Chapter 4

Coal

Overview

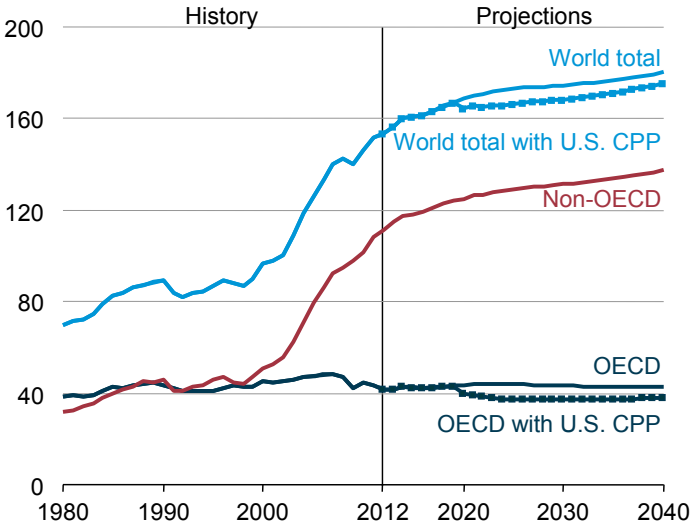
In the *International Energy Outlook 2016* (IEO2016) Reference case, coal remains the second-largest energy source worldwide—behind petroleum and other liquids—until 2030. From 2030 through 2040, it is the third-largest energy source, behind both liquid fuels and natural gas. World coal consumption increases from 2012 to 2040 at an average rate of 0.6%/year, from 153 quadrillion Btu in 2012 to 169 quadrillion Btu in 2020 and to 180 quadrillion Btu in 2040.

The Reference case estimates do not include the effect of the recently finalized Clean Power Plan (CPP) regulations in the United States, which would reduce world coal consumption to 165 quadrillion Btu in 2020 and to 176 quadrillion Btu in 2040 (about 2.5% in both years), based on EIA's analysis of the CPP proposed rule.[100] (EIA's analysis of the final rule is still being prepared; it is expected to show a roughly similar effect on projected coal use.) Over the 2012–40 projection period, total coal consumption in the non-OECD countries increases by an average of 0.8%/year, compared with an average increase of 0.1%/year in the OECD countries without the U.S. CPP and a decrease of 0.3%/year in the OECD countries with the U.S. CPP (Figure 4-1).

Throughout the projection, the top three coal-consuming countries are China, the United States, and India, which together account for more than 70% of world coal use. China accounted for 50% of world coal consumption in 2012, and its coal use continues to grow through 2025 in the Reference case before beginning a decline along with slower overall growth in energy consumption and the implementation of policies addressing air pollution and climate change. In 2040, China's share of world coal consumption falls to 46%. As a result of the slower growth and decline in China's coal use, the world coal share of total primary energy consumption declines steadily, from 28% in 2012 to 22% in 2040—in contrast to its sustained growth from 24% in 2001 to 29% in 2009, primarily as a result of increasing coal use in China. Total U.S. coal consumption per year, which peaked in 2007, remains largely unchanged from 2012 to 2040 without the CPP but declines significantly with the CPP. Although coal consumption in China does not change much from 2012 to 2040, coal use in India and the other countries of non-OECD Asia continues to rise. India's coal use surpasses the United States total around 2030, and its share of world coal consumption grows from 8% in 2012 to 14% in 2040 (Figure 4-2).

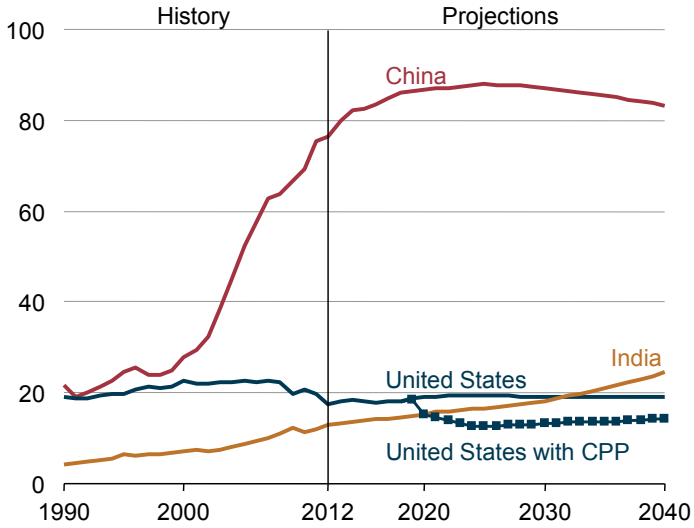
Electricity generation accounted for 59% of world coal consumption in 2012, and remains close to that share of coal use through 2040 in the IEO2016 Reference case (Figure 4-3). The industrial sector accounted for 36% of total coal use in 2012.[101, 102] Its share grows slightly in the Reference case, to 38% in 2040. Coal use in other sectors (residential and commercial), which made up 4% of total world coal consumption in 2012, accounts for 3% of the 2040 total. In the electric power sector, as renewable energy, natural

Figure 4-1. World coal consumption by region, 1980–2040 (quadrillion Btu)



Note: Dotted lines show projected effects of the U.S. Clean Power Plan.

Figure 4-2. Coal consumption in China, the United States, and India, 1990–2040 (quadrillion Btu)



Note: Dotted lines show projected effects of the U.S. Clean Power Plan.

[100] U.S. Energy Information Administration, *Analysis of the Impacts of the Clean Power Plan* (Washington, DC: May 2015), https://www.eia.gov/analysis/requests/powerplants/cleanplan/.

[101] In IEO2016, the electric power sector includes only power plants that generate electricity or electricity and heat mainly for selling electricity 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.

[102] 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.

gas, and nuclear power in combination account for a rising share of power generation. The share of electricity generated from coal worldwide declines from 40% in 2012 to 29% in 2040.

World coal production in the Reference case increases from 9 billion tons in 2012 to 10 billion tons in 2040,[103] with much of the growth occurring in India, China, and Australia (Figure 4-4). Their combined share of total world coal production increases in the IEO2016 Reference case from 60% in 2012 to 64% in 2040, but the share of the world's leading coal producer, China, decreases from 48% in 2012 to 44% in 2040. World coal production varies significantly from region to region in the Reference case, with sustained strong growth in India, slowing growth and a gradual decline after 2025 in China, and little change in the United States and OECD Europe.

Because most of the countries that consume substantial amounts of coal have domestic coal resources, the volume of world coal trade tends to be small relative to total consumption. On a tonnage basis, about 15% of the coal consumed worldwide in 2012 was imported. In the IEO2016 Reference case, the import share of world coal consumption declines slightly to 13% in 2020 and remains at that level through 2040. Total world coal trade also declines in the first few years of the projection, from 1,376 million short tons (MMst) in 2013 to 1,237 MMst in 2020, but increases thereafter to 1,354 MMst in 2040. The initial drop in world coal trade from 2013 to 2020 is attributable to projected declines in import demand for both China and India, where substantial expansion of domestic coal supplies reduces the need for imported coal. Coal trade increases from 2020 through 2040 but only to about its 2013 level. Increases in trade between 2020 and 2040 are attributable to additions of new coal-fired generating capacity, primarily in the countries of non-OECD Asia, and growing demand for imported coking coal in Asia.

International coal trade consists of 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 in industrial applications for the production of steam and direct heat. In the IEO2016 Reference case, international steam coal trade declines from 1,031 MMst in 2013 to 896 MMst in 2020, then increases to 960 MMst in 2040. Coking coal is used to produce coal coke, which in turn is used as a fuel and as a reducing agent for iron ore smelting in blast furnaces. World coking coal trade increases in the Reference case from 344 MMst in 2013 to 393 MMst in 2040. India, whose steel industry relies almost exclusively on imports of coking coal because of a lack of domestic reserves of coking coal, accounts for much of the growth, with its imports increasing from 43 MMst in 2013 to approximately 120 MMst in 2040.

World coal consumption

OECD coal consumption

With its total coal consumption remaining largely unchanged throughout the IEO2016 projection, the OECD share of world coal consumption shrinks as fuel market fundamentals and environmental regulations shift in favor of natural gas and renewables, particularly in the OECD Europe and OECD Americas regions. The United States is the largest coal consumer among the OECD countries, accounting for more than 40% of the OECD total from 2012 to 2040, and the decrease in its coal consumption from 2007 to 2012 led to a significant decline in total OECD coal consumption. In the Reference case, after a moderate recovery from 42 quadrillion Btu in 2012 to 44 quadrillion Btu in 2025, OECD coal consumption settles around 43 quadrillion Btu through 2040 (Figure 4-5), and the coal share of the OECD's total primary energy consumption falls from 18% in 2012 to 15% in 2040. Over the same period, the renewable energy (including hydropower) share of OECD energy use increases from 11% to 16%.

Figure 4-3. Coal share of world energy consumption by sector, 2012, 2020, and 2040 (percent)

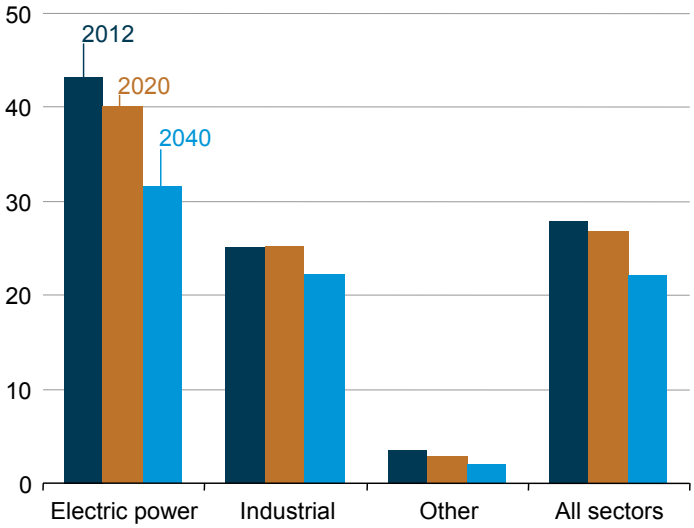
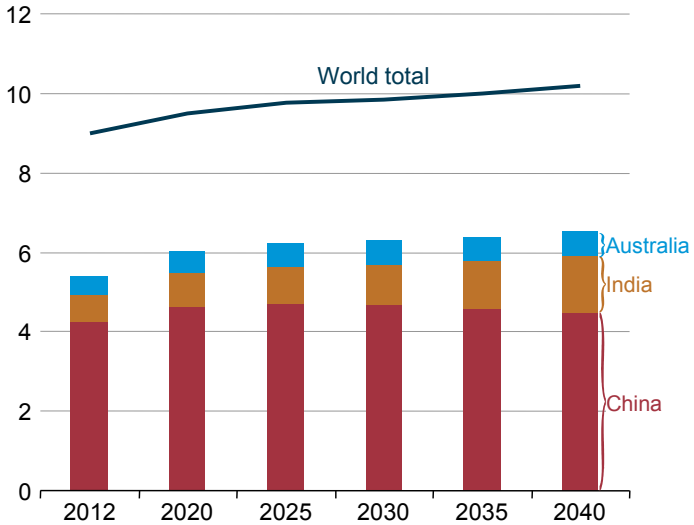


Figure 4-4. World coal production, 2012–40 (billion short tons)



[103]Throughout IEO2016, tons (of coal) refers to short tons (2,000 pounds) unless otherwise specified.

OECD Americas

Most of the OECD Americas coal is consumed in the United States, which accounted for 93% the region's total coal use in 2012. In the IEO2016 Reference case, U.S. coal use remains relatively flat rising by only 2 quadrillion Btu over the projection period. However, if the proposed CPP were implemented, U.S. coal consumption decline by almost 3 quadrillion Btu by 2040 and U.S. coal consumption would be almost 25% lower in 2040 compared to the IEO2016 Reference case. Moreover, strong growth in shale gas production, slowing electricity demand, environmental regulations, and development of renewable energy reduce the share of coal-fired generation for total U.S. electricity generation (including electricity generated at plants in the industrial and commercial sectors) from 37% in 2012 to 26% in 2040 in EIA's analysis of the proposed CPP.[104]

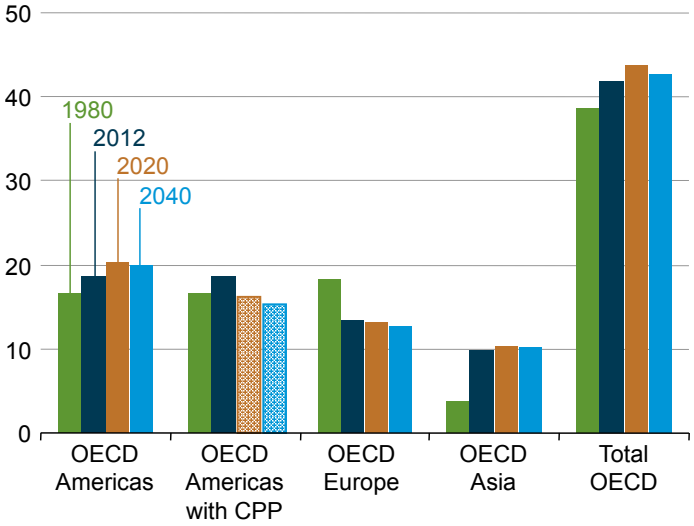
Coal plays a relatively minor role in Canada's energy supply system, and its role is expected to decline further with federal and provincial government efforts to reduce greenhouse gases. Canada's total coal consumption declines by 51% (0.4 quadrillion Btu) from 2012 to 2040 in the IEO2016 Reference case, and the share of coal in total primary energy supply declines from 5% in 2012 to 2% in 2040. In 2012, more than three-quarters of the coal consumed in Canada was used to generate electricity, with most of the rest going to industrial plants. The elimination of coal-fired generation in Ontario province in April 2014, followed by enactment of the Canadian government's "Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity" regulations on July 1, 2015, is likely to result in more closures of coal-fired power plants.[105, 106] Consequently, in the Reference case, the electric power sector share of Canada's total coal consumption falls to 36% in 2040, and the coal share of total electricity generation declines from 10% in 2012 to 1% in 2040.

