WORLD ENERGY COUNCIL

World Energy Resources
Coal | 2016

TABLE OF CONTENTS

HELE technology in Germany delivers high efficient power plants with ability to ramp quickly and to balance intermittent renewable loads

Strong support for coal to deliver affordable and reliable electricity

Gas and coal are big winners in electricity capacity auction in the UK

Study questions coal shutdown

Renewables aren't enough: clean coal is the future

Coal

China's coal-burning in significant decline

Canada's government tells provinces to phase out coal

A 100-year-old Australian coal mine returns as prices double

America's first 'clean coal' plant is now operational

Coal prices soar to $300 a tonne

KEY FINDINGS

1. Coal is the second most important energy source, covering 30% of global primary energy consumption.
2. Coal – hard coal and lignite (brown coal) is the leading energy source in power generation with 40% of globally generated power relying on this fuel.
3. Coal is predominantly an indigenous fuel, mined and used in the same country, allowing for security of supply where this is the case.
4. Technology that reduces the emissions from coal-fired power stations is essential to utilizing the abundant coal reserves in an increasingly carbon-constrained environment.
5. 75% of the global coal plants utilise subcritical technology. An increase in the efficiency of coal-fired power plants throughout the world from today's average of 33% to 40% could cut global carbon dioxide emissions by 1.7 billion tonnes each year.
6. Apart from the continued increase in the efficiency of power plants, the implementation of carbon capture utilisation and storage (CCUS) is one of the elementary strategies for climate protection.
7. Carbon Capture and Storage (CCS) is a critical component in a portfolio of low-carbon energy technologies. The quantities of CO_2 to be captured and stored represent tens of giga tonness, the coming years are critical for demonstrators at industrial scale, aiming at deployment in OECD and non-OECD countries.
8. Global coal consumption increased by 64% from 2000 to 2014. That classified coal as the fastest growing fuel in absolute numbers within the indicated period.
9. 2014 witnessed the first annual decrease in global thermal coal production since 1999.
10. Oversupply & price of natural gas has negatively impacted the coal industry.
11. China contributes 50% to global coal demand. 2014 was the first year within the past decades, in which there was no further increase in the coal demand in China
12. China is shifting to clean coal technologies.
13. India's coal consumption is set to increase.
14. The US is closing or replacing coal with gas in power plants.
15. In Western Europe coal faces much opposition as mitigation of climate change is targeted.

16. Some nations (China, India, Australia, Indonesia, South Africa and Poland) rely heavily on coal to supply base load electricity.

INTRODUCTION

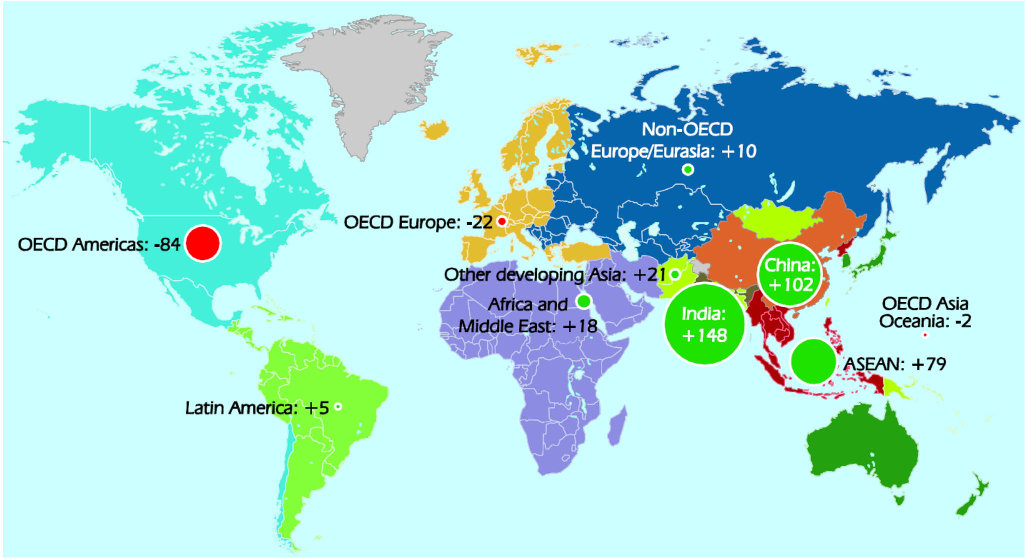
Coal plays an important role in the security of supply in developed countries, and is a key enabler for economic growth and development in developing countries. Coal resource exists in developing countries (including those with significant energy challenges). Therefore, coal has a key role to play in assisting the development of baseload electricity where it is most needed.

Developing countries are increasingly satisfying their growing energy demands with cheap coal in order to sustain economic growth to reduce energy poverty and to achieve the United Nations (U.N.) development goals. Many countries in Asia and Africa are currently making major investments in new coal infrastructures albeit with clean coal technologies[1]. The incremental demand for coal is visible because some regions, notably non-OECD Asia, are focused on maintaining the potential for continued economic growth, while simultaneously protecting the environment from excessive accumulation of anthropogenic greenhouse gas (GHG) emissions and other air pollutants (Figure 1).

Coal is known as the most carbon-intensive fossil fuel and the continuing use of coal in global electrification could have implications for climate change mitigation strategies only if low emissions and high efficiency technology will be utilised in high proportions. With modern technological advancements, coal plants could have technologies that allow higher efficiency and low carbon emissions in order to tackle climate change. A further step would be the incorporation of CCUS.

[1] Mercator Research Institute on Global Commons and Climate Change (2015): Renaissance of coal isn’t stopping at China

FIGURE 1: FORECAST OF INCREMENTAL GLOBAL COAL DEMAND 2014 - 2020 (MTCE)



Source: IEA (2015)

The step ahead is implementation of CCS. The individual component required technologies are well known and partially mature; for example, transport of CO_2 by pipelines and storage. Addressing the quantities (the order of magnitude is ¾ to 1 MTon CO_2 per TWh), the main challenges is the integration into large-scale demonstration projects, supported by governments if necessary, and accepted by the public and all stakeholders. Co-operation should be encouraging to ensure that the projects cover all the situations in the power industry and in others emitting industries as well. Sharing knowledge will be key for future investments. Given the rapid growth in energy demand in non-OECD countries, OECD and non-OECD countries must work together, and the multilateral institutions should establish the required and relevant support mechanisms.

This chapter seeks to highlight how climate change actions and market dynamics has impacted the coal industry. It discusses how the coal industry is advancing towards clean technologies in order to tackle greenhouse gas emissions and maintaining a role in securing energy supply. This chapter is organised into six sections:

1. Section 2 describes the current technologies available for coal mining, the mode of transportation, coal-fired generation and the investment costs associated with clean technologies.

2. Section 3 looks at different markets and their associated drivers influencing the production and supply of coal.

3. Section 4 focuses on case studies illustrating how the coal industry has impacted communities.

4. Section 5 discusses the extent to which coal-fired electricity generation contributes to water consumption, air and environmental pollution.

5. Section 6 offers the outlook for the coal industry.

6. Section 7 shows data associated with coal reserves and production.

1. TECHNOLOGIES

Comprehensive electrification is essential for sustainable economic development and coal-fired power is seen as a key input to global electricity generation. This accounts for around 40% of total generation[2]. This section briefly explains extraction techniques, transportation and handling, and plant technologies associated with coal-fired power generation.

EXTRACTION TYPES AND MINING TECHNIQUES

Coal, a product of organic sedimentation, occurs in seam-shaped deposits and must be extracted selectively from the surrounding strata. Flat deposits with no faults are of major commercial importance, which account for 50% of the world's deposits. These have few seams that are often of an even thickness and a wide horizontal spread. Flat, hardly disturbed deposits of little depth lend themselves to extraction in opencast operations. These mainly concern lignites, but most hard coal deposits from the Gondwana period on the Southern continents are also of this type.

Sloping to steeply inclined or fault-containing coal deposits have a large number of irregularly shaped seams in layer sequences that are often thousands of metres thick. The seams are encountered at varying depths, with the deposits frequently marked by complicated faults and disturbed conditions, so that extraction is mostly in underground operations. They are generally of high rank; high quality coking coal, non-bituminous coals and anthracites can usually be found in this type of deposit.

Depending on seam depth and formation and on the overlying loose or solid rock, the coal is extracted either in opencast or underground operations. In underground mining, access is by shafts and/or drifts while, in surface operations, the layer above the coal is stripped to permit extraction of the exposed coal. Depending on seam thickness, the composition of the overlying strata and surface use (e.g. inter alia, density of settlement). Opencast mining is an economic proposition down to depths of 500m.

Hard coal extracted in underground operations is mined either from the surface via drifts or shafts, depending on the depth of the deposit. In drift mining, the deposit is developed using slightly inclined drifts equipped with conveyor belts. By contrast, coal deposits at greater depths require shafts, which are also used for proper extraction. The coal is mined either in room-and-pillar or in long-walling operations, with the latter being predominant.

In room-and-pillar mining, continuous miners drive extraction roads into the coal to cross at right angles. Pillars are left standing in-between to support the overlying strata. This method is associated with high extraction losses, since a considerable quantity of coal remains underground. Transportation to the conveyor belts is often by shuttle car. A variant of the

[2] Office of Chief Economist (2015) Coal in India

room-and-pillar method extraction is by conventional drilling and blasting, with the conveyor belts being fed by wheel loader.

In long-walling, continuous miners are used to drive two parallel roads into the seam at intervals of 200 to 400 m; the roads are then connected at right angles using long-wall equipment. Actual extracted coal falls automatically onto a chain conveyor and is transported further. The long-wall is protected against falling rock by hydraulic shield and frame supports, although the latter are losing importance.

In underground mining, methane gas is released in the long-wall roads; thanks to suitable mine ventilation this gas is so diluted that no firedamp explosions occur. Where the coal is under high pressure from methane gas, gas relaxations are produced by horizontal drilling.

The mining technique used in the extraction of hard coal in open cast operations depends on the number and thickness of the seams and their inclination. In this respect, minimum thicknesses of 0.5 to 1m are considered workable; otherwise, the seams are crushed or loosened by drilling and blasting and removed by dragline/shovel and truck. The seam exposed in dragline operation is likewise drilled and blasted and then loaded by shovel or wheel loader onto heavy trucks for transportation. In this work, small draglines and, to a growing extent, hydraulic excavators are also used. By contrast, the extraction of several inclined seams is by truck and shovel, with the entire group of seams and inter-burden layers being worked in horizontal slices (benches).

