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World Energy Outlook 2014 projections to 2040: natural gas and coal trade, and the role of China

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The paper presents data and results from the World Energy Outlook (WEO) 2014, published by the International Energy Agency (IEA). Over the period to 2040, total energy use is projected to grow by almost 40 per cent, while the share of fossil fuels in the energy mix falls. Nonetheless, these fossil fuels remain the dominant sources of energy, with oil, coal and gas each accounting for around one quarter of global energy needs by 2040. Increasingly, modern renewables are projected to replace fossil fuels, especially in the power sector. Around 93 per cent of the projected increased primary energy demand comes from non-OECD countries, with two-thirds coming from developing Asia, led by China. By 2025, China could account for almost a quarter of global energy use, doubling its share since the turn of the century. After 2025, India and other Asian countries surpass China as the main centres of energy demand growth. The IEA's WEO 2014 concludes that even taking into account ambitious policy measures announced as of mid to late 2014, energy growth projections place the world on a path consistent with a long-term temperature increase of 3.6 degrees. Urgent action is required if the world's energy systems are to be steered towards lower greenhouse gas emissions.

1. Introduction

The analysis set out in this paper draws on the World Energy Outlook (WEO) 2014, in particular the projections to 2040 set out in its New Policies Scenario. This scenario incorporates a number of new policy proposals, including measures to reduce air pollution from the use of coal in China, plans to cut power sector emissions in the United States, a proposed climate and energy package for 2030 in the European Union, and energy efficiency measures in India.

By 2040, demand for natural gas is expected to grow by more than half, the fastest rate among the fossil fuels, and increasingly, flexible global trade in liquefied natural gas (LNG) offers some protection against the risk of supply disruptions. The main regions that push global gas demand higher are China and the Middle East, but gas also becomes the leading fuel in the OECD energy mix by around 2030, helped by new regulations in the United States limiting power sector emissions. Unconventional gas accounts for 60 per cent of global gas supply growth, increasing to a third of global gas supply. The key uncertainty – outside North America – is whether gas can be made available at prices that are attractive to consumers while still offering

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incentives for the necessary large capital-intensive investments in gas supply. This is an issue of domestic regulation in many of the emerging non-OECD markets, notably in India and across the Middle East, as well as a concern in international trade. Import needs are set to rise across much of Asia as well as in Europe, but concerns about the security of future gas supply are allayed in part by a growing cast of international gas suppliers, a near-tripling of global liquefaction sites and a rising share of LNG that can be re-directed in response to the short-term needs of increasingly interconnected regional markets.

While coal is abundant and its supply secure, its future use is constrained by measures to tackle pollution and reduce CO_2 emissions. Global coal demand grows by 15 per cent to 2040, but almost two-thirds of the increase occurs by the early 2020s. Chinese coal demand plateaus at just over 50 per cent of global consumption, before falling back somewhat after 2030. Demand declines in the OECD, including the United States, where coal use for electricity generation plunges by more than one-third. India overtakes the United States as the world's second biggest coal consumer before 2020, and soon after surpasses China as the largest importer. Current low coal prices have put pressure on coal producers worldwide to cut costs, but the shedding of high-cost capacity and demand growth are expected to support an increase in price sufficient to attract new investment.

China, India, Indonesia and Australia alone account for over 70 per cent of global coal output by 2040, underscoring Asia's importance in coal markets. The coal trade is projected to grow by around 40 per cent, with growth concentrated in steam coal. Australia and Indonesia consolidate their positions as the leading coal exporters, ahead of Colombia, Russia, South Africa and the United States. Adoption of high-efficiency coal-fired generation technologies, and of carbon capture and storage in the longer term, can be a prudent strategy to ensure a smooth transition to a low-carbon power system, while reducing the risk that capacity is idled before recovering its investment costs.

2. Natural gas

2.1 China—the new gas demand powerhouse

China is the country expected to experience the largest growth in natural gas demand between 2012 and 2040. Over the last few years, the Chinese government has progressively targeted an expansion of natural gas consumption as one of the preferred ways to diversify the energy mix, particularly in and around large urban areas, where air quality and pollutants have become paramount issues of social and political concern. This expansion will require the continuation of gas reform initiatives that China has launched in recent years, bringing domestic prices to levels that provide sufficient incentive to develop domestic resources as well as covering

the average costs of imported gas. Incentives are assumed to be put in place to develop domestic gas infrastructure for transmission and distribution as well as for storage, with various upstream players and shippers having reliable access to this infrastructure. China has already undertaken pilot programmes for gas price reforms: in September 2014, the Chinese government raised the wholesale price of natural gas for nonresidential use by over 20 per cent to about $10 per million British thermal units (Mbtu), following a similar 15 per cent increase for nonresidential gas consumers in July 2013. (All prices are in US dollars; $US1/Mbtu==$A1.30/GJ, assuming $A1=$US0.8).