OECD Europe

Total coal consumption in OECD Europe is largely flat in the Reference case, with a slight decline from 13.4 quadrillion Btu in 2012 (32% of the OECD total) to 12.6 quadrillion Btu in 2040 (30% of the OECD total). Although all nations in the region consume coal, 68% of OECD Europe's 2012 total coal consumption (in physical units) was concentrated in Germany, Poland, Turkey, and the United Kingdom. Germany alone accounted for 30% of the regional total. The electric power sector accounted for 70% of the region's total coal consumption in 2012, and the industrial sector accounted for most of the remainder.

With demand for coal declining in the electric power sector after 2025, the region's overall coal consumption also declines. The European Union's Industrial Emissions Directive, which requires the use of Best Available Technologies[107] for reduction of sulfur dioxide and nitrogen oxides among other pollutants beginning in 2016, is likely to trigger retirements of some coal-fired power plants, especially in the four leading coal-consuming countries.[108] However, new coal-fired capacity additions in Germany, Turkey, Poland, the Netherlands, and potentially Italy counterbalance the retirements. New coal-fired capacity in Germany fills a part of the supply gap left by a nuclear power phaseout; in Italy it replaces less competitive power plants (such as oil-to-coal conversions or replacement of older, less efficient units); in Turkey it supplies more power to meet demand growth.[109] After 2025, the expansion of renewable power and natural gas-fired generation leads to a gradual decline in coal-fired generation.

Figure 4-5. OECD coal consumption by region, 1980, 2012, 2020, and 2040 (quadrillion Btu)



OECD Asia

Japan's coal consumption declines gradually through 2040 in the IEO2016 Reference case. Japan is the largest coal consumer in OECD Asia, accounting for nearly half (approximately 5 quadrillion Btu) of the region's total coal consumption in 2012. Coal use in Japan in 2012 was split almost evenly between the electric power and industrial sectors, which together accounted for nearly all of the region's coal consumption. Despite a temporary increase in coal use following the shutdown of nuclear power plants after the Fukushima disaster in 2011, a shift toward renewable energy and natural gas for electricity generation reduces electric power sector demand for coal after 2015. Industrial sector use of coal begins to decline after 2020, primarily as a result of reductions in steel output as Japan's population and domestic demand decline.

[104] U.S. Environmental Protection Agency, "Clean Power Plan for Existing Power Plants" (Washington, DC: November 20, 2015).

[105] Ontario Ministry of Energy, "Creating Cleaner Air in Ontario: Province Has Eliminated Coal-Fired Generation" (April 15, 2014), http://news.ontario.ca/mei/en/2014/04/creating-cleaner-air-in-ontario-1.html.

[106] Government of Canada, "Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations" (August 30, 2012), http://www.gazette.gc.ca/rp-pr/p2/2012/2012-09-12/html/sor-dors167-eng.html.

[107] "Best Available Technologies" is defined as the latest stage of development ("state of the art") of processes, facilities, or methods of operation that indicate the practical suitability of a particular measure for limiting discharges.

[108] European Commission, "Prevention and control of industrial emissions," http://ec.europa.eu/environment/industry/stationary/.

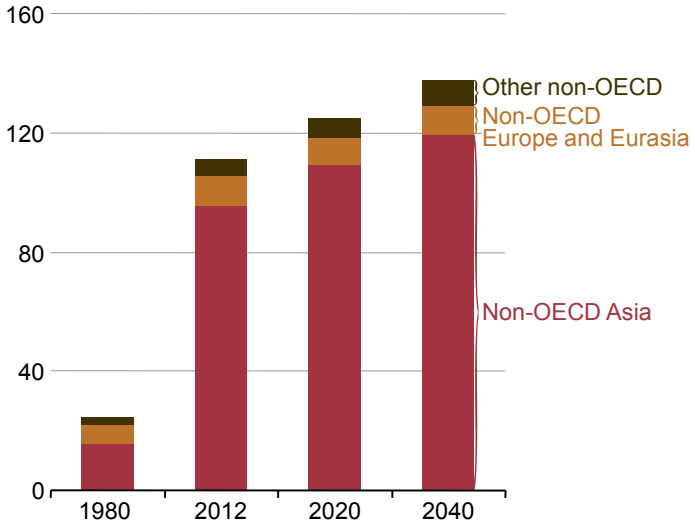
[109] IHS, "Global Steam Coal service: coal-fired power stations: operational and planned," https://connect.ihs.com/ (subscription site).

South Korea's coal consumption increases in the Reference case from 3 quadrillion Btu in 2012 to more than 4 quadrillion Btu in 2040. Coal consumption increases steadily in the country's industrial sector, driven by steel production. Coal consumption in the electric power sector, which accounted for 62% of total coal consumption in 2012, increases strongly in the near term, as a result of significant growth of the coal-fired generating fleet in response to the government's focus on thermal power expansion.[110] As nuclear and renewable power capacity continues to grow, coal consumption for electricity generation decreases in the medium term before recovering gradually after 2030 when the nuclear power expansion tapers off.

Non-OECD coal consumption

In the IEO2016 Reference case, total non-OECD coal consumption increases by 0.8%/year on average, from 111 quadrillion Btu in 2012 to 137 quadrillion Btu in 2040 (Figure 4-6). Non-OECD Asia accounts for more than 90% of the growth in total non-OECD coal use over the projection. Coal is the largest source of energy consumed in the non-OECD region until around 2030, when the use of petroleum and other liquid fuels surpasses coal use.

Figure 4-6. Non-OECD coal consumption by region, 1980, 2012, 2020, and 2040 (quadrillion Btu)



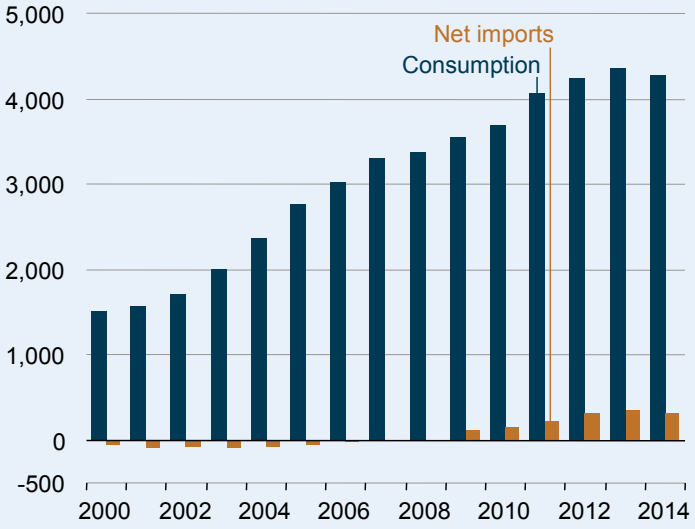
Non-OECD Asia

China and India are the top two coal consumers in non-OECD Asia. India, which is the second-largest coal user in the region, accounts for nearly one-half of the increase in coal consumption from 2012 to 2040, while China contributes less than one-third. China is the leading consumer of coal in the world, using 76 quadrillion Btu of coal in 2012—one-half of the world's coal consumption and more than four times as much as the United States, which was the world's second-largest coal consumer in 2012. In 2012, China's electricity-sector coal use alone was more than double total U.S. coal consumption, and China's industrial-sector coal use was nearly double total U.S. coal consumption. After rapid growth from 2003 to 2011, China's coal consumption began to slow in 2012. The slowing trend continues into the projection period, as the country's economy and energy system undergo structural changes *(see box below)*.

Structural transformations in China's energy economy

Economic deceleration, industry restructuring, and new energy and environmental policies have slowed the growth of coal consumption in China, leading to more centralized and cleaner use of coal. Despite rapidly rising coal prices, China's coal consumption increased by an average of 9%/year (based on energy content) from 2003 to 2011. In 2012 and 2013, increases in coal consumption were between 1% and 2%. In 2014, coal consumption based on energy content was largely the same as in 2013 and coal consumption in physical units decreased for the first time since 1998,[111] as the average heat content of the coal consumed increased after years of decline. China's coal imports also declined in 2014 for the first time since 2009, when China became a net coal importer (Figure 4-7). The sustained slowing of coal consumption growth stands in contrast to the sustained falling of coal prices since 2012, which led to prices in 2014 that were 35% lower than prices in 2011 (Figure 4-8). The trends continued into 2015, signaling that fast-paced growth in China's coal use may not return, and suggesting that the pattern of growth in the China's coal consumption could be changing gradually (although not necessarily implying an imminent peak in coal consumption).

Figure 4-7. China coal consumption and net imports, 2000–2014 (million short tons)



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[110]Ministry of Knowledge Economy, "The 6th basic plan of long-term electricity supply and demand (2013-2027)" (February 2013), www.kpx.or.kr/eng/downloadBbsFile.do?atchmnflNo=23330.

[111]U.S. Energy Information Administration, "Recent statistical revisions suggest higher historical coal consumption in China," *Today In Energy* (Washington, DC: September 16, 2015), http://www.eia.gov/todayinenergy/detail.cfm?id=22952&src=email.

Slower growth of gross domestic production (GDP) and shifts in GDP composition have slowed the growth of China's total energy consumption. In 2014, for the first time in 15 years, China did not meet or exceed its economic growth targets. Real GDP grew by 7.4%, below the 7.5% target the government set in March 2014 for the year and economic growth rates over the prior decade. For many years, China pursued high GDP growth through massive investments in energy-intensive industrial development, coupled with targeted monetary policy. The recent economic slowdown was in part a result of diminishing returns on investment, financial sector problems, and inefficiencies at state-owned enterprises, among other factors. Currently, the government is exploring ways to address those issues through deeper, market-oriented reforms; polices intended to accelerate the development of the service sector and to increase domestic consumption; and setting goals and implementing regulations to balance economic growth with environmental protection.

Changes in the composition of China's economy, with shifts toward the less energy-intensive service sector, also are affecting energy consumption. In 2013, the service sector share of nominal GDP (46.9%) surpassed the industry sector share (43.7%) for the first time in China's history. In 2014, the service sector share increased to 48.2%, exceeding the government's goal of 47% for 2015 (Figure 4-9). The government's ongoing policy push to accelerate the development of service industries,[112] as well as the history of developed economies, suggests that the service sector share of China's GDP will continue to increase in the long run, at the expense of the heavy manufacturing industries. This trend should moderate or reduce coal consumption.

In addition to the effects of slower economic growth and GDP composition changes on China's coal use, industry restructuring has slowed the growth of coal-intensive industries such as steel, cement, and fertilizer and increased the average energy efficiency of industrial processes (Figure 4-10). Direct coal burning in the industrial sector accounted for about 20% of China's coal consumption in 2012, compared with less than 5% in the United States. The Made in China 2025 blueprint unveiled by the State Council in May 2015[113] outlined an action plan to modernize China's manufacturing through innovation enhancements and the integration of information technology into manufacturing, while continuing to make efficiency improvements and shedding excess and outdated heavy manufacturing capacity. If successfully implemented, the plan could accelerate not only the reduction in the manufacturing sector's energy intensity but also the transformation of its energy consumption patterns. Coal use would be concentrated increasingly in large and more efficient energy conversion facilities (mainly, power and heat generation plants), as hundreds of thousands of scattered, inefficient, and highly polluting small coal-fired boilers are phased out.