The extraction of lignite worldwide is mainly by continuous opencast operation, i.e. bucket wheel excavator (BWE), conveyor belt and spreader. This is also true of the Rhenish lignite mining area to the west of Cologne. The large scale equipment deployed in this German mining area since the end of the 1970s yields a daily output of 240,000 m^3 (12,500 m^3/h). In the Lusatian mining area near Dresden, the equipment of choice for the removal of over-burden owing to the even formation of the lignite seams is the conveyor bridge. The coal is extracted by bucket wheel excavator and bucket chain dredger. The capacity of the conveyor bridges assuming three upstream bucket chain dredgers is up to 450,000 m^3 per day. In the Central German mining area near Leipzig, the same extraction technique has made headway like in the Rhenish area, although with limited use of mobile conveyor methods.

Most other European and non-European large-scale opencast mines also prefer continuous opencast techniques. In Victoria (Australia), for example, the opencast lignite mines employ BWEs, and the Mae Moh (Thailand) mine has been using BWEs for a number of years in the removal of over-burden. By contrast, the opencast lignite mines in Texas (USA) mostly use draglines, shovel and truck combinations. However, some companies have been deploying BWE systems with conveyor belts or cross mine dumpers for years now.

The general trend in extraction technology involves further development of the continuous mining technique that originated in lignite mining for use in harder materials like phosphate or hard coal, including the associated over-burden removal resulting in the non-blasting technique involved with direct extraction and selective mining.

BENEFICIATION, TRANSPORTING AND HANDLING

Owing to relatively high water content (40 to 60%) and a corresponding lower calorific value compared to hard coal, lignite is mostly utilised close to the mines. The focus of lignite use, accounting for nearly 90% worldwide, is on power generation. In Germany, lignite is transported by conveyor belts or train to power plants located near the deposits.

The hard coal quantities mined, a worldwide average of 83% is used in the country of origin itself. Unlike lignite, a functioning international trade exists in hard coal. Since hard coal is seriously contaminated owing to the high degree of mechanisation in mining operation, in that, in raw state its quality often fails to meet customer’s requirements, hence it must be subject to a cleaning process. In beneficiation, the raw coal is first crushed and then classified by grain size, i.e. as coarse, fine and ultrafine. In the subsequent sorting of coal and rock particles, the crucial features are specific weight in the case of coarse and fine grain, and surface properties in the case of ultrafine grain. The separating medium in the former case is either water or a heavy liquid (sink/float process), with the separation being in sink/float drum (coarse grain) or washers (jigs), or in water cyclones or in heavy media cyclones (medium grain). The ultrafine grain, by contrast, is cleaned by flotation. The crucial economic factor in beneficiation is product output, i.e. the share of washed coal to raw coal. This is around 80% for steam coal and 65 to 70% for coking coal.

The world trade in hard coal is based not only on an efficient mining industry, but also on capable infrastructure. Its interlocking phases, all the way from mining to consumer use extend via:

- port handling
- marine transportation
- discharge at the port of destination
- inland transportation (road or rail)
- and these are referred to as the coal chain.

Transportation of hard coal to the port of shipment is generally by rail or by truck. The feasible distances for economic transportation are limited by cost consideration, i.e. the export mines are located relatively near the coast. Rail transport is by complete trainloads with trains up to 1.5 km in length and a capacity of over 10,000 tonnes. Where rail links to the coast are non-existent, the coal can also be taken to the port by truck. Another option is shipping by inland waterway, e.g. to the US Gulf ports or, in Indonesia, to the deep-water ports/loading points.

In the port of shipment, the coal is discharged by wagon tippler and moved by belt conveyor to intermediate stockpiles. Recovery is by bucket wheel reclaimer or subsurface extractor onto conveyor belts, which take the coal available with loading capacities of up to 6000 t/h.

The marine transportation of coal is by bulk freighter. Depending on cargo size, distance to the port of discharge and permissible draught in the ports, and three ship sizes are deployed:

- 10,000 to 50,000 dwt (dead weight tonnage) = Handysize
- 50,000 to 80,000 dwt = Panama
- 80,000 to 150,000 dwt = Capesize

Handysize ships are mainly used for small quantities, short distances, coastal shipping and ports of shipment/destination with only little draught. However, most coal transportation is ocean-wide or between oceans, using panama and capesize freighters. The first can pass through the Panama Canal, while the second have to round Cape Horn or the Cape of Good Hope.

In the receiving countries, there are some 200 ports of discharge available, although this does have to be shared with other bulk dry goods. Some of these have dedicated coal terminals e.g. in the ARA ports (Amsterdam/Rotterdam/Antwerp). Coal discharge is usually by grab crane onto belt conveyors, which take the coal to intermediate stockpiles where coal can be collected for inland transportation.

GENERATION TECHNOLOGY

Subcritical boiler technology

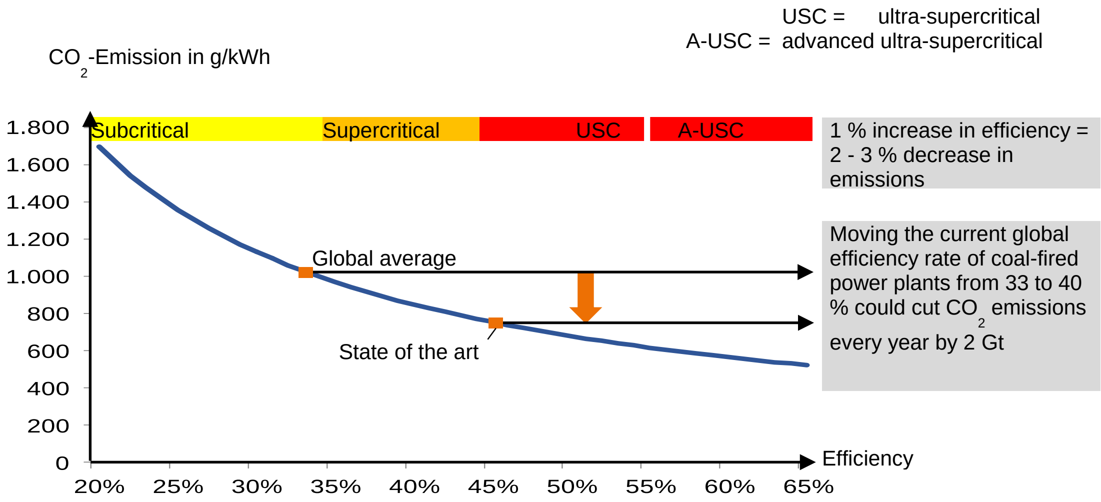
These have efficiencies of about 30% and are the most common type of plant globally because they are faster and less costly to build when compared to other technologies. With CO_2 mitigation on a global agenda, the International Energy Agency (IEA) and other international bodies propagate that global deployment and utilisation of subcritical technologies. In addition, the World Bank has made a decision to cease funding for coal fired projects with lower efficiencies in developing countries, unless there is no other viable option[3]. This may likely increase the rise in utilising more efficient technologies.

Supercritical

Supercritical plants make up 22% of the global coal-fired power fleet with thermal efficiencies of about 40%[4] (Figure 2). The high capital costs of supercritical technology are due largely to the alloys used and the welding techniques required for operation at higher steam pressures and temperatures. The higher costs may be partially or wholly offset by fuel savings (depending on the price of fuel). With respect to CO_2 emissions, a supercritical plant emits around 20% less than a subcritical plant[5].

[3] Reuters (2013) World Bank to limit financing coal-fired plants
[4] https://www.iea.org/media/workshops/2015/cop21/ieaday/1.3GRAY.pdf
[5] Office of Chief Economist (2015) Coal in India

FIGURE 2: REDUCING CO2 EMISSIONS THROUGH EFFICIENCY IMPROVEMENTS IN COAL-FIRED POWER STATIONS



Source: Coal Industry Advisory Board, Submission to the International Energy Agency for UNFCCC COP 21

Ultra-supercritical (USC) & advanced ultra-supercritical (AUSC)

Like supercritical technology, USC technology uses even higher temperatures and pressure to drive efficiency up to 45%. Currently, around 3% of the global coal fleet uses such technology. The technology also reduces CO_2 emissions by up to a third when compared to subcritical plants with the same amount of coal input. The introduction of USC technology has been driven over recent years in countries such as Denmark, Germany and Japan, in order to achieve improved plant efficiencies and reduce fuel costs[6]. Like supercritical plants, USC technology use high quality, low ash coal and these plants have very high capital cost which is about 40-50% more than a subcritical plant. Current state-of-the-art USC plants operate at up to 620°C, with steam pressures from 25 MPa to 29 MPa.

A further modification of USC is AUSC technology. This uses much higher temperatures and pressure, and as a result, steel which has a high melting point and very high nickel content is used. This makes it more expensive to build than USC plants. In China, United States (US), Europe, Japan and India, demonstration plants are being developed and it is expected that from an AUSC plant emissions would be 20% less than supercritical plants and efficiencies could be close to 50%[7].

Integrated Gasification Combined Cycle (IGCC)

Gasification can also be used for power generation. IGCC plants use a gasifier to convert coal (or other carbon-based materials) to syngas, which drives a combined cycle turbine to generate electricity. IGCC plants can achieve efficiencies of around 45% and has low emissions because the fuel is cleaned before it is fired in the gas cycle turbine. IGCC investment cost is relatively high and it could be twice the cost of supercritical plants. In

[6] http://www.worldcoal.org/setting-benchmark-worlds-most-efficient-coal-fired-power-plants
[7] Office of Chief Economist (2015) Coal in India

addition, IGCC technology is still in its nascent stages and the technology has not had much testing as supercritical units.

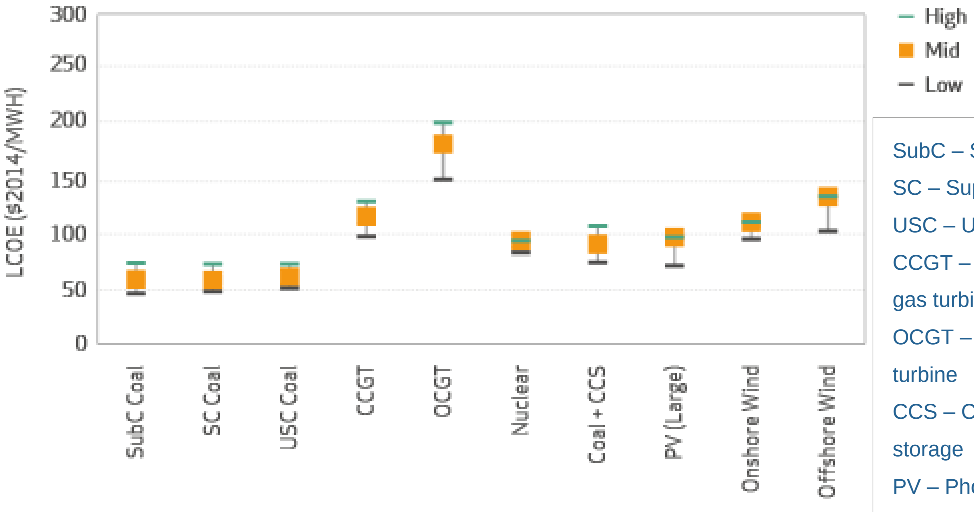
Gasification typically takes place in an aboveground gasification plant. However, the reaction can also take place below ground in coal seams. Underground coal gasification (UCG) uses a similar process to surface gasification. The main difference between both gasification processes is that in UCG the cavity itself becomes the reactor so that the gasification of coal takes place underground instead of at the surface.