The result is that, in the New Policies Scenario, gas demand in China increases from 148 bcm in 2012, to 430 bcm in 2025 and 650 bcm in 2040, accounting for 11 per cent of the country's primary energy demand by the end of the projection period, compared with 4 per cent in 2012. The largest increase by volume comes in electricity generation, where gas use reaches 190 bcm by 2040 – producing around 870 TWh of power. Gas use grows by more than four times in industry (including feedstocks) and more than triples in the building sector. Gas demand rises rapidly in the transport sector as China expands its natural gas vehicle (NGV) fleet, which helps to mitigate urban air pollution problems and oil import levels.

2.2 Growing global gas trade, with a growing cast of gas suppliers

Considering how growing gas needs are to be met, a key issue is the extent of future concentration in global gas supply, that is the degree to which global supply relies on a small number of producers. The share of the top-five global gas producers in global supply is expected to drop below 50 per cent by the end of the period to 2040 (a period over which total gas production rises substantially), and there is also a trend towards a less skewed distribution of production among them. By comparison, on the oil side, there are signs of increasing reliance on a smaller number of producers, the share of the top-five producers in total output rises from 44 per cent to about 50 per cent (see Figure 1).

Another consideration, particular in the case of gas, is diversity of sources of internationally traded gas, that is the number of exporters and the number of liquefaction sites.[1] Because of its low energy density compared with other fossil fuels, gas is expensive and difficult to transport. As a result, the majority of gas is consumed within its region of origin. At present, only around 20 per cent of the gas consumed globally is traded inter-regionally. This share increases very slightly over the projection period, reaching 21 per cent by 2040. But, within this share of internationally traded gas, there is a more

[1] The number of liquefaction sites operating worldwide (each of which can contain multiple projects or trains) has doubled since 2000, reaching 26 in 2013. In the New Policies Scenario, the anticipated number of sites increases to more than 70 by 2040.

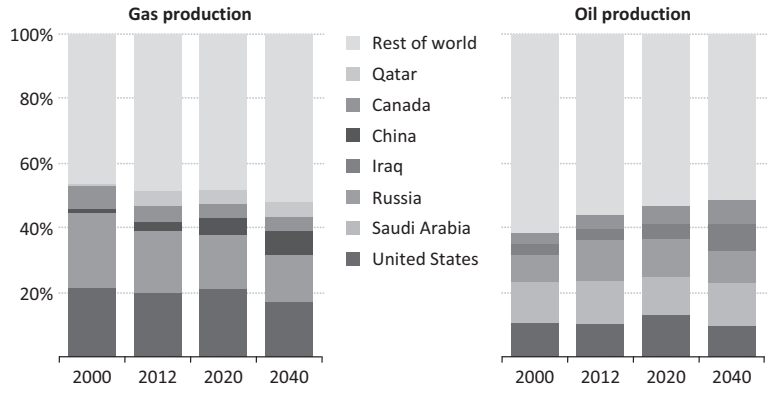


Figure 1 Shares of major oil and gas producers in total production in the New Policies Scenario.

significant shift, away from gas traded by pipeline and towards gas traded by LNG. By 2040, almost half of inter-regional trade in gas is in the form of LNG (Figure 2).

Inter-regional gas trade by pipeline is largely a Eurasian phenomenon. Considering the huge resource base in Turkmenistan and inland Siberia, there are simply no other viable options to move resources from the centre of the Eurasian landmass to large consuming markets. Over the projection period, the IEA anticipates that pipeline capacities are strengthened from the Caspian Sea and Middle East to South-East and Southern European markets, and from Turkmenistan to China. Further, it is expected that new infrastructure is put in place to bring gas from Russia to China as a result of the agreement reached in 2014 and, eventually (and more speculatively), from Turkmenistan southwards towards the expanding markets of South Asia. Between them, Russia and the Caspian exporters account for almost 70 per cent of inter-regional pipeline gas trade in 2040.

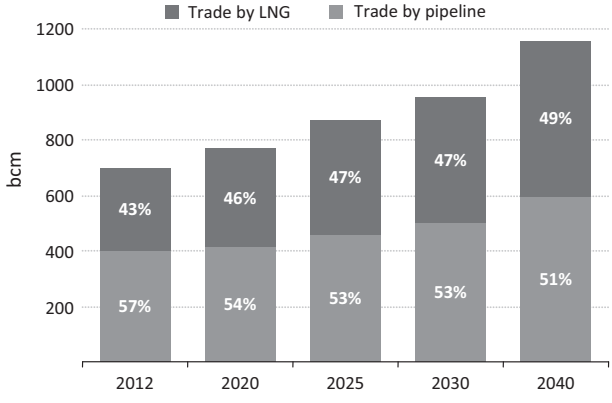


Figure 2 Inter-regional gas trade by pipeline and LNG in the New Policies Scenario.