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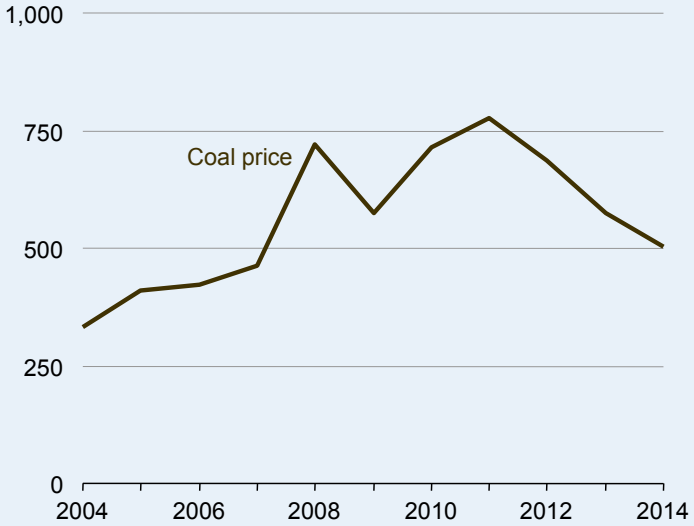
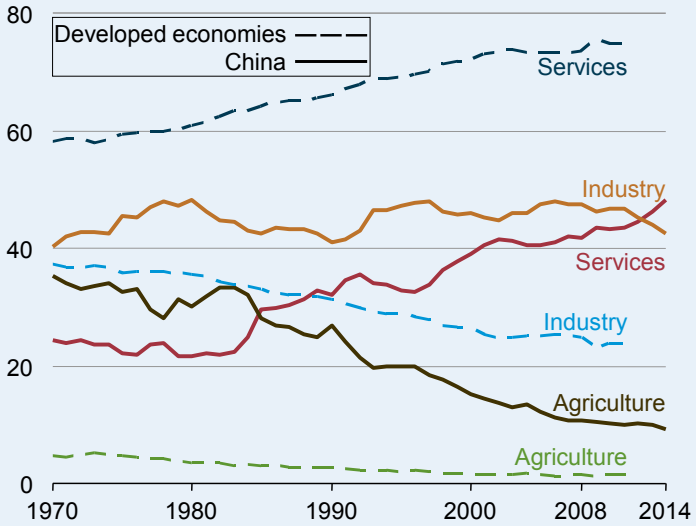
Figure 4-8. China coal prices, 2004–14 (nominal renminbi per short ton)



Notes: Price shown are annual spot prices for Datong 5,800 kcal/kg net as received, free on board Qinhuangdao, reported by IHS China Energy Services. The renminbi is the official currency of the People's Republic of China.

Figure 4-9. Economic composition of gross domestic product in China and developed economies by sector, 1970–2014 (value-added percent of nominal gross domestic product)



Notes: The "developed economies" are as defined in United Nations Conference on Trade and Development, "Development status groupings and composition" (July 3, 2015), http://unctadstat.unctad.org/EN/Classifications/DimCountries_DevelopmentStatus_Hierarchy.pdf. "Industry" here refers to an economic sector and is different from the IEO2016 "industrial sector," which includes agriculture.

[112]National Development and Reform Commission, "China's Policies and Actions on Climate Change" (November 2014), http://en.ccchina.gov.cn/archiver/ccchinaen/UpFile/Files/Default/20141126133727751798.pdf.

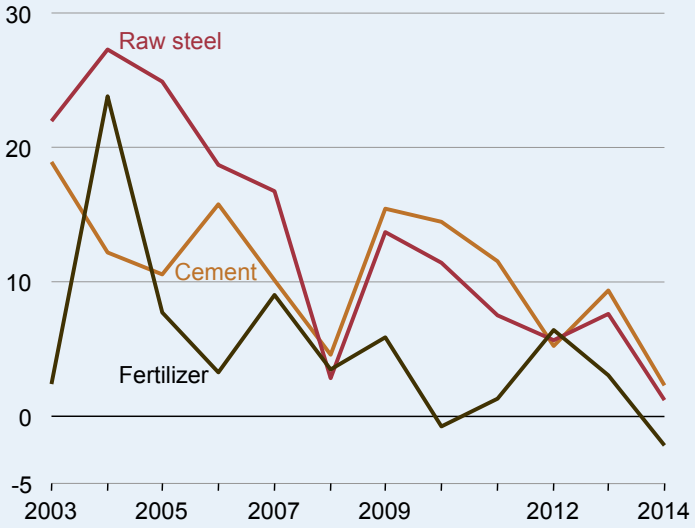
[113]The State Council, People's Republic of China, "'Made in China 2025' plan issued" (May 19, 2015,), http://english.gov.cn/policies/latest_releases/2015/05/19/content_281475110703534.htm.

China's energy policy focus has evolved from energy supply security to sustainability, calling for controlled, cleaner, and more efficient use of coal. Concerted new policies and regulations[114] galvanized by severe air pollution in 2013 and 2014 started a widespread campaign of upgrading the coal fleet nationwide, restricting coal use in coastal China, reducing coal consumption in targeted industries, and expediting the expansion of alternative energy sources. The coal share of China's energy consumption is expected to continue declining if the following goals are implemented successfully:

- The 2014-2020 Action Plan for Upgrading and Transforming Energy Conservation and Emission Reduction in Coal Power Industry,[115] issued jointly by China's National Development and Reform Commission (NDRC), Ministry of Environmental Protection, and National Energy Administration, sets strict, detailed standards on the size, technology, efficiency, and emissions of existing and new coal-fired power plants and requires the adoption of advanced coal technologies. Compliance with the standards will increase the average efficiency of China's fleet of coal-fired power plants, reduce coal consumption for every unit of electricity generated, and slow the rate of growth in demand for coal from the power sector compared with the growth rate of coal-fired power generation.
- An action plan[116] jointly announced by China's Ministry of Industry and Information Technology and the Ministry of Finance aims to cut coal consumption in coking and coal-to-chemicals processes, industrial boilers, and industrial kilns by more than 80 million metric tons by 2017 and by more than 160 million tons by 2020.[117]
- The Energy Development Strategy Action Plan (2014-2020),[118] released by the State Council immediately after the China-U.S. Joint Announcement on Climate Change,[119] set binding caps on annual primary energy and coal consumption until 2020 at absolute levels for the first time. It also specified targets for reducing the coal share of primary energy consumption to less than 62% and increasing the share of nonfossil energy to 15% by 2020 and to about 20% by 2030. Specific targets for reducing coal consumption in key eastern regions and specific development targets for natural gas, nuclear, hydropower, wind, and solar power capacity builds are assigned accordingly.

In addition, China's government leaders have taken actions to strengthen implementation of environmental policies and regulations. The revised Environmental Law[120] included provisions to add fulfillment of environmental targets to the performance assessment of governmental officials, raised both organizational and personal liabilities for noncompliance, enhanced emissions monitoring, increased public disclosure of environmental information, and provided protection for whistleblowers. Although many details remain to be developed and many controversies need to be resolved, passage of the law after three years of contentious debate suggests the central government's increasing commitment to more sustainable development.

Figure 4-10. Annual changes in production from China's coal-intensive industries, 2003–14 (percent)



The moderating growth of the total energy consumption and the shrinking coal share suggest that China's coal consumption could stay on the path of slow grow followed by decline. However, the sheer size of the country's additional future energy demand even with weaker economic growth, plus coal's dominance and economic appeal, indicate that coal will remain the leading energy source in China for many years to come. Therefore, while seeking to limit coal consumption on one hand, the Chinese government has also focused on consolidating and modernizing the domestic coal mining industry,[121] mitigating the environmental effects of

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[114]China Council for International Cooperation on Environment and Development (CCICED), *Progress in Environment and Development Policies in China (2013-2014) and CCICED Policy Recommendations Impact* (December 2014), http://www.cciced.net/encciced/policyresearch/impact/201504/P020150413373426638425.pdf.

[115](Chinese) Ministry of Environmental Protection (September 2014), http://www.mep.gov.cn/gkml/hbb/gwy/201409/W020140925407622627853.pdf.

[116]China Energy Conservation and Environmental Protection Group, "Three Ministries and Commissions Jointly Issue Action Plan for the Transformation and Upgrading of Coal Power Energy Conservation and Emission Reduction" (October 9, 2014), http://www.cecep.cn/g3621/s12528/t37687.aspx.

[117]Xinhua Finance Agency, "China targets industrial coal use for environmental protection" (March 2, 2015), http://en.xinfinance.com/html/Industries/Energy/2015/59603.shtml.

[118]Xinhuanet, "China unveils energy strategy, targets for 2020" (November 19, 2014), http://news.xinhuanet.com/english/china/2014-11/19/c_133801014.htm.

[119]L. Lan, "China, US promise to reduce emissions," China Daily (November 13, 2014), http://m.chinadaily.com.cn/en/2014-11/13/content_18904652.htm.

[120]"China's harsher environmental protection law to take effect," *China Daily* (January 1, 2015), http://www.chinadaily.com.cn/business/2015-01/01/content_19212213.htm.

[121](Chinese) Coal Industry Policy, National Energy Administration, February 2013, http://www.nea.gov.cn/2013-02/04/c_132149959.htm.

coal mining, and improving the logistics of coal supply[122] to ensure the steady operation and continued development of the country's coal sector and to improve the economic competitiveness of domestic coal relative to imports.

Coal consumption in China reaches a peak of nearly 90 quadrillion Btu around 2025 before gradually declining to 83 quadrillion Btu in 2040 (Figure 4-11). Government policy and an economic slowdown are responsible for the peak and ultimate decline in China's coal consumption. For many years, reducing energy intensity has been a part of the government's five-year plans. In the IEO2016 Reference case, total energy consumption growth slows to less than 2%/year from 2012 to 2040, compared to nearly 10%/year from 2003 to 2011.

China's economic growth averages 4.7%/year from 2012 to 2040, while the economy gradually transitions away from heavy manufacturing to less energy-intensive service industries. In addition, the government continues to pursue policies aimed at improving energy efficiency by setting binding industry-specific targets and monitoring implementation. Consistent with President Xi's 2014 pledge to stop CO2 emissions from increasing by around 2030, the central government has declared ambitious goals and provided incentives to expedite the development of nuclear and renewable power, and to replace coal with natural gas in some eastern regions. In the IEO2016 Reference case, natural gas, renewables (including hydroelectric power), and nuclear power together provide more than 70% of the increment in China's total primary energy needs from 2012 to 2040. Natural gas, renewables, and nuclear, which in combination accounted for less than 25% of China's total electricity generation in 2012, account for 55% of the total in 2040. As a result, the coal share of China's electricity generation declines from about 75% in 2012 to 45% in 2040, and the coal share of China's total primary energy consumption declines from 66% in 2012 to 44% in 2040 (Figure 4-12).

India, the world's third-largest coal consumer in 2012, is projected to surpass the United States as the second-largest coal consumer. Coal consumption in India increases from 13 quadrillion Btu in 2012 to 25 quadrillion Btu in 2040. Coal is especially important to India's electric power generation, and 63% of its total coal consumption in 2012 was for generation. India's rapid economic growth (average GDP growth of 5.5%/year from 2012 to 2040), combined with its growing population (average population growth of 0.8%/year from 2012 to 2040), leads to electricity demand growth of 3.5%/year in the IEO2016 Reference case. India's population surpasses China's in the late 2020s, with an expanding middle class using more electricity-consuming appliances. Coal-fired generation accounted for 72% of India's total electricity generation in 2012 and is expected to increase by 2.6%/year over the projection, as the country strives to provide enough electricity to meet growing demand. India's net coal-fired electricity generation grows by 783 terawatthours, which is more than the 2012 total; and its coal consumption for electricity generation nearly doubles, from 8 quadrillion Btu in 2012 to 15 quadrillion Btu in 2040.

Outside of China and India, coal consumption in the other nations of non-OECD Asia grows by an average of 2.3%/year in the Reference case, from 6 quadrillion Btu in 2012 to 11 quadrillion Btu in 2040. More than two-thirds of the additional coal consumed is for electricity generation. Indonesia, Malaysia, Taiwan, Vietnam, and Thailand were the major contributors to coal consumption growth in the other non-OECD Asia countries from 2000 to 2013, with Malaysia's coal demand growing at the fastest pace.[123] Favorable economics of coal-fired generation over natural gas-fired generation in Southeast Asia have sparked growth of coal-fired generating capacity in the region in the past decade, and significant additional capacity is already in the pipeline, particularly

Figure 4-11. Coal consumption in the United States and China and in China's electric power and industrial sectors, 2012, 2020, and 2040 (quadrillion Btu)

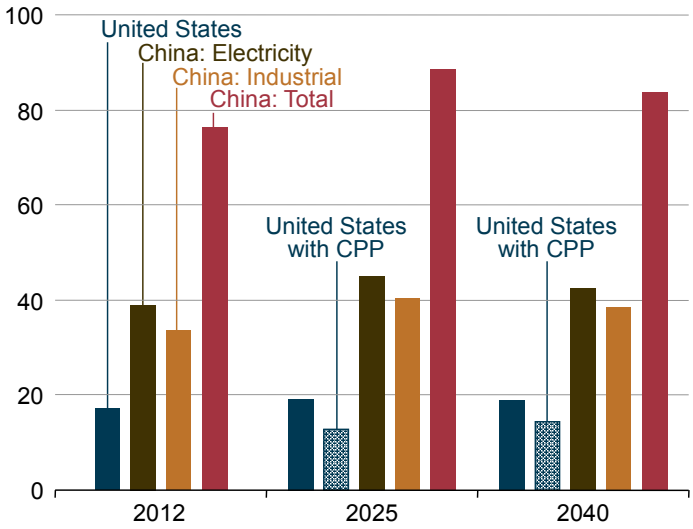
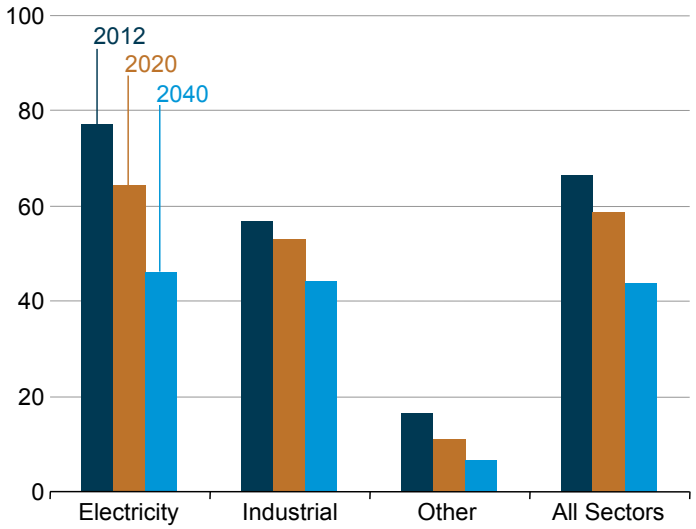


Figure 4-12. Coal share of China's energy consumption by sector, 2012, 2020, and 2040 (percent of total)



[122](Chinese) Coal Logistics Development Plan, National Development and Reform Commission (December 2013), http://www.sdpc.gov.cn/zcfb/zcfbghwb/201401/W020140221373227123903.pdf.