The advantages in the use of this technology are the low plant costs (as no surface gasifiers are required) and the absence of coal transport costs. UCG also presents the opportunity to reduce emissions, as there are fewer surface emissions. UCG technology could also have synergies with CCS as the CO_2 could be stored in the coal cavity after gasification.

South African companies Sasol and Eskom both have UCG pilot facilities that have been operating for some time, giving valuable information and data. In Australia, Linc Energy has the Chinchilla site, which first started operating in 2000. Demonstration projects and studies are also currently underway in a number of countries, including the US, Western and Eastern Europe, Japan, Indonesia, Vietnam, India, Australia and China, with work being carried out by both industry and research establishments.

The levelised cost of electricity (LCOE) with regards to India shows that coal is expected to remain the most affordable option through to 2035 (Figure 3). This is driven by low domestic coal prices and limited gas availability.

FIGURE 3: INDIA LEVELISED COST OF ELECTRICITY – 2035



- SubC – Sub critical
- SC – Super critical
- USC – Ultra super critical
- CCGT – Combine cycle gas turbine
- OCGT – Open cycle gas turbine
- CCS – Carbon capture & storage
- PV – Photovoltaic

Source: World Coal Associate (2015)

COAL TO LIQUID (CTL)

Converting coal to a liquid fuel is a process referred to as coal liquefaction. This allows coal to be utilised as an alternative to oil. CTL is particularly suited to countries that rely heavily on oil imports and have large domestic reserves of coal. South Africa has been producing coal-derived fuels since 1955 and has the only commercial coal to liquids industry in operation today[8]. Not only are CTL fuels used in cars and other vehicles, but South African energy company Sasol also has approval for CTL fuel to be used in commercial jets. Currently around 30% of the country's gasoline and diesel needs are produced from indigenous coal. The total capacity of the South African CTL operations stands in excess of 160,000 barrels per day. Fuels produced from coal can also be used outside the transportation sector. Coal-derived dimethyl ether (DME) is receiving particular attention today, as it is a product that holds out great promise as a domestic fuel. DME is non-carcinogenic and non-toxic to handle and generates less carbon monoxide and hydrocarbon air pollution than liquefied petroleum gas (LPG).

TECHNOLOGY OUTLOOK

Currently, subcritical coal capacity constitutes a significant share of global installed capacity. By 2025, however, policy interventions and technological progress are likely to drive deployment of high efficiency low emission (HELE) technologies and result in the subcritical fleet declining to around 50% or lower[9]. The rising economies of Asia will lead the efficiency drive, with India and Southeast Asia seeing particular growth. India, for instance, has recently mandated that power plants above 600 MW must employ supercritical or USC technology[10]. Elsewhere, the US and Japan also expect to use IGCC technology.

Deployment of CCS technology is key to reducing global CO_2 emissions, not only from coal, but also from all fossil fuels. As previously explored, CCS is an integrated suite of technologies that can capture up to 90% of the CO_2 emissions produced from the use of fossil fuels in electricity generation and industrial processes, preventing the CO_2 from entering the atmosphere. In recent years, positive developments have been made in CCS that suggests increased scope for deployment over the coming decades. For instance, in 2014, SaskPower launched the Boundary Dam Project in southern Saskatchewan, Canada. The project has the potential to reduce GHG emissions by one million tonnes of CO_2 each year. In addition, the Kemper County Energy Facility and Petra Nova Carbon Capture Project are two large-scale CCS projects in the power sector which are targeting operations in 2016 (see CCS chapter for more).

[8] https://www.worldcoal.org/sites/default/files/coal_liquid_fuels_report(03_06_2009).pdf
[9] World Coal (2015) Cleaning up the coal-fired market
[10] CSE India (2015) An epochal shift in the idea of India – Meeting Aspirations?

2. ECONOMICS & MARKETS

The world currently consumes over 7,800 Mt of coal which is used by a variety of sectors including power generation, iron and steel production, cement manufacturing and as a liquid fuel. The majority of coal is either utilised in power generation that utilises steam coal or lignite, or iron and steel production that uses coking coal.

COAL PRODUCTION IN 2014 – FIRST DECLINE IN DECADES

In 2014, global coal production was approximately 5.7 billion tonnes coal equivalent[11]. About 77% of the coal production was steam coal to be utilised in other industries and for power generation, 13% was coking coal to be used for coke production in the steel industry and 10% lignite. The total global coal production was 0.7% less than in 2013 and 2.8% less in 2015, making this the first decline in global coal production growth since the 1990s. This was primarily due to the weakening of world economic growth and the flagging electricity demand in some important Asian countries[12].

The largest coal producing countries are not confined to one region. The top five producers are China, the US, India, Indonesia, Australia and South Africa. Much of global coal production is used in the country in which it is produced and only around 18% of hard coal production is destined for the international coal market.

COAL CONSUMPTION

Coal plays a vital role in power generation and this role is set to continue. Coal currently fuels 40% of the world's electricity and is forecast to continue to supply a strategic share over the next three decades.

In 2014, coal demand in China fell for the first time since 1999 by 2.9% to 3.9 billion tonnes[13], but China remains the world's largest coal consumer with a share of 50%.

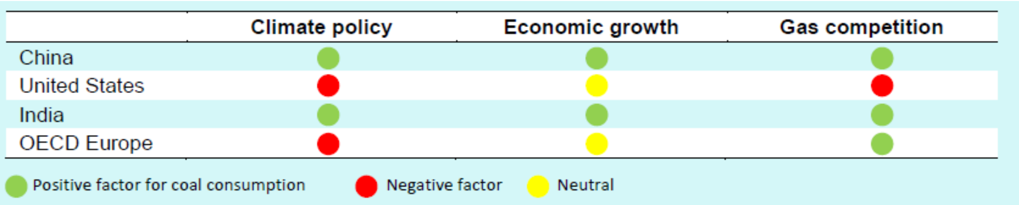
In addition, the US coal demand strongly dropped by more than 13% to 835 million tonnes in 2014. The US coal demand peaked at about 1 billion tonnes in 2007. The fall in US coal demand was mainly due to the increasing competition from natural gas. US gas prices visibly fell as a result of the enormous boost in production of unconventional (shale) gas. This led to a large fuel switch from coal to gas. Furthermore, weaker power demand from coal, stronger headwind from political/governmental opposition and increasingly more environmental regulations resulted in a fall in coal demand in the US[14] (Figure 4).

European (EU 28) coal demand fell by nearly 6%, which can partly be explained by continued pressure on coal-fired power generation due to environmental policies. Coal

[11] IEA Coal Information (2015) here coal comprises all primary coals like anthracite, coking coal, other bituminous coal, sub-bituminous coal and lignite
[12] German Coal Assosiation (GVSt e.V.), Steinkohle (2015)
[13] Reuters (2015) Peak coal by 2020 could save China thousands of lives: study
[14] IEA (2015) Medium-term Coal Market Report

demand of the Russian Federation also fell by more than 4% chiefly because of the economic turnaround after the massive oil price decline and due to the Western sanctions (within the scope of Ukraine crisis) and last but not least as a consequence of the mildest winter in the country' s weather history[15].

FIGURE 4: FACTORS IMPACTING COAL CONSUMPTION



Source: IEA (2015)

Consumption of steam coal is projected to grow by 20% from 2013 to 2040. Lignite, also used in power generation, has been forecasted to grow through to 2020. Demand for coking coal used in iron and steel production has more than doubled since 2000, but according to the IEA's World Energy Outlook 2015, demand will moderate over the coming decade as China enters a new phase of economic development.

The biggest market for coal is Asia, which currently accounts for 66% of global coal consumption, although China is responsible for a significant proportion of this[16]. Many countries do not have fossil resources sufficient to cover their energy needs, and therefore need to import energy to help meet their requirements. Japan, Chinese Taipei and Korea, for example, import significant quantities of steam coal for electricity generation and coking coal for steel production.

Coal will continue to play a key role in the world's energy mix, with demand in certain regions set to grow rapidly. Growth in both the steam and coking coal markets will be strongest in developing Asian countries, where demand for electricity and the need for steel in construction, car production, and demands for household appliances will increase as incomes rise.

ENERGY SECURITY

Minimising the risk of disruptions to our energy supplies is ever more important, whether they are caused by accident, political intervention, terrorism or industrial disputes. Coal has an important role to play at a time when we are increasingly concerned with issues relating to energy security.

[15] IEA (2015) Medium-term Coal Market Report
[16] https://www.worldcoal.org/sites/default/files/coal_resource_overview_of_coal_report(03_06_2009).pdf

The global coal market is large and diverse, with many different producers and consumers from every continent. Coal supplies do not come from one specific area, which would make consumers independent on the security of supplies and stability of only one region.

Many countries such as China, India, Indonesia, Australia and South Africa rely on domestic supplies of coal for their energy need. Others import coal from a variety of countries: in 2013 the UK, for example, imported coal from Australia, Colombia, Russia, South Africa, and the USA, as well as smaller amounts from a number of other countries and its own domestic supplies:

- Coal therefore has an important role to play in maintaining the security of the global energy mix.
- Coal reserves are very large and will be available for the near future without rising geopolitical or safety issues.
- Coal is readily available from a wide variety of sources in a well-supplied worldwide market.
- Coal can easily be stored at power stations and stocks can be relied upon in an emergency.
- Coal-based power is not dependent on the weather and can be used as a backup for wind and hydropower.
- Coal does not need high-pressure pipelines or dedicated supply routes.
- Coal supply routes do not need to be protected at enormous expense. These features help to facilitate efficient and competitive energy markets and help to stabilise energy prices through inter-fuel competition.