2.3 The cast of LNG suppliers grows rapidly

A much greater degree of flexibility comes from international supplies of LNG, where there is a much more visible shift in the cast of suppliers (Figure 3). Some existing LNG exporters fade from prominence, in South-East Asia but also in Africa (Egypt) and in the Middle East (Abu Dhabi, Oman, Yemen). This is more than compensated by the range of major new exporters arriving or a strengthening of their existing presence. The first of these is Australia, which expands exports over the course of this decade and, by early 2020s, is expected to export more than 100 bcm to international markets, up from 30 bcm exported in 2012. Australia is joined by the United States in 2016, as an international LNG exporter of its abundant domestic gas output.

The initial North American export projects are concentrated in the US Gulf of Mexico, but into the 2020s, they are joined by western Canada, taking advantage of its relative proximity to Asian markets. Total LNG exports from North America rise to 60 bcm by 2025, reach a peak above 80 bcm in 2035 and then slightly decline in the last part of the projection period. The outlook for LNG exports from the United States is somewhat tighter than in *WEO-2013*, as US policy and domestic wholesale prices push larger volumes of gas into domestic power generation and other end-use sectors, while the extension of the IEA *Outlook* to 2040 also brings into view a flattening of domestic gas production (based on current IEA estimates of recoverable resources and assumptions about the pace of technology learning) as well as a continued rise in US wholesale gas prices, which reach $8/MBtu by 2040 (Future prices are in constant 2013 dollars).

There is the prospect of an expansion in Russian LNG supply from the Yamal peninsula and from the Pacific coast, as well as the emergence of East Africa as a major global LNG player, based on the huge discoveries offshore Mozambique and Tanzania. Judging by the announcements from project developers, the start-up of many of these LNG export projects is planned for around the end of this decade and into the early 2020s – a period during

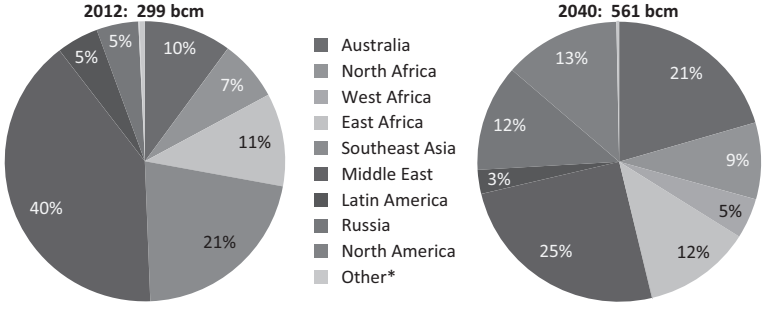


Figure 3 Inter-regional LNG exports by source in the New Policies Scenario. * Other includes OECD Europe and other developing Asian countries; anticipated exports from this region are less than 1 per cent of the total in both 2012 and 2040.

which new pipeline supply from Russia to China is also scheduled to begin. In practice, this means that some projects will be pushed back into a later period, as they will not find the critical mass of committed buyers necessary to justify an early final investment decision.

2.4 New business models for gas supply appear

This more diverse supply picture, and the emergence of new business models for gas supply that comes with it, will entail changes in the nature and allocation of risks along the gas value chain. One aspect is that three of the enlarged cast of suppliers are OECD countries, a consideration that may shift, in some cases, the perception of risks associated with reliance on imported gas. Another, more fundamental change is in the way that gas is set to be traded internationally, a transformation that is being led by LNG. In the past, LNG trade was typically structured in a way that emulated point-to-point pipeline projects, as part of an integrated project linking development of a specific resource to its use by a defined set of buyers (who would often in turn have monopolistic franchise areas). Over time, the system of international trade is set to become more open, with more of the characteristics of a standard commodity market.

One catalyst for this is the process of market liberalisation, entailing the removal of restrictions on trade, such as clauses limiting the resale of the gas. In Europe, against a backdrop of growing competition and uncertainty over long-term market share, many buyers have preferred more flexible contracts, often with shorter time horizons. A related shift, notably in northern Europe, has been towards prices set by the interplay of gas supply and demand, rather than prices indexed exclusively to oil or oil products. On the supply side, a small but growing share of international trade is taken by LNG marketers (often called aggregators) that sell gas from a global portfolio and look for arbitrage opportunities between the various regional import prices. Over the projection period, the IEA expects a continued trend towards hub-based pricing and shorter term or spot sales in Europe. In the Asia–Pacific region, contracting structures are also expected to become less rigid, albeit at a slower pace, including greater availability of LNG with shorter contract terms and diminishing reliance on oil indexation.