[123]U.S. Energy Information Administration, International Energy Statistics, http://www.eia.gov/beta/international/.

in Vietnam, Malaysia, Indonesia, and Taiwan. In the IEO2016 Reference case, coal-fired generating capacity in non-OECD Asia (excluding China and India) nearly doubles from 2012 to 2040.

Non-OECD Europe and Eurasia

In 2012, coal accounted for 20% of the total primary energy supply in non-OECD Europe and Eurasia, where natural gas use is more prevalent than other energy sources. Russia consumes more than half of the region's coal throughout the projection period, although coal provides only 16% to 17% of Russia's primary energy needs. Coal consumption in Russia increases slightly in the IEO2016 Reference case, whereas total coal consumption by the other countries in the region shows little change.

Russia's electric power and industrial sectors each consumed about the same amount of coal in 2012, and together they accounted for 90% of Russia's total coal consumption. The residential and commercial sectors used the remaining 10%—exceeding the world average share of 4% in 2012—primarily for space heating and water heating. Coal-fired generation, which accounted for only 16% of Russia's total electricity generation in 2012, declines further before 2025 as a result of increasing nuclear power generation and a short-term, temporary reduction in total electricity demand resulting from the effects of international financial sanctions imposed on Russia in 2014. After 2025, coal use in the electricity sector recovers as electricity demand grows and generation from nuclear power plants decreases. Coal use in the industrial sector declines as a result of the 2014 sanctions but recovers to slightly above the pre-sanction levels toward the end of the projection.

Africa

In the IEO2016 Reference case, total coal consumption in Africa increases from just under 5 quadrillion Btu in 2012 to 7 quadrillion Btu in 2040, mainly as a result of demand in the electric power sector and metallurgical industries. South Africa accounts for more than 90% of Africa's total coal consumption and more than 72% of its total primary energy consumption in 2012.[124] More than one-half of the coal consumed in South Africa is for electricity generation, one-third is for coal-to-liquids (CTL) production, and most of the remainder is for metallurgical use.[125] (CTL and metallurgical coal use are classified as industrial sector uses in IEO2016.) More than 85% of South Africa's installed electric generating capacity is powered by coal,[126] and although the government prefers a diversified generation portfolio with more renewable power,[127] chronic power shortages combined with the economic advantage of coal-fired generation suggest that coal will continue growing as a primary source of energy supply for South Africa.

World coal production

In the IEO2016 Reference case, world coal production increases by 1.2 billion tons from 2012 to 2040, with 0.7 billion tons (62% of the total increase) coming from India (Table 4-1). China remains the largest coal producer through 2040, although its annual production declines in the second half of the projection period after peaking at approximately 4.7 billion tons in 2025. Production in Australia, Africa, and Russia also increases substantially, with their combined increases representing 24% of the world's total production increase. As shown in Table 4-1, coal production in the United States and OECD Americas, as a whole is significantly reduced by the proposed U.S. Clean Power Plan. The actual effect of the CPP on U.S. coal production is likely to be sensitive to implementation decisions, and would tend to be larger than shown if states choose a mass-based implementation strategy.

Coal production trends in China and India hinge on their ability to meet domestic coal demand. China is expected to supply coal primarily from domestic sources through 2040, given the magnitude of its current coal consumption requirements and production capacity, its increasing reliance on newer, large coal mining bases that are farther from coastal export terminals, and its efforts to improve the competitiveness of its domestic coal production. India's sustained and accelerating domestic demand for coal throughout the projection period requires significant expansion of domestic production. A host of government policies, regulatory efforts, and investment activities are moving in the direction of enabling this long-awaited expansion *(see box below)*. In the IEO2016 Reference case, India's coal production expands strongly from 2015 to 2020 and eventually surpasses U.S. coal production, making India the world's second-largest coal producer.

India's coal supply chain: Challenges and reforms

India is the world's third-largest coal producer, with about 600 million metric tons (MMmt) of production in fiscal year 2013–14[128] falling behind the United States (900 MMmt in 2013) and China (about 4,000 MMmt in 2013). From 2005 to 2012, the total capacity of India's fleet of coal-fired power plants, already underutilized as a result of coal shortages, grew by about 9.4%/year while its coal production grew by only 4.7%/year (Figure 4-13). As a result of the imbalance between coal supply and demand, India frequently has resorted to forced outages of coal-fired generating plants, lower plant utilization rates, and increased coal imports. To end its coal supply shortfall, India has set an ambitious coal production target of 1.5 billion metric tons by 2020. Success in meeting that goal will depend heavily on the timing and effectiveness of reforms in the country's strained coal supply chain.

(continued on page 69)

[124]BP, Statistical Review 2015, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/downloads.html.
[125]Eskom, "Coal in South Africa," http://www.eskom.co.za/AboutElectricity/FactsFigures/Documents/CO_0007CoalSARev13.pdf.
[126]U.S. Energy Information Administration, "South Africa" (April, 2015), http://www.eia.gov/beta/international/analysis.cfm?iso=ZAF.
[127]U.S. Energy Information Administration, "South Africa" (April, 2015), http://www.eia.gov/beta/international/analysis.cfm?iso=ZAF.
[128]India production, 2013-14: Government of India, Ministry of Coal, *Provisional Coal Statistics 2013-14* (Kolkata, July 2014), Table 2.9, "Trends of Company Wise Production of Coal & Lignite During Last Three Years," http://www.coal.nic.in/sites/upload_files/coal/files/coalupload/provisional1314_0.pdf.

Coal production challenges

India's ambitious goal of 1,500 MMmt total annual coal production by 2020 includes 1,000 MMmt from its national coal producer, Coal India Ltd. (CIL). To attain this level, CIL's annual coal production alone must increase by more than 400 MMmt within 5 years; previously, it took the country more than 20 years to ramp up to such an increase in coal production. From 2002 to 2012, India's total coal production grew by 25 MMmt per year on average, with a peak annual increase of 45 MMmt in 2009. As of February 2015, CIL has identified coal projects capable of producing about 900 MMmt per year by FY2019–20.[129]

Despite coal distribution reforms, CIL continues to face challenges. Before 2008, CIL linkages (guarantees of certain levels of coal supply provided at a fixed price to coal consumers) were assigned in a discretionary manner by two CIL committees, and linkage recipients were not legally allowed to resell their coal. Beginning in 2007, CIL introduced a revised coal distribution policy that replaced linkages with auctions and fuel supply agreements (FSAs). FSAs allow a more transparent process by which coal consumers can negotiate guaranteed coal supplies under take-or-pay arrangements.

(continued on page 70)

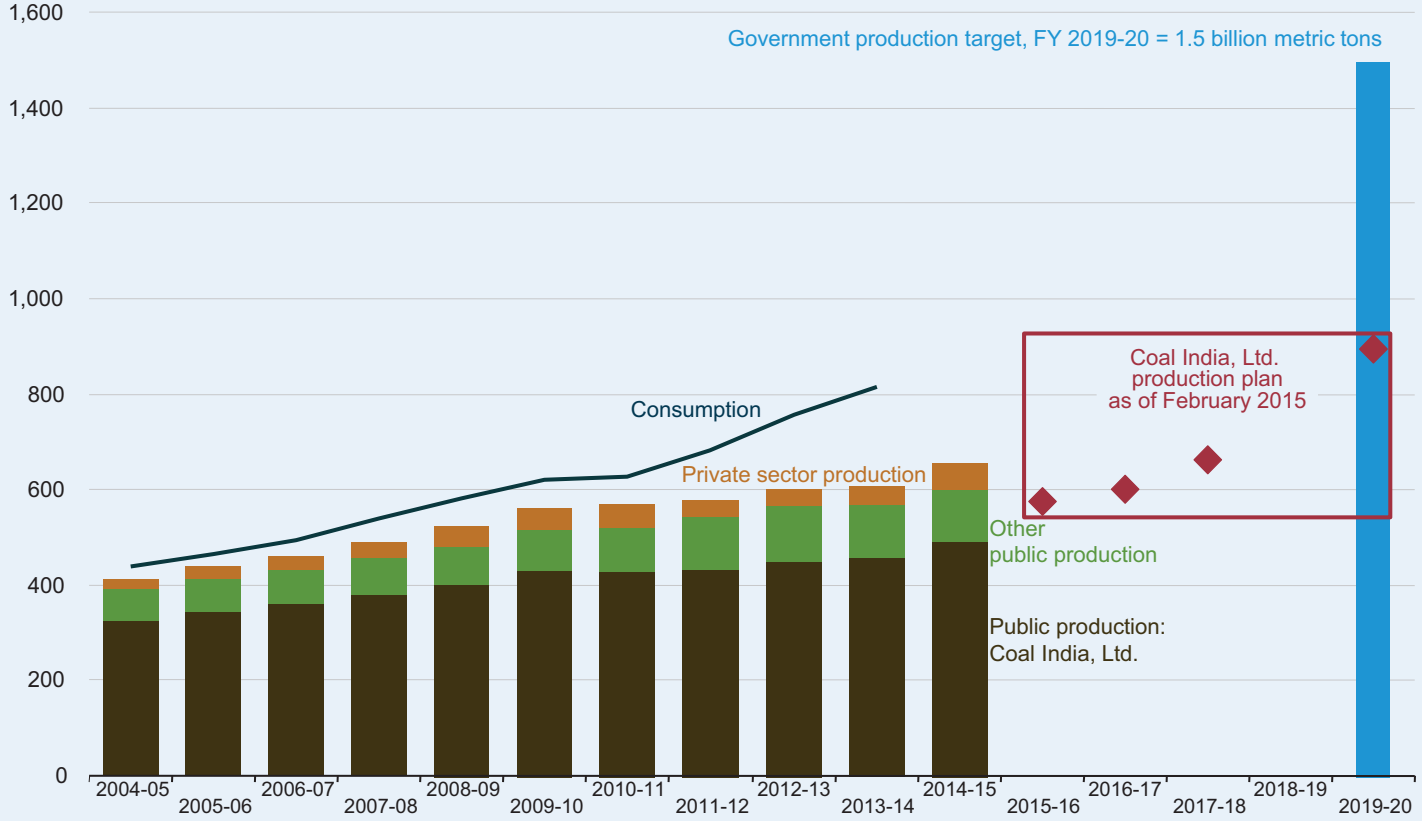
Table 4-1. World coal production by region, 2012–40 (million short tons)

Region/Country	2012	2020	2025	2030	2035	2040	Average annual percent change, 2012–40
OECD	**2,237**	**2,341**	**2,396**	**2,366**	**2,356**	**2,351**	**0.2**
OECD with CPP	**2,237**	**2,150**	**2,092**	**2,124**	**2,154**	**2,223**	**0.0**
OECD Americas	**1,107**	**1,125**	**1,143**	**1,122**	**1,122**	**1,096**	**0.0**
OECD Americas with CPP	1,107	934	839	880	920	968	-0.5
United States	1,016	1,044	1,060	1,048	1,045	1,020	0.0
United States with CPP	1,016	853	756	806	843	892	-0.5
Canada	73	67	70	60	63	61	-0.6
Mexico/Chile	17	14	13	13	14	15	-0.5
OECD Europe	**630**	**647**	**663**	**650**	**642**	**641**	**0.1**
OECD Asia	**501**	**569**	**591**	**594**	**593**	**614**	**0.7**
Japan	0	0	0	0	0	0	0.0
South Korea	2	2	2	2	2	1	-2.2
Australia/New Zealand	498	567	589	592	591	613	0.7
Non-OECD	**6,741**	**7,142**	**7,353**	**7,459**	**7,623**	**7,825**	**0.5**
Non-OECD Europe and Eurasia	**750**	**711**	**721**	**737**	**742**	**730**	**-0.1**
Russia	392	435	444	459	465	452	0.5
Other	358	276	278	278	278	277	-0.9
Non-OECD Asia	5,584	5,986	6,164	6,242	6,379	6,552	0.6
China	4,256	4,621	4,706	4,670	4,598	4,494	0.2
India	666	841	921	1,014	1,185	1,408	2.7
Other	663	524	537	558	597	650	-0.1
Middle East	**1**	**1**	**1**	**1**	**1**	**1**	**0.3**
Africa	**296**	**330**	**353**	**366**	**381**	**413**	**1.2**
Non-OECD Americas	**110**	**114**	**114**	**113**	**120**	**129**	**0.6**
Brazil	7	6	6	7	7	8	0.1
Other	103	107	107	106	113	122	0.6
Total World	**8,978**	**9,483**	**9,750**	**9,825**	**9,980**	**10,176**	**0.4**
Total World with CPP	**8,978**	**9,292**	**9,446**	**9,583**	**9,778**	**10,048**	**0.4**

Note: With the exception of North America, non-seaborne coal trade is not represented in EIA's forecast scenarios. As a result, the projected levels of production assume that net non-seaborne coal trade will balance out across the IEO2016 regions. Currently, a significant amount of non-seaborne 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.