CHINA

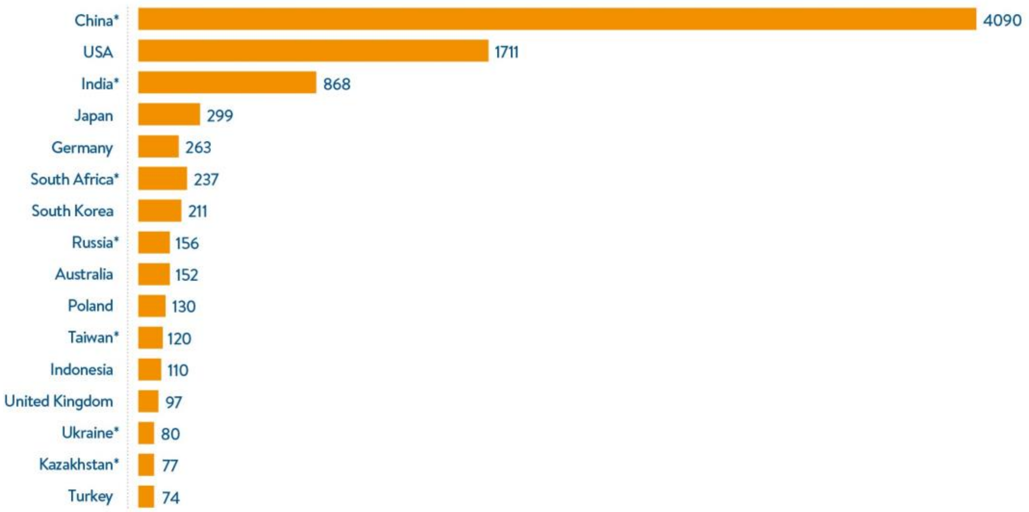
China has been the growth engine of world energy and coal demand over the last ten years. The development in China has largely been powered by coal, which accounted for about 72% of primary energy demand growth over the period 2004-2013. In 2013, the share of China's coal consumption was over 50%[17]. In 2014 the slowdown in Chinese coal consumption was influenced by the slower growth in the steel and cement sectors. Steel and cement have a share of over 26% of coal demand in China and when compared to that of the US of about 4% and some 14% in the EU[18]. Steel and cement production are largely dependent on infrastructure expansion in China, therefore coal consumption is also linked through these sectors to infrastructure developments.

Electricity generation accounts for the majority of coal demand in China (about 60%) and this nation tops the rank in coal-fired power generation (Figure 5). The main driver was

[17] IEA (2015) Medium Term Market Report
[18] Ibid 17

development in the industrial sector, which accounts for the bulk of electricity consumption in China, in contrast to regions such as the EU or North America, where the bulk of electricity consumption is in the service and residential sectors.

FIGURE 5: 2014 COUNTRY RANKING: COAL-FIRED POWER GENERATION (TWH)



Source: IEA (2015) Electricity Information (*for Non-OECD-countries numbers for 2013)

The decreased global supply in 2014 was caused mainly by declining supply in China and Indonesia (Table 1). For both countries, this was a significant change as supply in China and Indonesia grew strongly over the last decade with average growth rates of 7.5% in China and 15.3% in Indonesia.

TABLE 1: COAL SUPPLY OVERVIEW

	Total coal supply (Mt) 2013	Total coal supply (Mt) 2014	Relative growth (%) 2014
China	3749	3650	-2.6%
India	610	668	9.6%
Indonesia	488	471	-3.5%
Australia	459	491	7.0%

United States	904	916	1.4%

Source: IEA (2015)

INDIA

Out of the total coal production of 565.7 million tonnes in the country, public sector companies accounted for around 93.3% of the production led by Coal India Limited (CIL) and Singareni Collieries Company Limited (SCCL). Similarly, as far as lignite production is concerned, around 90% of the production is done through public sector companies, led by Neyveli Lignite Corporation (NLC). However, the contribution of the private sector is gradually gaining significance mainly facilitated by the Government policy of allocating coal blocks to private players.

Today, CIL is the largest coal producer in India and produces around 81% of the total coal[19] (Table 2).

TABLE 2: PRODUCTION SHARE OF COAL PRODUCING COMPANY IN INDIA

Company	Production (million tonnes)	Share
CIL	462.4	81.7%
SCCL	50.5	8.9%
Other Govt. Companies	15.2	2.7%
Total share of Govt. Companies	528.1	93.3%
Private Companies	37.7	6.6%

Source: Ministry of Coal, India (2013-2014)

Production and supply

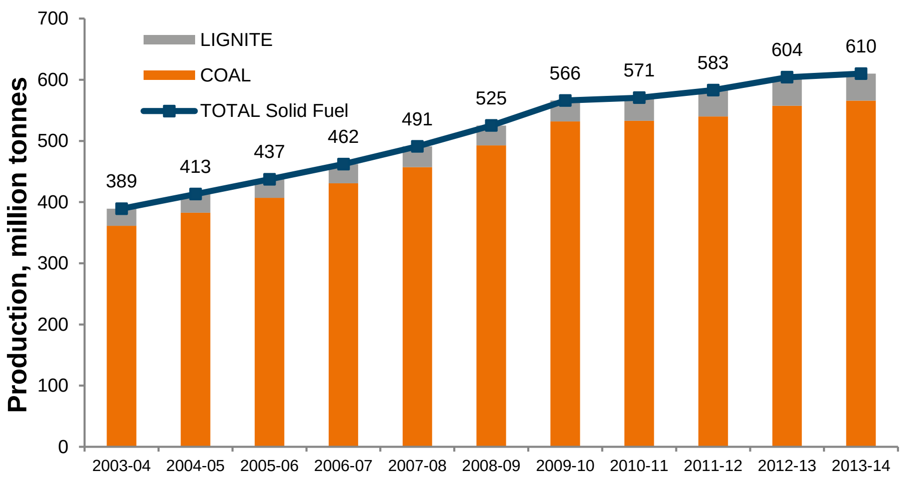
The total solid fuel (coal and lignite) production in India was 610.04 million tonnes (565.8 million tonnes of coal and 44.3 million tonnes of lignite) in 2013 and it was the fifth largest

[19] Data from Coal Directory of India (2013-14) Ministry of Coal

country in the world in terms of coal production. 90% of the total coal produced in the country is thermal coal while the rest consists of coking coal.

Domestic coal production has been inadequate to meet the total demand of coal in the country. The production has been slow mainly in the last five years starting from 2009 in comparison to previous years (Figure 6). In addition, this period also experienced increased coal based generation capacity in the country, which demanded large volume imports of coal from other countries to meet the shortfall in domestic coal production, compensation for India's low quality, high ash coal and the total coal demand.

FIGURE 6: COAL PRODUCTION IN INDIA



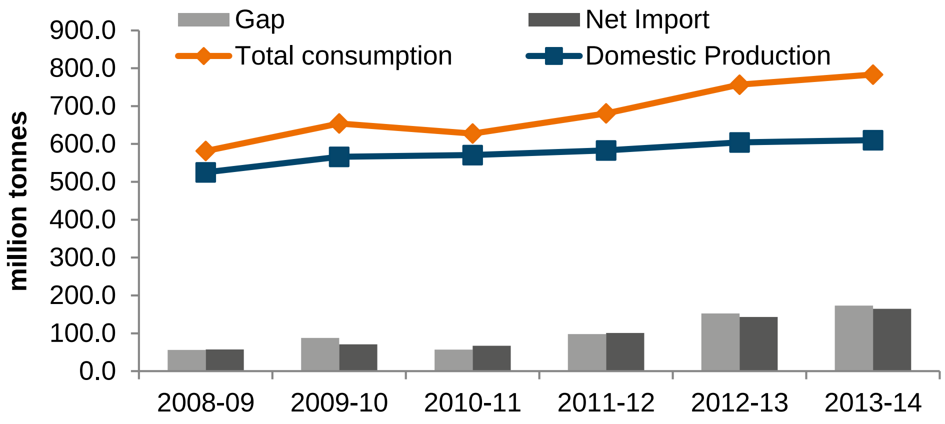
Source: Ministry of Coal, India

While the importance of coal in meeting the primary energy requirement has been increasing incessantly, the production of coal has not kept pace with the demand, particularly in recent years. The gap between domestic coal production and consumption is being met almost entirely through imports. The net import of coal increased by 193% from 2008 to 2013 (Figure 7).

The working group on coal in its report for the 12th five-year plan has estimated that the total demand in the country in the year 2016-2017 will be 980.50 million tonnes and the domestic coal availability has been projected at 715 million tonnes in the 'business as usual' scenario and 795 million tonnes in the 'optimistic scenario'[20].

[20] Planning Commission of India, 12th Working Group Report on Coal

FIGURE 7: DOMESTIC PRODUCTION AND TOTAL CONSUMPTION IN INDIA



Source: Ministry of Coal, India

As per the Import Policy 1993-1994, coal has been under Open General License (OGL) and therefore consumers are free to import coal based on their requirement. For importation, Indonesia has been a major exporter to India with regards to thermal coal and Australia a major source for coking coal.

The main reason for the increasing dependence of imports is the substantial coal-based power generation capacity added in the recent past. Coal based thermal capacity currently accounts for around 60% of the total generation capacity in the country. In terms of electricity generated in the country, the share of coal-based generation is still high, around 78% of the total generation. The share of thermal coal in the total import of coal has been increasing over the years and has reached 78% in 2013-2014.

The coal based generation capacity has increased by almost 104% in the period from March 2007 to March 2014 whereas the growth in thermal coal production in the country was only 29% in the same period. Because of this gap, the import of thermal coal increased by 40% on average in the same period. It is estimated that coal based power plants meet almost 26% of their total coal requirement through coal importation[21].

India is endowed with abundant quantity of coal, which serves as the main resource for meeting the primary energy and economic growth needs of the country. However, as the country is on the path to rapid economic growth with added generation capacity, the domestic coal production has not increased in the same proportion, resulting in a huge shortfall between coal demand and domestic coal supply. This has increased reliance on imported coal, which is generally more expensive compared to the domestic coal. Additionally, the imported coal is normally of better quality and this limits the generating plants in utilising domestic coal.

[21] Data from Central Electricity Authority, www.cea.nic.in

AUSTRALIA

Coal has always been the dominant fuel in the energy mix of Australia where about 75% of the electricity produced is from coal. This is predominantly hard coal, which makes up 47% of Australia's electricity supply. As a result, there are plans to extend mining capacity to a total of 10.8 million tonnes per annum over the next years. For example, in late 2016, the US$1.9 billion underground coking coal mine project in Grosvenor operated by Anglo American will come online with a capacity of 5 Mtpa[22].