The move towards a more interconnected and flexible global gas market does not mean the end of long-term contracting, which remains an important way to improve the bankability of new, capital-intensive gas infrastructure projects by guarding against the risk of their under-utilisation (this long-term contracting can either be of the gas itself, as per the traditional model of risk reduction, or of access to liquefaction capacity, as in the United States). At the margin, US LNG exports mean that buyers and sellers are able to react more readily to short-term circumstances. Buyers limit the risk of having to pay, under take-or-pay provisions, for unwanted volumes under contracts signed in the US but face the possibility that prices may be high if and when

they need additional gas. Sellers tend to have fewer guaranteed clients for all of their gas, but have the opportunity to seek the highest bidder and the most favourable price for some portion of their sales.

2.5 Competitive markets and investments

A fundamental question for gas security is whether more competitive markets, including those in which prices are set by gas-to-gas competition, can provide sufficient security for new large-scale investments in the upstream and in gas transportation infrastructure. Evidence from North America and liberalised parts of the European market suggests that they can, and this message has been reinforced by the decision, taken in late 2013, to proceed with Azerbaijan's multibillion dollar Shah Deniz project (which triggered, in turn, plans to expand infrastructure along the route to Italy). The Shah Deniz project is underpinned by multiple long-term contracts with different offtakers, with prices tied to European hubs, mainly the TTF in the Netherlands.

A more challenging environment arises in the Asia–Pacific region, where delivered costs for gas have been higher, but buyers are determinedly seeking lower purchase prices. The credibility of the traditional pricing mechanism underpinning long-term import contracts linked to the average price of crude oil imports to Japan is being called into question by the unwillingness of buyers to commit on this basis, even though there are, for the moment, no obvious alternative reference prices that would reflect supply and demand for gas in the region. Until there is greater certainty about the direction and speed of this commercial transition, there is a risk that both buyers and sellers will adopt a 'wait-and-see' approach. US export projects, priced off US wholesale gas prices, are largely insulated from this debate.

The Asia–Pacific market becomes the main destination for internationally traded gas over the period to 2040. The main existing importers, Japan and Korea, are joined by two emerging gas-consuming powers, China and India, and a host of other smaller consumers (Figure 4). As net exports from South-East Asia tail off, Asian importers rely even more, in the aggregate, on more distant supplies, as well as focusing – wherever possible – on developing indigenous gas output. But, despite the large increase in import needs, the overall supply outlook is promising, in part through the possibility of new pipeline links across Eurasia, but also from the array of potential LNG suppliers from different regions.

China becomes the cornerstone of Asian gas markets, not only because of the volume of its consumption but also due to the diversity of its pipeline and LNG supply, as well as its potential for sizeable domestic production. The gas agreement reached with Russia in 2014 confirmed that China appears to have a range of import options around the $10–13/MBtu range. This opens up the possibility – if regulation and physical infrastructure are in place – for domestic gas trading and transparent wholesale pricing, with the potential to set a new gas pricing benchmark for the broader region. With the rise of China and other

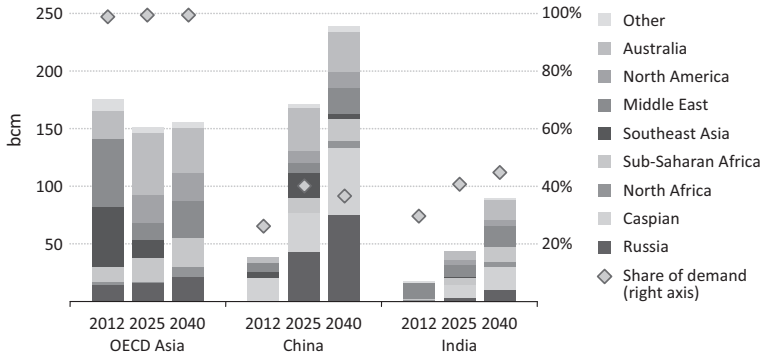


Figure 4 Gas imports by source to selected Asian markets in the New Policies Scenario.

emerging gas importers, the nature of Asia–Pacific import demand also has the potential to change over time, becoming more market- and price responsive than at present (assuming that contracting and pricing structures for LNG become less rigid). China's large stock of coal-fired power plants gives it greater scope, compared with Japan or Korea, to switch away from gas, and it also has an expanding upstream sector of its own. This makes it more probable that signals from a more integrated global gas market would elicit some kind of market response, whether on the demand side or on the supply side.