[129] S. Jha, "Coal India goes for makeover," *The Financial Express* (June 3, 2015), http://www.financialexpress.com/article/industry/companies/coal-india-goes-for-makeover/79443/; and "Coal India gearing up for 1 billion tonne coal production," Newsroom24x7 (February 20, 2015), http://newsroom24x7.com/2015/02/20/coal-india-gearing-up-for-1-billion-tonne-coal-production/.

Figure 4-13. India's domestic coal consumption, production, and production targets by fiscal year, 2004–20 (million metric tons)



Even with the ongoing challenges, India's coal production has risen in recent years. CIL's production grew by 32 MMmt to about 494 MMmt in FY2014–15, whereas in the past it had taken 4 years (FY2011–14) to achieve an increase of 31 MMmt.[130] Some of the recent production growth is attributable to improved mechanization in CIL's Western Coalfields subsidiary and mine expansions in the eastern part of Odisha.[131] Also, as of 2012, CIL began outsourcing production operations at its coal mines to private and foreign companies under a Mine Developers and Operators (MDO) program as one means to improve mechanization and operating expertise. Additional upcoming reforms include CIL's development of a turnkey MDO agreement to promote uniformity, efficiency, and transparency in its outsourcing effort.

Private sector coal development in transition

Anticipating difficulty in keeping pace with projected coal demand, India's government began allowing private mining in 1993, but only for captive purposes (own use). Between 1993 and 2014, a program was in place to encourage the allocation of coal blocks, or licenses to mine. More than 200 blocks were allocated to public and private licensees over that period, but buying and selling the coal produced from the allocated blocks was prohibited, and without the ability to adapt to market conditions, production from the captive blocks changed very little over the decade. For the FY2013–14 period (as of March 2014), 40 captive coal blocks (excluding lignite) were in production, with total production of 39 MMmt out of about 32,000 MMmt of reserves for all active licenses held at the time (138 coal blocks). A total of 61 out of 138 captive coal blocks were licensed to the private sector. They represented one-third of the total captive coal block reserves licensed and accounted for 4% (25 MMmt) of the country's total coal production.[132]

Although the cancellation of coal block allocations was disruptive for the coal supply chain, the government has quickly followed through with new e-auctions of many of the canceled blocks. In March 2015, the Indian Parliament passed the Coal Mines Special Provision Bill, legally allowing commercial coal mining (permitting the resale of coal) by both private and foreign companies with Indian subsidiaries. This bill represents a significant departure for India's coal mining industry, which has been nationalized for more than 40 years, and India has been wary of allowing foreign investment in its fuel minerals industry. In addition, the government is studying the possibility of an e-auction for commercial miners in FY2016. Even with the reforms, however, foreign

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[130]The Hindu Business Line, "Coal India to invest $20 billion in five years: Goyal" (May 15, 2015), http://www.thehindubusinessline.com/news/coal-india-to-invest-20-billion-in-five-years-goyal/article7209867.ece?utm_source=RSS_Feed&utm_medium=RSS&utm_campaign=RSS_Syndication.

[131]K.N. Das and J. Dash, "Coal India units see double-digit output growth in 2014/15," *Reuters Business News* (February 18, 2014), http://in.reuters.com/article/2014/02/18/coalindia-output-westerncoalfields-idINDEEA1H07F20140218.

[132]Government of India, *Provisional Coal Statistics 2013-14,* p. 32, Table 2.10, "Block wise production of raw coal during 2013-14," and p. 12, "Captive Coal Blocks," http://www.coal.nic.in/sites/upload_files/coal/files/coalupload/provisional1314_0.pdf.

companies still may be reluctant to invest directly in India's coal mines, given the complex permitting process that precedes the start of mine operations.

Permitting issues and environmental complications

Acquisition of a coal block represents the initial step in a long process (including approvals, permits, and land acquisition) toward actual production. Forest clearance permits are required, and typically they have been the most time-consuming part of the process—taking 3 to 6 years (although they can overlap in time with other steps). When successful, the whole process can take up to 8 years, despite the Ministry of Coal's guidelines suggesting a 36- to 42-month span for surface mining operations.[133]

In the past there have been significant environmental challenges for the coal mining industry. For example, just as national production began to grow at a faster rate—7%/year from 2006 to 2009—the Ministry of Environment and Forestry announced a *go, no-go* policy whereby coal block allocations could be rejected outright, depending on the forest density at a particular location. When the Ministry's designation process was completed in 2011, approximately 660 MMmt of coal reserves were labeled as ineligible for mining activity *(no-go)*, affecting 40 CIL projects.[134] Although the original purpose of the policy was to streamline the forestry permitting process, forest clearance permits still lagged for those mines categorized as *go*. From 2009 to 2012, while the policy was in effect, India's total coal production grew by only 2.2%/year. The policy was officially canceled in 2011, but without an immediate replacement, uncertainty continues to affect the permitting process and mine investment. As of August 2015, a new "inviolate forest" policy is pending. Details are not yet available, but early drafts suggest it may be more lenient toward coal mining. Despite its stringency, the *go, no-go* policy did provide clarity, and its absence now leaves coal block licensees in limbo.

Other environmental regulations also have affected coal production. For example, because of a prohibition on mining in industrial geographic clusters that violated the pollution index, CIL production was reduced by 19 MMmt in FY2010–11 and by 39 MMmt in FY2011–12.[135] In addition, a Ministry of Environment and Forestry circular issued in March 2011 stipulated that even if only a portion of a coal block lay under forest, none of it could be mined until all forest clearances were received for the entire block—a practice that had not been followed previously. As a direct effect of this policy, an estimated 11.5 MMmt of CIL coal could not be mined in FY2011–12.[136]

Even with the reallocation of coal blocks in 2015, permitting challenges may continue to obstruct development. A more efficient handling of the permit and approval process will be required to ensure the desired effect of smoother operation of the coal supply chain in the future. To facilitate achievement of India's ambitious production goals, the Ministry of Coal has established a detailed mine plan for CIL development and has established a coal portal database to track the progress of mining projects. The tracking system allows mine licensees to report progress and impediments in gaining their environmental clearances. When delays are noted, the government may intervene in order to speed the processing of applications.

Rail infrastructure issues

Inadequate rail infrastructure and a lack of dedicated freight infrastructure have impeded the growth of India's coal supply. With the bulk of coal reserves concentrated in the northeastern area of the country in the states of Jharkhand, Chhattisgarh, and Odisha, and with coal-fired generating plants located in nearly all the Indian states (Figure 4-14), rail plays a critical role in coal supply. In 2014, as a result of the shortage of transportation capacity, a total of 50 MMmt of coal lay in piles at CIL mines[137] while stockpiles at some generation plants dwindled to 4 days of burn. Decades-long projects—including dedicated freight lines—have yet to be completed, and several rail projects have stalled, including the 93-km Tori-Shivpur-Kathautia line to provide access to coal mines in Jharkhand, which was begun in 1999 and scheduled to be completed in 2005 but was only half complete as of 2015.[138]

In an effort to unlock an additional 300 MMmt of coal,[139] India's government is trying to fast-track three key rail projects that it says will add 100 MMmt of production capacity initially. Among them is the Tori-Shivpur stretch of the Jharkhand rail line, a subset of a full rail project that could open up about 40–50 MMmt of capacity. The second rail project, in Chhattisgarh, will connect Bhupdeopur,

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[133]Infrastructure Development Finance Company, Ltd., "Captive coal mining by private power developers – Issues and road ahead" (2008), http://www.idfc.com/pdf/publications/captive_coal_mining_final.pdf.

[134]S.P. Singh, "No-go ghost still haunts Coal India" (May 22, 2012), *Business Standard,* http://www.business-standard.com/article/companies/no-go-ghost-still-haunts-coal-india-112052200055_1.html.

[135]*The Economic Times,* "Coal India to take 11.5MT hit on latest green directive; stock up" (June 3, 2011), http://articles.economictimes.indiatimes.com/2011-06-03/news/29617105_1_environment-ministry-coal-projects-forest-clearances.

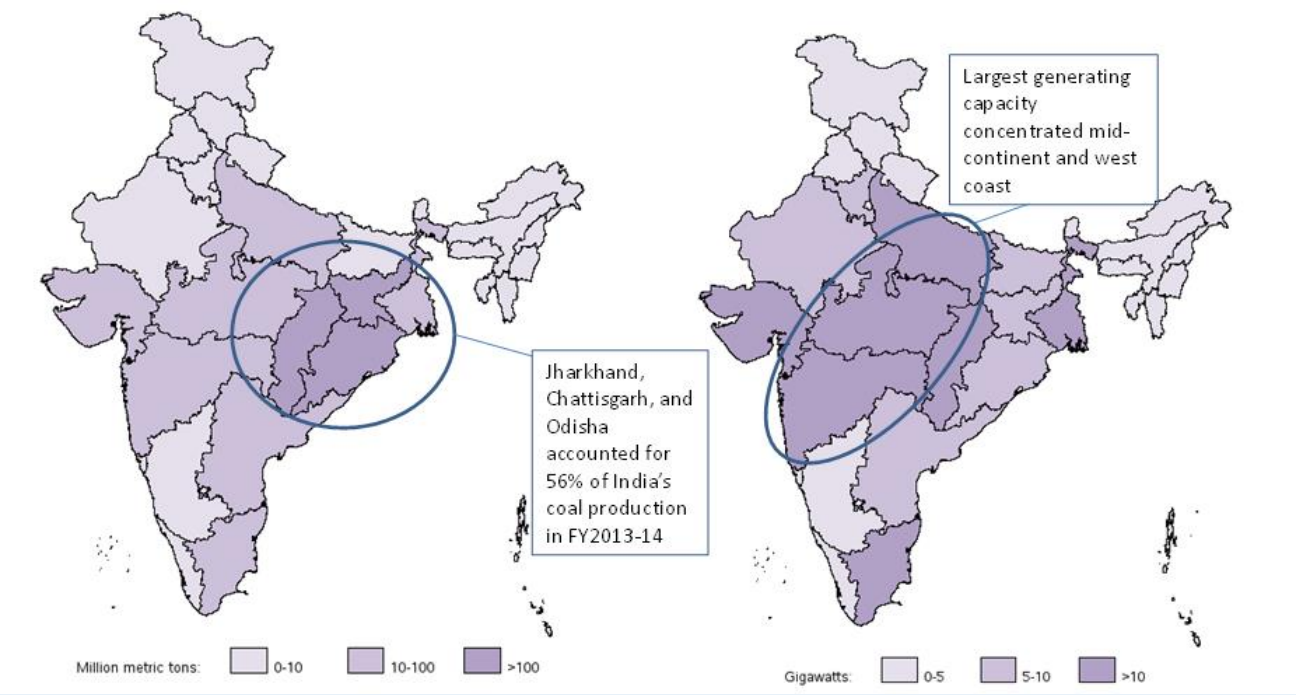
[136]*The Economic Times,* "Government panel says 'Go, No-Go' concept of forest area classification legally not tenable and should be abandoned" (July 29, 2011), http://articles.economictimes.indiatimes.com/2011-07-29/news/29829405_1_environment-ministry-coal-blocks-forest-clearance.

[137]S. Saraf, "India coal: transport bottlenecks as demand is expected to rise" (Platts: May 27, 2015), http://www.platts.com/news-feature/2015/coal/india-coal-transport/index?wt.mc_id=coap201505we_indiarail&wt.tsrc=eloqua.

[138]New Delhi Television, "Government to expedite construction of three rail lines to move coal" (July 8, 2014), http://profit.ndtv.com/budget/government-to-expedite-construction-of-three-rail-lines-to-move-coal-585385; and A. Swarup, "Odisha rail project for coal likely to complete by 2017: Coal India Ltd," *The Times of India: The Economic Times* (April 13, 2015), http://articles.economictimes.indiatimes.com/2015-04-13/news/61103072_1_bhupdeopur-raigarh-mand-area-coal-india-ltd-tori-shivpur-kathautia-area.

[139]Zeenews, "Govt to give priority to 3 critical rail links to carry coal" (May 26, 2014), http://zeenews.india.com/business/news/economy/govt-to-give-priority-to-3-critical-rail-links-to-carry-coal_100279.html.