Infrastructure investment has aided Australia towards an increase in production and export, but the falling coal prices have caused some coal port projects to be cancelled or postponed, including amongst others the Indgeon Point Terminal in the port of Hay Point. Overall, Australia was able to increase its exports in 2014, with an increase in volume from 29 million tonnes to 387 million tonnes.

The largest importers of Australian coking coal are China, India, Japan, Europe and South Korea. China's import of coking coal was 18% higher and India imported 21% more than in the previous year.

[22] IEA (2015) Coal Medium-Term Market Report

TABLE 3: AUSTRALIAN EXPORT DEVELOPMENT IN SELECTED REGIONS (HARD COAL, MT)

	2013	2014
China	27.0	31.9
India	25.1	30.4
Japan	20.6	21.9
Europe	15.1	15.9
South Korea	7.9	8.6
Total	**95.7**	**108.7**

Source: VDKI (2015)

SOUTHEAST ASIA

Indonesia

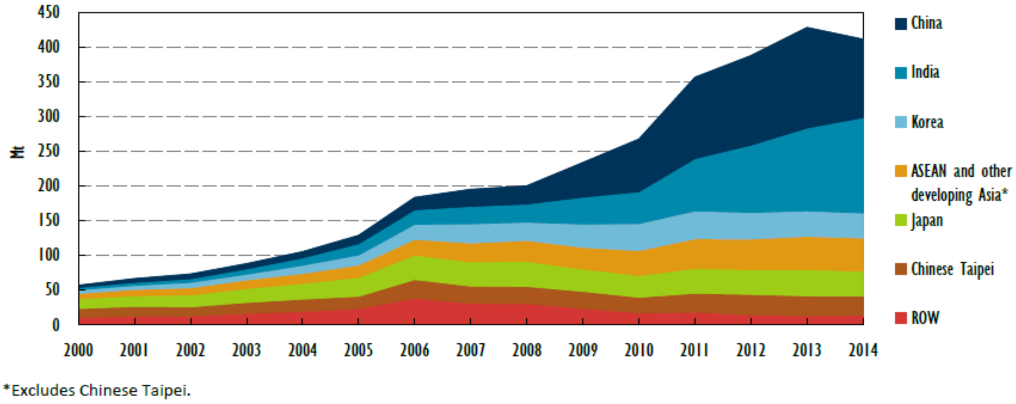
The supply of hard coal in Indonesia declined by 3.6% to 470.8 million tonnes in 2014 as the Indonesian government tried to limit production in order to stabilise prices in the oversupplied international coal market. Most of the coal supply served the export market, with about 8% of the supply utilised for domestic consumption. The decline in supply is because of the export market, more specifically in lower exports to China as well as new regulations in China, such as coal testing requirements to ensure that the imports comply with the new quality standards. The testing is supposed to be conducted exclusively by the Chinese customs and border authorities, and the entire cargo could be refused in the event of non-compliance with the threshold values. Indonesian coal exports in 2014 were also affected by new regulations that came into effect in October, which requires companies to be registered as official exporters in order to reduce exports from illegal mining activities.

In the period 2004-2013 China and India absorbed over 70% of additional coal supplies from Indonesia (Figure 8). Indonesian exports consist almost entirely of steam coal; as Indonesian coal typically has high moisture content, it does not meet the quality requirements for metallurgical/coking coal.

The five largest producers in Indonesia are Adaro, Bumi Resources, Kideco, Banpu and Berau Coal PT[23]. These producers account for more than 70% of production in Indonesia.

The increase in domestic coal demand is helping to balance the market oversupply, but the effect is limited, given the size of Indonesian domestic markets compared with the international market or Chinese market.

FIGURE 8: DEVELOPMENT OF INDONESIAN EXPORT DESTINATION



Source: IEA (2015)

The Indonesian government has announced plans to build 35 GW of new power generation capacity, and coal-fired capacity will consist of about 20 GW. This addition would be in place within the next five years in order to speed up electrification and provide a basis for economic growth in the coming decade. The government pushes coal-fired power generation because it increasingly wants to use the abundant domestic coal reserves as cheap fuel in the electricity sector.

VIETNAM

The economic growth in Vietnam's industry has propelled the increase in the consumption of power, which in turn leads to higher consumption of Vietnamese coal for power generation. The construction of new power plants lags behind the growth in the demand for electricity, forcing blackouts that could then lead to investment insecurity.

In 2014, 37 million tonnes of coal were produced and this consisted mainly of anthracite, however, lignite and sub-bituminous coal were also mined. The anthracite coal is most preferred for export while lignite and sub-bituminous are used exclusively for domestic consumption.

Vietnam imported about 3 million tonnes of coal, which was approximately 36% more than in 2013. The domestic production does not seem to be adequate in providing Vietnam's

[23] VDKI (2015) Annual Report

dynamically growing economy with a satisfactory amount of coal supplies[24]. This could be one of the reasons why the demand for imports of steam coal will steadily rise. Coal-fired power plants would still remain the most important source of power generation in Vietnam, fuelling 48% of the nation's total generation capacity[25]. The government estimates that coal demand is leaping upward as a result of the additional 24 coal-fired power plants that are planned or under construction which are scheduled to operate before 2016. It is estimated that the demand for coal will move from 43 million tonnes in 2014 to about 70 to 80 million tonnes in 2020[26].

THAILAND

There are significant reserves of brown coal estimated at 1.1 billion tonnes, which is produced for local use in power generation. In 2013, 7.3 million tonnes of coal were produced and the import of hard coal continues to rise in quantity, particularly from Indonesia and Australia, to fuel its power stations in coastal areas[27].

In 2013, the importation of coal stood at about 17 million tonnes, and this figure is expected to increase significantly in the coming decades due to an expanding coal-fired power generation fleet.

SOUTH AFRICA

South Africa has 70% of all coal found on the African continent and coal-fired generation accounts for about 80% of its electrification. South Africa has well developed infrastructure, unlike countries such as Botswana or Mozambique with undeveloped infrastructures, but with rich coal deposits.

In South Africa, some new mines will be commissioned such as the Boikarabelo mine in the Waterberg region, which is operated by the company Resource Generation and is projected to start in 2016[28]. Output from the deposits in Limpopo Province is initially supposed to be 6 million tonnes per year; this will be increased to a capacity of 25 million tonnes per year. The state-owned mining company African Exploration and Mining Finance Company (AEMFC) wants to open two new mines that are expected to supply coal to the Eskom power plants from 2017[29].

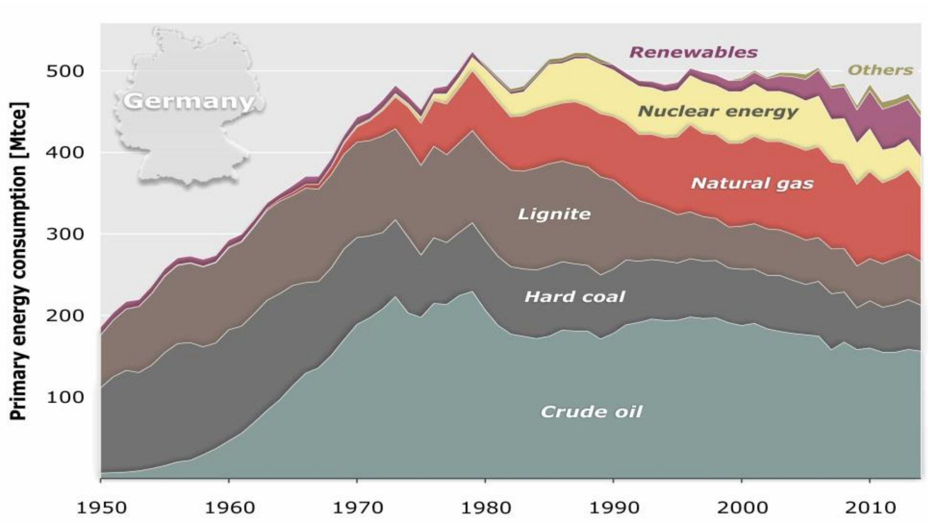
The exports from South Africa increased by 1 million tonnes in 2014 and totalled just slightly less than 77 million tonnes. The structure of exports continues to shift towards India. India imported 30 million tonnes of steam coal, about 10 million tonnes more than in 2013, while China reduced its imports from 13.5 million tonnes to 3.3 million tonnes. In view of India's high need for steam coal in the future, the exports to this country will presumably continue to rise.

[24] VDKI (2015) Annual Report
[25]http://www.renewableenergy.org.vn/index.php?mact=News,cntnt01,detail,0&cntnt01articleid=3256&cntnt01origid=53&cntnt01returnid=53
[26] VDKI (2015) Annual Report
[27] IEA (2015) Southeast Asia Energy Outlook Report
[28] IEA (2015) Coal Medium-Term Market Report
[29] VDKI (2015) Annual Report

GERMANY

In Germany primary energy consumption peaked at the end of the 1970s. Since then, energy demand has remained at a stable level with a slight downward trend. Today, more than 10 years after the energy transition was initiated, crude oil, natural gas, hard coal and lignite still contribute around 80%, and thus by far the largest share of energy consumption in Germany[30] (Figure 9).

FIGURE 9: GERMANY'S PRIMARY ENERGY CONSUMPTION 1950 TO 2014



Source: BGR 2015

Although renewables may dominate in the public's perception, Germany is likely to depend on an energy mix that also includes non-renewables for decades to come in order to achieve a safe transition to a low-carbon energy system. Information on the availability of fossil fuels therefore continues to be of vital importance for safeguarding Germany's energy supply and its role as a centre for industrialisation[31].

