8**	**9.9**	**10.9**	**12.3**	**14.1**	**16.0**	**18.2**	**2.5**
Electric power[a]								
Liquids	0.4	0.4	0.4	0.4	0.4	0.3	0.3	-1.0
Natural gas	1.1	1.4	1.8	2.4	3.0	3.6	4.3	4.7
Coal	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5
Nuclear	0.1	0.1	0.1	0.2	0.3	0.4	0.5	7.4
Total	**2.7**	**3.4**	**4.0**	**4.8**	**5.6**	**6.6**	**7.7**	**3.5**
Total energy consumption								
Liquids	4.7	4.9	5.1	5.5	5.9	6.4	7.0	1.4
Natural gas	2.6	3.0	3.6	4.4	5.3	6.3	7.5	3.6
Coal	0.6	0.7	0.7	0.7	0.8	0.8	0.8	1.2
Nuclear	0.1	0.1	0.1	0.2	0.3	0.4	0.5	7.4
Total	**8.8**	**9.9**	**10.9**	**12.3**	**14.1**	**16.0**	**18.2**	**2.5**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F6. Delivered energy consumption in OECD Europe by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	2.1	1.8	1.8	1.8	1.7	1.7	1.6	-0.8
Natural gas	5.6	5.6	5.9	6.3	6.5	6.6	6.8	0.7
Coal	0.8	0.7	0.7	0.7	0.6	0.6	0.5	-1.3
Electricity	3.3	3.8	4.1	4.4	4.6	4.8	5.0	1.4
Total	**11.7**	**11.9**	**12.5**	**13.1**	**13.5**	**13.7**	**13.9**	**0.6**
Commercial								
Liquids	0.9	0.8	0.8	0.8	0.7	0.7	0.7	-1.0
Natural gas	2.2	2.2	2.4	2.6	2.7	2.8	2.9	0.9
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-1.0
Electricity	3.3	3.8	4.1	4.4	4.7	5.0	5.3	1.7
Total	**6.5**	**6.9**	**7.4**	**7.8**	**8.3**	**8.6**	**9.0**	**1.1**
Industrial								
Liquids	9.6	9.0	9.5	10.1	10.5	10.9	11.3	0.5
Natural gas	6.6	6.3	6.4	6.6	6.7	6.7	6.8	0.1
Coal	3.1	3.0	3.0	3.1	3.1	3.1	3.1	0.0
Electricity	4.4	4.2	4.3	4.4	4.5	4.5	4.6	0.2
Total	**25.4**	**24.1**	**24.9**	**25.8**	**26.3**	**26.8**	**27.4**	**0.3**
Transportation								
Liquids	17.7	16.0	15.9	15.5	15.4	15.4	15.3	-0.5
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.4
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.7
Total	**18.0**	**16.3**	**16.2**	**15.8**	**15.7**	**15.8**	**15.7**	**-0.5**
All end-use sectors								
Liquids	30.2	27.5	28.0	28.1	28.3	28.6	28.8	-0.2
Natural gas	14.5	14.1	14.8	15.5	16.0	16.3	16.6	0.5
Coal	4.0	3.8	3.8	3.9	3.8	3.7	3.7	-0.3
Electricity	11.2	12.1	12.7	13.4	14.1	14.6	15.2	1.0
Delivered energy	**61.6**	**59.2**	**61.1**	**62.6**	**63.8**	**64.9**	**65.9**	**0.2**
Electricity-related losses	20.8	23.0	24.4	26.0	27.0	27.9	28.7	1.1
Total	**82.5**	**82.1**	**85.5**	**88.6**	**90.9**	**92.8**	**94.6**	**0.5**
Electric power[a]								
Liquids	0.4	0.4	0.4	0.4	0.3	0.3	0.3	-1.0
Natural gas	5.9	6.2	6.1	5.9	6.7	7.6	8.6	1.3
Coal	8.2	8.3	8.1	7.8	7.5	7.3	7.0	-0.5
Nuclear	8.9	9.2	9.6	10.8	11.0	11.1	11.1	0.7
Total	**32.0**	**35.1**	**37.1**	**39.5**	**41.1**	**42.6**	**43.9**	**1.1**
Total energy consumption								
Liquids	30.6	27.9	28.4	28.4	28.7	28.9	29.1	-0.2
Natural gas	20.4	20.3	21.0	21.4	22.7	23.9	25.2	0.7
Coal	12.2	12.2	11.9	11.6	11.3	11.0	10.7	-0.4
Nuclear	8.9	9.2	9.6	10.8	11.0	11.1	11.1	0.7
Total	**82.5**	**82.1**	**85.5**	**88.6**	**90.9**	**92.8**	**94.6**	**0.5**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.

Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F7. Delivered energy consumption in Japan by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.6	0.5	0.5	0.5	0.5	0.4	0.4	-1.2
Natural gas	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.3
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	1.1	1.2	1.2	1.3	1.3	1.3	1.3	0.6
Total	**2.1**	**2.1**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	**0.1**
Commercial								
Liquids	0.7	0.6	0.6	0.6	0.6	0.5	0.5	-0.9
Natural gas	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.4
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	1.3	1.3	1.4	1.4	1.5	1.6	1.6	0.8
Total	**2.7**	**2.7**	**2.8**	**2.9**	**3.0**	**3.0**	**3.0**	**0.3**
Industrial								
Liquids	3.6	3.9	4.2	4.2	4.2	4.1	3.9	0.3
Natural gas	0.5	0.6	0.6	0.7	0.7	0.6	0.6	0.3
Coal	2.5	2.4	2.4	2.5	2.4	2.4	2.3	-0.3
Electricity	0.9	0.9	0.9	0.9	0.9	0.9	0.8	-0.4
Total	**7.9**	**8.1**	**8.5**	**8.6**	**8.5**	**8.4**	**7.9**	**0.0**
Transportation								
Liquids	3.7	3.5	3.3	3.2	3.1	3.0	2.8	-0.9
Natural gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.2
Total	**3.7**	**3.6**	**3.4**	**3.3**	**3.2**	**3.1**	**2.9**	**-0.8**
All end-use sectors								
Liquids	8.5	8.6	8.6	8.5	8.3	8.1	7.6	-0.4
Natural gas	1.7	1.8	1.9	2.0	2.0	2.0	1.9	0.4
Coal	2.5	2.4	2.5	2.5	2.5	2.4	2.3	-0.3
Electricity	3.4	3.4	3.6	3.7	3.8	3.9	3.9	0.4
Delivered energy	**16.5**	**16.5**	**16.9**	**17.0**	**16.9**	**16.7**	**16.0**	
Electricity-related losses	5.6	5.2	5.6	5.9	6.1	6.2	6.2	0.3
Total	**22.1**	**21.7**	**22.5**	**23.0**	**23.0**	**22.9**	**22.2**	**0.0**
Electric power[a]								
Liquids	0.5	1.0	0.5	0.4	0.4	0.4	0.4	
Natural gas	2.3	2.7	2.9	3.2	3.4	3.5	3.6	1.5
Coal	2.3	2.5	2.3	2.3	2.2	2.1	2.0	-0.5
Nuclear	2.8	1.0	1.9	2.0	2.1	2.1	2.1	-0.9
Total	**9.1**	**8.6**	**9.2**	**9.7**	**9.9**	**10.1**	**10.1**	**0.4**
Total energy consumption								
Liquids	9.0	9.5	9.1	8.9	8.7	8.5	8.0	-0.4
Natural gas	4.1	4.6	4.8	5.2	5.4	5.5	5.5	1.0
Coal	4.8	4.9	4.8	4.7	4.6	4.5	4.3	-0.4
Nuclear	2.8	1.0	1.9	2.0	2.1	2.1	2.1	-0.9
Total	**22.1**	**21.7**	**22.5**	**23.0**	**23.0**	**22.9**	**22.2**	**0.0**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F8. Delivered energy consumption in South Korea by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Natural gas	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.9
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.2	0.2	0.3	0.3	0.3	0.4	0.4	2.3
Total	**0.8**	**0.8**	**0.9**	**1.0**	**1.0**	**1.1**	**1.1**	**1.2**
Commercial								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.6
Natural gas	0.2	0.2	0.2	0.2	0.3	0.3	0.3	2.0
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.5	0.5	0.6	0.7	0.8	1.0	1.1	2.6
Total	**0.8**	**0.9**	**1.0**	**1.1**	**1.2**	**1.4**	**1.5**	**2.1**
Industrial								
Liquids	2.5	2.7	2.9	3.0	3.1	3.1	3.2	0.8
Natural gas	0.3	0.3	0.4	0.4	0.4	0.5	0.5	1.4
Coal	1.0	1.1	1.3	1.3	1.4	1.4	1.5	1.2
Electricity	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1
Total	**4.7**	**5.2**	**5.6**	**5.9**	**6.1**	**6.2**	**6.3**	**1.0**
Transportation								
Liquids	1.8	1.8	1.9	1.9	2.0	2.0	2.0	0.5
Natural gas	0.0	0.0	0.1	0.1	0.1	0.1	0.1	--
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**1.8**	**1.9**	**2.0**	**2.0**	**2.1**	**2.1**	**2.1**	**0.6**
All end-use sectors								
Liquids	4.5	4.8	5.1	5.2	5.3	5.4	5.5	0.7
Natural gas	0.9	1.0	1.1	1.2	1.3	1.3	1.4	1.3
Coal	1.1	1.2	1.3	1.4	1.4	1.5	1.5	1.1
Electricity	1.5	1.7	1.9	2.1	2.3	2.5	2.7	1.9
Delivered energy	**8.1**	**8.7**	**9.5**	**10.0**	**10.4**	**10.7**	**11.1**	**1.1**
Electricity-related losses	2.7	3.1	3.6	3.9	4.3	4.5	4.9	1.9
Total	**10.8**	**11.8**	**13.0**	**13.8**	**14.7**	**15.3**	**15.9**	**1.3**
Electric power[a]								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-1.0
Natural gas	0.8	0.7	0.8	0.9	0.9	1.2	1.4	2.1
Coal	1.9	1.8	1.8	1.8	1.8	1.9	2.0	0.2
Nuclear	1.4	2.0	2.6	2.9	3.5	3.5	3.7	3.3
Total	**4.3**	**4.8**	**5.5**	**6.0**	**6.6**	**7.0**	**7.5**	**1.9**
Total energy consumption								
Liquids	4.6	4.9	5.2	5.3	5.4	5.5	5.5	0.6
Natural gas	1.7	1.7	1.8	2.1	2.2	2.6	2.8	1.7
Coal	3.0	3.0	3.1	3.2	3.2	3.4	3.5	0.5
Nuclear	1.4	2.0	2.6	2.9	3.5	3.5	3.7	3.3
Total	**10.8**	**11.8**	**13.0**	**13.8**	**14.7**	**15.3**	**15.9**	**1.3**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F9. Delivered energy consumption in Australia/New Zealand by end-use sector and fuel, 2008-2035
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Natural gas	0.1	0.1	0.2	0.2	0.2	0.2	0.2	1.5
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.2	0.3	0.3	0.3	0.3	0.3	0.3	1.0
Total	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.6**	**1.1**
Commercial								
Liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.2	0.3	0.3	0.3	0.3	0.4	0.4	1.6
Total	**0.3**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**	**0.5**	**1.2**
Industrial								
Liquids	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.4
Natural gas	0.8	0.8	1.0	1.0	1.1	1.2	1.2	1.4
Coal	0.3	0.2	0.3	0.3	0.3	0.3	0.3	-0.1
Electricity	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6
Total	**2.3**	**2.3**	**2.4**	**2.5**	**2.6**	**2.7**	**2.9**	**0.8**
Transportation								
Liquids	1.6	1.6	1.7	1.7	1.7	1.8	1.8	0.5
Natural gas	0.0	0.0	0.0	0.0	0.0	0.1	0.1	--
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**1.6**	**1.7**	**1.7**	**1.7**	**1.8**	**1.8**	**1.9**	**0.6**
All end-use sectors								
Liquids	2.2	2.3	2.3	2.3	2.4	2.5	2.6	0.5
Natural gas	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.5
Coal	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-0.1
Electricity	0.9	1.0	1.0	1.0	1.1	1.1	1.2	1.0
Delivered energy	**4.6**	**4.8**	**5.0**	**5.1**	**5.4**	**5.6**	**5.8**	**0.8**
Electricity-related losses	2.1	2.3	2.3	2.4	2.4	2.4	2.5	0.5
Total	**6.7**	**7.0**	**7.4**	**7.5**	**7.7**	**8.0**	**8.2**	**0.7**
Electric power[a]								
Liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Natural gas	0.4	0.4	0.4	0.5	0.6	0.7	0.8	2.4
Coal	2.1	2.0	1.9	1.9	1.8	1.7	1.7	-0.7
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**3.0**	**3.2**	**3.4**	**3.4**	**3.4**	**3.5**	**3.6**	**0.7**
Total energy consumption								
Liquids	2.2	2.3	2.4	2.4	2.4	2.5	2.6	0.5
Natural gas	1.4	1.5	1.6	1.8	2.0	2.2	2.3	1.7
Coal	2.3	2.2	2.2	2.1	2.1	2.0	2.0	-0.6
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**6.7**	**7.0**	**7.4**	**7.5**	**7.7**	**8.0**	**8.2**	**0.7**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F10. Total Non-OECD delivered energy consumption by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	5.1	5.4	5.2	5.1	5.1	5.0	4.9	-0.2
Natural gas	7.9	8.9	10.4	12.3	14.3	16.2	17.9	2.8
Coal	3.8	3.7	3.7	3.8	3.8	3.8	3.7	-0.1
Electricity	7.0	9.0	11.4	14.0	16.9	20.0	23.3	4.1
Total	**23.9**	**27.0**	**30.8**	**35.1**	**40.0**	**45.0**	**49.8**	**2.5**
Commercial								
Liquids	1.9	1.8	1.8	1.9	1.9	1.8	1.8	-0.1
Natural gas	1.6	1.8	2.1	2.6	3.1	3.6	4.1	3.2
Coal	1.0	1.0	1.0	1.1	1.2	1.2	1.3	0.8
Electricity	4.3	5.3	6.6	8.3	10.4	12.7	15.4	4.3
Total	**8.8**	**9.9**	**11.7**	**13.9**	**16.5**	**19.4**	**22.5**	**3.2**
Industrial								
Liquids	29.8	34.1	37.1	39.8	43.2	46.5	49.5	1.7
Natural gas	26.1	28.7	32.6	36.3	40.0	43.6	46.6	2.0
Coal	44.2	53.0	61.1	67.0	71.0	72.6	70.4	1.6
Electricity	18.2	22.9	27.4	30.9	33.9	36.1	36.8	2.4
Total	**128.1**	**148.5**	**169.2**	**186.0**	**201.3**	**213.5**	**219.8**	**1.8**
Transportation								
Liquids	39.6	46.9	52.7	58.3	64.0	70.9	78.9	2.3
Natural gas	2.8	2.7	2.8	3.1	3.4	3.7	3.9	1.1
Coal	0.1	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.6	0.8	0.8	0.9	0.9	1.0	1.1	2.1
Total	**43.1**	**50.3**	**56.4**	**62.3**	**68.3**	**75.6**	**83.9**	**2.3**
All end-use sectors								
Liquids	76.4	88.2	96.9	105.0	114.1	124.3	135.1	1.9
Natural gas	38.4	42.0	48.0	54.2	60.7	67.0	72.4	2.1
Coal	49.1	57.7	65.9	71.9	76.0	77.6	75.3	1.4
Electricity	30.2	37.9	46.2	54.1	62.1	69.9	76.5	3.2
Delivered energy	**203.9**	**235.7**	**267.9**	**297.2**	**326.2**	**353.5**	**375.9**	**2.1**
Electricity-related losses	77.8	92.3	107.3	120.5	133.8	147.5	159.1	2.4
Total	**281.7**	**327.9**	**375.3**	**417.7**	**460.0**	**501.0**	**535.1**	**2.2**
Electric power[a]								
Liquids	6.9	6.7	6.4	6.1	5.8	5.5	5.2	-1.0
Natural gas	21.0	22.1	24.6	27.9	31.8	36.2	40.7	2.2
Coal	53.6	64.8	72.1	81.3	89.2	96.3	101.5	2.2
Nuclear	4.7	8.4	13.5	17.7	21.8	25.9	29.0	6.2
Total	**108.0**	**130.2**	**153.6**	**174.6**	**195.9**	**217.4**	**235.6**	**2.6**
Total energy consumption								
Liquids	83.3	94.9	103.3	111.1	119.9	129.7	140.3	1.8
Natural gas	59.3	64.1	72.6	82.1	92.5	103.2	113.1	2.2
Coal	102.6	122.4	138.0	153.2	165.2	173.9	176.8	1.8
Nuclear	4.7	8.4	13.5	17.7	21.8	25.9	29.0	6.2
Total	**281.7**	**327.9**	**375.3**	**417.7**	**460.0**	**501.0**	**535.1**	**2.2**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F11. Delivered energy consumption in Russia by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
		Projections						
Residential								
Liquids	0.3	0.3	0.3	0.3	0.3	0.3	0.3	-0.7
Natural gas	2.8	2.7	2.8	2.9	3.1	3.3	3.5	0.8
Coal	0.3	0.3	0.3	0.3	0.2	0.2	0.2	-1.5
Electricity	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.7
Total	**3.9**	**3.8**	**3.9**	**4.2**	**4.5**	**4.7**	**5.0**	**0.8**
Commercial								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-1.5
Natural gas	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.7
Coal	0.2	0.2	0.2	0.1	0.1	0.1	0.1	-1.3
Electricity	0.6	0.6	0.8	0.9	1.1	1.2	1.3	2.8
Total	**1.3**	**1.3**	**1.4**	**1.6**	**1.8**	**1.9**	**2.1**	**1.6**
Industrial								
Liquids	2.7	3.0	3.1	3.2	3.5	3.6	3.5	1.0
Natural gas	5.1	5.1	5.5	6.0	6.4	6.6	6.5	0.8
Coal	2.2	2.1	2.2	2.4	2.5	2.7	2.6	0.6
Electricity	1.6	1.8	2.1	2.3	2.5	2.6	2.6	1.7
Total	**11.7**	**12.2**	**13.1**	**14.1**	**15.0**	**15.7**	**15.4**	**0.9**
Transportation								
Liquids	2.9	3.3	3.5	3.6	3.7	3.8	3.9	1.0
Natural gas	1.3	1.2	1.4	1.6	1.8	2.0	2.1	1.5
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.1
Total	**4.5**	**4.9**	**5.2**	**5.5**	**5.8**	**6.1**	**6.2**	**1.1**
All end-use sectors								
Liquids	5.9	6.8	7.0	7.2	7.5	7.7	7.7	0.9
Natural gas	9.7	9.5	10.1	11.0	11.9	12.5	12.6	0.9
Coal	2.7	2.6	2.6	2.8	2.9	3.0	2.9	0.3
Electricity	2.9	3.3	3.8	4.3	4.7	5.0	5.3	2.0
Delivered energy	**21.3**	**22.2**	**23.7**	**25.4**	**27.1**	**28.4**	**28.7**	**1.0**
Electricity-related losses	8.3	8.8	9.7	10.3	10.9	11.5	11.8	1.2
Total	**29.6**	**31.0**	**33.3**	**35.7**	**38.0**	**39.9**	**40.5**	**1.1**
Electric power[a]								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Natural gas	5.7	5.7	6.1	6.5	6.8	7.1	7.2	0.8
Coal	2.0	2.3	2.6	2.7	2.7	2.7	2.7	0.9
Nuclear	1.8	2.1	2.7	3.2	3.6	4.0	4.4	3.1
Total	**11.2**	**12.0**	**13.5**	**14.6**	**15.6**	**16.5**	**17.1**	**1.4**
Total energy consumption								
Liquids	6.0	6.9	7.1	7.3	7.6	7.8	7.8	0.9
Natural gas	15.3	15.1	16.2	17.5	18.6	19.6	19.8	0.9
Coal	4.8	4.9	5.2	5.5	5.6	5.7	5.6	0.5
Nuclear	1.8	2.1	2.7	3.2	3.6	4.0	4.4	3.1
Total	**29.6**	**31.0**	**33.3**	**35.7**	**38.0**	**39.9**	**40.5**	**1.1**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F12. Delivered energy consumption in Other Non-OECD Europe and Eurasia by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.1	0.2	0.1	0.1	0.1	0.1	0.1	-0.1
Natural gas	1.7	1.7	1.9	2.0	2.2	2.3	2.4	1.2
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-1.4
Electricity	0.5	0.5	0.6	0.7	0.8	0.8	1.0	2.4
Total	**2.4**	**2.5**	**2.7**	**2.9**	**3.2**	**3.4**	**3.6**	**1.3**
Commercial								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.3
Natural gas	0.5	0.5	0.6	0.7	0.7	0.8	0.9	1.8
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.0	-0.1
Electricity	0.3	0.3	0.3	0.4	0.5	0.6	0.7	3.4
Total	**0.9**	**1.0**	**1.1**	**1.2**	**1.4**	**1.5**	**1.7**	**2.1**
Industrial								
Liquids	1.4	1.7	1.6	1.5	1.7	1.8	2.0	1.2
Natural gas	2.7	2.6	2.8	3.0	3.2	3.5	3.7	1.1
Coal	1.5	1.5	1.6	1.8	1.9	2.1	2.3	1.4
Electricity	1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.2
Total	**6.7**	**6.9**	**7.1**	**7.5**	**8.2**	**8.9**	**9.6**	**1.2**
Transportation								
Liquids	2.0	2.8	2.9	3.1	3.3	3.6	3.9	2.3
Natural gas	0.2	0.2	0.3	0.3	0.3	0.3	0.4	1.3
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.1
Total	**2.3**	**3.1**	**3.3**	**3.5**	**3.7**	**4.0**	**4.4**	**2.2**
All end-use sectors								
Liquids	3.6	4.7	4.7	4.8	5.2	5.6	6.1	1.8
Natural gas	5.1	5.1	5.5	5.9	6.4	6.9	7.4	1.2
Coal	1.7	1.7	1.8	1.9	2.1	2.3	2.4	1.2
Electricity	1.8	1.9	2.1	2.3	2.6	2.9	3.3	2.0
Delivered energy	**12.3**	**13.5**	**14.2**	**15.1**	**16.4**	**17.8**	**19.3**	**1.5**
Electricity-related losses	5.3	5.4	5.7	6.0	6.4	6.9	7.3	1.1
Total	**17.6**	**18.9**	**20.0**	**21.1**	**22.8**	**24.7**	**26.6**	**1.4**
Electric power[a]								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-1.0
Natural gas	1.8	1.8	1.9	2.1	2.4	2.8	3.3	2.0
Coal	2.5	2.4	2.5	2.6	2.7	2.7	2.8	0.4
Nuclear	1.2	1.6	1.8	2.0	2.1	2.3	2.3	2.1
Total	**7.1**	**7.3**	**7.8**	**8.4**	**9.0**	**9.8**	**10.6**	**1.3**
Total energy consumption								
Liquids	3.7	4.9	4.8	4.9	5.3	5.7	6.2	1.7
Natural gas	7.0	6.8	7.4	8.0	8.8	9.7	10.7	1.4
Coal	4.2	4.1	4.3	4.5	4.8	5.0	5.2	0.8
Nuclear	1.2	1.6	1.8	2.0	2.1	2.3	2.3	2.1
Total	**17.6**	**18.9**	**20.0**	**21.1**	**22.8**	**24.7**	**26.6**	**1.4**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F13. Delivered energy consumption in China by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	1.2	1.1	1.1	1.1	1.0	1.0	0.9	-1.0
Natural gas	0.9	1.6	2.5	3.5	4.7	5.9	7.1	7.2
Coal	3.0	2.9	3.0	3.0	3.0	3.0	2.9	-0.2
Electricity	1.8	2.7	3.8	5.0	6.3	7.8	9.2	5.7
Total	**6.9**	**8.3**	**10.3**	**12.5**	**15.0**	**17.7**	**20.0**	**3.6**
Commercial								
Liquids	1.1	1.0	1.0	1.0	1.0	0.9	0.8	-0.8
Natural gas	0.2	0.4	0.6	0.9	1.2	1.5	1.8	7.1
Coal	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.1
Electricity	0.7	1.0	1.4	1.9	2.6	3.5	4.4	6.5
Total	**2.5**	**2.8**	**3.5**	**4.3**	**5.3**	**6.4**	**7.6**	**3.8**
Industrial								
Liquids	8.4	10.2	11.4	12.2	12.7	13.0	13.0	1.5
Natural gas	1.8	2.5	3.2	3.8	4.2	4.5	4.6	3.2
Coal	31.0	39.5	46.1	50.4	52.8	52.7	49.4	1.6
Electricity	9.9	14.4	17.8	20.4	22.3	23.3	22.9	2.9
Total	**51.5**	**67.3**	**79.3**	**87.8**	**93.1**	**94.7**	**91.0**	**1.9**
Transportation								
Liquids	8.4	11.5	14.3	17.1	19.3	22.3	25.8	3.8
Natural gas	0.3	0.3	0.3	0.3	0.3	0.4	0.4	1.0
Coal	0.1	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.1	0.2	0.3	0.3	0.3	0.4	0.4	3.8
Total	**9.0**	**12.0**	**14.9**	**17.7**	**20.0**	**23.1**	**26.6**	**3.7**
All end-use sectors								
Liquids	19.0	23.8	27.8	31.4	34.0	37.2	40.4	2.5
Natural gas	3.3	4.9	6.6	8.5	10.4	12.4	14.0	5.0
Coal	34.6	42.9	49.5	53.9	56.3	56.2	52.8	1.4
Electricity	12.4	18.2	23.2	27.6	31.6	35.0	36.8	3.7
Delivered energy	**69.9**	**90.5**	**108.0**	**122.3**	**133.4**	**141.9**	**145.2**	**2.5**
Electricity-related losses	31.4	41.7	50.9	58.6	65.6	71.4	74.7	2.9
Total	**101.2**	**132.2**	**159.0**	**180.9**	**198.9**	**213.3**	**219.9**	**2.6**
Electric power[a]								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.2
Natural gas	0.7	1.0	1.5	2.3	3.2	4.0	4.4	6.3
Coal	34.8	44.5	50.0	56.9	62.6	66.9	68.6	2.3
Nuclear	0.7	3.1	6.3	8.1	9.8	11.6	13.4	10.3
Total	**43.8**	**60.0**	**74.1**	**86.1**	**97.1**	**106.4**	**111.5**	**3.2**
Total energy consumption								
Liquids	19.1	23.8	27.9	31.4	34.0	37.2	40.5	2.5
Natural gas	4.0	5.9	8.1	10.8	13.7	16.4	18.4	5.3
Coal	69.4	87.4	99.6	110.8	118.9	123.2	121.5	1.9
Nuclear	0.7	3.1	6.3	8.1	9.8	11.6	13.4	10.3
Total	**101.2**	**132.2**	**159.0**	**180.9**	**198.9**	**213.3**	**219.9**	**2.6**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F14. Delivered energy consumption in India by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.9	1.1	1.0	1.0	1.0	1.0	0.9	-0.1
Natural gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal	0.1	0.2	0.2	0.2	0.2	0.2	0.3	2.4
Electricity	0.6	1.0	1.3	1.8	2.4	3.0	3.8	6.4
Total	**1.7**	**2.2**	**2.6**	**3.0**	**3.6**	**4.2**	**5.0**	**3.7**
Commercial								
Liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Natural gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal	0.2	0.2	0.2	0.3	0.3	0.4	0.4	3.0
Electricity	0.2	0.4	0.6	0.8	1.0	1.3	1.6	6.5
Total	**0.4**	**0.6**	**0.8**	**1.1**	**1.3**	**1.7**	**2.0**	**5.5**
Industrial								
Liquids	3.2	3.4	4.0	4.5	4.9	5.1	5.1	1.6
Natural gas	1.2	1.3	1.5	1.8	2.0	2.1	2.2	2.0
Coal	4.1	4.4	5.1	5.7	6.2	6.3	6.1	1.4
Electricity	1.5	1.5	1.6	1.8	2.0	2.1	2.3	1.4
Total	**11.3**	**11.9**	**13.7**	**15.3**	**16.7**	**17.5**	**17.6**	**1.5**
Transportation								
Liquids	2.3	2.8	3.6	4.8	6.2	8.1	10.6	5.2
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.1	0.1	0.1	0.1	0.1	0.2	0.2	4.3
Total	**2.4**	**3.0**	**3.8**	**5.0**	**6.5**	**8.4**	**10.9**	**5.1**
All end-use sectors								
Liquids	6.4	7.3	8.7	10.3	12.2	14.2	16.6	3.2
Natural gas	1.3	1.4	1.7	1.9	2.1	2.3	2.4	1.9
Coal	4.4	4.8	5.6	6.2	6.7	6.9	6.8	1.5
Electricity	2.4	2.9	3.7	4.5	5.5	6.6	7.9	4.1
Delivered energy	**15.8**	**17.7**	**20.9**	**24.4**	**28.1**	**31.8**	**35.5**	**2.7**
Electricity-related losses	8.6	9.9	11.2	12.8	14.5	16.9	19.5	2.8
Total	**24.4**	**27.5**	**32.1**	**37.2**	**42.6**	**48.7**	**55.0**	**2.8**
Electric power[a]								
Liquids	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-0.9
Natural gas	1.0	1.0	1.1	1.2	1.4	1.6	1.9	2.2
Coal	8.2	8.9	9.8	11.0	12.2	13.8	15.6	2.2
Nuclear	0.2	0.5	0.8	1.6	2.4	3.2	4.2	10.0
Total	**11.0**	**12.8**	**14.9**	**17.3**	**20.0**	**23.5**	**27.4**	**3.1**
Total energy consumption								
Liquids	6.6	7.5	8.9	10.5	12.4	14.4	16.8	3.1
Natural gas	2.4	2.4	2.8	3.1	3.5	3.9	4.3	2.0
Coal	12.6	13.7	15.3	17.2	18.9	20.8	22.4	1.9
Nuclear	0.2	0.5	0.8	1.6	2.4	3.2	4.2	10.0
Total	**24.4**	**27.5**	**32.1**	**37.2**	**42.6**	**48.7**	**55.0**	**2.8**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F15. Delivered energy consumption in Other Non-OECD Asia by end-use sector and fuel, 2010-2040 (quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.3
Natural gas	0.4	0.4	0.6	0.7	0.8	0.9	1.1	3.7
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
Electricity	1.1	1.3	1.5	1.8	2.1	2.4	2.8	3.2
Total	**2.1**	**2.3**	**2.7**	**3.1**	**3.5**	**4.0**	**4.6**	**2.7**
Commercial								
Liquids	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.7
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.2	2.5
Coal	0.0	0.0	0.0	0.0	0.0	0.1	0.1	--
Electricity	0.9	1.1	1.3	1.6	1.9	2.4	2.9	3.9
Total	**1.3**	**1.4**	**1.7**	**2.0**	**2.4**	**2.9**	**3.4**	**3.3**
Industrial								
Liquids	4.8	4.7	5.5	6.2	7.1	8.2	9.6	2.4
Natural gas	3.3	3.3	3.7	4.1	4.6	5.2	6.0	2.0
Coal	3.2	3.1	3.5	3.9	4.4	5.0	5.8	2.0
Electricity	1.5	1.5	1.6	1.8	2.1	2.3	2.7	2.1
Total	**14.8**	**14.6**	**16.5**	**18.4**	**20.8**	**23.7**	**27.5**	**2.1**
Transportation								
Liquids	8.2	8.3	9.1	9.7	10.4	11.0	11.5	1.1
Natural gas	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-0.7
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**8.5**	**8.5**	**9.3**	**9.8**	**10.5**	**11.2**	**11.7**	**1.1**
All end-use sectors								
Liquids	13.8	13.8	15.4	16.7	18.3	20.1	22.0	1.6
Natural gas	4.0	4.0	4.5	5.0	5.7	6.5	7.4	2.1
Coal	3.3	3.2	3.6	4.0	4.5	5.1	5.9	2.0
Electricity	3.5	3.8	4.5	5.2	6.1	7.2	8.4	3.0
Delivered energy	**26.6**	**26.9**	**30.2**	**33.3**	**37.3**	**41.9**	**47.1**	**1.9**
Electricity-related losses	6.8	7.7	9.0	10.1	11.6	13.4	15.4	2.8
Total	**33.4**	**34.6**	**39.2**	**43.5**	**48.9**	**55.2**	**62.6**	**2.1**
Electric power[a]								
Liquids	1.1	1.1	1.0	1.0	1.0	0.9	0.9	-0.8
Natural gas	3.9	4.0	4.3	4.9	5.6	6.5	7.3	2.1
Coal	3.1	3.3	3.5	4.1	4.7	5.7	7.1	2.7
Nuclear	0.4	0.5	1.0	1.3	1.6	1.8	1.9	5.1
Total	**10.3**	**11.5**	**13.4**	**15.3**	**17.7**	**20.5**	**23.8**	**2.8**
Total energy consumption								
Liquids	14.9	14.9	16.4	17.7	19.3	21.0	22.8	1.4
Natural gas	7.9	8.1	8.9	9.9	11.3	13.0	14.8	2.1
Coal	6.4	6.6	7.1	8.0	9.2	10.8	13.0	2.4
Nuclear	0.4	0.5	1.0	1.3	1.6	1.8	1.9	5.1
Total	**33.4**	**34.6**	**39.2**	**43.5**	**48.9**	**55.2**	**62.6**	**2.1**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F16. Delivered energy consumption in the Middle East by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.7	0.9	0.8	0.8	0.7	0.7	0.7	0.0
Natural gas	1.5	1.7	1.9	2.0	2.2	2.2	2.1	1.1
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	1.1	1.3	1.5	1.6	1.7	1.9	2.0	1.8
Total	**3.4**	**3.9**	**4.2**	**4.4**	**4.6**	**4.7**	**4.8**	**1.2**
Commercial								
Liquids	0.1	0.2	0.2	0.2	0.2	0.2	0.2	1.2
Natural gas	0.2	0.3	0.3	0.4	0.4	0.4	0.4	2.2
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.6	0.7	0.8	1.0	1.1	1.3	1.4	2.7
Total	**1.0**	**1.1**	**1.3**	**1.5**	**1.7**	**1.9**	**2.0**	**2.4**
Industrial								
Liquids	3.8	5.1	5.3	5.7	6.4	7.1	7.8	2.4
Natural gas	7.1	8.7	10.2	11.6	12.9	14.2	15.5	2.6
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.4
Electricity	0.5	0.5	0.6	0.7	0.7	0.8	0.9	1.9
Total	**11.5**	**14.4**	**16.2**	**18.0**	**20.1**	**22.2**	**24.2**	**2.5**
Transportation								
Liquids	5.8	7.2	7.8	8.0	8.2	8.6	9.2	1.5
Natural gas	0.2	0.2	0.3	0.3	0.3	0.3	0.3	1.0
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**6.0**	**7.4**	**8.1**	**8.3**	**8.6**	**9.0**	**9.5**	**1.5**
All end-use sectors								
Liquids	10.4	13.3	14.2	14.7	15.5	16.6	17.9	1.8
Natural gas	9.1	10.9	12.7	14.2	15.7	17.0	18.3	2.4
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.4
Electricity	2.3	2.5	2.9	3.3	3.6	4.0	4.3	2.1
Delivered energy	**21.9**	**26.8**	**29.8**	**32.3**	**35.0**	**37.7**	**40.5**	**2.1**
Electricity-related losses	5.9	6.3	6.8	7.2	7.6	8.0	8.3	1.1
Total	**27.8**	**33.1**	**36.6**	**39.5**	**42.5**	**45.7**	**48.8**	**1.9**
Electric power[a]								
Liquids	3.4	3.2	3.1	2.9	2.8	2.6	2.5	-1.0
Natural gas	4.6	5.2	5.7	6.3	6.8	7.3	7.9	1.8
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Nuclear	0.0	0.1	0.4	0.7	1.0	1.2	1.2	--
Total	**8.1**	**8.8**	**9.7**	**10.5**	**11.2**	**11.9**	**12.5**	**1.5**
Total energy consumption								
Liquids	13.8	16.5	17.2	17.6	18.3	19.2	20.4	1.3
Natural gas	13.7	16.2	18.4	20.5	22.5	24.3	26.3	2.2
Coal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.6
Nuclear	0.0	0.1	0.4	0.7	1.0	1.2	1.2	--
Total	**27.8**	**33.1**	**36.6**	**39.5**	**42.5**	**45.7**	**48.8**	**1.9**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F17. Delivered energy consumption in Africa by end-use sector and fuel, 2010-2040
(quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.5
Natural gas	0.2	0.2	0.3	0.3	0.4	0.5	0.6	3.4
Coal	0.1	0.1	0.1	0.1	0.1	0.2	0.2	2.5
Electricity	0.6	0.7	0.8	1.0	1.2	1.4	1.7	3.5
Total	**1.6**	**1.7**	**1.9**	**2.2**	**2.5**	**2.8**	**3.2**	**2.4**
Commercial								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.3
Natural gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal	0.0	0.0	0.1	0.1	0.1	0.1	0.1	--
Electricity	0.3	0.3	0.4	0.5	0.6	0.8	1.0	4.1
Total	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**1.0**	**1.2**	**3.5**
Industrial								
Liquids	1.5	1.7	1.8	1.9	2.2	2.6	3.0	2.2
Natural gas	1.6	1.7	2.0	2.3	2.7	3.1	3.5	2.7
Coal	1.6	1.5	1.8	2.0	2.2	2.6	2.9	2.1
Electricity	1.0	1.0	1.1	1.3	1.5	1.7	2.0	2.4
Total	**8.4**	**8.6**	**9.8**	**10.9**	**12.5**	**14.4**	**16.6**	**2.3**
Transportation								
Liquids	3.7	3.9	4.0	4.3	4.4	4.5	4.6	0.7
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.3
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**3.8**	**4.0**	**4.1**	**4.4**	**4.5**	**4.6**	**4.8**	**0.8**
All end-use sectors								
Liquids	6.0	6.4	6.6	7.0	7.5	8.0	8.5	1.2
Natural gas	1.8	2.0	2.4	2.7	3.1	3.6	4.2	2.8
Coal	1.7	1.7	1.9	2.2	2.5	2.8	3.2	2.1
Electricity	1.9	2.0	2.4	2.8	3.3	4.0	4.7	3.1
Delivered energy	**14.3**	**14.8**	**16.4**	**18.1**	**20.4**	**22.9**	**25.8**	**2.0**
Electricity-related losses	4.7	4.9	5.5	6.2	7.0	8.1	9.2	2.3
Total	**18.9**	**19.6**	**21.9**	**24.4**	**27.4**	**31.0**	**35.0**	**2.1**
Electric power[a]								
Liquids	0.8	0.8	0.7	0.7	0.7	0.6	0.6	-1.0
Natural gas	1.9	1.9	2.1	2.5	3.1	3.9	5.1	3.3
Coal	2.7	2.9	3.3	3.7	3.9	4.1	4.3	1.6
Nuclear	0.1	0.2	0.2	0.4	0.7	0.9	0.9	6.8
Total	**6.6**	**6.9**	**7.9**	**9.0**	**10.4**	**12.0**	**13.9**	**2.5**
Total energy consumption								
Liquids	6.9	7.2	7.3	7.7	8.1	8.6	9.1	1.0
Natural gas	3.7	3.9	4.5	5.2	6.2	7.6	9.3	3.1
Coal	4.4	4.6	5.2	5.8	6.3	6.9	7.5	1.8
Nuclear	0.1	0.2	0.2	0.4	0.7	0.9	0.9	6.8
Total	**18.9**	**19.6**	**21.9**	**24.4**	**27.4**	**31.0**	**35.0**	**2.1**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F18. Delivered energy consumption in Brazil by end-use sector and fuel, 2010-2040 (quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.0
Natural gas	0.0	0.0	0.0	0.0	0.1	0.1	0.1	--
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.4	0.5	0.6	0.7	0.8	0.9	1.1	3.1
Total	**0.7**	**0.8**	**0.9**	**1.0**	**1.1**	**1.3**	**1.4**	**2.2**
Commercial								
Liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Natural gas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.4	0.5	0.6	0.8	0.9	1.1	1.4	3.9
Total	**0.5**	**0.5**	**0.7**	**0.8**	**1.0**	**1.2**	**1.4**	**3.8**
Industrial								
Liquids	2.0	2.2	2.3	2.3	2.6	2.9	3.3	1.6
Natural gas	0.6	0.7	0.8	0.9	1.0	1.1	1.3	2.4
Coal	0.4	0.4	0.5	0.5	0.6	0.8	0.9	2.5
Electricity	0.7	0.7	0.8	0.8	0.9	1.0	1.2	1.9
Total	**6.4**	**6.5**	**7.0**	**7.5**	**8.3**	**9.3**	**10.6**	**1.7**
Transportation								
Liquids	2.9	3.2	3.4	3.5	3.7	3.8	4.1	1.2
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**2.9**	**3.3**	**3.5**	**3.6**	**3.8**	**3.9**	**4.2**	**1.2**
All end-use sectors								
Liquids	5.2	5.7	6.0	6.2	6.6	7.0	7.7	1.3
Natural gas	0.8	0.8	1.0	1.1	1.2	1.4	1.5	2.4
Coal	0.4	0.4	0.5	0.5	0.6	0.8	0.9	2.5
Electricity	1.6	1.7	2.0	2.3	2.6	3.1	3.6	2.9
Delivered energy	**10.5**	**11.1**	**12.1**	**13.0**	**14.2**	**15.7**	**17.7**	**1.7**
Electricity-related losses	3.2	3.8	4.3	4.9	5.6	6.6	7.7	3.0
Total	**13.7**	**14.9**	**16.5**	**17.8**	**19.9**	**22.3**	**25.4**	**2.1**
Electric power[a]								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-1.0
Natural gas	0.2	0.4	0.5	0.8	0.9	1.1	1.5	7.1
Coal	0.1	0.2	0.2	0.2	0.2	0.2	0.2	4.0
Nuclear	0.1	0.1	0.2	0.4	0.6	0.6	0.6	4.7
Total	**4.7**	**5.5**	**6.3**	**7.2**	**8.3**	**9.7**	**11.3**	**2.9**
Total energy consumption								
Liquids	5.4	5.8	6.1	6.3	6.7	7.1	7.8	1.2
Natural gas	0.9	1.2	1.5	1.9	2.1	2.5	3.0	3.9
Coal	0.5	0.6	0.7	0.7	0.8	0.9	1.1	2.7
Nuclear	0.1	0.1	0.2	0.4	0.6	0.6	0.6	4.7
Total	**13.7**	**14.9**	**16.5**	**17.8**	**19.9**	**22.3**	**25.4**	**2.1**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Table F19. Delivered energy consumption in Other Central and South America by end-use sector and fuel, 2010-2040 (quadrillion Btu)

Sector/fuel	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
Residential								
Liquids	0.3	0.4	0.3	0.3	0.3	0.3	0.3	-0.1
Natural gas	0.4	0.5	0.6	0.7	0.8	1.0	1.1	3.2
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.9
Total	**1.2**	**1.4**	**1.5**	**1.7**	**1.9**	**2.1**	**2.3**	**2.0**
Commercial								
Liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5
Natural gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.5
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.4	0.4	0.5	0.5	0.6	0.6	0.7	2.4
Total	**0.5**	**0.5**	**0.6**	**0.7**	**0.8**	**0.8**	**0.9**	**2.2**
Industrial								
Liquids	2.1	2.2	2.2	2.1	2.2	2.3	2.4	0.5
Natural gas	2.6	2.7	2.8	2.9	3.0	3.2	3.3	0.7
Coal	0.2	0.2	0.3	0.3	0.3	0.3	0.3	1.2
Electricity	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.8
Total	**6.0**	**6.2**	**6.3**	**6.4**	**6.8**	**7.0**	**7.3**	**0.7**
Transportation								
Liquids	3.4	3.9	4.0	4.3	4.8	5.2	5.4	1.5
Natural gas	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.5
Coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Electricity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total	**3.6**	**4.0**	**4.2**	**4.4**	**4.9**	**5.4**	**5.6**	**1.5**
All end-use sectors								
Liquids	5.9	6.5	6.5	6.8	7.3	7.8	8.2	1.1
Natural gas	3.3	3.4	3.6	3.8	4.1	4.5	4.6	1.2
Coal	0.2	0.2	0.3	0.3	0.3	0.3	0.3	1.2
Electricity	1.4	1.6	1.7	1.9	2.0	2.1	2.3	1.6
Delivered energy	**11.3**	**12.2**	**12.6**	**13.3**	**14.4**	**15.4**	**16.1**	**1.2**
Electricity-related losses	3.7	3.9	4.1	4.3	4.6	4.8	5.1	1.1
Total	**15.0**	**16.1**	**16.7**	**17.6**	**19.0**	**20.2**	**21.3**	**1.2**
Electric power[a]								
Liquids	1.0	1.0	0.9	0.9	0.8	0.8	0.8	-1.0
Natural gas	1.1	1.1	1.3	1.4	1.6	1.7	1.9	2.0
Coal	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nuclear	0.1	0.1	0.1	0.1	0.1	0.2	0.2	3.8
Total	**5.1**	**5.5**	**5.8**	**6.2**	**6.6**	**7.0**	**7.5**	**1.3**
Total energy consumption								
Liquids	6.9	7.4	7.5	7.7	8.2	8.6	8.9	0.9
Natural gas	4.3	4.6	4.8	5.2	5.8	6.2	6.6	1.4
Coal	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.8
Nuclear	0.1	0.1	0.1	0.1	0.1	0.2	0.2	3.8
Total	**15.0**	**16.1**	**16.7**	**17.6**	**19.0**	**20.2**	**21.3**	**1.2**

[a]Fuel inputs used in the production of electricity and heat, excluding captive generators.
Sources: **2010:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies; and International Energy Agency, "Balances of OECD and Non-OECD Statistics" (2012), www.iea.org (subscription site). **Projections:** EIA, World Energy Projection System Plus (2013).