Grounds for confidence in the adequacy and reliability of future gas supply do come with some important qualifications. The various infrastructure and regulatory barriers that hinder the efficient allocation of gas supplies across regions will not disappear overnight. And, even if existing traded volumes can be redirected efficiently in response to short-term market signals, the extent and speed with which prices would then drive a broader adjustment in supply and demand in the various regions is open to question. On the supply side, the high cost of putting gas infrastructure in place means that there are few commercial incentives to build slack into the system. Under-utilised liquefaction facilities and pipelines increase the resilience of a gas supply system and bring benefits in terms of security of supply, but they are anathema to investors (which is precisely why such infrastructure tends to be built only with long-term contractual guarantees underpinning its use). So, the expectation that a significant shortfall in a gas-importing region can quickly or economically be compensated for by calling upon additional international supply may be misplaced. On the demand side, it cannot be taken for granted that fuel-switching capability away from gas will increase over time; the opposite may well be the case in some markets, notably in the OECD, as coal plants (currently the main source of substitution capability) are decommissioned.

3. Coal

In the decade to 2013, coal demand grew by over 50 per cent, meeting almost half of the increase in the world's total primary energy needs. China was the

principal source of the surge in coal demand; OECD coal demand dropped by 8 per cent. The 2012 coal demand is approaching that of oil, while back in 2003, demand for oil was 45 per cent bigger. In the WEO 2014 New Policies Scenario, at 24 per cent of the global energy mix in 2040, coal remains just ahead of natural gas and behind oil. Renewables (including hydro) overtake coal around 2035 as the leading source of electricity generation: coal's share shrinks from 41 per cent in 2012 to 31 per cent.

Global coal demand in the New Policies Scenario is projected to grow on average by 0.5 per cent per year between 2012 and 2040. This compares with growth of 2.5 per cent per year over the past 30 years. Almost two-thirds of the projected increase in world coal demand occurs in the next 10 years. Coal demand to 2040 is projected to decline in all major OECD regions, led by the United States, where coal use for power plunges by more than a third between 2012 and 2040. China's coal demand growth also slows sharply, peaking around 2030. India, where demand continues to rise briskly, overtakes the United States as the world's second biggest coal consumer before 2020.

China, India, Indonesia and Australia alone account for over 70 per cent of global coal output by 2040, underscoring Asia's importance in global coal markets. Coal prices have already fallen by one-third from their 2008–2010 peaks, dropping to $86/tonne in 2013. Low coal prices, caused by overcapacity, have put pressure on coal mine owners worldwide to cut costs and close high-cost capacity. Coal prices in real terms are projected to recover to over $100/tonne in 2020, but will still be lower than international gas prices, on an energy-equivalent basis, especially in the key Asian power sector. Prices increasing to over $110/tonne in 2040 are expected as trade expands and supply becomes more costly.

In absolute terms, global coal trade grows by 40 per cent to 2040, from 18 per cent in 2012 to 23 per cent of global coal demand, driven by strong Asian demand. China surpassed the EU as the world's largest net coal importer in 2012 and it maintains this status over the current decade, although imports only account for around 8 per cent of Chinese coal demand. By 2025, when imports level off, China is overtaken by India, as the largest coal importer. By 2040, it is projected to have imports of 430 million tonnes coal equivalent (Mtce). Australia and Indonesia account for 70 per cent of the global increase in coal trade.

3.1 Global coal trade keeps growing steadily, led by steam coal

Coal trade between *WEO* regions in the New Policies Scenario is expected to increase and to reach 1 430 Mtce by 2040. Steam coal accounts for more than four-fifths of the increase in trade, due to strong growth in demand from coal-fired power plants in Asia. By 2040, 21 per cent of global steam coal production is traded inter-regionally, compared with 17 per cent in 2012. Steam coal trade is sensitive to power sector developments globally, for

example the impact on steam coal trade of nuclear power developments. The growth in the coking coal trade is more subdued, because global crude steel output reaches a plateau after 2025. Still, the share of global coking coal production that is traded increases from around 30 per cent in 2012 to 40 per cent by 2040, because many steel production centres are insufficiently endowed with this fundamental input in iron and steel production. Soon after 2020, the OECD as a whole becomes a coal net exporter, as buoyant volumes of coal are exported from Australia, and to a lesser extent from North America, exceeding imports into Europe, Japan and Korea.

The Pacific market consolidates its leading role in worldwide coal trade, accounting for 80 per cent of the global market by 2040 – up from 65 per cent in 2012. China overtook the European Union as the world's largest net coal importer in 2012, and it maintains this position over the current decade. By 2025, China's imports level off and China is overtaken by India. Even so, at over 250 Mtce in 2040, of which 80 per cent is steam coal, China's imports in 2040 remain above 2012 levels and China remains an important market for exporters, representing 18 per cent of global trade in 2040.