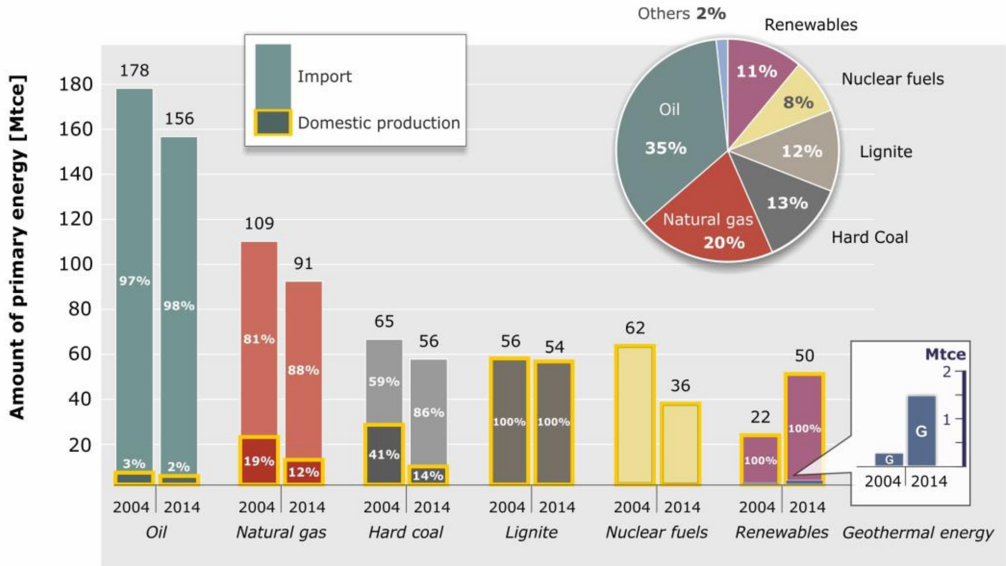
As a highly developed industrialised country and one of the worlds' largest energy consumers, Germany is most expected to import most of its fuel. Based on the value of all imported goods, fuel accounted US$116.9 billion and thus the largest share of import costs in 2014. Crude oil accounted for the largest share of the cost of fuel, at around 38.1%, followed by natural gas with 25.6% respectively. Hard coal (3.6%) and nuclear fuels (0.5%) accounted for the remaining costs[32].

Only around 2% of crude oil and about 12% of natural gas was attributed to domestic production in 2014 (Figure 10), because of declining production rates of domestic oil and

[30] BGR (2015): Energy Study 2015. Reserves, resources and availability of energy resources
[31] AGEB (Arbeitsgemeinschaft Energiebilanzene. V.) (2015): Energieverbrauch in Deutschland im Jahr 2014. – 42 p.; Berlin and Cologne.
[32] BGR (2015): Energy Study 2015. Reserves, resources and availability of energy resources.

gas fields due to natural depletion. When subsidies for domestic hard coal mining are stopped in 2018, the share of domestic hard coal (bituminous coal) will disappear altogether.

FIGURE 10: COMPARISON OF THE USE OF PRIMARY SOURCES OF ENERGY AND OF THE RATIO OF DOMESTIC SUPPLY TO IMPORTS FOR GERMANY IN 2004 AND 2014, AND RELATIVE SHARES IN 2014



Source: BGR (2015)

Imports of hard coal rose significantly during the last years. At the same time, the domestic hard coal production decreased (Figure 10) In 2014, imports of hard coal and coke amounted to an all-time high at 46.2 million tonnes. Imports were largely from Russia, the US, Australia, South Africa and Poland. Russia was again the most important supplier in 2014, with about 13.7 million tonnes (24.4%) and followed closely by the US (19.7%). Imports from Poland, the only remaining EU-28 major coal exporter, rose slightly to 4.4 million tonnes, with coke accounting for 1.5 million tonnes[33].

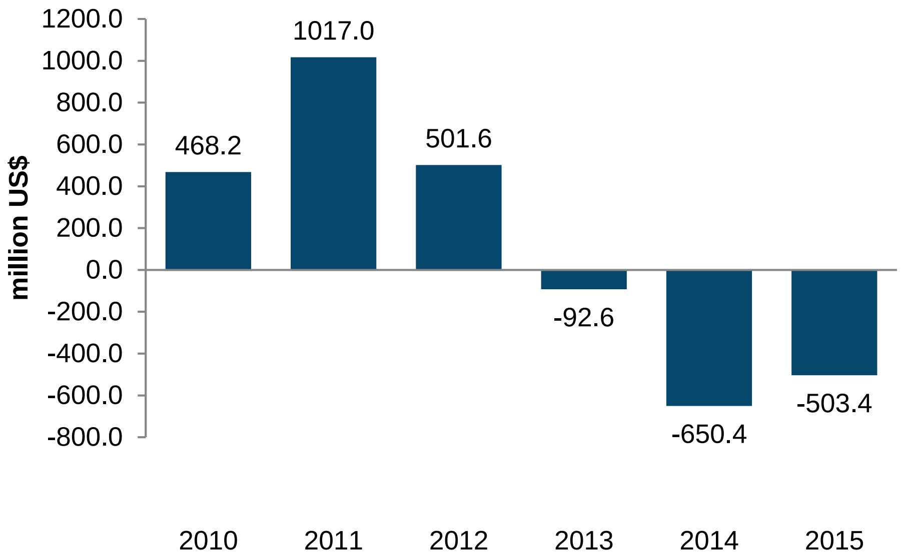
POLAND

The industry is undergoing a restructuring process and its main objectives have been focused on competitive pricing in comparison to the global markets and technical and economic reform of mining companies. The main problem was the high cost of coal production, partially due to the excessive employment and coal mining in exploitation fields with unfavorable geological and mining conditions (thin seams, often disturbed by faults, methane hazard conditions, dust explosions or rock outbursts) or outdated machinery. A characteristic feature was the high employment in the mining industry resulting in low production efficiency. Extensive restructuring processes supported by funds from the state

[33] Verein der Kohlenimporteure (VDKi) (2015): Jahresbericht 2015. - 140 p.; Hamburg.

budget, the World Bank and later by the European Union funds led to the industry's positive financial results in 2003.

FIGURE 11: THE FINANCIAL RESULTS OF HARD COAL MINING IN THE YEARS 2010 TO 2014.

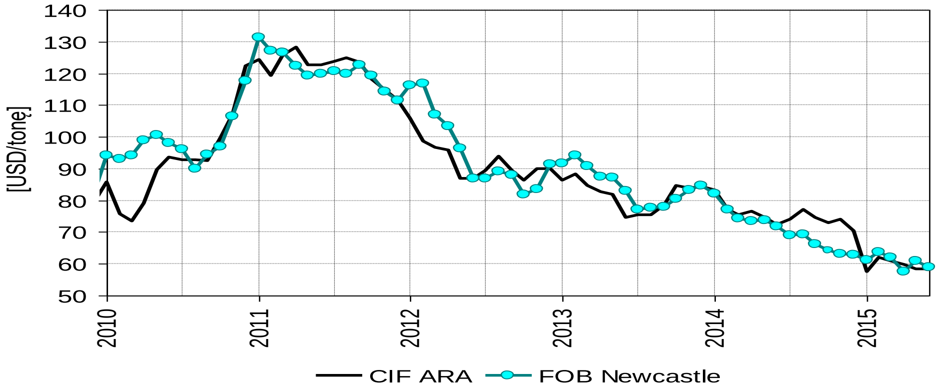


Source: Ministry of Economy, Poland (2015)

In 2011, Polish mining achieved a positive financial result of approximately US$1.017 billion (Figure 11). Unfortunately, this trend was short lived. In 2014 and in 2015, Polish mining reported heavy losses.

The reasons for such worsening of the financial situation of mining companies was due to several factors, among which the most important was the continued decrease in coal prices since 2011 (Figure 12). This shows two indicators of power coal prices: CIF ARA - representing the price of coal imported to Europe and FOB Newcastle - representing the price of coal exported from Australia.

FIGURE 12: COMPARISON OF THERMAL COAL SPOT PRICE INDICES: MONTHLY AVERAGES IN US$/TONNES

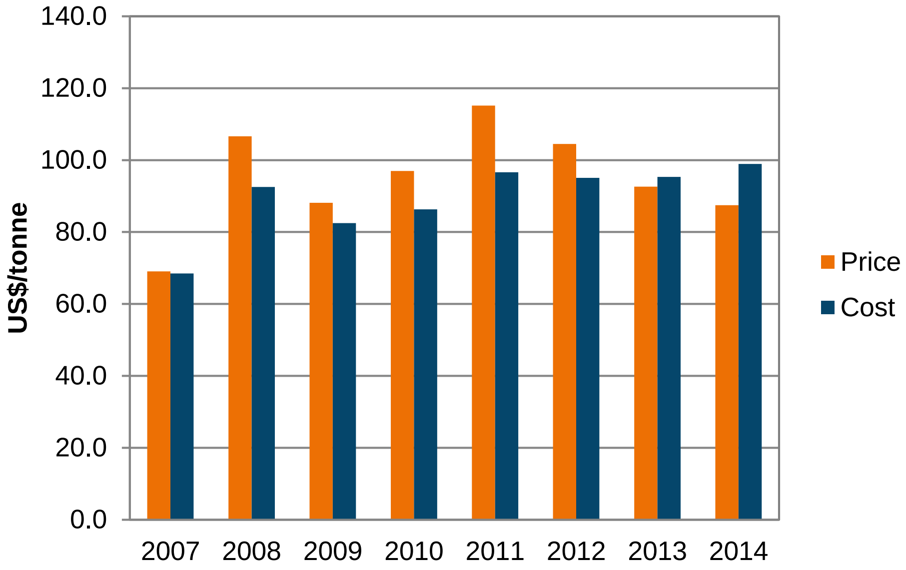


Source: Lorenz U. (2015)[34]

With the decreasing prices in international markets, the prices received by Polish manufacturers also decreased. In 2013, the average price of coal sold was lower by as much as 14% compared to the previous year which was followed by a further 6% decrease in 2014[35] (Figure 13).

[34] Lorenz U. (2015), Current situation and forecasts for international steam coal Polityka Energetyczna – Energy Policy Journal 18, 4, 5-18 (in Polish).
[35] Ministry of Economy, Poland (2015), Information about the functioning of hard coal mining industry and the evaluation of the realization of the activity strategy of the hard coal mining industry in Poland in the years 2007-2015, Warsaw

FIGURE 13: COMPARISON BETWEEN AVERAGE UNIT COSTS OF COAL EXTRACTION AND COAL PRICES.



Source: Ministry of Economy, Poland (2015)

The yearly rise in the unit of coal extraction resulted from the following:

- deteriorating exploitation conditions in the majority of coal mines
- the need to allocate higher funds for investment to ensure continuity of mining
- no proportional reduction of production capacities under decreasing sales
- the pressure on wage increases from the mining crews and trade unions
- no flexible wage model closely associated with the achieved results
- no solutions for continuous operation which would have contributed to more efficient use of the machinery
- conducting mining activities in unprofitable mines (unfavorable conditions, high costs, and low rank of coal).

As a result, average production costs per tonne of coal in 2014 were higher than the average selling price, which has led to the collapse of the mining industry. Lower coal prices were the reason why Polish coal has ceased to be competitive in international markets.

Mining remains a key supplier of primary fuels for the domestic economy, giving Poland one of the highest rates in Europe's energy security. Energy dependence of Poland on energy imports (for all energy products) was 30.4% in 2012 in comparison to 53.4% for the EU-28 during the same period[36]. The low dependence is due to the structure of electricity production in the country; in 2013, 83.7% of electricity was produced from solid fuels (49.6% from hard coal and 34.1% from lignite).