Appendix G

Projections of petroleum and other liquids production in three cases

- *Reference*
- *High Oil Price*
- *Low Oil Price*

Table G1. World petroleum and other liquids production by region and country, Reference case, 2010-2040
(million barrels per day)

Region/country	History (estimates) 2010	2011	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC[a]	**34.9**	**35.1**	**36.1**	**38.4**	**40.0**	**42.5**	**45.7**	**48.9**	**1.1**
Middle East	23.8	25.4	24.5	26.7	28.2	30.4	33.1	35.8	1.4
North Africa	3.8	2.4	3.5	3.3	3.3	3.5	3.8	4.0	0.2
West Africa	4.4	4.3	5.1	5.3	5.5	5.6	5.8	5.9	0.9
South America	2.9	3.0	3.0	3.1	3.1	3.0	3.1	3.3	0.4
Non-OPEC	**51.8**	**51.7**	**55.8**	**58.2**	**60.3**	**61.9**	**63.7**	**66.0**	**0.8**
OECD	**21.4**	**21.4**	**23.9**	**23.9**	**23.4**	**23.0**	**23.8**	**24.8**	**0.5**
OECD Americas	**16.0**	**16.4**	**19.5**	**19.8**	**19.6**	**19.3**	**19.7**	**20.0**	**0.8**
United States	9.4	9.8	12.2	12.8	12.1	11.5	11.6	11.7	0.8
Canada	3.6	3.7	4.7	5.1	5.6	5.9	6.1	6.2	1.8
Mexico/Chile	3.0	3.0	2.6	2.0	1.8	2.0	2.0	2.1	-1.2
OECD Europe	**4.6**	**4.2**	**3.7**	**3.4**	**3.1**	**2.9**	**3.1**	**3.6**	**-0.8**
North Sea	3.6	3.3	2.8	2.6	2.3	2.1	2.0	2.2	-1.6
Other	1.0	0.9	0.9	0.8	0.8	0.8	1.1	1.4	1.3
OECD Asia	**0.8**	**0.8**	**0.7**	**0.7**	**0.7**	**0.8**	**1.0**	**1.1**	**0.9**
Australia and New Zealand	0.7	0.6	0.6	0.5	0.5	0.6	0.8	0.9	1.1
Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Non-OECD	**30.4**	**30.4**	**32.0**	**34.2**	**36.8**	**38.9**	**39.9**	**41.3**	**1.0**
Non-OECD Europe and Eurasia	**13.4**	**13.5**	**14.2**	**15.0**	**15.9**	**16.4**	**17.1**	**17.4**	**0.9**
Russia	**10.1**	**10.2**	**10.5**	**10.8**	**11.0**	**11.5**	**12.0**	**11.6**	**0.5**
Caspian Region	**2.9**	**3.0**	**3.4**	**3.9**	**4.7**	**4.8**	**4.9**	**5.5**	**2.1**
Kazakhstan	1.6	1.6	2.1	2.5	3.3	3.4	3.6	3.9	3.0
Other	1.3	1.3	1.3	1.5	1.4	1.4	1.4	1.6	0.6
Other	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**-0.6**
Non-OECD Asia	**8.2**	**8.1**	**8.1**	**8.1**	**8.4**	**8.7**	**8.6**	**8.7**	**0.2**
China	4.3	4.3	4.4	4.6	5.0	5.5	5.6	5.6	0.8
India	0.9	0.9	1.0	0.9	1.0	1.0	1.0	1.1	0.6
Other	2.9	2.8	2.8	2.6	2.4	2.1	1.9	2.0	-1.2
Middle East (Non-OPEC)	**1.6**	**1.4**	**1.3**	**1.2**	**1.2**	**1.1**	**1.0**	**1.0**	**-1.6**
Africa (Non-OPEC)	**2.7**	**2.7**	**2.7**	**3.1**	**3.2**	**3.2**	**3.1**	**3.5**	**0.9**
Central and South America (Non-OPEC)	**4.6**	**4.7**	**5.7**	**6.8**	**8.2**	**9.5**	**10.1**	**10.7**	**2.9**
Brazil	2.5	2.5	3.3	4.4	5.6	7.0	7.5	7.7	3.8
Other	2.1	2.2	2.3	2.4	2.6	2.6	2.6	3.0	1.3
Total world	**86.6**	**86.8**	**92.0**	**96.6**	**100.2**	**104.4**	**109.4**	**115.0**	**0.9**
OPEC share of world production	40%	40%	39%	40%	40%	41%	42%	43%	
Persian Gulf share of world production	27%	29%	27%	28%	28%	29%	30%	31%	

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
Note: Petroleum liquids include crude oil and lease condensates, natural gas plant liquids, bitumen, extra-heavy oil, and refinery gains. Other liquids include gas-to-liquids, coal-to-liquids, kerogen, and biofuels.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Table G2. World petroleum production by region and country, Reference case, 2010-2040
(million barrels per day)

Region/country	History (estimates) 2010	2011	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC[a]	**34.8**	**35.0**	**35.9**	**38.2**	**39.7**	**42.2**	**45.4**	**48.7**	**1.1**
Middle East	23.8	25.3	24.3	26.5	27.9	30.1	32.8	35.6	1.4
North Africa	3.8	2.4	3.5	3.3	3.3	3.5	3.8	4.0	0.2
West Africa	4.4	4.3	5.1	5.3	5.4	5.6	5.7	5.9	0.9
South America	2.9	3.0	3.0	3.1	3.1	3.0	3.1	3.3	0.4
Non-OPEC	**50.2**	**50.2**	**54.0**	**55.8**	**57.5**	**58.6**	**59.9**	**61.7**	**0.7**
OECD	**20.5**	**20.5**	**22.9**	**22.8**	**22.2**	**21.7**	**22.4**	**23.1**	**0.4**
OECD Americas	**15.4**	**15.8**	**18.7**	**18.9**	**18.6**	**18.3**	**18.6**	**18.6**	**0.6**
United States	8.8	9.1	11.5	11.9	11.2	10.5	10.5	10.4	0.6
Canada	3.6	3.6	4.7	5.1	5.6	5.9	6.1	6.2	1.8
Mexico/Chile	3.0	3.0	2.6	2.0	1.8	2.0	2.0	2.1	-1.2
OECD Europe	**4.4**	**4.0**	**3.5**	**3.2**	**2.9**	**2.7**	**2.8**	**3.4**	**-0.9**
North Sea	3.6	3.2	2.8	2.5	2.2	2.0	2.0	2.2	-1.7
Other	0.8	0.7	0.7	0.6	0.6	0.6	0.9	1.2	1.5
OECD Asia	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**1.0**	**1.1**	**0.9**
Australia and New Zealand	0.7	0.6	0.5	0.5	0.5	0.6	0.8	0.9	1.1
Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Non-OECD	**29.7**	**29.7**	**31.1**	**33.0**	**35.2**	**36.9**	**37.5**	**38.7**	**0.9**
Non-OECD Europe and Eurasia	**13.4**	**13.5**	**14.2**	**15.0**	**15.9**	**16.4**	**17.1**	**17.4**	**0.9**
Russia	**10.1**	**10.2**	**10.5**	**10.8**	**11.0**	**11.5**	**12.0**	**11.6**	**0.5**
Caspian Region	**2.9**	**3.0**	**3.4**	**3.9**	**4.7**	**4.8**	**4.9**	**5.5**	**2.1**
Kazakhstan	1.6	1.6	2.1	2.5	3.3	3.4	3.6	3.9	3.0
Other	1.3	1.3	1.3	1.5	1.4	1.4	1.4	1.6	0.6
Other	**0.3**	**0.3**	**0.2**	**0.3**	**0.2**	**0.2**	**0.2**	**0.2**	**-0.6**
Non-OECD Asia	**8.1**	**8.0**	**8.0**	**7.9**	**7.8**	**7.8**	**7.5**	**7.6**	**-0.2**
China	4.3	4.3	4.3	4.5	4.7	4.9	4.7	4.7	0.3
India	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.3
Other	2.8	2.7	2.7	2.5	2.3	2.0	1.8	1.9	-1.3
Middle East (Non-OPEC)	**1.6**	**1.4**	**1.3**	**1.2**	**1.2**	**1.1**	**1.0**	**1.0**	**-1.6**
Africa (Non-OPEC)	**2.5**	**2.5**	**2.5**	**2.8**	**2.8**	**2.8**	**2.8**	**3.1**	**0.8**
Central and South America (Non-OPEC)	**4.2**	**4.3**	**5.2**	**6.2**	**7.5**	**8.7**	**9.1**	**9.6**	**2.8**
Brazil	2.2	2.2	2.9	3.9	5.0	6.3	6.6	6.6	3.8
Other	2.0	2.1	2.3	2.3	2.5	2.5	2.5	2.9	1.3
Total world	**85.1**	**85.2**	**89.9**	**94.0**	**97.2**	**100.9**	**105.3**	**110.4**	**0.9**
OPEC share of world production	41%	41%	40%	41%	41%	42%	43%	44%	
Persian Gulf share of world production	28%	30%	27%	28%	29%	30%	31%	32%	

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
Note: Petroleum liquids include crude oil and lease condensates, natural gas plant liquids, bitumen, extra-heavy oil, and refinery gains.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Table G3.World nonpetroleum liquids production by region and country, Reference case, 2010-2040
(million barrels per day)

Region/country	History (estimates) 2010	2011	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC[a]	**0.0**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	**0.3**	**12.5**
Biofuels[b]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Gas-to-liquids	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.3	
Non-OPEC	**1.6**	**1.6**	**1.9**	**2.3**	**2.8**	**3.3**	**3.8**	**4.3**	**3.5**
OECD	**0.8**	**0.9**	**1.0**	**1.2**	**1.2**	**1.3**	**1.4**	**1.7**	**2.4**
Biofuels[b]	0.8	0.9	1.0	1.1	1.1	1.1	1.2	1.4	1.8
Coal-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	
Gas-to-liquids	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	--
Kerogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Non-OECD	**0.7**	**0.7**	**0.9**	**1.2**	**1.6**	**2.1**	**2.4**	**2.6**	**4.4**
Biofuels[b]	0.5	0.5	0.8	1.0	1.2	1.4	1.5	1.5	3.8
Coal-to-liquids	0.2	0.2	0.2	0.4	0.7	0.9	1.1	1.1	6.5
Gas-to-liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.8
Total World	**1.6**	**1.6**	**2.1**	**2.6**	**3.1**	**3.6**	**4.1**	**4.6**	**3.7**
Biofuels[b]	**1.3**	**1.3**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.8**	**2.6**
Brazil	0.3	0.3	0.4	0.5	0.6	0.7	0.9	1.0	3.8
China	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	6.4
India	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4
United States	0.6	0.6	0.7	0.8	0.8	0.8	0.9	1.1	2.1
Coal-to-liquids	**0.2**	**0.2**	**0.2**	**0.4**	**0.7**	**1.0**	**1.2**	**1.2**	**6.7**
Australia/New Zealand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
China	0.0	0.0	0.0	0.1	0.3	0.5	0.7	0.7	15.4
Germany	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
India	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	--
South Africa	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	1.8
United States	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	--
Gas-to-liquids	**0.1**	**0.1**	**0.3**	**0.4**	**0.4**	**0.5**	**0.5**	**0.6**	**7.3**
Qatar	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2	12.0
South Africa	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	1.0
United States	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	--
Kerogen	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.6**

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
[b]Ethanol values are reported on a gasoline-equivalent basis.
Note: Nonpetroleum liquids include gas-to-liquids, coal-to-liquids, kerogen, and biofuels.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Table G4. World petroleum and other liquids production by region and country, High Oil Price case, 2010-2040
(million barrels per day)

Region/country	History (estimates) 2010	2011	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC[a]	**34.9**	**35.1**	**34.1**	**34.5**	**36.8**	**39.5**	**43.1**	**45.6**	**0.9**
Middle East	23.8	25.4	23.1	23.8	25.6	28.1	31.0	33.2	1.1
North Africa	3.8	2.4	3.3	3.0	3.1	3.2	3.6	3.7	-0.1
West Africa	4.4	4.3	4.7	4.7	5.1	5.2	5.4	5.4	0.6
South America	2.9	3.0	2.9	3.0	3.0	3.0	3.1	3.3	0.4
Non-OPEC	**51.6**	**51.6**	**56.0**	**58.7**	**60.6**	**63.8**	**67.5**	**73.6**	**1.2**
OECD	**21.2**	**21.2**	**24.0**	**24.8**	**24.8**	**24.9**	**25.9**	**27.5**	**0.9**
OECD Americas	**15.8**	**16.3**	**19.6**	**20.8**	**21.1**	**21.3**	**21.8**	**22.6**	**1.2**
United States	9.3	9.7	12.1	12.9	12.7	12.1	12.1	12.6	1.0
Canada	3.6	3.7	5.0	6.0	6.6	7.3	7.6	7.8	2.6
Mexico/Chile	3.0	3.0	2.5	1.9	1.8	2.0	2.1	2.1	-1.1
OECD Europe	**4.6**	**4.2**	**3.7**	**3.3**	**2.9**	**2.8**	**3.1**	**3.8**	**-0.6**
North Sea	3.6	3.3	2.8	2.5	2.1	2.0	2.0	2.3	-1.6
Other	0.9	0.9	0.8	0.8	0.8	0.9	1.1	1.6	1.7
OECD Asia	**0.8**	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**1.0**	**1.1**	**1.0**
Australia and New Zealand	0.7	0.6	0.5	0.5	0.5	0.6	0.8	0.9	1.2
Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Non-OECD	**30.4**	**30.4**	**32.0**	**33.9**	**35.9**	**38.9**	**41.6**	**46.1**	**1.4**
Non-OECD Europe and Eurasia	**13.4**	**13.5**	**14.3**	**14.8**	**15.2**	**16.2**	**17.4**	**17.8**	**1.0**
Russia	**10.1**	**10.2**	**10.7**	**10.8**	**10.7**	**11.5**	**12.3**	**12.0**	**0.6**
Caspian Region	**2.9**	**3.0**	**3.4**	**3.8**	**4.3**	**4.6**	**4.9**	**5.5**	**2.1**
Kazakhstan	1.6	1.6	2.0	2.4	3.1	3.3	3.5	3.9	3.0
Other	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.6	0.6
Other	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**-0.3**
Non-OECD Asia	**8.2**	**8.1**	**8.1**	**8.1**	**8.4**	**8.9**	**9.6**	**11.7**	**1.2**
China	4.3	4.3	4.4	4.6	5.3	5.8	6.6	8.5	2.3
India	0.9	1.0	0.9	0.9	1.0	1.0	1.1	1.2	0.7
Other	2.9	2.8	2.7	2.5	2.2	2.0	1.9	2.1	-1.1
Middle East (Non-OPEC)	**1.6**	**1.4**	**1.3**	**1.2**	**1.2**	**1.1**	**1.0**	**1.0**	**-1.6**
Africa (Non-OPEC)	**2.7**	**2.7**	**2.7**	**3.0**	**3.0**	**3.1**	**3.2**	**3.5**	**0.9**
Central and South America (Non-OPEC)	**4.6**	**4.7**	**5.7**	**6.8**	**8.1**	**9.6**	**10.5**	**12.0**	**3.2**
Brazil	2.5	2.6	3.4	4.5	5.7	7.2	7.8	8.9	4.3
Other	2.1	2.2	2.3	2.3	2.4	2.5	2.6	3.2	1.4
Total world	**86.5**	**86.7**	**90.1**	**93.2**	**97.4**	**103.3**	**110.6**	**119.2**	**1.1**
OPEC share of world production	40%	40%	38%	37%	38%	38%	39%	38%	
Persian Gulf share of world production	27%	29%	26%	26%	26%	27%	28%	28%	

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
Note: Petroleum liquids include crude oil and lease condensates, natural gas plant liquids, bitumen, extra-heavy oil, and refinery gains. Other liquids include gas-to-liquids, coal-to-liquids, kerogen, and biofuels.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Table G5. World petroleum production by region and country, High Oil Price case, 2010-2040
(million barrels per day)

Region/country	History (estimates) 2010	2011	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC[a]	**34.8**	**35.0**	**33.9**	**34.2**	**36.5**	**39.3**	**42.8**	**45.3**	**0.9**
Middle East	23.8	25.3	23.0	23.6	25.4	27.9	30.8	33.0	1.1
North Africa	3.8	2.4	3.3	3.0	3.1	3.2	3.6	3.7	-0.1
West Africa	4.4	4.3	4.7	4.7	5.0	5.1	5.3	5.3	0.6
South America	2.9	3.0	2.9	3.0	3.0	3.0	3.1	3.3	0.4
Non-OPEC	**50.1**	**50.0**	**54.1**	**55.9**	**56.8**	**59.5**	**62.2**	**65.7**	**0.9**
OECD	**20.4**	**20.3**	**23.1**	**23.6**	**23.4**	**23.4**	**24.2**	**25.2**	**0.7**
OECD Americas	**15.2**	**15.6**	**18.9**	**19.9**	**20.1**	**20.1**	**20.4**	**20.7**	**1.0**
United States	8.6	9.0	11.4	12.0	11.7	11.0	10.8	10.8	0.7
Canada	3.6	3.6	5.0	6.0	6.6	7.2	7.6	7.8	2.6
Mexico/Chile	3.0	3.0	2.5	1.9	1.8	2.0	2.1	2.1	-1.1
OECD Europe	**4.4**	**4.0**	**3.5**	**3.1**	**2.7**	**2.6**	**2.8**	**3.4**	**-0.8**
North Sea	3.6	3.2	2.8	2.4	2.1	2.0	1.9	2.2	-1.6
Other	0.8	0.7	0.7	0.6	0.6	0.6	0.9	1.2	1.5
OECD Asia	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**1.0**	**1.1**	**1.0**
Australia and New Zealand	0.7	0.6	0.5	0.5	0.5	0.5	0.8	0.9	1.1
Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Non-OECD	**29.7**	**29.7**	**31.0**	**32.3**	**33.4**	**36.0**	**38.0**	**40.6**	**1.0**
Non-OECD Europe and Eurasia	**13.4**	**13.5**	**14.3**	**14.8**	**15.2**	**16.2**	**17.4**	**17.8**	**1.0**
Russia	**10.1**	**10.2**	**10.7**	**10.8**	**10.7**	**11.5**	**12.3**	**12.0**	**0.6**
Caspian Region	**2.9**	**3.0**	**3.4**	**3.8**	**4.3**	**4.6**	**4.9**	**5.5**	**2.1**
Kazakhstan	1.6	1.6	2.0	2.4	3.1	3.3	3.5	3.9	3.0
Other	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.6	0.6
Other	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**-0.4**
Non-OECD Asia	**8.1**	**8.0**	**7.9**	**7.6**	**7.3**	**7.7**	**7.9**	**9.0**	**0.4**
China	4.3	4.3	4.3	4.3	4.4	4.9	5.1	6.1	1.2
India	0.9	0.9	0.9	0.9	0.8	0.9	0.9	1.0	0.3
Other	2.8	2.7	2.7	2.5	2.1	2.0	1.8	1.9	-1.3
Middle East (Non-OPEC)	**1.6**	**1.4**	**1.3**	**1.2**	**1.2**	**1.1**	**1.0**	**1.0**	**-1.6**
Africa (Non-OPEC)	**2.5**	**2.5**	**2.5**	**2.7**	**2.6**	**2.7**	**2.8**	**3.1**	**0.8**
Central and South America (Non-OPEC)	**4.2**	**4.3**	**5.1**	**6.0**	**7.0**	**8.4**	**9.0**	**9.6**	**2.8**
Brazil	2.2	2.2	2.9	3.7	4.7	6.0	6.5	6.6	3.7
Other	2.0	2.1	2.3	2.3	2.3	2.4	2.5	3.0	1.3
Total world	**84.9**	**85.0**	**88.0**	**90.1**	**93.3**	**98.8**	**105.0**	**111.0**	**0.9**
OPEC share of world production	41%	41%	39%	38%	39%	40%	41%	41%	
Persian Gulf share of world production	28%	30%	26%	26%	27%	28%	29%	30%	

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
Note: Petroleum liquids include crude oil and lease condensates, natural gas plant liquids, bitumen, extra-heavy oil, and refinery gains.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Table G6.World nonpetroleum liquids production by region and country, High Oil Price case, 2010-2040
(million barrels per day)

Region/country	History (estimates) 2010	2011	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC[a]	**0.0**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.3**	**0.3**	**12.1**
Biofuels[b]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Gas-to-liquids	0.0	0.1	0.2	0.2	0.2	0.2	0.3	0.3	12.1
Non-OPEC	**1.6**	**1.6**	**1.9**	**2.7**	**3.7**	**4.2**	**5.2**	**7.8**	**5.5**
OECD	**0.9**	**0.9**	**0.9**	**1.2**	**1.3**	**1.5**	**1.7**	**2.3**	**3.4**
Biofuels[b]	0.8	0.9	0.9	1.1	1.1	1.2	1.3	1.9	2.7
Coal-to-liquids	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	18.5
Gas-to-liquids	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	--
Kerogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Non-OECD	**0.7**	**0.7**	**1.0**	**1.5**	**2.4**	**2.7**	**3.5**	**5.4**	**6.9**
Biofuels[b]	0.5	0.5	0.6	0.9	1.2	1.4	1.7	2.9	6.1
Coal-to-liquids	0.2	0.2	0.2	0.5	1.1	1.1	1.7	2.5	9.3
Gas-to-liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.0
Total World	**1.6**	**1.7**	**2.1**	**2.9**	**3.9**	**4.4**	**5.4**	**8.0**	**5.6**
Biofuels[b]	**1.3**	**1.4**	**1.6**	**2.0**	**2.3**	**2.7**	**3.0**	**4.8**	**4.3**
Brazil	0.4	0.3	0.5	0.7	0.8	1.0	1.2	2.2	6.2
China	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.4	8.8
India	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	10.1
United States	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.3	2.4
Coal-to-liquids	**0.2**	**0.2**	**0.2**	**0.6**	**1.2**	**1.2**	**1.8**	**2.6**	**9.5**
Australia/New Zealand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
China	0.0	0.0	0.1	0.2	0.7	0.7	1.3	2.0	19.4
Germany	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
India	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	--
South Africa	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	2.0
United States	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	--
Gas-to-liquids	**0.1**	**0.1**	**0.2**	**0.4**	**0.4**	**0.5**	**0.6**	**0.6**	**7.8**
Qatar	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	11.7
South Africa	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	1.2
United States	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Kerogen	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.8**

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
[b]Ethanol values are reported on a gasoline-equivalent basis.
Note: Nonpetroleum liquids include gas-to-liquids, coal-to-liquids, kerogen, and biofuels.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Table G7. World petroleum and other liquids production by region and country, Low Oil Price case, 2010-2040
(million barrels per day)