India's imports more than triple over 2012–2040 to 430 Mtce, or 30 per cent of global coal trade. Indian coal output, despite registering the largest global increase over the projection period, fails to keep pace with consistently strong growth in demand, most of which comes from power plants located at the coast in order to use imported coal. By 2040, India's coal import dependency reaches nearly 40 per cent compared with 25 per cent in 2012. Coal imports into other Asian non-OECD countries (including Malaysia, Thailand, Chinese Taipei, Bangladesh and Pakistan) nearly triple collectively by 2040, to over 290 Mtce, a larger figure than projected Chinese imports. Imports into Japan and Korea drop by 30 per cent by 2040, as end-use electricity efficiency improves and the share of low-carbon fuels in the power generation fuel mix rises. Europe's coal imports also fall heavily over the projection period, despite expensive domestic mines being shut due to competition from international suppliers. The region's import dependency nonetheless continues to rise, more slowly towards the end of the projection period, to 56 per cent by 2040, compared with 46 per cent in 2012.

Among the coal-exporting countries, Australia and Indonesia see the largest increases in absolute terms and remain the leading exporters over the *Outlook* period (Figure 5). Before 2030, Australia regains from Indonesia the position as the world's leading coal exporter, in part due to a slowdown in Indonesian exports stemming from robust domestic demand. However, Indonesia remains the world's largest exporter of steam coal, with under 40 per cent of the global trade, while Australia continues to command nearly 60 per cent of global coking coal trade. Colombia, Russia and South Africa also increase exports. Increasing volumes from new suppliers, including Mongolia and Mozambique, help to diversify the global coal market. By 2040, coking coal exports from Mozambique reach 20 Mtce, or 6 per cent of the global market. The United States sees a fall in exports, resuming its role as a

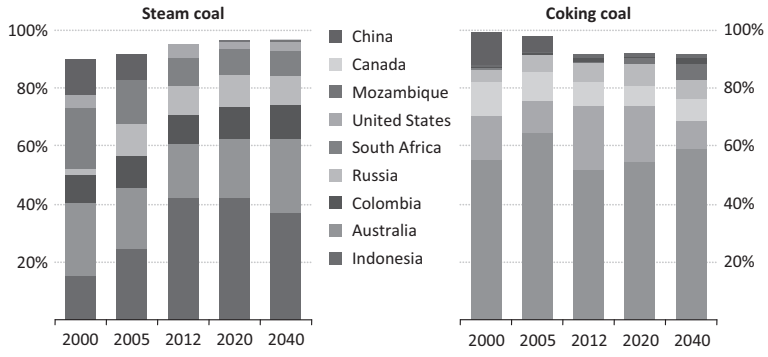


Figure 5 Share of world coal trade by type and key country in the New Policies Scenario.

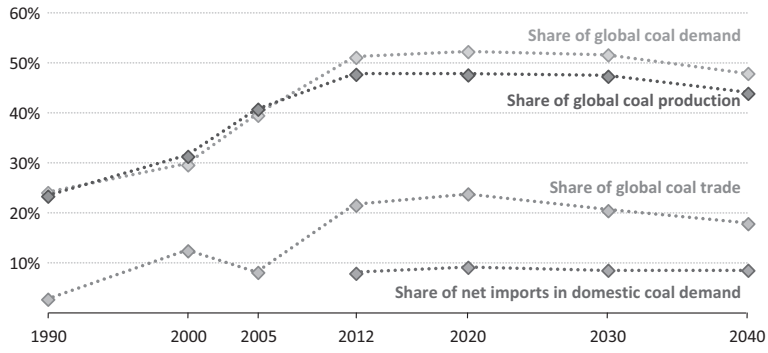
high-cost swing supplier. Steam coal exports remain fairly flat over the projection period, at around 25 Mtce, while coking coal exports drop. US coking coal exports currently come exclusively from the Appalachian Basin, a relatively high cost and mature producing region facing depletion and stiff competition from other exporters over the projection period.

3.2 China remains the mainstay of global coal

China is presently the world's largest consumer, producer and importer of coal. In 2012, more than half of all the coal produced worldwide was consumed in China. Chinese economic prosperity has been underpinned mainly by coal, which currently provides over two-thirds of China's primary energy supply. The country is set to consume more coal than the rest of the world combined for the next two decades, with China's share in global coal demand dipping below 50 per cent only after 2035 in the New Policies Scenario. Chinese coal demand growth slows well before 2025, reaches a plateau by around 2030 and starts to decline slowly after 2035. This trend is driven by a slowdown in economic growth and a rebalancing of the economy away from heavy industry, as well as policies to diversify the fuel mix in the power sector, enhance energy security, reduce CO_2 emissions, improve air quality and increase energy efficiency. For example, China is set to expand renewable power by more than 1600 terawatt hours (TWh) between 2012 and 2030 (equivalent to more than seven times total Australian power output); Chinese renewable power will nearly double over the period 2012–2020.