The coal market in Poland is currently facing a number of serious challenges arising from the rapidly changing conditions in the sector. Its long-term role depends on many factors, both at the national and international level. In spite of high coal reserves, the future and role of hard coal mining industry will depend on the successful combat of the deep crisis currently experienced in Poland. In view of the high losses and lack of financial liquidity, the mining companies and the government have to undertake a better restructuring process which should be carried out in a planned and systematic manner. It seems that the sector needs some aid and financial support, as demanded by trade unions.

The EU climate policy is a challenge for the Polish national fuel and energy sector. Its intensification can directly affect the position of coal as a fuel for power generation and as a result can affect the entire economy because coal is an enabler for Poland’s economic growth.

UNITED STATES

No significant additions to export mining capacity are expected to come on line over the next five years because of the weak domestic coal demand and low international prices.

Coal exports from the US to Asian markets are currently limited by scarce port capacity at the US West Coast. To alleviate the problem, projects like the Gateway Pacific is underway with a planned export capacity of 24-38 Mtpa and Millennium Bulk Logistics project and the Port Westward project both have a projected capacity of 15-30 Mtpa. These projects are currently in the approval process[37].

The ongoing limited export capacity and the replacement of coal-fired power plants with power plants fired with natural gas and the plan initiated by the Obama administration to reduce emissions in the energy sector nationwide to 30% below the 2005 level by 2030 could have a major effect on the coal-producing and coal-consuming industry.

Overall, coal will continue as a major part of the US energy mix. It is expected to account for about one quarter of the countries generation capacity in 2030[38].

FUTURE OUTLOOK

The total world coal production (lignite and hard coal) declined in 2014 by about 53 million tonnes, which is the first annual decline since 1999[39]. After more than a decade of strong growth in global coal production and consumption, the coal sector entered a phase of

[36] Eurostat (2014). Energy, transport and environment indicators. Luxemburg.
[37] IEA (2015) Medium-term Coal Market Report
[38] http://www.whitecase.com/publications/insight/power-dynamics-forces-shaping-future-coal-united-states
[39] IEA (2015b): Coal Information 2015. – 674 p.; Paris.

oversupply and a stagnating global demand. The former high growth rates in coal consumption lead to huge investments in coal exploration, and subsequently to expansions in coal mining capacities worldwide. Due to the continuing oversupply in the global coal market, prices for coal have fallen since 2011 for nearly four consecutive years. In August 2015, thermal coal prices decreased by 50% to about US$50 per tonne. On the contrary, world coking coal production increased by 2.6% in 2014[40]. This increase has been consistent since 2002, driven by growth in production intended for export by Australia, the world's largest exporter of coking coal and second largest producer (Table 4).

TABLE 4: MAJOR COKING COAL (1) PRODUCERS (MT)

Country	2012	2013	2014p
China	515.7	561.6	567.9
Australia	146.9	159.5	184.8
Russia	72.8	73.8	75
United States	81.3	77.9	75
India	43.5	49.6	51.4
Canada	31.1	34.1	30.6
Kazakhstan	13	13	15.3
Ukraine	20.9	19.7	12.8
Poland	11.7	12.1	12.3
Mongolia	8.8	6.9	10.3
Colombia	4.5	4.2	5.1
Germany	6.3	4.8	4.8
Czech Republic	5.1	4.6	4.6
Mozambique	2.8	3.3	3.8
Indonesia	3.1	3.6	2.7
South Africa	1.6	3.4	2.6
Other	7.1	5.8	6.0

[40] IEA (2015): Coal information 2015

World	**976.1**	**1,037.6**	**1,064.8**

'(1)' significant proportions of production in some countries may be designated for thermal usage.

Data for Australia and India are provided on a fiscal basis.

Source: IEA (2015) Coal Information

In the last years, more mines with high production costs were closed down, most of them in the United States, Australia and China. At the same time, all coal producers were focusing on cost-saving initiatives and improving their productivity in coal mining. Thus, it seems the global oversupply situation may hardly change in the near future. Furthermore, reductions through mine closures are offset by the commissioning of new production capacities.

In the European coal mining industry, particularly hard coal, there are plans for major restructuring processes. Furthermore, the phasing out of subsidies for hard coal mining in the EU by the end of 2018 based on the EU rules governing state aid for the coal sector as decided on 10 December 2010 by the Competitiveness Council, will have a major impact on hard coal mining in nearly all hard coal producing EU member countries[41]. Nonetheless, coal will continue to play an important role, as the rise in global primary energy consumption is expected to continue, particularly in Asian countries[42].

[41] Council of the European Union (2010) COUNCIL DECISION of 10 December 2010 on State aid to facilitate the closure of uncompetitive coal mines (2010/787/EU). Official Journal of the European Union
[42] BGR (2014) Energy Study 2014. Reserves, resources and availability of energy resources, Hannover.

3. SOCIO-ECONOMICS

Coal has been a support for the economy in both developed and developing countries, but there are still over 1.2 billion people in the world who live without adequate electricity, which is vital for basic needs[43]. Electrification is a critical element in the development of societies; the ability to provide reliable electricity has far-reaching effects on economic and social development. Electrification leads to advancements in public health, education, transportation, communications, manufacturing and trade. In some places, access to electricity is a fundamental social right, and yet the demand for electricity continues to outstrip some regions' ability to supply it because of a lack of fuels, transmission, or infrastructure.[44]

In many cases, achieving electrification would simply not be possible without coal-fuelled power plants. Its role in the electricity system is an important one in ending electricity poverty for billions of people and contributing to economic development.

For example, in South Africa, coal accounts for over 70% of the country's primary energy consumption, more than 80% electricity generation and 30% liquid fuels[45]. This has aided the development in infrastructure, industrialisation, and the economy as a whole. Medupi and Kusile, the two new power stations under construction will be South Africa's first supercritical power plants with operating efficiencies of 40% and equipped with flue gas desulphurisation (FGD) installation. The first unit (800 MW) of the 4,800 MW Medupi coal-fired power station was synchronised to the grid in March 2015. The first unit of the 4,800 MW Kusile coal-fired power station is expected to be synchronised during the first half of 2017.

The World Bank estimates that in the last three decades 600 million people have been lifted out of poverty, almost all of whom were in China. Remove China from the mix and poverty levels in the rest of the world have barely improved. The link between access to affordable power from coal, economic growth and prosperity is clear. In China close to 99% of the population is connected to the grid [46]. Advanced boilers and state-of-the-art emission control technology are moving to the forefront in order to tackle China's severe air quality challenge and rapidly growing need for electricity.

Coal also plays a significant role in global steel production. According to recent statistics issued by the World Steel Association, there was an increase in global steel production in 2014 up to 1665 million tonnes, which was a 16.2% increase from 2010 values[47]. Coking

[43] IEA (2015) World Energy Outlook Electricity access database
[44] Coal Industry Advisory Board to the IEA, The Socioeconomic Impacts of Advanced Technology Coal-Fuelled Power Stations, Paris 2015
[45] Mutemi, A. (2013). MUI Coal mines: A blessing or a curse? Socioeconomic and environmental intricacies. University of Nairobi.
[46] World Coal Asssociation, http://www.worldcoal.org/sustainable-societies/improving-access-energy
[47] https://www.worldsteel.org/dms/internetDocumentList/bookshop/2015/World-Steel-in-Figures-2015/document/World%20Steel%20in%20Figures%202015.pdf p.7

coal is an essential element in blast furnace steel production, making up 70% of total steel production (the remainder is produced from electric arc furnaces using scrap steel).

Steel is an essential material for modern life. Manufacturing steel delivers the goods and services that our societies need – healthcare, telecommunications, improved agricultural practices, better transport networks and access to reliable and affordable energy. Steel is a critical component in the construction of transport infrastructure and high energy efficiency residential housing and commercial buildings.

China is by far the world's largest steel producer followed by Japan, the United States, India and Russia. There has been a significant shift towards China in global steel markets over the past decade. China's share of global production increased from just over 15% in 2000 to more than 49% in 2014[48].

However, other developing economies in Latin America, Asia, Africa and the Indian sub-continent, where steel will be vital in improving economic and social conditions, are also expected to see significant increases in steel production. In these regions, according to the World Steel Association, more than 60% of steel consumption will be used to create new infrastructure. With world steel production expected to continue to grow, the outlook for the coking coal sector will also be strong.

There are socio-economic benefits and concerns with regards to managing coal resource. Firstly, one can look at the benefit of coal mining in rural and remote areas where transport infrastructural development becomes the norm since roads or rail needs to be present for the transfer of coal. The impact of coal on infrastructure development is more noticeable in developing nations due to the absence of pre-existing infrastructure. The rail line used to transport coal can also be utilised by a variety of industries. The investment in infrastructure caused by the energy industry helps to foster economic development. Also, the local population will benefit since employment is provided and hence, other businesses will begin to prosper owing to the increase in market transactions and needs.

On the other hand, concerns can also be seen in that the natural topography of land close to the mining area is disrupted and disfigured. In addition, air quality significantly deteriorates as coal dust particles linger in the atmosphere; however, this is mainly due to poor emissions control. Another effect of poor management practices is the change that mining brings to ground water, as the water course is diverted in order for extraction process to occur[49]. This often would have an impact on communities that depend on underground water to sustain their source of income or for survival.

Coal resource developments in several regions do have significant socio-economic impacts especially for the cities and communities near the project sites. The following looks at these benefits.

[48] https://www.worldsteel.org/dms/internetDocumentList/bookshop/2015/World-Steel-in-Figures-2015/document/World%20Steel%20in%20Figures%202015.pdf p.9
[49] Mutemi, A. (2013). MUI Coal mines: A blessing or a curse? Socioeconomic and environmental intricacies. University of Nairobi.

COMMUNITY IMPACTS FROM TAXES

The taxes that come from coal related activities provide significant revenue for the government. In 2011, the direct contribution from the US mining activity provided over US$20 billion in tax payments to all tier of the government - federal, state and local[50].

In Germany, about US$112 million of tax revenue was collected as a result of the construction phase of Neurath Units F&G between 2005 and 2011.

China also had tax revenues of about US$19 million and US$65 million annually based on the on-grid prices for Zhoushan Unit 4 and Ninghai Units 5. For this nation, electricity consumption is a significant source of tax revenue via a Value Added Tax (VAT) of 17%[51].