Region/country	History (estimates) 2010	2011	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC[a]	**34.9**	**35.1**	**37.6**	**43.9**	**47.5**	**50.7**	**56.3**	**61.5**	**1.9**
Middle East	23.8	25.4	25.5	30.7	33.6	36.1	40.5	44.7	2.1
North Africa	3.8	2.4	3.7	3.7	3.9	4.0	4.4	4.6	0.7
West Africa	4.4	4.3	5.2	5.8	6.1	6.5	6.8	7.1	1.6
South America	2.9	3.0	3.1	3.6	3.9	4.2	4.6	5.1	2.0
Non-OPEC	**51.6**	**51.6**	**55.5**	**56.8**	**57.8**	**59.2**	**58.9**	**59.6**	**0.5**
OECD	**21.2**	**21.2**	**23.5**	**23.2**	**22.5**	**22.0**	**21.6**	**22.0**	**0.1**
OECD Americas	**15.8**	**16.3**	**19.1**	**19.1**	**18.8**	**18.3**	**17.4**	**17.1**	**0.3**
United States	9.3	9.7	11.9	12.0	11.3	10.4	9.6	9.7	0.1
Canada	3.6	3.7	4.7	5.2	5.7	6.2	6.2	5.8	1.6
Mexico/Chile	3.0	3.0	2.6	1.9	1.7	1.8	1.7	1.7	-1.9
OECD Europe	**4.6**	**4.2**	**3.7**	**3.4**	**3.1**	**3.0**	**3.2**	**3.8**	**-0.6**
North Sea	3.6	3.3	2.9	2.5	2.2	2.0	2.0	2.3	-1.6
Other	0.9	0.9	0.9	0.9	0.9	0.9	1.2	1.6	1.8
OECD Asia	**0.8**	**0.8**	**0.7**	**0.7**	**0.7**	**0.8**	**1.0**	**1.0**	**0.7**
Australia and New Zealand	0.7	0.6	0.6	0.5	0.5	0.6	0.8	0.8	0.8
Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.6
Non-OECD	**30.4**	**30.4**	**32.0**	**33.6**	**35.3**	**37.1**	**37.3**	**37.6**	**0.7**
Non-OECD Europe and Eurasia	**13.4**	**13.5**	**14.1**	**14.4**	**14.8**	**15.1**	**15.2**	**14.7**	**0.3**
Russia	**10.1**	**10.2**	**10.4**	**10.3**	**10.2**	**10.9**	**11.4**	**10.9**	**0.2**
Caspian Region	**2.9**	**3.0**	**3.4**	**3.8**	**4.3**	**4.1**	**3.6**	**3.5**	**0.6**
Kazakhstan	1.6	1.6	2.1	2.4	3.1	2.8	2.5	2.4	1.3
Other	1.3	1.3	1.4	1.4	1.3	1.2	1.1	1.2	-0.5
Other	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**-0.3**
Non-OECD Asia	**8.2**	**8.1**	**8.2**	**8.1**	**8.2**	**8.7**	**8.7**	**8.9**	**0.3**
China	4.3	4.3	4.4	4.6	4.9	5.6	5.7	5.7	0.9
India	0.9	1.0	1.0	0.9	1.0	1.0	1.1	1.1	0.7
Other	2.9	2.8	2.8	2.6	2.3	2.1	1.9	2.0	-1.1
Middle East (Non-OPEC)	**1.6**	**1.4**	**1.3**	**1.2**	**1.2**	**1.1**	**1.0**	**1.0**	**-1.6**
Africa (Non-OPEC)	**2.7**	**2.7**	**2.7**	**3.0**	**3.0**	**3.1**	**3.1**	**3.4**	**0.8**
Central and South America (Non-OPEC)	**4.6**	**4.7**	**5.7**	**6.9**	**8.1**	**9.2**	**9.4**	**9.6**	**2.5**
Brazil	2.5	2.6	3.4	4.5	5.8	6.7	6.8	6.6	3.2
Other	2.1	2.2	2.4	2.4	2.4	2.5	2.6	3.0	1.3
Total world	**86.5**	**86.7**	**93.1**	**100.7**	**105.3**	**109.9**	**115.2**	**121.1**	**1.1**
OPEC share of world production	40%	40%	40%	44%	45%	46%	49%	51%	
Persian Gulf share of world production	27%	29%	27%	30%	32%	33%	35%	37%	

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
Note: Petroleum liquids include crude oil and lease condensates, natural gas plant liquids, bitumen, extra-heavy oil, and refinery gains. Other liquids include gas-to-liquids, coal-to-liquids, kerogen, and biofuels.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Table G8. World petroleum production by region and country, Low Oil Price case, 2010-2040
(million barrels per day)

Region/country	History (estimates) 2010	2011	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OPEC[a]	**34.8**	**35.0**	**37.4**	**43.6**	**47.2**	**50.4**	**56.0**	**61.2**	**1.9**
Middle East	23.8	25.3	25.4	30.5	33.4	35.8	40.3	44.4	2.1
North Africa	3.8	2.4	3.7	3.7	3.9	4.0	4.4	4.6	0.7
West Africa	4.4	4.3	5.2	5.8	6.1	6.4	6.8	7.0	1.5
South America	2.9	3.0	3.1	3.6	3.9	4.2	4.6	5.1	2.0
Non-OPEC	**50.1**	**50.0**	**53.5**	**54.1**	**54.2**	**54.8**	**53.8**	**53.9**	**0.2**
OECD	**20.4**	**20.3**	**22.6**	**22.2**	**21.3**	**20.7**	**20.2**	**20.4**	**0.0**
OECD Americas	**15.2**	**15.6**	**18.4**	**18.3**	**17.8**	**17.3**	**16.4**	**15.9**	**0.2**
United States	8.6	9.0	11.1	11.2	10.5	9.5	8.6	8.6	0.0
Canada	3.6	3.6	4.7	5.2	5.7	6.1	6.1	5.7	1.6
Mexico/Chile	3.0	3.0	2.6	1.9	1.7	1.8	1.7	1.7	-1.9
OECD Europe	**4.4**	**4.0**	**3.5**	**3.1**	**2.8**	**2.6**	**2.8**	**3.4**	**-0.8**
North Sea	3.6	3.2	2.8	2.5	2.1	2.0	1.9	2.2	-1.6
Other	0.8	0.7	0.7	0.7	0.7	0.7	0.9	1.2	1.6
OECD Asia	**0.8**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0.9**	**1.0**	**0.7**
Australia and New Zealand	0.7	0.6	0.5	0.5	0.5	0.6	0.7	0.8	0.7
Other	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4
Non-OECD	**29.7**	**29.7**	**30.9**	**31.9**	**32.9**	**34.0**	**33.7**	**33.5**	**0.4**
Non-OECD Europe and Eurasia	**13.4**	**13.5**	**14.1**	**14.4**	**14.8**	**15.1**	**15.1**	**14.7**	**0.3**
Russia	**10.1**	**10.2**	**10.4**	**10.3**	**10.2**	**10.9**	**11.4**	**10.9**	**0.2**
Caspian Region	**2.9**	**3.0**	**3.4**	**3.8**	**4.3**	**4.1**	**3.6**	**3.5**	**0.6**
Kazakhstan	1.6	1.6	2.1	2.4	3.1	2.8	2.5	2.4	1.3
Other	1.3	1.3	1.4	1.4	1.3	1.2	1.1	1.2	-0.5
Other	**0.3**	**0.3**	**0.3**	**0.3**	**0.2**	**0.2**	**0.2**	**0.3**	**-0.4**
Non-OECD Asia	**8.1**	**8.0**	**8.0**	**7.8**	**7.6**	**7.7**	**7.5**	**7.6**	**-0.2**
China	4.3	4.3	4.3	4.4	4.5	4.8	4.7	4.7	0.3
India	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	0.3
Other	2.8	2.7	2.7	2.5	2.2	2.0	1.8	1.9	-1.3
Middle East (Non-OPEC)	**1.6**	**1.4**	**1.3**	**1.2**	**1.2**	**1.1**	**1.0**	**1.0**	**-1.6**
Africa (Non-OPEC)	**2.5**	**2.5**	**2.5**	**2.7**	**2.7**	**2.8**	**2.8**	**3.1**	**0.8**
Central and South America (Non-OPEC)	**4.2**	**4.3**	**5.0**	**5.8**	**6.7**	**7.4**	**7.3**	**7.1**	**1.8**
Brazil	2.2	2.2	2.7	3.5	4.4	5.0	4.8	4.3	2.2
Other	2.0	2.1	2.3	2.3	2.3	2.4	2.5	2.9	1.2
Total world	**84.9**	**85.0**	**90.9**	**97.7**	**101.5**	**105.2**	**109.8**	**115.1**	**1.0**
OPEC share of world production	41%	41%	41%	45%	47%	48%	51%	53%	
Persian Gulf share of world production	28%	30%	28%	31%	33%	34%	37%	39%	

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
Note: Petroleum liquids include crude oil and lease condensates, natural gas plant liquids, bitumen, extra-heavy oil, and refinery gains.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Table G9.World nonpetroleum liquids production by region and country, Low Oil Price case, 2010-2040
(million barrels per day)

	History (estimates)		Projections						Average annual percent change, 2010-2040
Region/country	2010	2011	2015	2020	2025	2030	2035	2040	
OPEC[a]	**0.0**	**0.1**	**0.2**	**0.2**	**0.3**	**0.3**	**0.3**	**0.3**	**12.2**
Biofuels[b]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Coal-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Gas-to-liquids	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.3	12.2
Non-OPEC	**1.6**	**1.6**	**2.0**	**2.7**	**3.6**	**4.4**	**5.1**	**5.7**	**4.4**
OECD	**0.9**	**0.9**	**0.9**	**1.1**	**1.2**	**1.3**	**1.4**	**1.6**	**2.2**
Biofuels[b]	0.8	0.9	0.9	1.1	1.2	1.3	1.4	1.6	2.2
Coal-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Gas-to-liquids	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Kerogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Non-OECD	**0.7**	**0.7**	**1.1**	**1.7**	**2.4**	**3.1**	**3.7**	**4.1**	**5.9**
Biofuels[b]	0.5	0.5	0.8	1.2	1.7	2.2	2.6	3.0	6.2
Coal-to-liquids	0.2	0.2	0.2	0.4	0.6	0.8	1.0	1.0	6.0
Gas-to-liquids	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.1
Total World	**1.6**	**1.7**	**2.2**	**3.0**	**3.9**	**4.7**	**5.3**	**6.0**	**4.5**
Biofuels[b]	**1.3**	**1.4**	**1.8**	**2.3**	**3.0**	**3.5**	**4.0**	**4.7**	**4.3**
Brazil	0.4	0.3	0.7	1.0	1.4	1.7	2.0	2.3	6.4
China	0.0	0.0	0.0	0.1	0.1	0.3	0.3	0.4	8.7
India	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	10.0
United States	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.8
Coal-to-liquids	**0.2**	**0.2**	**0.2**	**0.4**	**0.6**	**0.8**	**1.0**	**1.0**	**6.0**
Australia/New Zealand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
China	0.0	0.0	0.0	0.1	0.3	0.5	0.7	0.7	15.1
Germany	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.6
India	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	--
South Africa	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.9
United States	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Gas-to-liquids	**0.1**	**0.1**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**5.3**
Qatar	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2	11.7
South Africa	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
United States	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Kerogen	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**-0.3**

[a]OPEC=Organization of the Petroleum Exporting Countries (OPEC-13).
[b]Ethanol values are reported on a gasoline-equivalent basis.
Note: Nonpetroleum liquids include gas-to-liquids, coal-to-liquids, kerogen, and biofuels.
Sources: **History:** U.S. Energy Information Administration (EIA). **Projections:** EIA, Generate World Oil Balance Model (2013) application.