Figure 4-14. India's coal production and coal-fired electricity generation capacity by state, FY2013–14



Raigarh, and Mand Area. The third project, a Jharsuguda-Barpali railway link in Odisha, is slated for the earliest completion, in 2017. CIL's production growth goals depend on the successful and timely completion of these projects. Additional projects also have been proposed, to accommodate an incremental 200 MMmt of coal production capacity.[140] The Dedicated Eastern Freight Corridor—supported by the World Bank—will be an important project for India to move coal northward. With the CIL production path indicating a planned increase of 247 MMmt between FY 2018–19 and FY2019–20,[141] along with its plans to purchase 2,000 rail cars,[142] the government has noted the importance of transportation infrastructure in meeting its goals for coal production.

Land acquisition challenges

Because coal reserves and rail projects, as well as prospective coal-fired generating plants, are in areas under or near privately owned or state-owned land, land acquisition has been a significant barrier to improving the coal supply chain. India is still an agricultural-based economy, with roughly 47% of its workforce engaged in farming,[143] and a new or expanding mine project means displacing not only homes but also livelihoods. As indicated in CIL's updated Rehabilitation and Resettlement Policy, the population affected by land acquisition is an important barrier to robust coal production. The controversial Land Acquisition Reform Act pending in India's parliament may make it easier for the government to force sales of land by private owners, and if it is passed, projects may advance at a faster pace.

A more reliable, growing coal supply would allow more efficient operation of existing coal-fired power plants. For example, an improvement of 5 percentage points in plant utilization alone—without adding any additional coal-fired capacity or displacing any coal imports—would require about 50 MMmt of additional domestic coal production per year.[144]

World coal trade

Imports

For the three major coal-importing regions represented in IEO2016, overall demand for coal imports in the Reference case is nearly the same in 2040 as in 2013, with total coal imports to Asia slightly higher in 2040, imports to Europe/Other[145] slightly lower, and imports to the Americas in 2040 about the same as in 2013 (Figure 4-15 and Table 4-2).

[140]New Delhi Television, "Government to expedite construction of three rail lines to move coal" (July 8, 2014), http://profit.ndtv.com/budget/government-to-expedite-construction-of-three-rail-lines-to-move-coal-585385.

[141]CNBCTV18 moneycontrol, "Targeting 10% total sales via e-auction route: Coal India" (April 08, 2015), http://www.moneycontrol.com/news/business/targeting-10total-sales-via-e-auction-routecoal-india_1351734.html?utm_source=ref_article.

[142]S. Jha, "Coal India goes for makeover," *The Financial Express* (June 3, 2015), http://www.financialexpress.com/article/industry/companies/coal-india-goes-for-makeover/79443/.

[143]World Bank, "India: Data," http://data.worldbank.org/country/india (2015).

[144]Derived by assuming 200 gigawatts of coal-fired power plant capacity (utility and non-utility plants) and 0.6 MMmt of coal per additional kilowatthour of generation.

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

Asia is the predominant destination for coal exports, with the region's share of total world international coal imports ranging from a low of 75% in 2020 to a high of 78% in 2040. The projected trend for Asian coal imports mirrors that of global demand for coal imports, declining from 1,053 MMst in 2013 to 927 MMst in 2020 and increasing to 1,057 MMst in 2040. The initial decline in Asia's coal imports through 2020 is the result of declining imports to China and India, by 183 MMst from 2013 to 2020. From 2020 to 2040, coal imports to Asia increase by 130 MMst. Coal imports to China and India combined stabilize, with imports to India (primarily coking coal) increasing by 58 MMst and imports to China declining by 50 MMst. Much of the overall growth in coal imports to Asia between 2020 and 2040 is projected for Vietnam, South Korea, Taiwan, and Malaysia. Vietnam's electricity demand is expected to increase substantially in future years, and the government's energy plan indicates that much of the increase will be met by generation from new coal-fired power plants *(see box in Electricity Chapter)*. In the IEO2016 Reference case, coal-fired generating capacity in the countries of non-OECD Asia (including Vietnam, Taiwan, and Malaysia but excluding China and India) increases by 33 gigawatts from 2020 to 2040. In South Korea, coking coal accounts for nearly all of the 25 MMst of incremental growth in coal imports from 2020 to 2040.

In the Europe/Other region, total coal imports increase slightly, from 255 MMst in 2013 to 263 MMst in 2015, then decline to 230 MMst in 2040. Coal becomes a less significant component of the region's fuel mix for electricity generation,

Figure 4-15. World coal imports by major importing region, 1995–2040 (million short tons)

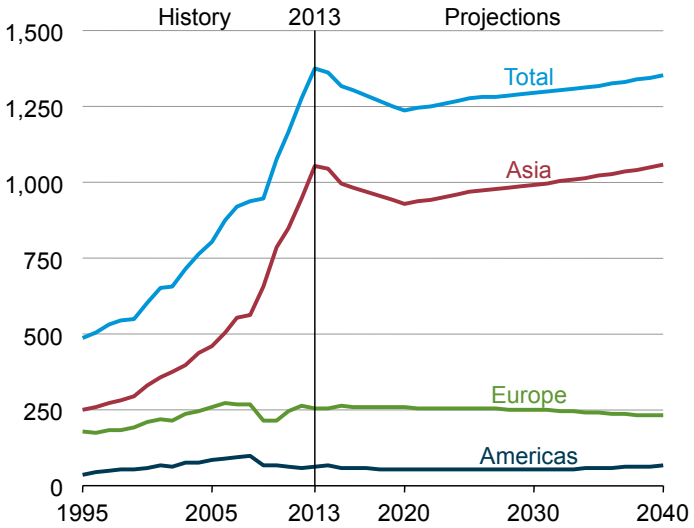


Table 4-2. World coal flows by importing and exporting regions and coal type, Reference case, 2013, 2020, and 2040 (million short tons)

	Steam coal			Coking coal			Total		
Exporting region	2013	2020	2040	2013	2020	2040	2013	2020	2040
				Exports to Europe/Other[a, b]					
Australia	0.6	2.0	1.5	20.1	16.9	20.3	20.7	18.9	21.8
United States	33.5	8.4	4.9	31.2	24.9	17.0	64.7	33.2	21.8
Southern Africa[c]	26.9	45.3	33.8	0.3	0.0	10.0	27.2	45.3	43.8
Eurasia[d]	57.2	59.9	56.3	5.0	4.8	6.1	62.2	64.7	62.4
Poland	7.9	3.9	3.8	0.4	1.0	0.5	8.2	4.9	4.3
Canada	0.3	0.0	2.4	4.3	10.0	4.2	4.5	10.5	6.6
China	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South America	58.8	78.9	68.0	0.0	0.0	0.0	58.8	78.9	68.0
Vietnam and North Korea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indonesia[e]	9.2	0.5	0.7	0.0	0.4	0.4	9.2	0.9	1.1
Total	**194.2**	**198.9**	**171.6**	**61.3**	**58.0**	**58.4**	**255.5**	**256.9**	**229.9**
				Coal Exports to Asia[b]					
Australia	204.8	219.7	238.6	161.2	189.4	219.4	365.9	409.2	458.0
United States	8.8	8.8	15.3	18.4	8.1	0.4	27.2	16.9	15.6
Southern Africa[c]	51.9	43.0	48.2	3.8	9.9	17.6	55.7	52.9	65.8
Eurasia[d]	49.8	60.6	61.3	13.4	13.2	20.9	63.3	73.9	82.3
Poland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Canada	3.2	4.4	3.6	31.2	15.4	20.0	34.4	19.8	23.6
China	6.8	10.8	15.6	1.2	1.0	1.0	8.0	11.8	16.6
South America	1.1	0.0	12.8	0.0	0.0	0.0	1.1	0.0	12.8
Vietnam and North Korea	34.9	14.1	7.2	0.0	0.2	0.2	34.9	14.3	7.4
Indonesia[e]	434.4	302.6	349.2	27.6	25.9	25.9	462.0	328.5	375.1
Total	**795.7**	**664.2**	**751.6**	**256.8**	**263.1**	**305.5**	**1,052.5**	**927.3**	**1,057.1**

See notes at end of table.

(continued on page 74)

with most European countries placing greater emphasis on renewable energy and natural gas for electricity generation. The relatively modest change in imports through 2040 belies some significant shifts within the region. Growth in coal imports for some countries, such as Turkey and Morocco, partially offsets declines for other countries in the region, including the United Kingdom, Germany, Spain, and France.

Environmental initiatives in Europe include efforts to reduce emissions of sulfur dioxide, nitrogen oxide, and particulates, leading to some significant retirements of coal-fired generating capacity and the phasing out of domestic hard coal production in Germany by 2018.[146] Restrictions on carbon dioxide emissions, primarily based on the European Union's Emissions Trading System (ETS), are another potential issue for Europe's coal consumption and imports. Thus far, however, carbon dioxide emission prices have been relatively low and have not significantly affected Europe's coal demand. In contrast, the United Kingdom's recent doubling of its

Table 4-2. World coal flows by importing and exporting regions and coal type, Reference case, 2013, 2020, and 2040 (million short tons) *(continued)*

	Steam coal			Coking coal			Total		
Exporting region	2013	2020	2040	2013	2020	2040	2013	2020	2040
				Coal Exports to America					
Australia	1.4	0.0	0.0	4.6	0.0	0.0	6.1	0.0	0.0
United States	9.7	9.3	4.7	16.0	11.9	16.3	25.7	21.2	21.0
Southern Africa[c]	1.5	0.1	0.1	0.3	0.0	0.0	1.9	0.1	0.1
Eurasia[d]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Poland	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1
Canada	0.3	0.0	0.0	3.4	8.0	12.9	3.7	8.0	12.9
China	0.0	0.2	1.0	0.0	0.0	0.0	0.0	0.2	1.0
South America	23.2	21.8	29.3	0.0	0.0	0.0	23.2	21.8	29.3
Vietnam and North Korea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indonesia[e]	1.3	1.1	2.1	0.6	0.0	0.0	1.9	1.1	2.1
Total	**37.4**	**32.5**	**37.3**	**24.9**	**19.9**	**29.2**	**62.3**	**52.4**	**66.5**
				Total Coal Exports[f]					
Australia	207.4	221.8	240.1	187.0	206.3	239.7	394.3	428.1	479.8
United States	52.0	26.5	24.8	65.7	44.8	33.7	117.7	71.4	58.5
Southern Africa[c]	82.5	88.4	82.2	4.5	9.9	27.6	87.0	98.3	109.7
Eurasia[d]	107.0	120.5	117.7	18.4	18.1	27.0	125.4	138.5	144.7
Poland	7.9	4.0	4.0	0.4	1.0	0.5	8.3	5.0	4.5
Canada	3.8	4.4	6.0	38.9	33.4	37.1	42.7	37.8	43.0
China	6.8	11.0	16.5	1.2	1.0	1.0	8.0	12.0	17.5
South America	83.4	100.7	110.1	0.0	0.0	0.0	83.4	100.7	110.1
Vietnam and North Korea	34.9	14.1	7.2	0.0	0.2	0.2	34.9	14.3	7.4
Indonesia[e]	445.5	304.2	352.0	28.2	26.3	26.3	473.7	330.5	378.3
Total[g]	**1,031.4**	**895.6**	**960.5**	**344.2**	**341.0**	**393.1**	**1,375.5**	**1,236.6**	**1,353.5**

[a]Import Regions: **Europe/Other:** Algeria, Austria, Belgium, Bulgaria, Croatia, Denmark, Egypt, Finland, France, Germany, Greece, Ireland, Israel, Italy, Luxembourg, Malta, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Tunisia, Turkey, and the United Kingdom. **Asia:** Bangladesh, China, Hong Kong, India, Iran, Japan, Malaysia, North Korea, Pakistan, Philippines, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam. **America:** Argentina, Brazil, Canada, Chile, Mexico, Puerto Rico, and United States.
[b]Excludes non-seaborne shipments of coal to Europe and Asia. Includes exports to the Middle East and Northern Africa.
[c]Southern Africa consists of the countries of South Africa, Mozambique, and Botswana.
[d]Eurasia consists of Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
[e]In 2013, exports from Indonesia include an additional 6.3 million short tons of exports from other countries not included in the forecast period.
[f]Excludes non-seaborne shipments of coal to Europe and Asia.
[g]In 2013, total world coal flows include a balancing item term used to reconcile discrepancies between reported exports and imports. For 2013, the balancing item amounted to 5.2 million short tons.
Note: Totals may not equal sum of components due to independent rounding.

[146]P. Baruya, Impacts of seaborne trade on coal importing countries – global summary, IEA Clean Coal Center, CCC/197 (London, United Kingdom, May 2012), pp. 27-29, http://www.iea-coal.org.uk (subscription site); EURACOAL members and secretariat, EURACOAL Market Report 1/2015, Euracoal (Brussels, Belgium, April 2015), pp. 5-7; and "Turkey Coal Profile," IHS Energy Global Steam Coal Service Country Profiles (September 2015), http://connect.ihs.com/DisplayDocument/Show?source=gi&docid=2437095&connectPath=EmailAlerts&utm_campaign=Immediate%202437095%20from%20gi&utm_source=EmailAlerts&utm_medium=email (subscription site).

Carbon Price Support (CPS) tax (to $28 per metric ton CO2 equivalent in early 2015, which is in addition to the European Union's standard ETS costs) did lead to substantial declines in both coal-fired electricity generation and coal imports for the year.[147]

The countries of OECD Europe accounted for more than 90% of total seaborne coal imports to the Europe/Other region in 2013, and they account for only slightly less than 90% in 2040. Although there is significant overland coal trade among 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 problems and the increased complexity associated with modeling non-seaborne coal trade.