China has also become the dominant force in coal trade, with one out of five tonnes traded internationally being shipped to the Chinese coast – a trend that continues over the medium term. After 2020, China's share in international trade declines as demand growth slows and other key importers emerge in Asia. As the largest emitter of energy-related greenhouse gases, China and its coal use are pivotal to global efforts to combat climate change (Figure 6).

With GDP growing nearly 10 per cent per year on average over the last two decades, China's coal consumption has grown exceptionally quickly. In the



Note: China was a net exporter of coal in 1990, 2000 and 2005.

Figure 6 Share of China in global coal markets and China's coal import dependence in the New Policies Scenario. Note: China was a net exporter of coal in 1990, 2000 and 2005.

period 2000–2006, coal demand grew by 11 per cent per year on average, slowing to over 7 per cent per year between 2006 and 2012. Preliminary estimates suggest that GDP growth dropped to 7.5 per cent and coal consumption growth to 5.3 per cent in 2013 – still high, but a marked slowdown compared to previous years.

In 2011, Chinese authorities adopted the 12th Five-Year Plan, covering the period to 2015, which sets targets for cutting energy and CO_2 intensity. Diversification of the fuel mix away from coal in the power sector is central to meeting these goals: 60 GW of renewable energy capacity was added in 2013, almost half of which was wind and solar photovoltaic (PV). Continued political support for renewables, nuclear energy and gas, combined with measures to reduce air pollution, is set to curb growth in coal-fired power generation over the projection period. Hence, the growth rate of coal-fired power drops from over 11 per cent per year in the decade to 2012 to just 0.6 per cent per year between 2030 and 2040, but coal-fired power generation continues to grow throughout the projection period, increasing by almost half. Combined with the progressive deployment of more efficient coal-fired technology, coal use in the power sector plateaus after 2030, but still increases by more than a quarter to 2040. Other authors have projected an earlier peak in Chinese coal use, notably in the power sector, driven by more rapid efficiency improvements in generation, plus faster deployment of low-carbon power sources such as renewable and nuclear energy, plus markedly higher natural gas use in the sector, driven in turn by concerns about energy security and price volatility, and local air pollution (Teng and Jotzo 2014). Garnaut (2014) also argues that, although coal-fired power output increases by almost a third from 2010 to 2020, coal use in the sector has essentially plateaued at 2013 levels, as more efficient plant will replace older generators.

China has been undertaking an extensive infrastructure development programme since the early 2000s, constructing and expanding a large network of roads, motorways, bridges and railway lines. Together with urbanisation, this has resulted in a surge in demand for building materials, such as cement

and steel. Much of the infrastructure has been completed, and urbanisation is now slowing down. In addition, the government is seeking to rebalance the economy away from energy-intensive industries. Crude steel output growth is already in decline, having grown by 9.5 per cent per year in the period 2006-2012, compared with over 22 per cent per year between 2000 and 2006. It peaks before 2020 and then declines (although remaining above 2012 levels until 2030), dragging down coking coal demand. Cement production follows a similar declining trend, falling by 1.3 per cent per year on average over the *Outlook* period, compared with growth rates of 10 per cent per year over the last six years. Total industrial coal demand peaks around 2020 and then declines to 2012 levels by 2040, despite increasing coal use in the chemical industry (growing 2 per cent per year) and rising coal consumption in coal-to-liquids and coal-to-gas transformation processes (15 per cent per year).

Chinese coal production is projected to grow by 0.7 per cent per year between 2012 and 2020. As a result of sluggish demand growth and rising costs in the mature mining regions, production stays fairly flat throughout the 2020s and then goes into slow decline after 2030. Although small coal mines are spread across China, the main production centres are concentrated in the northern and north-eastern provinces of Shanxi, Shaanxi and Inner Mongolia. Together, these three provinces account for roughly 60 per cent of the country's total coal output. Power plants and industrial hubs, however, are primarily located in the coastal provinces, requiring large amounts of coal to be transported over long distances, either directly by railway or by a combination of railway and coastal shipping through the ports in the gulf of Bohai (including Qinhuangdao, Huanghua and Jingtang).