Appendix H

Reference case projections for electricity capacity and generation by fuel

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Table H1. World total installed generating capacity by region and country, 2010-2040
(gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**1,248**	**1,316**	**1,324**	**1,379**	**1,456**	**1,546**	**1,669**	**1.0**
United States[a]	1,033	1,080	1,068	1,098	1,147	1,206	1,293	0.8
Canada	137	144	152	163	174	185	198	1.2
Mexico/Chile	78	93	104	118	135	155	177	2.8
OECD Europe	**946**	**1,028**	**1,096**	**1,133**	**1,159**	**1,185**	**1,211**	**0.8**
OECD Asia	**441**	**444**	**473**	**489**	**501**	**516**	**524**	**0.6**
Japan	287	275	293	300	304	309	306	0.2
South Korea	85	93	100	107	114	122	130	1.5
Australia/New Zealand	69	76	81	83	83	85	87	0.8
Total OECD	**2,635**	**2,788**	**2,894**	**3,002**	**3,116**	**3,247**	**3,403**	**0.9**
Non-OECD								
Non-OECD Europe and Eurasia	**408**	**421**	**455**	**480**	**508**	**538**	**563**	**1.1**
Russia	229	239	264	282	299	315	325	1.2
Other	179	182	191	198	209	223	239	1.0
Non-OECD Asia	**1,452**	**1,820**	**2,188**	**2,479**	**2,772**	**3,057**	**3,277**	**2.8**
China	988	1,301	1,589	1,804	2,007	2,176	2,265	2.8
India	208	241	285	327	376	440	510	3.0
Other	256	278	314	347	390	441	502	2.3
Middle East	**185**	**197**	**216**	**233**	**247**	**267**	**280**	**1.4**
Africa	**134**	**147**	**164**	**184**	**211**	**244**	**283**	**2.5**
Central and South America	**247**	**279**	**304**	**329**	**362**	**400**	**447**	**2.0**
Brazil	114	137	152	169	191	221	256	2.8
Other	134	142	152	160	171	179	191	1.2
Total non-OECD	**2,426**	**2,864**	**3,327**	**3,705**	**4,099**	**4,505**	**4,850**	**2.3**
Total world	**5,061**	**5,652**	**6,221**	**6,707**	**7,214**	**7,752**	**8,254**	**1.6**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H2. World installed liquids-fired generating capacity by region and country, 2010-2040
(gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**128**	**119**	**107**	**98**	**88**	**85**	**81**	**-1.5**
United States[a]	107	99	88	80	71	68	66	-1.6
Canada	4	4	4	4	4	3	3	-1.0
Mexico/Chile	17	16	15	14	14	13	12	-1.0
OECD Europe	**55**	**52**	**50**	**47**	**45**	**43**	**41**	**-1.0**
OECD Asia	**55**	**55**	**50**	**48**	**45**	**43**	**41**	**-1.0**
Japan	50	50	45	43	41	39	37	-1.0
South Korea	4	4	4	4	4	3	3	-1.0
Australia/New Zealand	1	1	1	1	1	1	1	-1.0
Total OECD	**238**	**227**	**207**	**193**	**178**	**171**	**163**	**-1.3**
Non-OECD								
Non-OECD Europe and Eurasia	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**-0.9**
Russia	6	6	5	5	5	5	5	-0.7
Other	20	19	18	17	16	15	14	-1.0
Non-OECD Asia	**51**	**50**	**48**	**45**	**43**	**41**	**39**	**-0.9**
China	14	14	13	13	12	11	11	-0.9
India	4	4	4	4	3	3	3	-0.8
Other	33	32	31	29	28	27	25	-0.9
Middle East	**37**	**35**	**33**	**32**	**30**	**29**	**27**	**-1.0**
Africa	**15**	**15**	**14**	**13**	**13**	**12**	**11**	**-1.0**
Central and South America	**32**	**30**	**29**	**27**	**26**	**25**	**23**	**-1.0**
Brazil	6	6	6	6	5	5	5	-1.0
Other	25	24	23	22	21	20	19	-1.0
Total non-OECD	**160**	**154**	**147**	**140**	**133**	**127**	**120**	**-1.0**
Total world	**399**	**381**	**354**	**333**	**311**	**297**	**283**	**-1.1**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H3. World installed natural-gas-fired generating capacity by region and country, 2010-2040 (gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**402**	**435**	**461**	**505**	**568**	**631**	**697**	**1.9**
United States[a]	350	379	390	420	472	519	566	1.6
Canada	20	19	26	28	29	32	35	1.9
Mexico/Chile	31	36	45	56	68	80	95	3.8
OECD Europe	**217**	**219**	**213**	**204**	**218**	**234**	**252**	**0.5**
OECD Asia	**128**	**134**	**140**	**144**	**148**	**157**	**163**	**0.8**
Japan	83	90	96	97	100	101	101	0.7
South Korea	27	26	26	28	29	35	38	1.1
Australia/New Zealand	18	18	18	19	20	22	23	1.0
Total OECD	**746**	**787**	**814**	**853**	**934**	**1,022**	**1,112**	**1.3**
Non-OECD								
Non-OECD Europe and Eurasia	**145**	**143**	**155**	**167**	**181**	**197**	**210**	**1.3**
Russia	100	100	110	118	126	133	137	1.1
Other	45	43	45	49	55	63	74	1.7
Non-OECD Asia	**163**	**171**	**186**	**214**	**251**	**291**	**321**	**2.3**
China	33	39	48	63	83	98	105	4.0
India	23	23	25	28	32	38	45	2.2
Other	107	108	113	123	136	154	171	1.6
Middle East	**136**	**147**	**156**	**166**	**176**	**185**	**197**	**1.3**
Africa	**50**	**49**	**53**	**61**	**73**	**90**	**113**	**2.7**
Central and South America	**59**	**63**	**70**	**78**	**84**	**91**	**102**	**1.9**
Brazil	12	16	19	24	26	31	38	3.9
Other	47	47	50	54	58	60	64	1.1
Total non-OECD	**553**	**573**	**619**	**686**	**765**	**853**	**945**	**1.8**
Total world	**1,299**	**1,360**	**1,434**	**1,538**	**1,699**	**1,876**	**2,057**	**1.5**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H4. World installed coal-fired generating capacity by region and country, 2010-2040
(gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**345**	**328**	**303**	**303**	**303**	**303**	**304**	**-0.4**
United States[a]	317	301	277	276	277	277	278	-0.4
Canada	19	16	16	15	15	15	15	-0.8
Mexico/Chile	10	11	11	11	11	11	11	0.5
OECD Europe	**204**	**203**	**196**	**188**	**182**	**175**	**169**	**-0.6**
OECD Asia	**109**	**110**	**105**	**103**	**100**	**99**	**98**	**-0.3**
Japan	49	52	49	47	45	44	42	-0.5
South Korea	28	27	27	27	27	29	31	0.2
Australia/New Zealand	31	30	29	28	27	26	25	-0.7
Total OECD	**658**	**640**	**604**	**594**	**584**	**577**	**571**	**-0.5**
Non-OECD								
Non-OECD Europe and Eurasia	**104**	**104**	**110**	**113**	**113**	**112**	**112**	**0.3**
Russia	51	54	58	59	59	58	57	0.4
Other	52	50	52	53	54	54	55	0.1
Non-OECD Asia	**842**	**1,014**	**1,113**	**1,245**	**1,363**	**1,469**	**1,544**	**2.0**
China	659	819	903	1,008	1,096	1,162	1,187	2.0
India	120	131	144	162	181	206	234	2.3
Other	62	64	66	75	86	100	123	2.3
Middle East	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**--**
Africa	**39**	**43**	**49**	**54**	**58**	**60**	**64**	**1.7**
Central and South America	**6**	**9**	**9**	**9**	**9**	**9**	**9**	**1.1**
Brazil	4	7	7	6	6	6	6	1.6
Other	3	3	3	3	3	3	3	0.3
Total non-OECD	**991**	**1,171**	**1,281**	**1,422**	**1,543**	**1,651**	**1,729**	**1.9**
Total world	**1,649**	**1,811**	**1,884**	**2,015**	**2,127**	**2,228**	**2,300**	**1.1**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H5. World installed nuclear generating capacity by region and country, 2010-2040
(gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**115**	**119**	**123**	**130**	**133**	**130**	**135**	**0.5**
United States[a]	101	104	111	114	114	109	113	0.4
Canada	13	13	11	13	16	16	16	0.7
Mexico/Chile	1	2	2	3	4	5	6	5.1
OECD Europe	**132**	**124**	**128**	**142**	**143**	**143**	**142**	**0.3**
OECD Asia	**67**	**45**	**65**	**71**	**79**	**80**	**82**	**0.7**
Japan	49	20	34	35	36	37	37	-0.9
South Korea	18	25	32	36	43	43	45	3.2
Australia/New Zealand	0	0	0	0	0	0	0	--
Total OECD	**314**	**288**	**316**	**343**	**355**	**352**	**359**	**0.5**
Non-OECD								
Non-OECD Europe and Eurasia	**42**	**49**	**58**	**65**	**73**	**80**	**85**	**2.4**
Russia	24	28	35	40	45	50	55	2.8
Other	17	20	23	25	27	29	29	1.8
Non-OECD Asia	**21**	**54**	**102**	**136**	**171**	**204**	**236**	**8.4**
China	11	40	80	100	120	140	160	9.5
India	5	7	9	20	30	41	52	8.5
Other	6	7	13	17	21	23	24	5.0
Middle East	**0**	**1**	**7**	**10**	**13**	**15**	**15**	**--**
Africa	**2**	**2**	**2**	**5**	**9**	**12**	**12**	**6.5**
Central and South America	**3**	**4**	**5**	**7**	**9**	**10**	**10**	**4.1**
Brazil	2	2	3	5	7	7	7	4.4
Other	1	2	2	2	2	3	3	3.6
Total non-OECD	**67**	**109**	**174**	**224**	**274**	**321**	**358**	**5.7**
Total world	**381**	**397**	**490**	**568**	**630**	**673**	**717**	**2.1**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H6. World installed hydroelectric and other renewable generating capacity by region and country, 2010-2040 (gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**258**	**316**	**329**	**343**	**364**	**398**	**452**	**1.9**
United States[a]	158	196	203	208	215	233	270	1.8
Canada	81	91	96	102	111	120	130	1.6
Mexico/Chile	20	28	31	34	39	45	52	3.3
OECD Europe	**339**	**430**	**510**	**552**	**571**	**589**	**607**	**2.0**
OECD Asia	**82**	**101**	**113**	**124**	**129**	**137**	**139**	**1.8**
Japan	56	62	68	77	81	88	88	1.5
South Korea	7	11	12	12	12	13	13	2.3
Australia/New Zealand	19	27	33	35	35	36	38	2.3
Total OECD	**679**	**846**	**952**	**1,019**	**1,064**	**1,124**	**1,198**	**1.9**
Non-OECD								
Non-OECD Europe and Eurasia	**93**	**100**	**109**	**113**	**120**	**129**	**137**	**1.3**
Russia	48	50	55	59	64	68	71	1.3
Other	45	50	54	54	57	61	66	1.3
Non-OECD Asia	**375**	**531**	**739**	**838**	**943**	**1,052**	**1,136**	**3.8**
China	271	388	545	620	696	764	802	3.7
India	56	77	103	114	129	151	176	3.9
Other	48	66	91	104	119	137	158	4.0
Middle East	**12**	**15**	**21**	**24**	**28**	**38**	**40**	**4.0**
Africa	**28**	**37**	**46**	**51**	**59**	**70**	**83**	**3.7**
Central and South America	**147**	**173**	**192**	**207**	**233**	**264**	**302**	**2.4**
Brazil	89	106	118	127	146	171	200	2.7
Other	58	66	74	80	87	93	102	1.9
Total non-OECD	**655**	**856**	**1,107**	**1,233**	**1,384**	**1,554**	**1,698**	**3.2**
Total world	**1,334**	**1,702**	**2,059**	**2,253**	**2,448**	**2,678**	**2,896**	**2.6**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding. Other renewable energy includes wind, geothermal, solar, biomass, waste, and tide/wave/ocean.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H7. World installed hydroelectric generating capacity by region and country, 2010-2040 (gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**170**	**177**	**181**	**190**	**201**	**214**	**228**	**1.0**
United States[a]	78	78	79	79	79	80	81	0.1
Canada	75	78	80	85	93	101	109	1.3
Mexico/Chile	17	20	22	25	29	33	38	2.8
OECD Europe	**151**	**155**	**169**	**176**	**183**	**189**	**195**	**0.9**
OECD Asia	**37**	**39**	**40**	**40**	**40**	**40**	**41**	**0.3**
Japan	22	24	24	24	24	25	25	0.3
South Korea	2	2	2	2	2	2	2	0.3
Australia/New Zealand	13	13	13	13	14	14	14	0.3
Total OECD	**358**	**371**	**389**	**405**	**424**	**443**	**464**	**0.9**
Non-OECD								
Non-OECD Europe and Eurasia	**87**	**91**	**99**	**103**	**110**	**118**	**125**	**1.2**
Russia	47	49	54	58	62	66	69	1.3
Other	41	42	45	45	48	52	56	1.1
Non-OECD Asia	**300**	**369**	**477**	**514**	**557**	**618**	**675**	**2.7**
China	219	264	325	343	362	389	409	2.1
India	41	53	77	84	96	113	133	4.0
Other	40	52	75	87	100	115	134	4.1
Middle East	**12**	**13**	**16**	**16**	**16**	**16**	**16**	**1.0**
Africa	**24**	**29**	**33**	**35**	**42**	**49**	**59**	**3.0**
Central and South America	**136**	**157**	**176**	**190**	**215**	**244**	**280**	**2.5**
Brazil	81	96	107	116	134	157	185	2.8
Other	55	61	69	74	81	87	95	1.9
Total non-OECD	**559**	**658**	**801**	**859**	**940**	**1,045**	**1,155**	**2.5**
Total world	**917**	**1,030**	**1,190**	**1,264**	**1,363**	**1,488**	**1,619**	**1.9**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H8. World installed wind-powered generating capacity by region and country, 2010-2040
(gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**44**	**75**	**79**	**81**	**85**	**95**	**116**	**3.3**
United States[a]	40	59	60	61	62	70	88	2.7
Canada	4	11	13	14	15	16	17	5.1
Mexico/Chile	1	5	6	6	7	9	10	9.1
OECD Europe	**86**	**134**	**194**	**225**	**234**	**242**	**250**	**3.6**
OECD Asia	**5**	**13**	**20**	**23**	**23**	**24**	**25**	**5.5**
Japan	2	3	6	8	8	8	8	4.2
South Korea	0	3	3	3	4	4	4	--
Australia/New Zealand	2	7	12	12	12	13	13	5.9
Total OECD	**135**	**222**	**293**	**329**	**342**	**361**	**391**	**3.6**
Non-OECD								
Non-OECD Europe and Eurasia	**1**	**4**	**5**	**5**	**5**	**6**	**6**	**6.5**
Russia	0	0	0	0	0	0	0	--
Other	1	4	5	5	5	6	6	6.5
Non-OECD Asia	**45**	**103**	**170**	**214**	**258**	**292**	**310**	**6.7**
China	31	84	148	191	233	263	277	7.6
India	13	17	19	20	21	25	28	2.6
Other	1	2	3	3	4	4	5	7.2
Middle East	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**--**
Africa	**1**	**5**	**6**	**6**	**7**	**9**	**10**	**8.4**
Central and South America	**1**	**5**	**5**	**5**	**6**	**6**	**7**	**5.6**
Brazil	1	3	3	3	3	4	4	5.3
Other	0	2	2	2	3	3	3	--
Total non-OECD	**48**	**118**	**186**	**231**	**278**	**314**	**335**	**6.7**
Total world	**183**	**340**	**480**	**560**	**619**	**676**	**726**	**4.7**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H9. World installed geothermal generating capacity by region and country, 2010-2040
(gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**3**	**4**	**5**	**6**	**7**	**8**	**10**	**3.6**
United States[a]	2	3	4	4	6	7	8	3.9
Canada	0	0	0	0	0	0	0	--
Mexico/Chile	1	1	1	1	2	2	2	2.8
OECD Europe	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**1.0**
OECD Asia	**1**	**2**	**3**	**3**	**3**	**4**	**4**	**3.6**
Japan	1	1	1	2	2	2	2	3.5
South Korea	0	0	0	0	0	0	0	--
Australia/New Zealand	1	1	2	2	2	2	2	3.7
Total OECD	**6**	**8**	**9**	**11**	**13**	**14**	**15**	**3.1**
Non-OECD								
Non-OECD Europe and Eurasia	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**--**
Russia	0	0	0	0	0	0	0	--
Other	0	0	0	0	0	0	0	--
Non-OECD Asia	**3**	**7**	**7**	**8**	**9**	**10**	**12**	**4.4**
China	0	0	0	0	0	0	0	--
India	0	0	0	0	0	0	0	--
Other	3	7	7	7	9	10	12	4.4
Middle East	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**--**
Africa	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**--**
Central and South America	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2.6**
Brazil	0	0	0	0	0	0	0	--
Other	1	1	1	1	1	1	1	2.6
Total non-OECD	**4**	**9**	**9**	**9**	**11**	**12**	**14**	**4.3**
Total world	**10**	**16**	**18**	**20**	**23**	**26**	**29**	**3.6**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H10. World installed solar generating capacity by region and country, 2010-2040
(gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**3**	**20**	**23**	**25**	**28**	**36**	**52**	**10.2**
United States[a]	3	19	22	24	27	35	51	10.3
Canada	0	1	1	1	1	1	1	--
Mexico/Chile	0	0	0	0	0	0	0	--
OECD Europe	**28**	**64**	**69**	**72**	**75**	**77**	**80**	**3.5**
OECD Asia	**5**	**10**	**15**	**22**	**26**	**33**	**33**	**6.7**
Japan	4	7	10	16	20	27	27	6.9
South Korea	1	1	1	1	1	1	1	2.7
Australia/New Zealand	1	2	3	4	4	5	5	7.8
Total OECD	**36**	**94**	**107**	**119**	**129**	**146**	**165**	**5.2**
Non-OECD								
Non-OECD Europe and Eurasia	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**--**
Russia	0	0	0	0	0	0	0	--
Other	0	0	1	1	1	1	1	--
Non-OECD Asia	**1**	**16**	**40**	**49**	**56**	**63**	**67**	**15.2**
China	1	14	36	42	48	53	56	14.8
India	0	1	3	6	7	8	10	--
Other	0	1	1	1	2	2	2	--
Middle East	**0**	**1**	**4**	**7**	**11**	**21**	**22**	**--**
Africa	**0**	**1**	**4**	**6**	**7**	**9**	**10**	**--**
Central and South America	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**--**
Brazil	0	0	0	0	0	0	0	--
Other	0	0	0	0	0	0	1	--
Total non-OECD	**1**	**19**	**49**	**64**	**75**	**93**	**101**	**16.6**
Total world	**37**	**113**	**157**	**183**	**204**	**239**	**266**	**6.8**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H11. World installed other renewable generating capacity by region and country, 2010-2040
(gigawatts)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**38**	**40**	**41**	**42**	**43**	**45**	**47**	**0.7**
United States[a]	35	38	39	39	40	41	43	0.7
Canada	2	2	2	2	2	2	2	0.6
Mexico/Chile	1	1	1	1	1	1	2	1.3
OECD Europe	**73**	**75**	**76**	**77**	**78**	**79**	**80**	**0.3**
OECD Asia	**33**	**36**	**36**	**36**	**36**	**36**	**37**	**0.3**
Japan	27	27	27	27	27	27	27	0.1
South Korea	4	6	6	6	6	6	6	1.2
Australia/New Zealand	2	3	3	3	3	3	3	1.4
Total OECD	**144**	**151**	**153**	**155**	**158**	**160**	**163**	**0.4**
Non-OECD								
Non-OECD Europe and Eurasia	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**0.2**
Russia	1	1	1	1	1	1	1	0.3
Other	3	3	3	3	3	3	3	0.2
Non-OECD Asia	**26**	**36**	**45**	**54**	**63**	**69**	**73**	**3.4**
China	20	27	36	45	53	59	61	3.9
India	3	4	4	4	5	5	6	2.6
Other	4	4	5	5	5	5	6	1.2
Middle East	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**--**
Africa	**2**	**2**	**2**	**2**	**3**	**3**	**3**	**0.4**
Central and South America	**10**	**10**	**10**	**10**	**11**	**12**	**13**	**1.0**
Brazil	8	8	8	8	9	10	11	1.1
Other	2	2	2	2	2	2	2	0.7
Total non-OECD	**43**	**52**	**61**	**71**	**81**	**88**	**93**	**2.6**
Total world	**187**	**203**	**215**	**226**	**238**	**248**	**256**	**1.1**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding. Other renewable energy includes wind, geothermal, solar, biomass, waste, and tide/wave/ocean.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H12. World total net electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
		Projections						
OECD								
OECD Americas	**5,016**	**5,193**	**5,550**	**5,915**	**6,270**	**6,659**	**7,102**	**1.2**
United States[a]	4,110	4,165	4,389	4,590	4,777	4,979	5,212	0.8
Canada	591	632	691	757	818	882	952	1.6
Mexico/Chile	315	396	470	567	676	798	938	3.7
OECD Europe	**3,496**	**3,787**	**3,993**	**4,210**	**4,406**	**4,590**	**4,765**	**1.0**
OECD Asia	**1,794**	**1,858**	**1,987**	**2,107**	**2,201**	**2,294**	**2,374**	**0.9**
Japan	1,053	1,042	1,088	1,138	1,166	1,185	1,186	0.4
South Korea	468	516	582	641	700	760	821	1.9
Australia/New Zealand	272	301	317	329	335	350	366	1.0
Total OECD	**10,306**	**10,838**	**11,530**	**12,232**	**12,877**	**13,543**	**14,240**	**1.1**
Non-OECD								
Non-OECD Europe and Eurasia	**1,605**	**1,725**	**1,972**	**2,183**	**2,396**	**2,621**	**2,807**	**1.9**
Russia	985	1,081	1,262	1,404	1,529	1,650	1,729	1.9
Other	621	644	710	779	867	971	1,078	1.9
Non-OECD Asia	**5,899**	**8,062**	**10,064**	**11,941**	**13,802**	**15,599**	**17,023**	**3.6**
China	3,904	5,740	7,295	8,673	9,942	11,003	11,595	3.7
India	904	1,100	1,331	1,603	1,910	2,303	2,736	3.8
Other	1,090	1,222	1,438	1,665	1,950	2,293	2,692	3.1
Middle East	**758**	**859**	**984**	**1,097**	**1,198**	**1,306**	**1,405**	**2.1**
Africa	**632**	**666**	**788**	**924**	**1,092**	**1,298**	**1,537**	**3.0**
Central and South America	**1,039**	**1,159**	**1,294**	**1,430**	**1,595**	**1,787**	**2,023**	**2.2**
Brazil	507	590	680	772	887	1,037	1,217	3.0
Other	533	570	614	658	708	750	806	1.4
Total non-OECD	**9,934**	**12,471**	**15,102**	**17,575**	**20,082**	**22,611**	**24,794**	**3.1**
Total world	**20,240**	**23,309**	**26,632**	**29,808**	**32,959**	**36,154**	**39,034**	**2.2**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H13. World net liquids-fired electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**93**	**74**	**68**	**66**	**64**	**62**	**60**	**-1.5**
United States[a]	37	20	17	18	18	18	18	-2.3
Canada	7	7	6	6	6	5	5	-1.0
Mexico/Chile	49	47	45	42	40	38	36	-1.0
OECD Europe	**77**	**73**	**70**	**66**	**63**	**60**	**57**	**-1.0**
OECD Asia	**112**	**157**	**102**	**97**	**92**	**87**	**83**	**-1.0**
Japan	92	137	83	79	75	71	68	-1.0
South Korea	18	17	16	15	15	14	13	-1.0
Australia/New Zealand	3	3	3	3	2	2	2	-1.0
Total OECD	**282**	**303**	**239**	**229**	**219**	**209**	**200**	**-1.1**
Non-OECD								
Non-OECD Europe and Eurasia	**21**	**22**	**21**	**20**	**19**	**19**	**18**	**-0.5**
Russia	9	11	10	10	10	9	9	0.0
Other	12	12	11	10	10	9	9	-1.0
Non-OECD Asia	**148**	**149**	**142**	**136**	**129**	**123**	**118**	**-0.8**
China	12	13	12	12	11	11	10	-0.5
India	25	25	23	22	21	20	19	-0.8
Other	111	112	106	101	97	92	88	-0.8
Middle East	**260**	**248**	**235**	**224**	**213**	**202**	**193**	**-1.0**
Africa	**76**	**73**	**69**	**66**	**62**	**59**	**56**	**-1.0**
Central and South America	**126**	**120**	**114**	**109**	**103**	**98**	**94**	**-1.0**
Brazil	15	14	14	13	12	12	11	-1.0
Other	111	106	101	96	91	87	82	-1.0
Total non-OECD	**632**	**612**	**582**	**554**	**528**	**502**	**478**	**-0.9**
Total world	**914**	**915**	**822**	**783**	**746**	**711**	**678**	**-1.0**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H14. World net natural-gas-fired electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**1,162**	**1,362**	**1,525**	**1,691**	**1,904**	**2,157**	**2,348**	**2.4**
United States[a]	970	1,132	1,185	1,253	1,379	1,519	1,582	1.6
Canada	49	46	94	115	123	148	174	4.3
Mexico/Chile	143	183	246	323	401	490	591	4.9
OECD Europe	**817**	**860**	**853**	**817**	**937**	**1,073**	**1,218**	**1.3**
OECD Asia	**427**	**504**	**522**	**587**	**634**	**708**	**765**	**2.0**
Japan	286	363	375	410	439	457	470	1.7
South Korea	97	92	96	114	122	163	191	2.3
Australia/New Zealand	43	49	52	63	72	88	104	3.0
Total OECD	**2,405**	**2,726**	**2,900**	**3,095**	**3,475**	**3,937**	**4,330**	**2.0**
Non-OECD								
Non-OECD Europe and Eurasia	**632**	**638**	**729**	**825**	**934**	**1,051**	**1,157**	**2.0**
Russia	489	503	573	635	692	749	778	1.6
Other	143	136	155	190	241	302	378	3.3
Non-OECD Asia	**614**	**681**	**805**	**1,009**	**1,274**	**1,551**	**1,766**	**3.6**
China	63	108	175	285	422	533	586	7.7
India	111	112	124	141	166	200	241	2.6
Other	440	461	505	583	687	817	940	2.6
Middle East	**480**	**574**	**654**	**743**	**825**	**902**	**1,004**	**2.5**
Africa	**188**	**188**	**221**	**279**	**367**	**491**	**654**	**4.2**
Central and South America	**160**	**189**	**232**	**290**	**332**	**384**	**460**	**3.6**
Brazil	34	61	83	115	130	168	214	6.3
Other	125	129	149	175	202	216	246	2.3
Total non-OECD	**2,074**	**2,271**	**2,642**	**3,146**	**3,732**	**4,380**	**5,041**	**3.0**
Total world	**4,479**	**4,997**	**5,541**	**6,241**	**7,206**	**8,317**	**9,372**	**2.5**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H15. World net coal-fired electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**1,976**	**1,737**	**1,781**	**1,854**	**1,892**	**1,932**	**1,957**	**0.0**
United States[a]	1,847	1,614	1,656	1,727	1,767	1,807	1,829	0.0
Canada	83	69	72	71	69	69	70	-0.6
Mexico/Chile	46	54	54	56	56	56	58	0.7
OECD Europe	**854**	**870**	**842**	**811**	**787**	**762**	**738**	**-0.5**
OECD Asia	**664**	**669**	**639**	**631**	**612**	**613**	**613**	**-0.3**
Japan	286	305	285	276	266	257	248	-0.5
South Korea	206	198	194	199	194	210	223	0.3
Australia/New Zealand	172	166	160	157	152	146	142	-0.6
Total OECD	**3,494**	**3,276**	**3,263**	**3,296**	**3,291**	**3,307**	**3,308**	**-0.2**
Non-OECD								
Non-OECD Europe and Eurasia	**366**	**386**	**442**	**477**	**493**	**503**	**512**	**1.1**
Russia	156	185	223	240	246	248	248	1.6
Other	209	201	219	237	248	255	265	0.8
Non-OECD Asia	**3,926**	**5,241**	**6,064**	**7,134**	**8,094**	**8,961**	**9,594**	**3.0**
China	2,988	4,190	4,887	5,741	6,463	7,021	7,263	3.0
India	614	704	810	957	1,112	1,306	1,524	3.1
Other	324	347	367	436	520	634	807	3.1
Middle East	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**--**
Africa	**244**	**274**	**316**	**359**	**385**	**405**	**437**	**2.0**
Central and South America	**21**	**36**	**37**	**40**	**40**	**39**	**39**	**2.1**
Brazil	11	26	26	26	26	26	25	2.9
Other	10	10	11	13	14	14	14	1.0
Total non-OECD	**4,557**	**5,937**	**6,859**	**8,010**	**9,013**	**9,909**	**10,583**	**2.9**
Total world	**8,052**	**9,213**	**10,122**	**11,306**	**12,304**	**13,216**	**13,891**	**1.8**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H16. World net nuclear electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**899**	**932**	**978**	**1,032**	**1,054**	**1,030**	**1,066**	**0.6**
United States[a]	807	820	885	912	908	875	903	0.4
Canada	86	99	81	99	117	118	118	1.0
Mexico/Chile	6	12	12	21	29	37	46	7.3
OECD Europe	**867**	**892**	**929**	**1,045**	**1,065**	**1,077**	**1,073**	**0.7**
OECD Asia	**415**	**301**	**447**	**490**	**551**	**557**	**576**	**1.1**
Japan	274	103	192	200	206	209	209	-0.9
South Korea	141	198	255	291	346	348	367	3.2
Australia/New Zealand	0	0	0	0	0	0	0	--
Total OECD	**2,181**	**2,124**	**2,354**	**2,567**	**2,670**	**2,664**	**2,715**	**0.7**
Non-OECD								
Non-OECD Europe and Eurasia	**274**	**344**	**414**	**475**	**533**	**592**	**630**	**2.8**
Russia	162	197	250	294	336	379	416	3.2
Other	112	147	164	181	196	213	213	2.2
Non-OECD Asia	**132**	**401**	**776**	**1,052**	**1,327**	**1,600**	**1,868**	**9.2**
China	70	298	610	780	946	1,116	1,289	10.2
India	19	49	69	146	223	309	396	10.6
Other	42	54	97	126	158	175	182	5.0
Middle East	**0**	**6**	**43**	**71**	**94**	**113**	**113**	**--**
Africa	**13**	**15**	**15**	**39**	**64**	**89**	**89**	**6.7**
Central and South America	**20**	**26**	**36**	**52**	**67**	**77**	**77**	**4.5**
Brazil	14	14	23	39	54	55	55	4.7
Other	7	13	13	13	13	22	22	4.1
Total non-OECD	**439**	**792**	**1,284**	**1,688**	**2,085**	**2,471**	**2,777**	**6.3**
Total world	**2,620**	**2,917**	**3,638**	**4,255**	**4,755**	**5,134**	**5,492**	**2.5**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H17. World net hydroelectric and other renewable generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**886**	**1,089**	**1,198**	**1,272**	**1,357**	**1,479**	**1,671**	**2.1**
United States[a]	448	579	647	681	705	760	879	2.3
Canada	366	410	438	466	503	542	585	1.6
Mexico/Chile	71	100	113	125	149	176	207	3.6
OECD Europe	**882**	**1,091**	**1,298**	**1,471**	**1,554**	**1,618**	**1,680**	**2.2**
OECD Asia	**176**	**228**	**277**	**303**	**311**	**329**	**336**	**2.2**
Japan	115	134	153	174	180	190	191	1.7
South Korea	6	10	22	23	23	25	27	4.9
Australia/New Zealand	54	83	103	107	108	113	119	2.7
Total OECD	**1,943**	**2,408**	**2,774**	**3,046**	**3,222**	**3,426**	**3,687**	**2.2**
Non-OECD								
Non-OECD Europe and Eurasia	**313**	**335**	**366**	**386**	**417**	**457**	**490**	**1.5**
Russia	168	186	206	225	245	265	277	1.7
Other	145	149	160	161	171	192	213	1.3
Non-OECD Asia	**1,078**	**1,590**	**2,278**	**2,611**	**2,977**	**3,364**	**3,676**	**4.2**
China	771	1,131	1,612	1,856	2,100	2,321	2,446	3.9
India	135	211	304	338	388	468	556	4.8
Other	172	248	362	418	489	575	675	4.7
Middle East	**18**	**31**	**51**	**59**	**65**	**87**	**94**	**5.7**
Africa	**111**	**116**	**166**	**181**	**214**	**254**	**301**	**3.4**
Central and South America	**712**	**787**	**874**	**940**	**1,053**	**1,188**	**1,353**	**2.2**
Brazil	433	475	534	579	664	777	911	2.5
Other	279	312	340	361	388	411	442	1.5
Total non-OECD	**2,232**	**2,859**	**3,736**	**4,177**	**4,725**	**5,350**	**5,914**	**3.3**
Total world	**4,175**	**5,267**	**6,509**	**7,222**	**7,948**	**8,775**	**9,601**	**2.8**

[a]Includes the 50 States and the District of Columbia.

Note: Totals may not equal sum of components due to independent rounding. Other renewable energy includes wind, geothermal, solar, biomass, waste, and tide/wave/ocean.

Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H18. World net hydroelectric generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**666**	**730**	**762**	**801**	**853**	**911**	**974**	**1.3**
United States[a]	260	283	290	293	294	297	299	0.5
Canada	348	375	391	416	449	484	522	1.4
Mexico/Chile	58	72	81	92	110	130	152	3.3
OECD Europe	**550**	**546**	**598**	**637**	**671**	**699**	**725**	**0.9**
OECD Asia	**122**	**136**	**137**	**137**	**137**	**140**	**142**	**0.5**
Japan	81	93	93	93	93	94	94	0.5
South Korea	4	4	4	4	4	4	4	0.6
Australia/New Zealand	37	39	39	39	40	42	44	0.6
Total OECD	**1,338**	**1,412**	**1,497**	**1,574**	**1,661**	**1,749**	**1,841**	**1.1**
Non-OECD								
Non-OECD Europe and Eurasia	**307**	**324**	**346**	**365**	**394**	**432**	**463**	**1.4**
Russia	165	181	201	220	240	259	271	1.7
Other	143	143	145	145	154	173	192	1.0
Non-OECD Asia	**969**	**1,210**	**1,623**	**1,765**	**1,933**	**2,164**	**2,387**	**3.1**
China	714	870	1,090	1,157	1,223	1,321	1,392	2.3
India	113	159	245	268	311	375	446	4.7
Other	142	181	288	340	398	469	550	4.6
Middle East	**18**	**27**	**39**	**39**	**39**	**40**	**43**	**3.0**
Africa	**105**	**106**	**133**	**143**	**169**	**201**	**238**	**2.8**
Central and South America	**665**	**727**	**814**	**875**	**980**	**1,106**	**1,260**	**2.2**
Brazil	399	437	496	538	618	722	847	2.5
Other	266	289	317	337	362	384	412	1.5
Total non-OECD	**2,064**	**2,393**	**2,955**	**3,188**	**3,516**	**3,943**	**4,390**	**2.6**
Total world	**3,402**	**3,805**	**4,452**	**4,762**	**5,177**	**5,692**	**6,232**	**2.0**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H19. World net wind-powered electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**106**	**204**	**220**	**226**	**238**	**269**	**334**	**3.9**
United States[a]	95	163	165	168	174	197	254	3.3
Canada	10	26	38	40	43	46	50	5.7
Mexico/Chile	2	15	17	18	21	25	30	10.3
OECD Europe	**152**	**297**	**441**	**564**	**598**	**623**	**647**	**5.0**
OECD Asia	**11**	**31**	**57**	**65**	**66**	**69**	**72**	**6.4**
Japan	4	7	14	20	20	21	21	5.7
South Korea	1	3	9	10	10	11	12	9.4
Australia/New Zealand	6	21	34	35	36	37	39	6.2
Total OECD	**269**	**531**	**718**	**855**	**903**	**961**	**1,052**	**4.7**
Non-OECD								
Non-OECD Europe and Eurasia	**2**	**5**	**13**	**13**	**14**	**16**	**18**	**8.4**
Russia	0	0	0	0	0	0	0	--
Other	2	5	13	13	14	16	18	8.4
Non-OECD Asia	**66**	**211**	**372**	**479**	**587**	**671**	**716**	**8.3**
China	45	172	327	429	531	605	637	9.3
India	20	33	36	41	45	55	65	4.0
Other	1	6	8	9	10	12	14	8.7
Middle East	**0**	**1**	**3**	**3**	**3**	**4**	**4**	**--**
Africa	**2**	**5**	**18**	**19**	**22**	**26**	**31**	**8.9**
Central and South America	**3**	**13**	**13**	**13**	**15**	**17**	**19**	**6.2**
Brazil	2	6	6	7	8	9	10	5.4
Other	1	7	7	7	7	8	8	7.5
Total non-OECD	**73**	**235**	**418**	**527**	**641**	**733**	**787**	**8.3**
Total world	**342**	**767**	**1,136**	**1,383**	**1,544**	**1,694**	**1,839**	**5.8**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H20. World net geothermal electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**22**	**26**	**35**	**41**	**54**	**63**	**73**	**4.1**
United States[a]	15	18	25	31	42	49	56	4.5
Canada	0	0	0	0	0	0	0	--
Mexico/Chile	7	8	9	10	12	14	16	3.1
OECD Europe	**11**	**12**	**12**	**13**	**14**	**14**	**15**	**1.0**
OECD Asia	**9**	**14**	**20**	**25**	**26**	**27**	**27**	**4.0**
Japan	3	3	6	10	10	10	10	4.7
South Korea	0	0	0	0	0	0	0	--
Australia/New Zealand	6	11	14	15	16	16	17	3.6
Total OECD	**41**	**52**	**68**	**79**	**93**	**104**	**115**	**3.5**
Non-OECD								
Non-OECD Europe and Eurasia	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**5.4**
Russia	1	2	2	2	2	2	2	5.3
Other	0	0	0	0	0	0	0	--
Non-OECD Asia	**20**	**49**	**53**	**54**	**63**	**75**	**87**	**5.1**
China	0	0	0	0	0	0	0	--
India	0	1	1	1	1	2	2	--
Other	20	48	51	53	62	73	85	5.0
Middle East	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**--**
Africa	**1**	**2**	**4**	**4**	**5**	**6**	**7**	**5.2**
Central and South America	**3**	**6**	**6**	**7**	**7**	**8**	**8**	**3.0**
Brazil	0	0	0	0	0	0	0	--
Other	3	6	6	7	7	8	8	3.0
Total non-OECD	**25**	**60**	**65**	**67**	**78**	**91**	**105**	**4.9**
Total world	**66**	**112**	**133**	**146**	**171**	**195**	**220**	**4.1**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H21. World net solar electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**4**	**33**	**38**	**42**	**48**	**63**	**101**	**11.1**
United States[a]	4	32	37	40	46	62	99	11.2
Canada	0	1	1	1	1	1	1	--
Mexico/Chile	0	0	0	0	0	1	1	--
OECD Europe	**23**	**78**	**85**	**89**	**94**	**98**	**102**	**5.1**
OECD Asia	**5**	**12**	**22**	**33**	**39**	**50**	**50**	**8.1**
Japan	4	7	14	23	29	39	39	8.1
South Korea	1	1	2	2	2	2	2	3.6
Australia/New Zealand	0	4	6	8	8	9	9	--
Total OECD	**32**	**123**	**145**	**165**	**181**	**211**	**253**	**7.1**
Non-OECD								
Non-OECD Europe and Eurasia	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**--**
Russia	0	0	0	0	0	0	0	--
Other	0	0	1	1	1	1	1	--
Non-OECD Asia	**1**	**31**	**76**	**94**	**107**	**120**	**129**	**17.2**
China	1	26	67	79	90	100	105	17.0
India	0	3	7	13	14	17	20	--
Other	0	2	2	2	3	3	4	--
Middle East	**0**	**2**	**9**	**16**	**22**	**44**	**47**	**--**
Africa	**0**	**0**	**8**	**13**	**15**	**18**	**21**	**--**
Central and South America	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**--**
Brazil	0	0	0	0	0	0	0	--
Other	0	1	1	1	1	1	1	--
Total non-OECD	**1**	**34**	**95**	**124**	**146**	**183**	**199**	**18.6**
Total world	**34**	**157**	**240**	**288**	**327**	**394**	**452**	**9.1**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table H22. World net other renewable electricity generation by region and country, 2010-2040
(billion kilowatthours)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**88**	**98**	**143**	**163**	**165**	**173**	**190**	**2.6**
United States[a]	74	84	129	148	149	155	170	2.8
Canada	9	9	9	9	10	11	12	1.0
Mexico/Chile	5	5	5	5	6	7	9	1.8
OECD Europe	**146**	**157**	**162**	**167**	**177**	**184**	**191**	**0.9**
OECD Asia	**29**	**35**	**41**	**43**	**43**	**44**	**45**	**1.5**
Japan	23	24	25	27	27	27	27	0.4
South Korea	1	3	7	7	7	8	8	6.9
Australia/New Zealand	5	8	9	9	9	10	10	2.7
Total OECD	**263**	**290**	**346**	**373**	**385**	**401**	**426**	**1.6**
Non-OECD								
Non-OECD Europe and Eurasia	**3**	**4**	**4**	**4**	**5**	**5**	**6**	**1.7**
Russia	3	3	3	3	3	4	4	1.0
Other	1	1	1	1	1	2	2	3.6
Non-OECD Asia	**23**	**90**	**155**	**220**	**287**	**334**	**357**	**9.6**
China	11	64	128	191	255	296	312	11.7
India	2	15	15	15	16	20	23	8.5
Other	9	11	12	13	16	18	22	2.9
Middle East	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**--**
Africa	**2**	**2**	**2**	**3**	**3**	**4**	**4**	**2.1**
Central and South America	**40**	**41**	**41**	**44**	**50**	**57**	**65**	**1.6**
Brazil	31	31	31	34	39	45	53	1.8
Other	9	9	9	10	11	11	12	1.0
Total non-OECD	**69**	**137**	**202**	**270**	**344**	**400**	**432**	**6.3**
Total world	**332**	**427**	**549**	**643**	**729**	**800**	**858**	**3.2**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding. In this table, other renewable energy includes biomass, waste, and tide/wave/ocean.
Sources: **History:** Derived from U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Appendix I

Reference case projections for natural gas production

Table I1. World total natural gas production by region, Reference case, 2010-2040
(trillion cubic feet)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**28.4**	**30.4**	**33.5**	**36.1**	**38.2**	**41.1**	**44.4**	**1.5**
United States[a]	21.2	23.9	26.5	28.4	29.7	31.3	33.1	1.5
Canada	5.4	5.0	5.4	5.9	6.4	7.0	7.6	1.1
Mexico	1.8	1.5	1.6	1.6	2.1	2.8	3.5	2.3
Chile	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.7
OECD Europe	**10.4**	**9.0**	**8.1**	**8.0**	**8.6**	**9.2**	**9.9**	**-0.2**
North Europe	10.1	8.4	7.4	7.3	7.9	8.5	9.1	-0.3
South Europe	0.3	0.3	0.4	0.4	0.4	0.5	0.5	1.7
Southwest Europe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Turkey/Israel	0.1	0.3	0.3	0.2	0.2	0.2	0.3	4.5
OECD Asia	**2.1**	**2.8**	**4.0**	**5.0**	**5.7**	**6.3**	**6.9**	**4.0**
Japan	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-0.8
South Korea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Australia/New Zealand	1.9	2.7	3.8	4.9	5.6	6.2	6.7	4.3
Total OECD	**41.0**	**42.3**	**45.6**	**49.1**	**52.5**	**56.7**	**61.2**	**1.3**
Non-OECD								
Non-OECD Europe and Eurasia	**26.7**	**29.0**	**32.0**	**35.6**	**39.8**	**43.5**	**45.6**	**1.8**
Russia	20.9	21.6	23.6	26.3	29.4	32.1	33.3	1.6
Central Asia	4.6	6.2	7.1	7.9	8.9	9.9	10.7	2.8
Non-OECD Europe	1.1	1.3	1.3	1.3	1.4	1.5	1.6	1.2
Non-OECD Asia	**14.8**	**14.9**	**15.6**	**16.9**	**19.2**	**22.0**	**24.5**	**1.7**
China	3.3	3.8	4.2	5.2	6.7	8.5	10.1	3.8
India	1.8	1.6	1.7	1.8	2.1	2.6	3.0	1.6
LNG Exporters	5.4	5.6	6.0	6.3	6.7	7.1	7.5	1.1
Other Asia	4.2	3.9	3.8	3.7	3.7	3.8	3.9	-0.2
Middle East	**15.9**	**20.1**	**22.7**	**25.2**	**27.5**	**29.4**	**31.5**	**2.3**
Arabian Producers	3.9	4.2	4.5	4.9	5.2	5.5	5.7	1.3
Iran	5.2	6.4	7.5	8.5	9.4	10.1	10.6	2.4
Iraq	0.0	0.1	0.1	0.3	0.6	0.8	1.2	--
Qatar	3.4	6.0	6.9	7.3	7.6	7.9	8.3	3.0
Saudi Arabia	3.1	3.2	3.6	4.0	4.5	4.9	5.4	1.9
Other Middle East	0.3	0.3	0.3	0.2	0.2	0.2	0.2	-1.8
Africa	**7.4**	**8.0**	**9.3**	**10.3**	**11.2**	**12.4**	**13.6**	**2.1**
North Africa	5.8	5.7	6.2	6.2	6.4	6.8	7.4	0.8
West Africa	1.4	2.0	2.4	3.3	4.0	4.7	5.2	4.5
East Africa	0.1	0.2	0.5	0.5	0.6	0.7	0.8	6.0
Other Africa	0.0	0.1	0.2	0.2	0.3	0.3	0.3	--
Central and South America	**5.4**	**6.4**	**7.4**	**7.9**	**8.5**	**9.5**	**10.4**	**2.2**
Brazil	0.4	1.0	1.4	1.8	2.0	2.4	2.8	6.3
Northern Producers	2.8	2.8	2.9	2.8	2.9	3.0	3.2	0.5
Southern Cone	1.4	1.7	2.2	2.5	2.8	3.1	3.5	3.0
Andean	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.3
Central America and Caribbean	0.0	0.1	0.1	0.1	0.1	0.1	0.2	--
Total non-OECD	**70.2**	**78.5**	**87.1**	**96.0**	**106.2**	**116.8**	**125.6**	**2.0**
Total world	**111.1**	**120.8**	**132.7**	**145.1**	**158.7**	**173.5**	**186.8**	**1.7**
Discrepancy[b]	-1.8	0.4	0.6	0.9	0.5	0.8	0.6	

[a]Includes supplemental production less any forecast discrepancy.
[b]Balancing item. Differences between global production and consumption totals results from independent rounding and differences in conversion factors derived from heat contents of natural gas that is produced and consumed regionally.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections: United States:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), www.eia.gov/aeo. **Other:** EIA, International Natural Gas Model (2013).

Table I2. World tight gas, shale gas and coalbed methane production by region, Reference case, 2010-2040
(trillion cubic feet)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**15.4**	**19.2**	**22.9**	**25.7**	**28.2**	**31.0**	**34.6**	**2.7**
United States[a]	12.9	16.3	19.2	21.1	22.5	24.0	26.2	2.4
Canada	2.5	2.8	3.7	4.4	5.1	5.7	6.4	3.2
Mexico	0.0	0.0	0.0	0.2	0.6	1.2	2.0	--
Chile	0.0	0.0	0.0	0.0	0.0	0.1	0.1	--
OECD Europe	**0.0**	**0.1**	**0.5**	**1.3**	**2.5**	**3.5**	**4.3**	**19.5**
North Europe	0.0	0.1	0.5	1.3	2.4	3.4	4.2	19.3
South Europe	0.0	0.0	0.0	0.0	0.1	0.1	0.1	--
Southwest Europe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Turkey/Israel	0.0	0.0	0.0	0.0	0.0	0.0	0.1	--
OECD Asia	**0.2**	**0.3**	**1.2**	**2.1**	**2.6**	**3.2**	**3.6**	**10.6**
Japan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
South Korea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Australia/New Zealand	0.2	0.3	1.2	2.1	2.6	3.1	3.6	10.6
Total OECD	**15.6**	**19.5**	**24.5**	**29.1**	**33.4**	**37.7**	**42.5**	**3.4**
Non-OECD								
Non-OECD Europe and Eurasia	**0.0**	**0.2**	**0.8**	**1.6**	**2.7**	**3.7**	**4.5**	**--**
Russia	0.0	0.2	0.8	1.5	2.2	2.7	3.2	--
Central Asia	0.0	0.0	0.0	0.1	0.4	0.8	1.1	--
Non-OECD Europe	0.0	0.0	0.0	0.0	0.1	0.1	0.2	--
Non-OECD Asia	**0.1**	**0.7**	**1.9**	**3.5**	**5.8**	**8.5**	**10.9**	**19.4**
China	0.1	0.6	1.5	2.8	4.6	6.6	8.3	18.4
India	0.0	0.0	0.1	0.2	0.5	1.0	1.3	--
LNG Exporters	0.0	0.1	0.3	0.4	0.6	0.7	0.8	--
Other Asia	0.0	0.0	0.0	0.0	0.1	0.2	0.3	--
Middle East	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.2**	**--**
Arabian Producers	0.0	0.0	0.0	0.0	0.0	0.1	0.1	--
Iran	0.0	0.0	0.0	0.0	0.0	0.1	0.1	--
Iraq	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Qatar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Saudi Arabia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Other Middle East	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Africa	**0.0**	**0.0**	**0.1**	**0.4**	**0.7**	**1.1**	**1.6**	**--**
North Africa	0.0	0.0	0.1	0.2	0.3	0.6	1.0	--
West Africa	0.0	0.0	0.0	0.0	0.1	0.3	0.4	--
East Africa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Other Africa	0.0	0.0	0.0	0.2	0.2	0.2	0.2	--
Central and South America	**0.0**	**0.3**	**0.7**	**1.1**	**1.5**	**2.2**	**2.9**	**--**
Brazil	0.0	0.0	0.0	0.1	0.2	0.3	0.5	--
Northern Producers	0.0	0.0	0.0	0.1	0.1	0.2	0.3	--
Southern Cone	0.0	0.3	0.6	0.9	1.2	1.6	1.9	--
Andean	0.0	0.0	0.0	0.0	0.1	0.1	0.2	--
Central America and Caribbean	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Total non-OECD	**0.1**	**1.2**	**3.5**	**6.6**	**10.8**	**15.6**	**20.1**	**21.9**
Total world	**15.6**	**20.8**	**28.0**	**35.7**	**44.1**	**53.3**	**62.6**	**4.7**

[a]Includes supplemental production less any forecast discrepancy.

Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections: United States:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), www.eia.gov/aeo. **Other:** EIA, International Natural Gas Model (2013).

Table I3. World other natural gas production by region, Reference case, 2010-2040
(trillion cubic feet)

Region/country	2010	2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
		Projections						
OECD								
OECD Americas	**13.0**	**11.3**	**10.7**	**10.4**	**10.0**	**10.1**	**9.8**	**-1.0**
United States[a]	8.3	7.5	7.3	7.4	7.1	7.2	6.9	-0.6
Canada	2.9	2.2	1.8	1.5	1.3	1.2	1.2	-2.9
Mexico	1.8	1.5	1.6	1.4	1.5	1.5	1.6	-0.4
Chile	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
OECD Europe	**10.4**	**8.9**	**7.6**	**6.6**	**6.1**	**5.7**	**5.6**	**-2.0**
North Europe	10.0	8.3	6.9	6.0	5.5	5.1	5.0	-2.3
South Europe	0.3	0.3	0.4	0.4	0.4	0.4	0.4	1.0
Southwest Europe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Turkey/Israel	0.1	0.3	0.3	0.2	0.2	0.2	0.2	--
OECD Asia	**1.9**	**2.6**	**2.8**	**3.0**	**3.1**	**3.2**	**3.3**	**1.8**
Japan	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-1.0
South Korea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Australia/New Zealand	1.7	2.4	2.7	2.8	2.9	3.0	3.1	2.0
Total OECD	**25.4**	**22.8**	**21.1**	**20.0**	**19.2**	**19.0**	**18.7**	**-1.0**
Non-OECD								
Non-OECD Europe and Eurasia	**26.7**	**28.8**	**31.2**	**34.0**	**37.1**	**39.8**	**41.0**	**1.4**
Russia	20.9	21.4	22.8	24.8	27.3	29.4	30.1	1.2
Central Asia	4.6	6.2	7.1	7.9	8.5	9.1	9.6	2.5
Non-OECD Europe	1.1	1.3	1.3	1.3	1.3	1.3	1.4	0.6
Non-OECD Asia	**14.8**	**14.2**	**13.8**	**13.4**	**13.4**	**13.5**	**13.7**	**-0.3**
China	3.3	3.2	2.7	2.4	2.1	1.9	1.8	-2.0
India	1.8	1.6	1.6	1.5	1.6	1.6	1.7	-0.3
LNG Exporters	5.4	5.5	5.7	5.9	6.1	6.4	6.6	0.7
Other Asia	4.2	3.9	3.8	3.7	3.6	3.6	3.6	-0.5
Middle East	**15.9**	**20.1**	**22.7**	**25.2**	**27.4**	**29.3**	**31.3**	**2.3**
Arabian Producers	3.9	4.2	4.5	4.9	5.2	5.4	5.7	1.3
Iran	5.2	6.4	7.5	8.5	9.3	10.0	10.5	2.4
Iraq	0.0	0.1	0.1	0.3	0.6	0.8	1.2	--
Qatar	3.4	6.0	6.9	7.3	7.6	7.9	8.3	3.0
Saudi Arabia	3.1	3.2	3.6	4.0	4.5	4.9	5.4	1.9
Other Middle East	0.3	0.3	0.3	0.2	0.2	0.2	0.2	-1.9
Africa	**7.4**	**8.0**	**9.2**	**9.9**	**10.6**	**11.3**	**12.0**	**1.6**
North Africa	5.8	5.7	6.1	6.1	6.1	6.2	6.4	0.3
West Africa	1.4	2.0	2.4	3.3	3.9	4.4	4.8	4.2
East Africa	0.1	0.2	0.5	0.5	0.6	0.7	0.8	6.0
Other Africa	0.0	0.1	0.1	0.1	0.0	0.0	0.0	--
Central and South America	**5.4**	**6.1**	**6.7**	**6.9**	**7.0**	**7.3**	**7.6**	**1.1**
Brazil	0.4	1.0	1.4	1.7	1.8	2.1	2.3	5.6
Northern Producers	2.8	2.8	2.9	2.8	2.8	2.8	2.9	0.2
Southern Cone	1.4	1.4	1.5	1.6	1.6	1.6	1.5	0.3
Andean	0.8	0.8	0.8	0.8	0.7	0.7	0.7	-0.5
Central America and Caribbean	0.0	0.1	0.1	0.1	0.1	0.1	0.1	--
Total non-OECD	**70.1**	**77.2**	**83.6**	**89.4**	**95.5**	**101.2**	**105.6**	**1.4**
Total world	**95.5**	**100.0**	**104.7**	**109.4**	**114.6**	**120.2**	**124.2**	**0.9**

[a]Includes supplemental production less any forecast discrepancy.
Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections: United States:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), www.eia.gov/aeo. **Other:** EIA, International Natural Gas Model (2013).

Table I4. World net trade in natural gas by region, Reference case, 2010-2040
(trillion cubic feet)

Region/country	2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD								
OECD Americas	**0.7**	**0.9**	**0.0**	**-0.8**	**-1.0**	**-1.5**	**-2.5**	**--**
United States[a]	2.6	1.4	-0.1	-1.6	-2.1	-2.5	-3.6	--
Canada	-2.5	-1.9	-1.8	-1.8	-2.0	-2.3	-2.7	0.3
Mexico	0.5	1.2	1.6	2.3	2.6	2.8	3.0	6.3
Chile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	5.8
OECD Europe	**9.4**	**11.2**	**12.9**	**13.4**	**14.1**	**14.6**	**15.2**	**1.6**
North Europe	3.7	5.6	7.1	7.5	7.8	7.9	8.1	2.6
South Europe	2.8	2.6	2.7	2.7	2.9	3.0	3.2	0.5
Southwest Europe	1.4	1.5	1.5	1.5	1.6	1.8	1.9	0.9
Turkey/Israel	1.4	1.5	1.6	1.6	1.8	1.9	2.1	1.3
OECD Asia	**4.6**	**4.4**	**3.8**	**3.5**	**3.3**	**3.3**	**3.1**	**-1.3**
Japan	3.7	4.2	4.5	4.9	5.1	5.2	5.2	1.1
South Korea	1.5	1.5	1.6	1.8	2.0	2.3	2.5	1.7
Australia/New Zealand	-0.6	-1.3	-2.4	-3.3	-3.8	-4.2	-4.6	7.0
Total OECD	**14.7**	**16.6**	**16.6**	**16.1**	**16.4**	**16.4**	**15.8**	**0.2**
Non-OECD								
Non-OECD Europe and Eurasia	**-4.9**	**-6.9**	**-8.2**	**-9.9**	**-12.1**	**-14.1**	**-15.3**	**3.9**
Russia	-6.0	-6.1	-7.0	-8.5	-10.5	-12.2	-13.5	2.8
Central Asia	-1.5	-3.1	-3.8	-4.3	-4.9	-5.4	-5.7	4.6
Non-OECD Europe	2.6	2.3	2.6	2.9	3.3	3.6	3.9	1.4
Non-OECD Asia	**-0.9**	**1.2**	**3.7**	**6.4**	**8.7**	**10.8**	**12.1**	**--**
China	0.4	1.9	3.7	5.3	6.7	7.6	7.7	10.1
India	0.4	0.8	1.0	1.2	1.3	1.3	1.2	3.4
LNG Exporters	-2.8	-2.8	-2.8	-2.8	-2.7	-2.5	-2.3	-0.6
Other Asia	1.0	1.3	1.8	2.6	3.5	4.5	5.5	6.0
Middle East	**-2.7**	**-4.7**	**-5.3**	**-5.7**	**-6.1**	**-6.3**	**-6.7**	**3.0**
Arabian Producers	-0.2	0.0	0.3	0.5	0.7	1.0	1.3	--
Iran	-0.1	-0.6	-0.9	-1.1	-1.3	-1.5	-1.6	11.8
Iraq	0.0	0.0	0.0	-0.3	-0.5	-0.7	-1.1	--
Qatar	-2.6	-4.4	-4.9	-5.1	-5.3	-5.5	-5.8	2.6
Saudi Arabia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
Other Middle East	0.1	0.2	0.2	0.3	0.4	0.4	0.5	4.8
Africa	**-3.8**	**-4.4**	**-5.2**	**-5.5**	**-5.5**	**-5.4**	**-5.0**	**0.9**
North Africa	-2.8	-3.1	-3.2	-2.7	-2.0	-1.3	-0.6	-4.9
West Africa	-1.0	-1.3	-1.8	-2.5	-3.1	-3.7	-4.0	4.7
East Africa	-0.1	-0.1	-0.3	-0.3	-0.3	-0.4	-0.4	4.3
Other Africa	0.1	0.1	0.0	0.0	0.0	0.0	0.0	--
Central and South America	**-0.5**	**-1.0**	**-1.4**	**-1.2**	**-1.1**	**-1.3**	**-1.4**	**3.3**
Brazil	0.4	0.2	0.0	0.0	0.0	0.0	0.0	-8.6
Northern Producers	-0.7	-0.7	-0.7	-0.5	-0.4	-0.4	-0.4	-1.7
Southern Cone	0.1	0.1	-0.2	-0.3	-0.4	-0.6	-0.7	--
Andean	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.8
Central America and Caribbean	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-5.2
Total non-OECD	**-12.9**	**-15.8**	**-16.4**	**-15.9**	**-16.0**	**-16.2**	**-16.4**	**0.8**
Total world	**1.8**	**0.7**	**0.3**	**0.2**	**0.4**	**0.1**	**-0.6**	**--**

[a]Includes supplemental production less any forecast discrepancy.