Coal imports to the Americas decline from 62 MMst in 2013 to a low of 52 MMst in 2020 in the Reference case, followed by an increase to 67 MMst in 2040. Steam coal imports decline from 37 MMst in 2013 to 32 MMst in 2020, then rise to 37 MMst in 2040, while coking coal imports increase from 25 MMst in 2013 to 29 MMst in 2040. Brazil, which has substantial iron ore resources and was the world's ninth-largest producer of pig iron in 2013,[148] accounts for nearly all the growth in coking coal imports to the Americas region. Relative to global coal trade, the coal import market for the Americas is relatively small, accounting for only about 5% of the world total in both 2013 and 2040.

Exports

Based on the relatively flat outlook for world coal imports, both worldwide and in each of the three major coal-importing regions, exports from some regions increase while exports from other regions decline. The lack of growth in total world coal imports represents a substantial change to the long-term historical trend of continuous annual growth, which led to substantial increases in coal exports for a number of regions. In the IEO2016 Reference case, regions whose coal exports increase from 2013 to 2040 include Australia (85 MMst), Southern Africa (23 MMst); Eurasia (19 MMst), and South America (27 MMst). On the other side of the ledger, declines in exports from 2013 to 2040 are projected for Indonesia (-95 MMst), the United States (-59 MMst), and Vietnam/North Korea (-28 MMst).

Most of the world's coal trade consists of steam coal. In 2013, the top five exporters of steam coal were Indonesia, Australia, Eurasia (primarily Russia), South America (primarily Colombia), and Southern Africa (primarily South Africa) *(see box below).* Indonesia, which was the world's largest exporter of steam coal in 2013, remains the top exporter through 2040. The three top exporters of coking coal in 2013 were Australia, the United States, and Canada; and despite a substantial drop in coking coal exports from the United States and increases in exports from Southern Africa and Eurasia, the same countries continue to be the top three exporters of coking coal through 2040.

A substantial portion of the growth in coal exports projected for Australia and Southern Africa from 2013 to 2040 is attributable to increases in coking coal imports to Asia. Australia's exports of steam coal also grow somewhat, primarily as the result of recent improvements in coal mining productivity that have improved the cost competitiveness of their exports relative to those from other regions.[149] The projected increase in coking coal exports from Southern Africa is attributable primarily to investments in new mining capacity and transportation infrastructure that are underway in Mozambique with the goal of exploiting its substantial deposits of coking-quality coals.[150, 151]

Recent developments in world coal trade

From 2008 to 2013, international seaborne shipments of coal increased by 47%, from 937 MMst to 1,376 MMst (Figure 4-16). Most of the growth in world coal trade occurred in Asia. The Americas and the Europe/Other region (Europe, Eurasia, Middle East, and Africa)[152] saw modest declines in overall coal imports—by 34 MMst and 14 MMst, respectively.[153] From 2009 to 2013, world

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[147]B. Lee, "UK fuel switch gains traction but road not smooth," ICIS (November 16, 2015), http://www.icis.com/resources/news/2015/11/16/9944374/analysis-uk-fuel-switch-gains-traction-but-road-not-smooth; and J. Holman, "UK July thermal coal imports fall 71% on-year to 821,375 mt," *Platts Coal Trader International*, Vol. 15, No. 175 (October 14, 2015), pp. 1 & 11, http://www.platts.com (subscription site).

[148]World Steel Association, *Steel Statistical Yearbook 2015* (Brussels, Belgium: 2015), pp. 91-92, https://www.worldsteel.org/statistics/statistics-archive/yearbook-archive.html.

[149]Australian Government, Department of Industry and Science, Office of the Chief Economist, *Coal in India* (June 2015), pp. 79-83, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Coal-in-India.aspx.

[150]Financial pressures related to the recent decline in both international coal trade and prices have led some companies to back away from their investments in Mozambique's coal industry (e.g., Rio Tinto sold its three coal mining projects in the country to the Indian company International Coal Ventures Private Limited (ICVL) in 2014 for a price much lower than it paid for them in 2011). However, other companies have remained and are continuing to move forward with their investment projects. For example, Vale is continuing its work to complete a 567-mile rail line to the port of Nacala in Mozambique. That project, scheduled for completion in 2016, will have an initial annual coal transport capacity of 20 MMst. Upgrades to the 357-mile Sena Railway, also underway, will increase its annual transport capacity from 7 MMst to approximately 22 MMst by June 2016.

[151]K. Campbell, "Mozambique's coal sector still embattled, but bottlenecks should soon go," *Creamer Media's Mining Weekly* (October 16, 2015), http://www.miningweekly.com/article/mozambiques-coal-sector-still-embattled-but-bottlenecks-should-soon-go-2015-10-16; P. Fauvet, "Tata Steel to Sell Benga Coal Assets," *allAfrica* (February 20, 2015), http://allafrica.com/stories/201505131549.html; J. Rowland, "Vale coal production down y/y in 3Q15," *World Coal* (October 21, 2015), http://www.worldcoal.com/mining/21102015/Vale-coal-production-down-year-on-year-in-3Q15-3041; and L. Caruana, "Isaac Plains, Integra reduce Vale's coal output," *International Coal News* (October 21, 2015), http://www.internationalcoalnews.com/storyview.asp?storyID=826957202&section=News&sectionsource=s46&aspdsc=yes.

[152]Europe/Other includes the countries of Europe, Eurasia, the Middle East, and Africa.

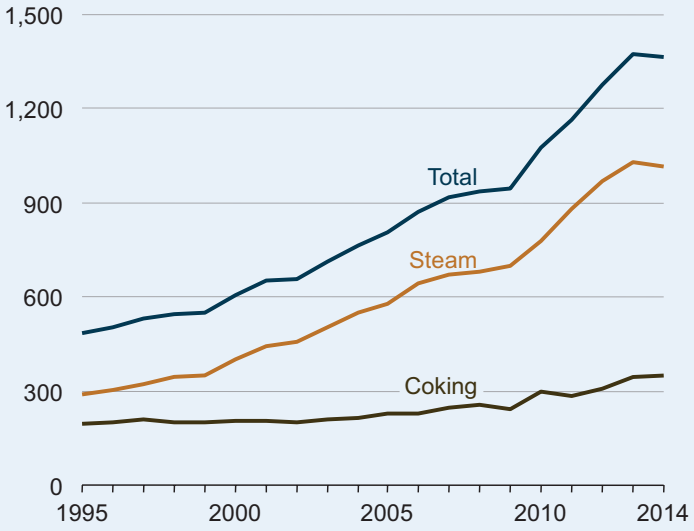
[153]U.S. Energy Information Administration, "International energy data and analysis," http://www.eia.gov/beta/international/.

coal trade grew by approximately 100 MMst each year, surpassing the previous high of 69 MMst from 2005 to 2006. However, the data for 2014 and 2015 indicate a retreat from the record-breaking 2009–13 increases in annual trade, with declines in China's coal imports currently on pace to more than offset increases in other countries during both years (Figure 4-17).

Coal imports

Almost all (98%) of the 2008–13 growth in world coal trade involved imports to Asia by China and India (Figure 4-18). China's imports rose from 45 MMst in 2008 to 341 MMst in 2013, and India's imports rose from 69 MMst in 2008 to 203 MMst in 2013. Steam coal imports accounted for 74% and 90% of the growth in coal imports to China and India, respectively, with coking coal accounting for the remainder. The increases in coal imports by China and India resulted primarily from mismatches between domestic coal supply and demand, as coal production and transportation infrastructure were unable to keep up with increases in domestic coal use.

Figure 4-16. World coal trade by coal type, 1995–2014 (million short tons)



India's coal imports continued to rise in 2014 and through the first half of 2015, as demand rose at a faster pace than domestic coal supplies. In China, however, coal imports fell in 2014 and are estimated to have declined further in 2015.[154] Increased output from China's domestic coal mines, improvements in its coal transportation infrastructure, and minimal growth in domestic coal demand improved the balance between domestic supply and demand in 2014 and 2015, resulting in lower prices for domestic coal supplies and reducing demand for coal imports. In addition, the Chinese government introduced a number of measures in late 2014 and early 2015 to support the domestic coal industry, including taxes on coal imports (3% for anthracite and coking coal and 6% for thermal coal); limits on allowable sulfur, ash, and trace elements in imported coal; and a directive for major utilities to reduce their annual coal imports by a combined total of approximately 55 MMst.[155]

The markets for world coal trade present significant challenges in terms of their predictability. On the demand side, the recent emergence of China and India—both of which have substantial

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Figure 4-17. Annual changes in total world coal trade, 1995–2014 (million short tons)

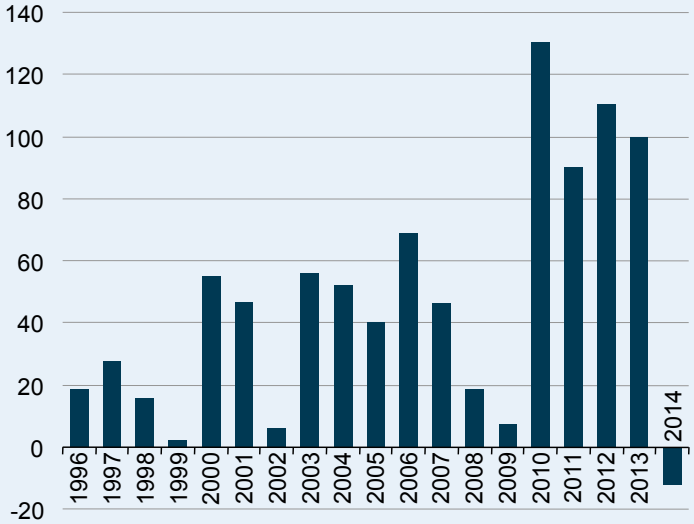
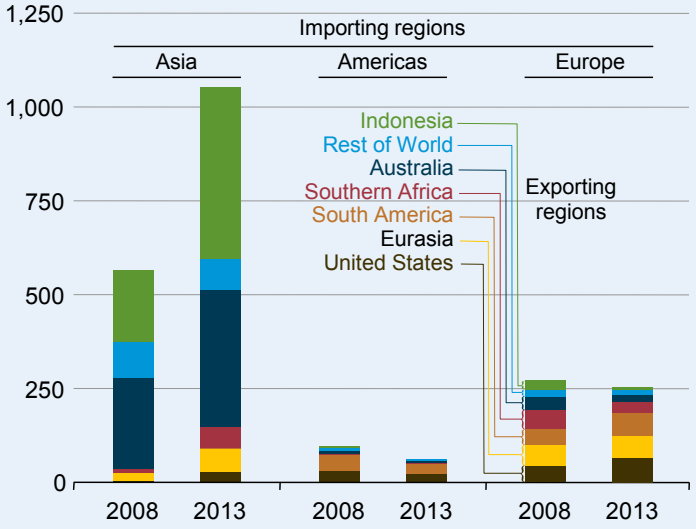


Figure 4-18. World coal trade by importing and exporting regions, 2008 and 2013 (million short tons)



[154]Xiaomin Liu and Shan Xue, "China Coal Market Briefing: Third quarter 2015" *IHS Energy* (August 2015), p. 2, http://connect.ihs.com/DisplayDocument/Show?source=gi&docid=2831005&connectPath=EmailAlerts&utm_campaign=Immediate%202831005%20from%20gi&utm_source=EmailAlerts&utm_medium=email (subscription site).

[155]R. Somwanshi, "After import tariff, China to impose coal resource tax," *SNL Energy Extra* (October 13, 2014), http://www.snl.com (subscription site); J. Yang, "China reinstates coal import tariffs to support domestic miners," *Bloomberg News* (October 9, 2014), http://www.bloomberg.com/news/articles/2014-10-09/china-reinstates-coal-import-tariffs-to-support-domestic-miners; and Australian Government, Department of Industry and Science, Office of the Chief Economist, *Resources and Energy Quarterly,* Vol. 4, No. 3 (Canberra, Australia: March 2015), pp. 49-50, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Resources-and-energy-quarterly.aspx.

coal resources and well-developed coal industries—as major coal-importing countries increases the complexity of the Pacific market. In the past, most of the coal trade in Pacific markets was based on a more predictable buildup of coal-fired generating capacity and integrated steelmaking capacity in countries such as Japan, South Korea, and Taiwan, which have very little domestic coal production and are almost entirely dependent on imports. More recently, however, China's domestic seaborne shipments of coal (primarily consisting of coal shipped from loading ports in northeastern China to unloading ports located along the eastern and southern coasts) have expanded rapidly, creating the possibility of substantial variations in its coal imports, depending on the domestic and imported coal prices. Recent data indicate that China's annual domestic seaborne shipments and imports of coal together amounted to about 1 billion short tons, or about one-fourth of its total annual coal consumption.[156] India, which imported approximately 25% of the coal it consumed in 2013, has ambitious goals to more than double domestic coal production between 2013 and 2020, which conceivably could eliminate its need for imports of steam coal.[157] However, India's history of failing to meet production targets and not completing major coal transportation projects leads to considerable uncertainty regarding its future requirements for coal imports.[158]

Coal exports

Coal exports from producers in Indonesia and Australia satisfied most of the increase in demand for imports over the 2008–13 period, with Indonesia's exports growing by 247 MMst (56% of the total increase) and Australia's exports growing by 106 MMst (24% of the total increase) over that period (Figure 4-18). Among the other suppliers, exports from Eurasia and the United States increased by 49 MMst and 36 MMst, respectively, over the same period. In contrast, China's coal exports fell substantially, from 50 MMst in 2008 to 8 MMst in 2013.