Chinese production costs increased on average by 11 per cent (in nominal terms) between 2012 and 2014, although production costs vary widely. More than 80 per cent of the country's output can be produced at less than $65/tonne, but some older and deeper mines, particularly in Shanxi, have production costs closer to $80/tonne. Transportation can add up to $35/tonne to the cost of supply to Chinese consumers, depending on where the mines are located. The relatively high cost of some domestic coal has created arbitrage opportunities between domestic and imported coal in China's southern coastal provinces, leading to a surge in imports over the last four years. Coal imports increased by over 15 per cent in 2013 to reach around 255 Mtce, but preliminary data indicates they have fallen back somewhat, as 2014 power growth slowed sharply, and hydro power output grew.

Along the southern coast, imported coal is competitive with domestic Chinese coal throughout the projection period. Imports peak before 2020 at around 285 Mtce and go into slow decline thereafter, though they remain around current levels by 2040. Much of the imported coal comes from Indonesia, which is only a short distance from southern China. Shipping costs from Indonesia to Guangdong are in much the same range as the costs of transporting coal southward along the coast from Qinhuangdao. Despite higher freight rates, Australian companies can still export to China profitably

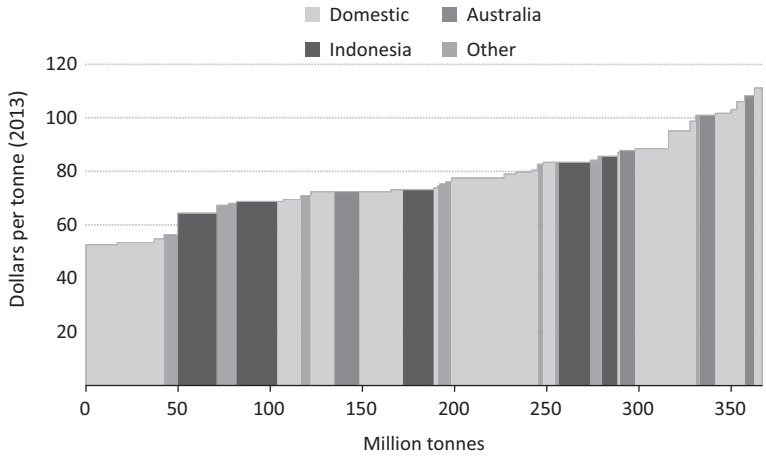


Figure 7 Cash costs of steam coal to southern coastal China*, 2020. * In this graph, southern coastal China comprises the provinces of Guangxi, Hainan, Guangdong, Fujian and Zheijang. It is in these provinces that competition between imports and domestic supply is most pronounced. Total Chinese coastal coal trade is larger, amounting to about 900 Mt in 2012. Sources: IEA analysis and Wood Mackenzie databases.

throughout the projection period, thanks to the high-quality coal. Given the wide range of import costs, the projected slowdown in coastal Chinese coal demand is expected to affect high-cost domestic producers before significant amounts of imports are displaced. Such an outcome is heavily policy dependent. Import regulations governing coal quality (which continued to be discussed in 2014 and 2015) and import taxes for coal (which were announced in mid-October 2014) may limit procurement from the international market and affect the source of imports as well (Figure 7).

4. Implications for emissions

The IEA projections conclude that global fossil fuel demand will continue to grow over the projection period to 2040, even taking into account ambitious policies announced as of mid to late 2014. Globally, gas is projected to increase by more than half, and coal by almost one-sixth, although with growth slowing sharply in the next decade. By 2040, fossil fuels will still provide around three-quarters of global energy use.

A number of major energy consuming nations are proposing ambitious new policies that are climate relevant, and China's coal use and emissions may peak sooner than expected. Nonetheless, the International Energy Agency's World Energy Outlook 2014 concludes that these measures are not sufficient to achieve the goal of keeping temperature increases to below 2 degrees C. Annual emissions in 2040 increase by 20 per cent compared to 2012 levels, to 38 Gt. Such emission levels are consistent with a long-term temperature increase of 3.6 degrees.

Emissions in some countries and regions peak over the projection period, including in the United States (before 2020), and China (peaking soon after 2030), joining the EU, where emissions have already peaked. However, these trends are insufficient to offset growth elsewhere. The IEA concludes that achieving the 2 degree goal will entail a substantial transformation in the ways the world produces and uses energy, including major improvements in energy efficiency, and widespread deployment of low-carbon technologies. An understanding of the dynamics and projections of gas and coal out to 2040, and trade in these commodities, is critical to developing appropriate strategies to respond to climate change.

To achieve the 2 degree goal requires urgent action to steer the global energy system onto a safer path. The upcoming UN climate talks in Paris at the end of 2015, where countries are anticipated to make important post-2020 commitments, will be pivotal. A number of major emitters have made significant announcements since WEO 2014 was finalised, notably by China and the United States. Should these commitments be realised, there is the possibility that annual global carbon emissions projected in 2040 by the IEA could be substantially less.

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