Sources: **History:** U.S. Energy Information Administration (EIA), International Energy Statistics database (as of November 2012), www.eia.gov/ies. **Projections: United States:** EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), www.eia.gov/aeo. **Other:** EIA, International Natural Gas Model (2013).

Appendix J

Kaya Identity factor projections

- *Carbon dioxide intensity*
- *Energy intensity*
- *GDP per capita*
- *Population*

Table J1. World carbon dioxide intensity of energy use by region, Reference case, 2009-2040
(metric tons per billion Btu)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**55.1**	**55.4**	**53.4**	**52.5**	**52.1**	**51.8**	**51.5**	**50.7**	**-0.3**
United States[a]	57.1	57.3	55.3	54.3	54.1	54.0	54.0	53.1	-0.3
Canada	40.1	40.5	38.8	38.9	37.9	36.8	36.3	35.9	-0.4
Mexico/Chile	57.2	57.4	55.6	55.0	54.2	53.2	52.3	51.6	-0.4
OECD Europe	**51.9**	**51.2**	**49.4**	**47.9**	**46.2**	**45.7**	**45.3**	**45.0**	**-0.4**
OECD Asia	**55.3**	**55.5**	**56.3**	**53.5**	**52.5**	**51.6**	**51.3**	**50.8**	**-0.3**
Japan	52.7	53.2	57.2	54.1	53.3	52.8	52.2	51.8	-0.1
South Korea	52.8	53.7	50.7	48.1	47.2	45.4	46.0	45.8	-0.5
Australia/NewZealand	67.1	66.3	63.1	60.9	60.1	59.5	58.7	58.0	-0.4
Total OECD	**54.0**	**54.0**	**52.5**	**51.1**	**50.2**	**49.7**	**49.4**	**48.8**	**-0.3**
Non-OECD									
Non-OECD Europe and Eurasia	**55.4**	**56.0**	**55.2**	**54.4**	**53.9**	**53.4**	**52.9**	**52.5**	**-0.2**
Russia	52.3	53.8	53.3	52.5	51.9	51.2	50.6	49.8	-0.3
Other	60.3	59.7	58.3	57.6	57.4	57.1	56.7	56.7	-0.2
Non-OECD Asia	**73.2**	**72.6**	**71.3**	**68.7**	**67.8**	**66.8**	**65.6**	**64.2**	**-0.4**
China	78.9	77.9	75.8	72.5	71.6	70.5	69.3	67.8	-0.5
India	70.1	69.5	67.4	65.6	64.5	63.2	61.8	60.5	-0.5
Other	58.9	58.6	57.3	55.4	55.0	54.7	54.6	54.9	-0.2
Middle East	**59.6**	**59.4**	**59.2**	**58.0**	**57.3**	**56.9**	**56.4**	**56.5**	**-0.2**
Africa	**56.9**	**56.5**	**57.2**	**55.9**	**55.1**	**53.8**	**52.5**	**51.8**	**-0.3**
Central and South America	**41.3**	**41.8**	**42.1**	**41.1**	**40.7**	**40.1**	**39.3**	**38.5**	**-0.3**
Brazil	32.3	32.8	33.9	33.2	32.7	31.8	31.0	30.4	-0.3
Other	49.2	50.2	49.6	48.9	48.7	48.7	48.4	48.1	-0.1
Total non-OECD	**64.5**	**64.3**	**64.0**	**62.4**	**61.9**	**61.1**	**60.1**	**59.0**	**-0.3**
Total world	**59.6**	**59.5**	**59.1**	**57.9**	**57.4**	**56.9**	**56.3**	**55.5**	**-0.2**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table J2. World energy intensity by region, Reference case, 2009-2040
(thousand Btu per 2005 dollar of GDP)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**7.6**	**7.5**	**6.7**	**6.1**	**5.5**	**5.0**	**4.5**	**4.2**	**-2.0**
United States[a]	7.4	7.5	6.6	6.0	5.4	4.8	4.3	3.9	-2.1
Canada	11.7	11.2	10.5	9.7	9.3	8.9	8.4	8.0	-1.1
Mexico/Chile	5.3	5.3	4.8	4.4	4.2	4.1	3.9	3.7	-1.1
OECD Europe	**5.6**	**5.6**	**5.3**	**4.9**	**4.6**	**4.3**	**4.0**	**3.8**	**-1.3**
OECD Asia	**6.5**	**6.5**	**6.0**	**5.8**	**5.5**	**5.3**	**5.0**	**4.8**	**-1.0**
Japan	5.6	5.6	5.2	5.1	5.0	4.9	4.8	4.7	-0.6
South Korea	8.1	8.2	7.4	6.7	6.0	5.6	5.1	4.6	-1.9
Australia/NewZealand	8.7	8.4	7.7	7.3	6.7	6.3	5.8	5.4	-1.5
Total OECD	**6.6**	**6.6**	**6.0**	**5.6**	**5.2**	**4.8**	**4.4**	**4.1**	**-1.6**
Non-OECD									
Non-OECD Europe and Eurasia	**10.1**	**10.5**	**9.1**	**7.8**	**6.8**	**6.1**	**5.5**	**4.9**	**-2.5**
Russia	13.9	14.7	12.7	11.2	10.3	9.7	9.2	8.8	-1.7
Other	6.9	7.1	6.2	5.1	4.4	3.8	3.3	2.9	-2.9
Non-OECD Asia	**8.9**	**8.7**	**7.6**	**6.6**	**5.8**	**5.0**	**4.3**	**3.8**	**-2.7**
China	11.2	11.0	9.6	8.4	7.2	6.1	5.2	4.5	-2.9
India	6.9	6.7	5.4	4.4	3.8	3.2	2.9	2.5	-3.2
Other	6.4	6.2	5.1	4.6	4.2	3.9	3.6	3.3	-2.1
Middle East	**11.7**	**12.1**	**11.9**	**11.0**	**10.8**	**10.7**	**10.8**	**11.0**	**-0.3**
Africa	**4.9**	**4.8**	**4.0**	**3.5**	**3.2**	**2.8**	**2.5**	**2.3**	**-2.4**
Central and South America	**5.8**	**5.8**	**5.2**	**4.6**	**4.2**	**4.0**	**3.8**	**3.6**	**-1.6**
Brazil	6.9	7.0	6.3	5.8	5.4	5.1	4.9	4.8	-1.3
Other	5.1	5.1	4.4	3.9	3.5	3.2	3.0	2.8	-2.0
Total non-OECD	**8.3**	**8.3**	**7.3**	**6.5**	**5.7**	**5.0**	**4.4**	**3.9**	**-2.5**
Total world	**7.4**	**7.4**	**6.7**	**6.1**	**5.5**	**4.9**	**4.4**	**4.0**	**-2.0**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo; and World Energy Projection System Plus (2013).

Table J3. World gross domestic product (GDP) per capita by region expressed in purchasing power parity, Reference case, 2009-2040

(2005 dollars per person)

Region	History		Projections						Average annual percent change, 2010-2040
	2009	2010	2015	2020	2025	2030	2035	2040	
OECD									
OECD Americas	**32,959**	**33,559**	**36,264**	**39,848**	**43,145**	**46,824**	**51,175**	**56,306**	**1.7**
United States[a]	41,478	42,130	45,224	49,521	53,259	57,343	62,044	67,452	1.6
Canada	34,582	35,285	37,485	40,040	41,910	43,909	46,715	50,028	1.2
Mexico/Chile	12,215	12,750	14,862	16,996	19,460	22,324	25,830	30,192	2.9
OECD Europe	**25,770**	**26,269**	**27,363**	**29,924**	**32,694**	**35,369**	**38,368**	**41,753**	**1.6**
OECD Asia	**28,623**	**29,875**	**32,912**	**36,117**	**39,347**	**42,264**	**45,505**	**48,961**	**1.7**
Japan	29,469	30,827	33,255	35,494	37,780	39,295	40,663	41,396	1.0
South Korea	25,941	27,455	32,529	39,168	45,688	52,481	60,418	70,252	3.2
Australia/NewZealand	29,409	29,672	32,045	33,646	35,317	37,406	40,187	43,613	1.3
Total OECD	**28,998**	**29,666**	**31,741**	**34,862**	**37,976**	**41,168**	**44,846**	**49,076**	**1.7**
Non-OECD									
Non-OECD Europe and Eurasia	**12,856**	**13,322**	**15,990**	**19,983**	**24,336**	**29,205**	**34,901**	**40,997**	**3.8**
Russia	13,754	14,402	17,103	21,026	24,985	28,665	32,431	35,178	3.0
Other	12,215	12,554	15,196	19,252	23,892	29,567	36,529	44,770	4.3
Non-OECD Asia	**4,626**	**5,013**	**6,720**	**8,711**	**11,035**	**13,833**	**16,989**	**20,298**	**4.8**
China	6,219	6,836	10,014	13,625	18,066	23,569	29,664	35,573	5.7
India	2,785	2,989	3,908	5,247	6,781	8,614	10,790	13,356	5.1
Other	4,718	5,046	5,986	7,035	8,179	9,571	11,331	13,533	3.3
Middle East	**11,118**	**11,015**	**12,128**	**13,275**	**13,595**	**13,796**	**13,910**	**13,771**	**0.7**
Africa	**3,830**	**3,927**	**4,336**	**4,965**	**5,673**	**6,539**	**7,570**	**8,788**	**2.7**
Central and South America	**10,175**	**10,726**	**12,415**	**14,165**	**15,880**	**17,756**	**19,946**	**22,580**	**2.5**
Brazil	9,486	10,111	11,633	13,591	15,350	17,500	20,261	23,741	2.9
Other	10,686	11,178	12,980	14,572	16,247	17,929	19,738	21,834	2.3
Total non-OECD	**5,673**	**6,003**	**7,469**	**9,205**	**11,109**	**13,326**	**15,805**	**18,399**	**3.8**
Total world	**9,876**	**10,247**	**11,721**	**13,604**	**15,629**	**17,930**	**20,536**	**23,330**	**2.8**

[a]Includes the 50 States and the District of Columbia.
Notes: Totals may not equal sum of components due to independent rounding. GDP growth rates for non-OECD Europe and Eurasia (excluding Russia), China, India, Africa, and Central and South America (excluding Brazil) were adjusted, based on the analyst's judgment.
Sources: Derived from Oxford Economic Model (October 2012), www.oxfordeconomics.com (subscription site); IHS Global Insight, *World Overview* (Lexington, MA, various issues); and EIA, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013), AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo.

Table J4. World population by region, Reference case, 2009-2040
(millions)

Region	History 2009	History 2010	Projections 2015	2020	2025	2030	2035	2040	Average annual percent change, 2010-2040
OECD									
OECD Americas	**470**	**475**	**499**	**523**	**547**	**569**	**591**	**612**	**0.8**
United States[a]	308	310	325	340	356	372	388	404	0.9
Canada	34	34	36	38	40	42	44	46	1.0
Mexico/Chile	129	131	138	144	150	155	159	162	0.7
OECD Europe	**553**	**556**	**570**	**580**	**588**	**594**	**598**	**601**	**0.3**
OECD Asia	**202**	**203**	**204**	**205**	**204**	**203**	**201**	**199**	**-0.1**
Japan	128	128	127	125	122	119	117	114	-0.4
South Korea	48	48	49	50	50	50	50	49	0.1
Australia/NewZealand	26	27	28	30	32	33	34	35	0.9
Total OECD	**1,226**	**1,234**	**1,273**	**1,307**	**1,339**	**1,366**	**1,390**	**1,411**	**0.4**
Non-OECD									
Non-OECD Europe and Eurasia	**338**	**338**	**342**	**342**	**342**	**340**	**337**	**334**	**0.0**
Russia	141	140	142	141	139	136	134	131	-0.2
Other	197	198	199	201	203	203	203	202	0.1
Non-OECD Asia	**3,595**	**3,631**	**3,813**	**3,975**	**4,116**	**4,233**	**4,325**	**4,391**	**0.6**
China	1,335	1,341	1,370	1,388	1,395	1,393	1,381	1,361	0.0
India	1,208	1,225	1,308	1,387	1,459	1,523	1,580	1,627	1.0
Other	1,052	1,066	1,135	1,201	1,262	1,316	1,363	1,403	0.9
Middle East	**204**	**208**	**229**	**250**	**269**	**288**	**305**	**321**	**1.5**
Africa	**987**	**1,009**	**1,123**	**1,242**	**1,363**	**1,487**	**1,615**	**1,747**	**1.8**
Central and South America	**454**	**459**	**485**	**508**	**529**	**547**	**562**	**574**	**0.7**
Brazil	193	195	203	210	216	220	223	224	0.5
Other	261	264	281	297	313	326	339	349	0.9
Total non-OECD	**5,578**	**5,646**	**5,991**	**6,317**	**6,619**	**6,894**	**7,143**	**7,366**	**0.9**
Total world	**6,804**	**6,880**	**7,264**	**7,624**	**7,958**	**8,260**	**8,533**	**8,777**	**0.8**

[a]Includes the 50 States and the District of Columbia.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **United States:** U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2013*, DOE/EIA-0383(2013) (Washington, DC: April 2013); AEO2013 National Energy Modeling System, run REF2013.D102312A, www.eia.gov/aeo. **Other countries:** IHS Global Insight, *World Overview* (Lexington, MA, various issues).

Appendix K

Comparisons with International Energy Agency and *IEO2011* projections

Comparisons with IEA's *World Energy Outlook 2012*

The International Energy Agency (IEA) in its *World Energy Outlook 2012* provides projections comparable with those in *IEO2013*. In both reports, 2010 is the latest year of historical data on which the projections are based. Although the *IEO2013* projections now extend to 2040, IEA projections extend only to 2035. As a result, two time periods can be compared—2010 to 2020 and 2020 to 2035.

IEA's *World Energy Outlook 2012* presents three scenario cases: New Policies Scenario (the report's "central scenario"), Current Policies Scenario, and 450 Scenario. Much of the text of the IEA report concentrates on the New Policies Scenario, which "takes into account broad policy commitments and plans that have already been implemented to address energy-related challenges . . . even when specific measures to implement these commitments have yet to be introduced."[48] In contrast, the IEA Current Policies Scenario incorporates only "those government policies and measures that had been enacted or adopted by mid-2012." The *IEO2013* Reference case is most directly comparable with the IEA Current Policies Scenario, which is used here for comparison purposes.

Although world oil price assumptions in 2011 and 2035 are similar in the IEA Current Policies Scenario and the *IEO2013* Reference case, the two outlooks have much different expectations for prices in the intervening years. In the *IEO2013* Reference case, Brent crude oil prices decline from $111 per barrel in 2011 to $96 per barrel in 2015 (all prices in real 2011 dollars per barrel). Thereafter, oil prices in the *IEO2013* Reference case continue rising to $145 per barrel in 2035. In the IEA Current Policies Scenario, crude oil import prices increase from $108 per barrel in 2011 to $121 per barrel in 2015, decline to $118 per barrel in 2025, and then increase to $145 in 2035. Despite the differences in mid-term price assumptions, demand for liquid fuels in 2020 is similar in the two outlooks. Liquids demand in the IEA Current Policies Scenario is 98 million barrels per day in 2020, compared with 97 million barrels per day in the *IEO2013* Reference case. Prices begin to increase more rapidly after 2020 in the *IEO2013* Reference case than in the IEA Current Policies Scenario. As a result, demand for petroleum and other liquid fuels in 2035 in the *IEO2013* Reference case is 109 million barrels per day, compared with 112 million barrels per day in the IEA Current Policies Scenario.

For the period from 2010 to 2020, world energy consumption increases by 1.9 percent per year in both the IEA Current Policies Scenario and the *IEO2013* Reference case (Table K1). The two outlooks have similar projections for growth in total OECD energy consumption—0.4 percent per year in the IEA Current Policies Scenario and 0.5 percent per year in the *IEO2013* Reference case. There are some differences in the projections for OECD regions, however, with the *IEO2013* Reference case projecting slightly slower growth than the IEA Current Policies Scenario for the OECD Americas, but twice as rapid growth for OECD Europe and OECD Asia, from 2010 to 2020.

Table K1. Comparison of *IEO2013* and IEA world energy consumption growth rates by region, 2010-2020 (average annual percent growth)

Region	*IEO2013*	IEA
OECD	**0.5**	**0.4**
Americas	0.5	0.6
United States	0.3	0.3
Europe	0.4	0.2
Asia	0.8	0.4
Non-OECD	**2.9**	**2.9**
Europe and Eurasia	1.2	1.2
China	4.6	3.8
India	2.8	3.9
Other non-OECD Asia	1.6	2.8
Middle East	2.8	2.8
Africa	1.5	1.9
Central & South America	1.5	2.6
World	**1.9**	**1.9**

Sources: ***IEO2013***: U.S. Energy Information Administration, World Energy Projection System Plus (2013). **IEA**: International Energy Agency, *World Energy Outlook 2012* (Paris, France, November 2012), pp. 552-627, Current Policies Scenario.

For the entire group of non-OECD countries, the IEA projections for total energy consumption are the same as those in the *IEO2013* Reference case, with demand growth averaging 2.9 percent per year from 2010 to 2020. On a regional basis, however, there are fairly wide variations between the IEA and *IEO2013* reports in the near term. Projected growth rates in the IEA report exceed those in *IEO2013* for India and the other countries of non-OECD Asia (excluding China), non-OECD Africa, and non-OECD Central and South America. For India, IEA projects annual increases in energy consumption averaging 3.9 percent per year from 2010 to 2020, whereas *IEO2013* projects average increases of 2.8 percent per year. For the other non-OECD Asia nations (excluding China and India), IEA projects a 2.8-percent average annual increase in total energy use, compared with 1.6 percent in *IEO2013*. For Africa, IEA projects average increases in total energy demand of 1.9 percent per year from 2010 to 2020, compared with 1.5 percent per year in the *IEO2013* Reference case. For non-OECD Central and South America, IEA and *IEO2013* project average annual increases of 2.6 percent and 1.5 percent, respectively. China is the only non-OECD region for which projected growth in energy consumption from 2010 to 2020 in the *IEO2013* Reference case exceeds that in the IEA Current Policies Scenario projection, at 4.6 percent per year and 3.8 percent per year, respectively.

[48] International Energy Agency, *World Energy Outlook 2012: Executive Summary* (Paris, France, November 2012), p. 34.

For the period from 2020 to 2035, both the *IEO2013* Reference case and the IEA Current Policies Scenario project slowing growth in world energy demand. In the *IEO2013* Reference case, world energy consumption rises by an average of 1.4 percent per year from 2020 to 2035, compared with 1.3 percent per year in the IEA Current Policies Scenario (Table K2). Among the OECD regions, demand growth is similar in the *IEO2013* and IEA projections, although *IEO2013* projects slightly higher anticipated growth for all OECD regions. In both projections, U.S. energy consumption grows by an average of 0.2 percent per year.

For total non-OECD energy consumption, the *IEO2013* Reference case and the IEA Current Policies Scenario project similar overall growth rates in energy demand from 2020 to 2035. However, four non-OECD regions show relatively large differences. For China and Africa, *IEO2013* projects a higher growth rate than in the IEA projection, and for India and the Middle East, *IEO2013* projects a lower growth rate than in the IEA projection. In the *IEO2013* Reference case, China's energy consumption growth averages 2.0 percent per year, and Africa's energy consumption growth averages 2.3 percent per year from 2020 to 2035; in IEA's Current Policies Scenario, the average growth rates for energy demand in the two regions are 1.5 percent and 1.4 percent per year, respectively. The relatively large difference between the two projections for energy demand growth in Africa reflect different assumptions about the region's economic growth rate over the 2020-2035 period: 4.6 percent per year on average in the *IEO2013* Reference case, as compared with 3.8 percent in the IEA Current Policies Scenario.

The projections vary not only with respect to levels of energy demand but also with respect to the mix of primary energy inputs. For the 2010-2020 period, IEA projects faster growth in the use of coal and natural gas and slower growth in the use of nuclear and renewable energy sources than does *IEO2013* (Table K3). The IEA projection shows world coal consumption increasing by an annual average of 2.4 percent from 2010 to 2020, compared with 2.0 percent in the *IEO2013* Reference case. World natural gas consumption in the IEA Current Policies Scenario increases by 2.0 percent per year between 2010 and 2020, compared with 1.5 percent per year in *IEO2013*.

In the *IEO2013* Reference case, growth in renewable energy use from 2010 to 2020 averages 3.7 percent per year, compared with 2.3 percent per year in the IEA Current Policies Scenario (adjusted for this comparison by removing biofuels from total renewables and reporting them as liquid fuels, consistent with EIA's treatment of biofuels). The differences are, in large part, a result of IEA's inclusion of traditional, nonmarketed biomass in its renewable energy projections, whereas the *IEO2013* projections do not include consumption of nonmarketed renewable fuels, which is not likely to expand significantly, because developing countries tend to move away from traditional fuels to commercial fuels as their energy infrastructures and standards of living increase. Still, consumption of traditional fuels in some developing countries is estimated to be quite large, with effects on total renewable energy use that would tend to mask any growth in the consumption of energy from marketed, commercial renewable sources—particularly, wind and other nonhydroelectric renewables.

The IEA Current Policies Scenario projections for nuclear power generally are more conservative than those in the *IEO* Reference case. In the IEA projection, world nuclear power consumption increases by an average of 2.1 percent per year from 2010 to 2020, compared with 3.3 percent per year in the *IEO2013* Reference case. Slower growth in nuclear power is offset by IEA's higher growth projections for coal and natural gas consumption. The difference between the IEA and *IEO2013* projections for nuclear energy can be explained in part by different expectations for the OECD region, which accounted for 83 percent of the world's total nuclear power use in 2010. The IEA Current Policies Scenario assumes that both Japan and OECD Europe will experience declines in nuclear power consumption from 2010 to 2020 following

Table K2. Comparison of *IEO2013* and IEA world energy consumption growth rates by region, 2020-2035 (average annual percent growth)

Region	*IEO2013*	IEA
OECD	**0.5**	**0.4**
Americas	0.6	0.4
United States	0.2	0.2
Europe	0.5	0.3
Asia	0.5	0.3
Non-OECD	**1.9**	**1.8**
Europe and Eurasia	1.3	1.1
China	2.0	1.5
India	2.8	3.4
Other non-OECD Asia	2.3	2.4
Middle East	1.5	2.0
Africa	2.3	1.4
Central & South America	1.7	1.6
World	**1.4**	**1.3**

Sources: ***IEO2013*:** U.S. Energy Information Administration, World Energy Projection System Plus (2013). **IEA:** International Energy Agency, *World Energy Outlook 2012* (Paris, France, November 2012), pp. 552-627, Current Policies Scenario.