By coal type, Australia's exports of both steam coal and coking coal increased from 2008 to 2013, while nearly all of the increase in Indonesia's exports consisted of steam coal. In 2006 Indonesia surpassed Australia as the world's largest supplier of steam coal, and in 2013 it accounted for more than 40% of the world's seaborne shipments of steam coal. Australia has continued to dominate world trade in coking coal, accounting for more than 50% of all international shipments in 2013.

World coal export supplies and patterns are constantly changing and evolving and, similar to coal imports, can be challenging to predict. As noted, the recent surge in demand for coal imports has led to substantial increases in coal exports from Australia and Indonesia, both of which benefit from their close geographic proximity to China and India. At the same time, the large expansion in the Pacific coal market has led to a shift in Southern Africa's coal exports from Europe to Asia, substantial growth in Eurasia's export shipments to the Pacific market, and a revival in U.S. coal exports to Asia. In turn, Southern Africa's substantial shift away from the Atlantic to the Pacific coal market, combined with reduced exports from Australia and Indonesia to Europe, has led to increased exports to Europe from both the United States and South America.

In addition to changes in international demand for coal imports, coal export supplies are susceptible to a host of often unpredictable factors, such as floods, labor strikes, changes in government policies, and transportation bottlenecks. Examples of some recent supply disruptions include heavy rains and flooding from a strong La Niña weather phenomenon that slowed coal exports from Colombia in 2010, heavy rains and flooding in late 2010 and early 2011 that reduced coking coal exports from Australia in 2011, and labor strikes and rebel attacks on rail lines that adversely affected coal exports from Colombia in 2013.

The increase in world coal trade from 2008 to 2013 resulted in some sharp increases in international coal prices (both steam and coking coal), as coal exporters struggled to bring on additional coal mining and transportation capacity (Figure 4-19 and Figure 4-20). In turn, the elevated prices provided an opportunity for higher-cost suppliers to participate in international markets. For example, U.S. coal producers, which typically act as swing suppliers in world coal markets, had effectively been locked out of coal markets in Asia for several years until 2008–12, when much higher international prices for steam coal and coking coal allowed U.S. coal exports to generate positive financial returns. In 2014 and 2015, however, world coal trade showed relatively little growth, and expansions of coal production capacity, primarily in Australia, led to substantial reductions in coal export prices and decreases in coal exports from higher cost supplies, including exports from U.S. coal mines.

Uncertainties in future prospects for international coal trade

Currently, international coal trade is on track for a modest decline in 2015. Looking forward, however, there are considerable uncertainties about future levels and distribution patterns for world coal trade. They include the question of how demand for coal imports in China and India will evolve in coming years. Although both countries are working to expand domestic coal production and complete major new coal transportation infrastructure projects, it is possible that either country could become more dependent on coal imports in the future. In addition, other countries in Asia also have the potential to increase coal imports substantially, given that coal-fired power plants generally are cost-competitive in the region, particularly in comparison with natural gas-fired power plants

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[156]Argus Consulting Services, *Argus Seaborne Thermal Coal Report,* Issue 15-11 (November 6, 2015), p. 5, http://www.argusmedia.com (subscription site); and personal communication (e-mail) from Mr. Hayden Atkins, Argus Consulting Services, New York, NY (November 23, 2015).

[157]R. Somwanshi, "Government eyes zero Indian coal imports by 2020, experts say not possible," *SNL Daily Coal Report,* Vol. 9, No. 43 (March 6, 2015), pp. 10-11, http://www.snl.com (subscription site).

[158]U.S. Energy Information Administration, "India's coal industry in flux as government sets ambitious coal production targets," *Today in Energy* (Washington, DC: August 25, 2015), http://www.eia.gov/todayinenergy/detail.cfm?id=22652.

that to a large extent rely on imports of liquefied natural gas. In Vietnam, where electricity demand has been increasing at a rapid pace in recent years, there are ambitious plans to increase coal-fired generating capacity. As of January 2016, more than 12 GW of coal-fired capacity was under construction, and there are plans to add an additional 60 gigawatts of new coal-fired generating capacity by 2030, much of which is expected to be fueled by imported coal.[159] Evolving environmental policies also have the potential to affect world coal consumption and, consequently, coal trade. In particular, significant commitments to reduce greenhouse gas emissions worldwide could lead to substantial reductions in coal use by key coal-importing countries in both Asia and Europe.

Uncertainties about coal export supplies also loom large. Indonesia's government has been assessing the potential need to curtail its coal exports to assure adequate supplies of domestic coal for planned additions to its coal-fired generating capacity, including announced plans to add 20 gigawatts of new coal-fired capacity by the end of 2020.[160] Australia, which during the boom years of 2008–13 was having difficulty adding sufficient new mining and transportation capacity to meet demand for its coal exports, now has excess coal mining capacity. Other factors affecting the outlook for world coal export supplies and distribution patterns include whether industry will be successful in financing and completing major new coal export projects across the globe, and how coal prices (including both mining and transportation cost components) will change over time. Examples of major new projects oriented toward coal exports include new mining, rail, and port projects currently under development in Mozambique; plans by Adani Enterprises Ltd.to develop the large Carmichael mine in Australia's Galilee Basin; and the proposed Gateway Pacific and Millennium coal export facilities in the U.S. Pacific Northwest.[161]

Figure 4-19. Average annual steam coal export prices by country of origin, 1990–2014 (2013 dollars per short ton, f.o.b. port of exit)

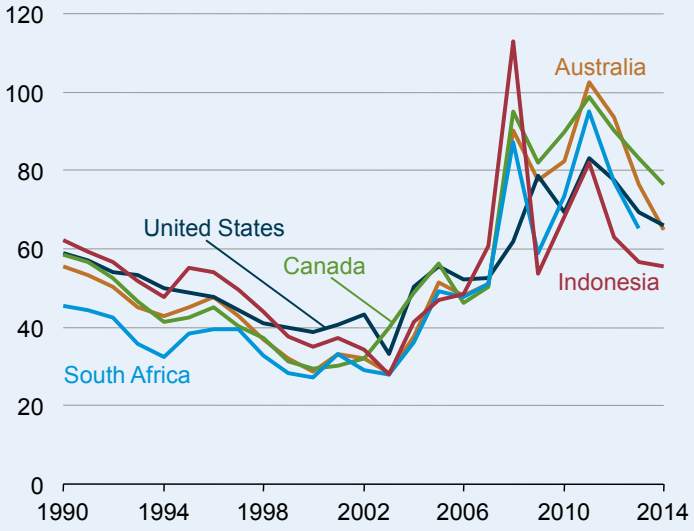
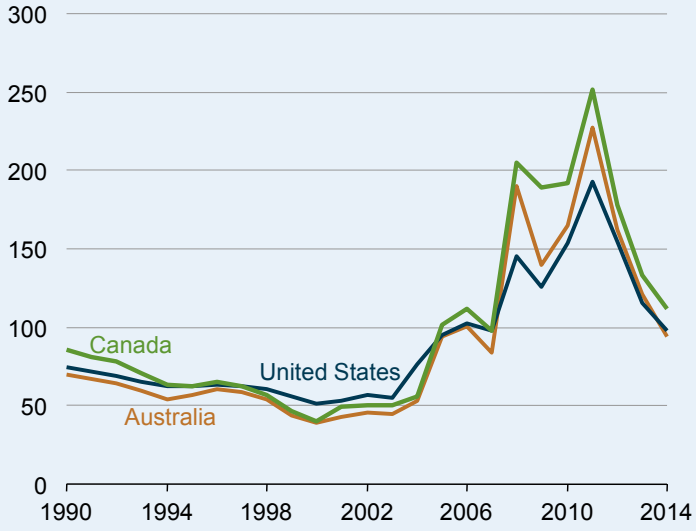


Figure 4-20. Average annual coking coal export prices by country of origin, 1990–2014 (2013 dollars per short ton, f.o.b. port of exit)



World coal reserves

As of January 1, 2012, total recoverable reserves of coal around the world were estimated at 978 billion tons—providing a reserves-to-production ratio of approximately 110 years (Table 4-3). 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.[162, 163] In the most recently published reserves data (as of January 1, 2009, and January 1, 2012), estimates of total world coal reserves increased, with new

[159] R. Somwanshi, "Coal 'importing is inevitable' for Vietnam, expert says," *SNL Energy* (November 19, 2014), http://www.snl.com (subscription site); E. Adourian, "Global Steam Coal Service: Vietnam Coal Profile" *IHS Energy* (July 2015), http://connect.ihs.com (subscription site); and C. Shearer et al., *Boom and Bust 2016: Tracking the Global Coal Plant Pipeline* (March 2016), p. 38, http://sierraclub.org/sites/www.sierraclub.org/files/uploads-wysiwig/final%20boom%20and%20bust%202017%20(3-27-16).pdf.

[160] R. Somwanshi, "Global coal exports slip in April, but continued growth in seaborne markets seen," *SNL Energy Exclusive* (June 30, 2015), http://www.snl.com (subscription site).

[161] Mitsui & Co., "News release: Mitsui to participate in Coal and Rail & Port Infrastructure Business in Mozambique" (December 9, 2014), https://www.mitsui.com/jp/en/release/2014/1203631_5699.html; R. Somwanshi, "Major banks end advisory roles, cast doubt over big coal project in Australia," *SNL Energy Extra* (August 11, 2015), http://www.snl.com (subscription site); and M. Christian, "West Coast coal terminal developers keep eyes on prize in face of opposition," *SNL Energy Exclusive* (June 12, 2015), http://www.snl.com (subscription site).

[162] 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 reserves estimates and data on world coal production for 2012 (Table C3).

[163] U.S. Energy Information Administration, *International Energy Annual 1991,* DOE/EIA-0219(91) (Washington, DC: December 1992), Table 33, https://books.google.com/books?id=2JEtMwEACAAJ&dq=International+Energy+Annual+1991&hl=en&sa=X&ved=0ahUKEwi51N6UlNLJAhVDQSYKHRHJD9kQ6AEIHTAA; and *Annual Energy Review 2009,* DOE/EIA-0384 (2009) (Washington, DC, August 2010), Table 11.13, http://www.eia.gov/totalenergy/data/annual/index.cfm.

assessments for Germany (2009) adding 37 billion tons of recoverable coal reserves, Indonesia (2012) adding 25 billion tons, and Turkey (2012) adding 7 billion tons. Although the overall decline in estimated reserves from 1991 to 2012 was 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.

Although coal deposits are widely distributed, 76% of the world's recoverable reserves are located in five regions: the United States (26%), Russia (18%), China (13%), non-OECD Europe and Eurasia outside of Russia (10%), and Australia/New Zealand (9%). In 2012, those five regions together produced 6.4 billion tons of coal, or 72% of total world coal production by tonnage. By rank, anthracite and bituminous coal account for 45% of the world's estimated recoverable coal reserves on a tonnage basis, subbituminous coal accounts for 32%, and lignite accounts for 23%.

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 in 2012 had an estimated heat content of 28.7 million Btu/ton and a relatively low sulfur content of approximately 0.9% by weight. 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 2012 indicate that the average heat content of lignite in major producing countries varies from a low of 4.8 million Btu/ton in Greece to a high of 12.9 million Btu/ton in Canada.

Table 4-3. World recoverable coal reserves as of January 1, 2012 (billion short tons)

	2012	2020	2025	2030		
Region/Country	Bituminous and anthracite	Sub-bituminous	Lignite	Total	2012 production	Reserves-to-production ratio (years)
World total	**442.4**	**314.3**	**221.2**	**977.9**	**8.898**	**110**
United States[a]	117.5	106.3	32.9	256.7	1.016	253
Russia	54.1	107.4	11.5	173.1	0.392	442
China	68.6	37.1	20.5	126.2	4.256	30
Other non-OECD Europe and Eurasia	42.2	18.5	39.9	100.9	0.358	282
Australia and New Zealand	40.9	2.5	41.4	84.8	0.418	203
OECD Europe	5.7	0.9	61.9	66.8	0.630	106
India	61.8	0.0	5.0	61.6	0.666	92
Other non-OECD Asia	2.2	31.6	5.6	34.9	0.663	53
Africa	34.8	0.2	0.0	14.7	0.296	50
Other Central and South America	8.0	0.6	0.0	8.6	0.103	84
Brazil	0.0	7.3	0.0	7.3	0.007	995
Canada	3.8	1.0	2.5	5.0	0.073	69
Other[b]	2.6	0.8	0.1	3.6	0.021	170

[a]Data for the U.S. represent recoverable coal estimates as of January 1, 2014.
[b]Includes Mexico, Middle East, Japan, South Korea, and Greenland.