Table K3. Comparison of *IEO2013* and IEA world energy consumption growth rates by fuel, 2010-2020 (average annual percent growth)

Fuel	*IEO2013*	IEA
Liquids	1.0	1.1
Natural gas	1.5	2.0
Coal	2.0	2.4
Nuclear	3.3	2.1
Renewables/Other	3.7	2.3
Total	**1.9**	**1.9**

Sources: ***IEO2013*:** U.S. Energy Information Administration, World Energy Projection System Plus (2013). **IEA:** International Energy Agency, *World Energy Outlook 2012* (Paris, France, November 2012), pp. 552-627, Current Policies Scenario.

the Fukushima disaster, with Japan's nuclear power consumption decreasing on average by 1.9 percent per year and OECD Europe's by 1.1 percent per year. *IEO2013* projects a steeper decline in Japan's nuclear power consumption in the short term, averaging 3.9 percent per year, with the country's nuclear power plants being brought back into operation slowly over the period, but does not anticipate a decline in OECD Europe's nuclear power consumption, which increases by an average of 0.7 percent per year from 2010 to 2020.

Similar to the OECD nuclear projections, *IEO2013* also projects higher growth in non-OECD nuclear power demand than does the IEA Current Policies Scenario over the 2010-2020 period. In the *IEO2013* Reference case, the average annual growth rate for non-OECD nuclear power generation is more than 2 percentage points higher than in the IEA projection, at 11.1 percent per year as compared with 8.9 percent per year in the IEA Current Policies Scenario. The *IEO2013* projections for nuclear power growth are higher than the IEA projections for every non-OECD region. Both outlooks acknowledge the increased uncertainty in their projections for nuclear power relative to earlier projections.

For the period from 2020 to 2035, the most noticeable differences between the *IEO2013* Reference case and IEA projections are again for nuclear power and renewable energy sources (Table K4). In the IEA projection, the average annual growth rate for world nuclear electricity consumption slows from 2.1 percent in the 2010-2020 period to 0.9 percent in the 2020-2035 period; *IEO2013* projects average annual increases of 3.3 percent from 2010 to 2020 and 2.3 percent from 2020 to 2035. In the IEA Current Policies Scenario, renewable energy use increases by 2.3 percent per year over the 2010-2020 period and by 1.4 percent per year from 2020 to 2035; in the *IEO2013* Reference case, renewable energy use increases by 3.7 percent per year from 2010 to 2020 and 2.0 percent per year from 2020 to 2035.

Comparisons with *IEO2011*

The *IEO2011* projections extended only to 2035, and as a result, comparisons with the *IEO2013* projections are made for the years 2020 and 2035. The *IEO2013* Reference case projection for total energy consumption in 2020 is 10 quadrillion Btu (about 2 percent) higher than projected in *IEO2011*. Total marketed energy consumption in 2020 in the *IEO2013* Reference case is 630 quadrillion Btu, as compared with 619 quadrillion Btu in *IEO2011* (Table K5). The largest regional difference between the two outlooks is for China: *IEO2013* projects 18 quadrillion Btu (about 13 percent) higher energy demand for China in 2020 than was projected in *IEO2011*. The *IEO2013* projection for OECD energy consumption is 6 quadrillion Btu (about 2 percent) lower than the *IEO2011* projection, with nearly all of the difference attributable to the OECD Americas and, primarily, the United States.

The near-term differences between the *IEO2013* and *IEO2011* projections are continued throughout the projection. The *IEO2013* projection for total world energy use in 2035 is 7 quadrillion Btu (about 1 percent) higher than projected in *IEO2011*. Again, higher demand in China is offset by lower demand in the OECD Americas (mainly the United States), explaining much of the difference between the two outlooks. China's total energy consumption in 2035 is 22 quadrillion Btu (11 percent) higher in *IEO2013* than it was in *IEO2011*. In contrast, projected energy consumption in the OECD Americas is 11 quadrillion Btu (4 percent) higher in *IEO2013* than in *IEO2011*. There are modest differences in other regions, but for the most part the 2035 projections for marketed energy use outside of China and the OECD Americas are similar in *IEO2013* and *IEO2011*.

Table K4. Comparison of *IEO2013* and IEA world energy consumption growth rates by fuel, 2020-2035 (average annual percent growth)

Fuel	*IEO2013*	IEA
Liquids	0.9	0.8
Natural gas	1.8	1.8
Coal	1.2	1.5
Nuclear	2.3	0.9
Renewables/Other	2.0	1.4
Total	**1.4**	**1.3**

Sources: ***IEO2013*:** U.S. Energy Information Administration, World Energy Projection System Plus (2013). **IEA:** International Energy Agency, *World Energy Outlook 2012* (Paris, France, November 2012), pp. 552-627, Current Policies Scenario.

Along with regional differences between the *IEO2013* and *IEO2011* projections, there are some differences in the projected mix of energy resources consumed (Table K6). The largest difference is in the 2020 projection for world coal consumption, which in the *IEO2013* Reference case is 16 quadrillion Btu higher than projected in *IEO2011*. In 2020, demand for every type of energy is lower in *IEO2013* than in *IEO2011*, reflecting increased demand for coal in China. In 2035, demand for all energy sources is higher in *IEO2013* than in *IEO2011* for all energy sources except liquid fuels and renewable energy sources. The largest increase relative to *IEO2011* is for coal consumption in China, which in 2035 is nearly 10 quadrillion Btu (about 8 percent) higher in *IEO2013*. A downward revision in U.S. liquids consumption helps to offset the increase in China's coal use. U.S. liquids consumption in 2035 is about 6 quadrillion Btu (15 percent) lower in *IEO2013*, mostly as a result of vehicle efficiency gains.

Table K5. Total Reference Case energy consumption in *IEO2013* and *IEO2011*, 2020 and 2035 (quadrillion Btu)

Region	2020		2035		Difference between *IEO2013* and *IEO2011*	
	IEO2013	*IEO2011*	*IEO2013*	*IEO2011*		
OECD	**255**	**261**	**276**	**288**	**-6**	**-12**
Americas	**126**	**131**	**137**	**148**	**-5**	**-11**
United States	100	105	104	114	-4	-10
Canada	15	16	17	19	-1	-1
Mexico/Chile	11	10	16	15	1	1
Europe[a]	85	87	93	94	-1	-1
Asia	**43**	**43**	**46**	**47**	**0**	**-1**
Japan	23	23	23	24	-1	-1
South Korea	13	12	15	14	1	1
Australia/NewZealand	7	8	8	9	0	-1
Non-OECD	**375**	**359**	**501**	**482**	**16**	**19**
Non-OECD Europe and Eurasia[a]	**53**	**52**	**65**	**58**	**1**	**6**
Russia	33	31	40	36	2	4
Other	20	21	25	23	-1	2
Non-OECD Asia	**230**	**215**	**317**	**299**	**15**	**18**
China	159	141	213	191	18	22
India	32	33	49	49	-1	0
Other	39	41	55	58	-2	-3
Middle East[a]	37	34	46	45	3	0
Africa	22	24	31	31	-2	0
Central and South America	33	34	42	48	-1	-5
Total world	**630**	**619**	**777**	**770**	**10**	**7**

[a]In *IEO2011*, Estonia was reported in non-OECD Europe and Eurasia, and Israel was reported in the Middle East. In *IEO2013* both are reported in OECD Europe.

Sources: ***IEO2011***: U.S. Energy Information Administration, *International Energy Outlook 2011*, DOE/EIA-0484(2011) (Washington, DC: September 2011). ***IEO2013***: U.S. Energy Information Administration, World Energy Projection System Plus (2013).

Table K6. Reference Case energy consumption by energy source in *IEO2013* and *IEO2011*, 2020 and 2035 (quadrillion Btu)

Fuel	2020		2035		Difference between *IEO2013* and *IEO2011*	
	IEO2013	*IEO2011*	*IEO2013*	*IEO2011*		
Liquids	195	196	221	225	-1	-4
Natural gas	136	138	177	175	-2	3
Coal	180	165	217	209	16	8
Nuclear	38	39	53	51	-1	2
Renewables/Other	81	82	108	110	-1	-1
Total	**630**	**619**	**777**	**770**	**10**	**7**

Note: In *IEO2011*, Estonia was reported in non-OECD Europe and Eurasia, and Israel was reported in the Middle East. In *IEO2013* both are reported in OECD Europe.

Sources: ***IEO2011***: U.S. Energy Information Administration, *International Energy Outlook 2011*, DOE/EIA-0484(2011) (Washington, DC: September 2011). ***IEO2013***: U.S. Energy Information Administration, World Energy Projection System Plus (2013).

Appendix L

Models used to generate the *IEO2013* projections

The *IEO2013* projections of world energy consumption and supply were generated from EIA's World Energy Projections Plus (WEPS+) model. WEPS+ consists of a system of individual sectoral energy models, using an integrated iterative solution process that allows for convergence of consumption and prices to an equilibrium solution. It is used to build the Reference case energy projections, as well as alternative energy projections based on different assumptions for GDP growth and fossil fuel prices. It can also be used to perform other analyses.

WEPS+ produces projections for 16 regions or countries of the world, including OECD Americas (United States, Canada, and Mexico/Chile), OECD Europe, OECD Asia (Japan, South Korea, and Australia/New Zealand), Russia, other non-OECD Europe and Eurasia, China, India, other non-OECD Asia, Brazil, and other Central and South America. Currently, the projections extend to 2040.

The WEPS+ platform allows the various individual models to communicate through a common, shared database and provides a comprehensive, central series of output reports for analysis. In the individual models, the detail also extends to the subsector level. In WEPS+, the end-use demand models (residential, commercial, industrial, and transportation) project consumption of the key primary energy sources: several petroleum products, other liquids, natural gas, coal, nuclear power, hydropower, wind, geothermal, and other renewable sources. These models also provide intermediate consumption projections for electricity in the end-use demand sectors.

The end-use model projections generally depend on retail supply prices, economic activity as represented by GDP (or gross output in the industrial sector), and population. The transformation models (power generation and district heat) satisfy electricity and heat requirements and also project consumption of primary energy sources at resulting price levels. The supply models (petroleum, natural gas, and coal) generate supply and wholesale price projections for the key supply sources corresponding to the primary consumption sources. The refinery model makes retail price projections for a variety of petroleum products corresponding to the world oil price. The main model in the WEPS+ system monitors the convergence sequence for all the models and projects energy-related carbon dioxide emissions from fossil fuels (including emissions from the use of petrochemical feedstocks but excluding flared natural gas) at the regional level.

Small improvements were made throughout the WEPS+ modeling system, and with the exception of the macroeconomics, the models themselves are essentially unchanged from those used for *IEO2011*. The model enhancements implemented in this year's version of the WEPS+ model include a new suite of macroeconomic models, improvements to the modeling platform and improvements in the individual models. For the WEPS+ World Industrial Model, these improvements included:

- A fuel switching algorithm was added which employs World Bank regional cross-price elasticities for the industrial sector.
- A coal feedstock sub-module for China was added to accommodate new coal-based capacity growths in the Chinese chemical sector.
- Adjusted near-term industrial electricity efficiency improvements in Japan were implemented to reflect recent post-Fukushima energy efficiency efforts.

In addition, the following minor changes were implemented:

- The World Electricity Model has been recoded to Python from Fortran.
- The benchmarking of historical data has been automated using Python and SQL.
- Estonia and Israel have joined the OECD. For statistical purposes, they are reported with OECD Europe.

The Reference case reflects the underlying relationships incorporated in the complete set of models interacting with each other in supply/demand relationships communicated through macroeconomic variables, prices, and consumption. The system of models is run iteratively to a point at which prices and consumption have converged to a reasonable equilibrium. Accumulated knowledge from the results of other complex models that focus on specific supply or demand issues and analysts' expert judgments also are taken into account and incorporated into the final projections. After the Reference case has been established, WEPS+ is used to run alternative cases that reflect different assumptions about future economic growth and energy prices. WEPS+ also can be used for other analyses, such as the effects of carbon prices.

The Oxford Economics Global Economic Model (GEM) and Global Industry Model (GIM) are used to generate projections of gross domestic product (GDP) and gross output (GO) for the various IEO countries and regions and their respective industrial sectors. The theoretical structure of the GEM differentiates between the short and long-run for each country, with extensive coverage of the links between different economies. The GEM outputs GDP for use with WEPS+ and also provides drivers for the GIM. The structure of the GIM is based on input-output relationships, and this model outputs GO in the IEO sectors for each country or region in WEPS+.

The Generate World Oil Balance (GWOB) application is used to create a "bottom up" projection of world liquids supply—based on current production capacity, planned future additions to capacity, resource data, geopolitical constraints, and prices—and to generate conventional crude oil production cases. The scenarios (Oil Price cases) are developed through an iterative process of examining demand levels at given prices and considering price and income sensitivity on both the demand and supply sides of the equation. Projections of conventional liquids production for 2010 through 2015 are based on analysis of investment and development trends around the globe. Data from EIA's *Short-Term Energy Outlook* are integrated to ensure consistency between short- and long-term modeling efforts. Projections of unconventional liquids production are based on exogenous analysis.

Ten major streams of liquids production are tracked on a volume basis: (1) crude oil and lease condensate, (2) natural gas plant liquids, (3) refinery gains, (4) Canadian oil sands, (5) extra-heavy oils, (6) coal-to-liquids, (7) gas-to-liquids, (8) shale oils, (9) ethanol, and (10) biodiesel. Biofuels are tracked on both a volume basis and an oil equivalent basis. All liquid fuels are reported in physical volumes, unless otherwise stated.

The *IEO2013* projections of global natural gas production and trade were generated from EIA's International Natural Gas Model (INGM), a tool that estimates natural gas production, demand, and international trade. It combines estimates of natural gas reserves, natural gas resources and resource extraction costs, energy demand, and transportation costs and capacity in order to estimate future production, consumption, and prices of natural gas.

INGM incorporates regional energy consumption projections by fuel from the WEPS+ model, as well as more detailed U.S. projections from NEMS, which is used to generate U.S. energy projections for the *Annual Energy Outlook*. An iterative process between INGM and WEPS+ is used to balance world natural gas markets, with INGM providing supply curves to WEPS+ and receiving demand estimates developed by WEPS+. INGM uses regional natural gas demand estimates from NEMS for the United States rather than those computed as part of the WEPS+ output, so that the final output for the United States is consistent with *AEO* projections.

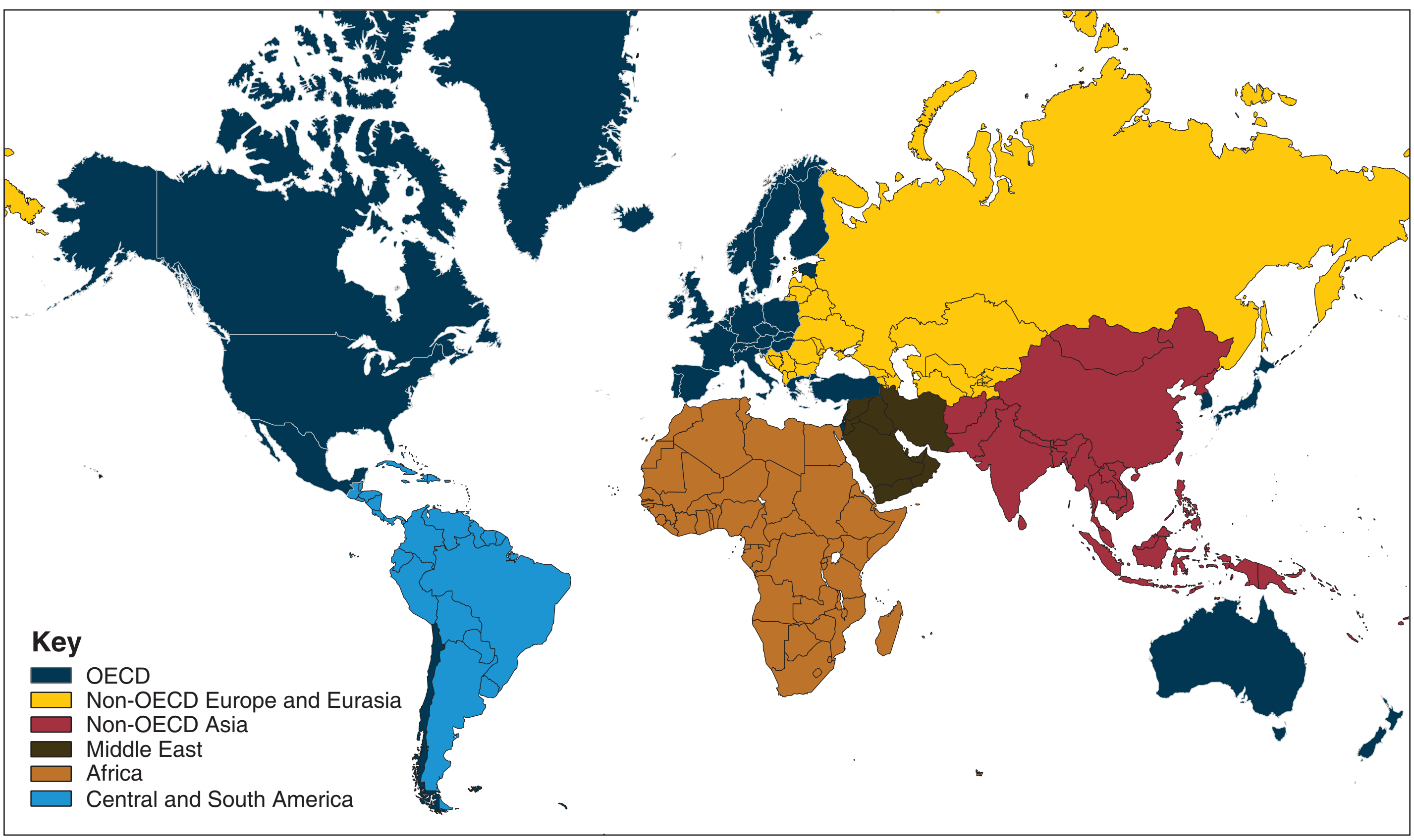
Appendix M

Regional definitions

The six basic country groupings used in this report (Figure M1) are defined as follows:

- **OECD** (18 percent of the 2013 world population): **OECD Americas**—United States, Canada, Chile, and Mexico; **OECD Europe**—Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom. Israel is reported in OECD Europe for statistical purposes. **OECD Asia**—Japan, South Korea, Australia, and New Zealand.
- **Non-OECD** (82 percent of the 2013 world population):
  - **Non-OECD Europe and Eurasia** (5 percent of the 2013 world population)—Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Malta, Moldova, Montenegro, Romania, Russia, Serbia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
  - **Non-OECD Asia** (53 percent of the 2013 world population)—Afghanistan, American Samoa, Bangladesh, Bhutan, Brunei, Cambodia (Kampuchea), China, Cook Islands, Fiji, French Polynesia, Guam, Hong Kong, India, Indonesia, Kiribati, Laos, Macau, Malaysia, Maldives, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, Niue, North Korea, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Taiwan, Thailand, Timor-Leste (East Timor), Tonga, U.S. Pacific Islands, Vanuatu, Vietnam, and Wake Islands.
  - **Middle East** (3 percent of the 2013 world population)—Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, the United Arab Emirates, and Yemen.
  - **Africa** (15 percent of the 2013 world population)—Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo (Brazzaville), Congo (Kinshasa), Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, St. Helena, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, and Zimbabwe.
  - **Central and South America** (7 percent of the 2013 world population)—Antarctica, Antigua and Barbuda, Argentina, Aruba, The Bahamas, Barbados, Belize, Bolivia, Brazil, British Virgin Islands, Cayman Islands, Colombia, Costa Rica, Cuba, Dominica,

Figure M1. Map of the six basic country groupings



Source: Energy Information Administration, Office of Energy Analysis.

Dominican Republic, Ecuador, El Salvador, Falkland Islands, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Kitts-Nevis, St. Lucia, St. Vincent/Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay, U.S. Virgin Islands, and Venezuela.

In addition, the following commonly used country groupings are referenced in this report:

- Annex I Countries participating in the Kyoto Climate Change Protocol on Greenhouse Gas Emissions: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom.[49]
- European Union (EU): Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.
- Organization of the Petroleum Exporting Countries (OPEC): Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela.
- Persian Gulf Countries: Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.
- Natural Gas Production Regions:
  - Arabian Producers: Bahrain, Kuwait, Oman, United Arab Emirates, and Yemen.
  - North Africa: Algeria, Egypt, Libya, Morocco, Tunisia, and Western Sahara.
  - East Africa: Comoros, Kenya, Madagascar, Malawi, Mauritius, Mayotte, Mozambique, Reunion, Seychelles, and Tanzania.
  - West Africa: Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Congo (Brazzaville), Congo (Kinshasa), Côte d'Ivoire, Equatorial Guinea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Sao Tome and Principe, Sierra Leone, and Togo.
  - North Europe: Austria, Belgium, Channel Islands, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greenland, Hungary, Iceland, Ireland, Isle of Man, Luxembourg, Netherlands, Norway, Poland, Slovakia, Slovenia, Sweden, Switzerland, and the United Kingdom.
  - South Europe: Greece and Italy.
  - Southwest Europe: Portugal and Spain.
  - Andean Producers: Bolivia, Ecuador, and Peru.
  - Central America and Caribbean: Antigua and Barbuda, Aruba, The Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Granada, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama, Puerto Rico, St. Kitts-Nevis, St. Lucia, St. Vincent/Grenadines, Turks and Caicos Islands, and U.S. Virgin Islands.
  - Northern Producers (South America): Colombia, French Guiana, Guyana, Suriname, Trinidad and Tobago, and Venezuela.
  - Southern Cone: Antarctica, Argentina, Falkland Islands, Paraguay, and Uruguay.
  - Southeast Non-OECD Asia: American Samoa, Bangladesh, Cambodia, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Laos, Maldives, Marshall Islands, Micronesia, Myanmar (Burma), Nauru, New Caledonia, Niue, North Korea, Northern Mariana Islands, Palau, Philippines, Samoa, Solomon Islands, Sri Lanka, Thailand, Timor-Leste (East Timor), Tonga, U.S. Pacific Islands, Vanuatu, Vietnam, and Wake Island.
  - Central Asia: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan.
  - LNG Exporters (Non-OECD Asia): Brunei, Indonesia, Malaysia, and Papua New Guinea.
  - Non-OECD Europe: Albania, Andorra, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Faroe Islands, Gibraltar, Latvia, Liechtenstein, Lithuania, Macedonia, Malta, Moldova, Monaco, Montenegro, Romania, Serbia, and Ukraine.

[49]Turkey is an Annex I nation that has not ratified the Framework Convention on Climate Change and did not commit to quantifiable emissions targets under the Kyoto Protocol. In 2001, the United States withdrew from the Protocol.