PUBLIC HEALTH AND ENVIRONMENTAL IMPROVEMENT

Cleaner coal technologies can mitigate the present situation by replacing old coal units and through retrofitting older plants, which will result in emissions reduction. Advanced coal power plants have better efficiencies and produce fewer emissions than older generation units. Besides boiler efficiency, new advanced coal units' employ emissions control systems that eliminate more than 95% of nitrogen oxide, sulphur dioxide, and particulate matter. In addition to these air emissions, advanced plants also aid in the reduction of GHG emissions.

LOWER ELECTRICITY PRICES

Economies benefit from lower electricity prices because of reduced energy costs, but this also increases industrial competitiveness. Nations that enjoy reduced cost in energy can manufacture goods at lower prices, thus increasing domestic profits and rise in economic activity.

The efficiencies of modern coal plants have gone beyond 43%, as evidenced by the Neurath F and G lignite plants commissioned in August 2012[52]. Charles River Associate (CRA) estimated that if all German coal was converted overnight to state-of-the-art technology, German power prices would decrease by 6.8% amounting to consumer savings of about US$2.53 billion annually[53]. This highlights the negative correlation between advanced coal technology and lower electricity prices.

[50] CIAB (2014). The socio-economic impacts of advanced technology coal-fuelled power stations.
[51] https://www.gov.uk/government/publications/exporting-to-china/exporting-to-china
[52] https://www.rwe.com/web/cms/mediablob/en/208030/data/12068/3/rwe-power-ag/fuels/kw-neurath-boa-2-3/Neurath-F-and-G-set-new-benchmarks-Article-by-Dr.-Reinhold-Elsen-RWE-Power-and-Matthias-Fleischmann-Alstom-published-in-Modern-Power-Systems-June-2008.pdf
[53] CIAB (2014). The socio-economic impacts of advanced technology coal-fuelled power stations

CASE STUDIES

This section focuses on the benefits that coal facilities and mines bring to economies and environments.

7. In India, the Sasan Ultra Mega Power Project (UMPP) an advanced 4 GW coal fuelled power plant.

8. Kraftwerk Neurath, a 4.2GW lignite fuel in western Germany. This has two advanced supercritical units of 1,100 MW each.

9. Usibelli Coal Mine (UCM), located in Healy, Alaska, has been producing coal for more than 70 years. UCM's year-round mining activity produced an annual average of 2 million tonnes of coal from 2009 to 2013 for both domestic use and export market.

SASAN UMPP FACILITY, INDIA

- Reliance Sasan Power is expected to provide about US$42 billion during the operating lifetime of 25 years (Table 5).
- From an environmental perspective, the increased efficiency reduces greenhouse gas emissions. The plant's effect is equal to the removal of 641,000 vehicles from the road annually.
- The increased access to electricity due to Sasan would result in an addition of more than 157,000 new jobs.

TABLE 5: ECONOMIC IMPACTS DUE TO CONSTRUCTION AND OPERATION OF RELIANCE SASAN

	Construction phase: 4 years (US$ billion)	Operation and Maintenance: 25 year period (US$ billion)
Direct economic impact	2.4	9.21
Indirect economic impact	3.51	11.29
Induced economic impact	6.24	21.88
Total impact	12.15	42.39

Source: CIAB (2014)

- During Sasan's operating lifetime of 25 years, Sasan would employ about 600 people directly for its operations and a further 19,500 people would benefit through indirect and induced jobs (Table 6).

- At full capacity, the plant generates enough power to supply electricity to 17.5 million people across seven states; enabling 22 million people to get access to safe water supplies.

TABLE 6: SASAN UMPP EMPLOYMENT IMPACTS

	Construction phase: 4 years	Operation and Maintenance: 25 year period	Total
Direct jobs	5000	639	5639
Indirect jobs	3700	3970	7670
Induced jobs	12250	15532	27782
Total jobs created	20950	20141	41091

Source: CIAB (2014)

- 12,000 schools are expected to be powered by Sasan power plant, which will increase enrolment by more than 96,000 students and is expected to provide street lighting to approximately 400,000 households.

KRAFTWERK NEURATH FACILITY, GERMANY

- The development of Neurath, its construction and engineering costs added US$7.2 billion to the local economy (Table 7)

TABLE 7: ECONOMIC IMPACTS DUE TO CONSTRUCTION AND OPERATION OF NEURATH F AND G

	Construction (million US$, 2006-2012)	Operation and Maintenance (million US$ per year)
Direct economic impact	3469	70
Indirect economic impact	2773	34
Induced economic impact	1000	12
Total impact	7242	116

Source: CIAB (2014)

- Since the operation of the Neurath units in 2012, over US$77 million in wages were paid out. This has also been directly responsible for the employment of 420 employees (including contractors) and other estimated 270 indirect employees (Table 8).

TABLE 8: NEURATH F&G EMPLOYMENT IMPACTS

	Construction (Full time employment, 2006-2012)	Operation and Maintenance (full time employment per year)
Direct jobs	2500	840
Indirect jobs	2800	419
Induced jobs	1700	285
Total jobs created	7000	1544

- Source: CIAB (2014)

In addition, the Rhenish lignite mining industry contributes about 3.7 billion annually to the regional economy, with approximately 42,000 jobs in Germany.

USIBELLI COAL MINE (UCM), ALASKA, US[54]

- Government payments

US$3 million was paid to the government of Alaska for rent, royalties and taxes.

- Charity support

US$272,000 was contributed to about 100 non-profit organisations in 16 communities by UCM and The Usibelli Foundation.

UCM also supported more than 20 academic scholarships annually, for example US$1000 scholarships were presented to students of UCM employees who graduated high school and enrolled for post-secondary education. Five academic scholarships were also granted to graduating seniors at Healy's Tri-Valley School. In addition, three University of Alaska Fairbank's staff were honoured with a US$10,000 prize for outstanding teaching, research and public service.

- UCM and other borough economies

UCM spent about US$270,000 with 21 Denali Borough vendors.

About 28% of enrolment in Healy's K-12 Tri-Valley School came from the family of UCM employees. UCM also provided employment for 117 Healy residents (Table 9)

TABLE 9: SEASONAL VARIATION IN THE DENALI BOROUGH WORKFORCE, RESIDENT AND NON-RESIDENT, 2013

	January		July	
	Number of jobs	Percentage (%)	Number of jobs	Percentage
Government	314	40	411	11

[54] http://www.usibelli.com/pdf/McDowell-Report-Statewide-Socioeconomic-Impacts-of-UCM-2015l.pdf

Professional services	132	17	167	4
Usibelli Coal MIne	117	15	117	3
Leisure	102	13	2,673	70
Trade, transportation and utilities	67	8	338	9
Educational and health services	15	2	48	1
Other services	48	6	81	2
Total	**794**	**100**	**3,834**	**100**

Source: McDowell group (2015) State-wide Socioeconomic Impact of Usibelli Coal Mine

Its operations directly provided 25% of all employment for Healy year-round residents and 31% of all employment for residents working in the private sector. US$12.9 million was paid to Healy employees by UCM and this represented about 60% of all wages paid to Healy residents.

- Employment and wages

The average wage paid to employees of UCM and its subsidiary mining operator in Healy, Aurora Energy Services (AES) was US$21.3 million (including benefits of US$6.6 million) in 2013. UCM/AES also employed local employees, hence creating work, improving the skills and the standard of living for residents of Alaska.

4. ENVIRONMENTAL IMPACTS

Our consumption of energy can have a significant impact on the environment. Minimising the negative impacts of human activities on the natural environment, including energy use is a key global priority. The coal industry works to ensure environmental impacts are minimised.

COAL MINING & THE ENVIRONMENT

Coal mining, in particular surface mining, requires large areas of land to be temporarily disturbed. This raises a number of environmental challenges, including soil erosion, dust, noise and water pollution, and impacts on local biodiversity. Steps are taken in modern mining operations to minimise these impacts. Good planning and environmental management minimises the impact of mining on the environment and helps to preserve biodiversity.

Land disturbance

In best practice, studies of the immediate environment are carried out several years before a coal mine opens in order to define the existing conditions and to identify sensitivities and potential problems. The studies look at the impact of mining on surface and ground water, soils, local land use, and native vegetation and wildlife populations. Computer simulations can be undertaken to model impacts on the local environment. The findings are then reviewed as part of the process leading to the award of a mining permit by the relevant government authorities.

Mine subsidence

A consideration that can be associated with underground coal mining is subsidence, whereby the ground level lowers as a result of coal having been mined beneath. Any land use activity that could place public or private property or valuable landscapes at risk is clearly a concern, as shown in the Witbank-Middelburg case study where poor management practices were undertaken. A thorough understanding of subsistence patterns in a particular region allows the effects of underground mining on the surface to be quantified. This ensures the safe, maximum recovery of a coal resource, while providing protection to other land uses.

WITBANK-MIDDELBURG AREA, SOUTH AFRICA

Close to the Middelburg Steam Mine is Ligazi, a settlement area in which the land trembles and sinks. Residents found the 126 sinkholes and the trembling worrying. The holes appeared suddenly in homes and sometimes it was quite laborious for residents to keep filling the holes. Objects sometimes fell into the earth and residents saw these sinkholes as a hazard to the children or night travellers. This was clearly as a result of poor management practices.

Source: Victor Munnik (2010) The social and environmental consequences of coal mining in South Africa.

Dust & noise pollution

During mining operations, the impact of air and noise pollution on workers and local communities can be minimised by modern mine planning techniques and specialised equipment. Dust at mining operations can be caused by trucks being driven on unsealed roads, coal crushing operations, drilling operations and wind blowing over areas disturbed by mining. Dust levels can be controlled by spraying water on roads, stockpiles and conveyors. However, this should be guided by strong water management practices in order to increase water efficiency and reduce the strain on water scarcity in certain regions. Other steps can also be taken, including fitting drills with dust collection systems and purchasing additional land surrounding the mine to act as a buffer zone between the mine and its neighbours. Trees planted in these buffer zones can also minimise the visual impact of mining operations on local communities.

Noise can be controlled through the careful selection of equipment and insulation and sound enclosures around machinery. In best practice, each site has noise and vibration monitoring equipment installed, so that noise levels can be measured to ensure the mine is within specified limits.

Rehabilitation

Coal mining is only a temporary use of land, so it is vital that rehabilitation of land takes place once mining operations have ceased. In best practice, a detailed rehabilitation or reclamation plan is designed and approved for each coal mine, covering the period from the start of operations until well after mining has finished. Land reclamation is an integral part of modern mining operations around the world and the cost of rehabilitating the land once mining has ceased is factored into the mine's operating costs.

Reclaimed land can have many uses, including agriculture, forestry, wildlife habitation and recreation.

Using methane from coal mines

Methane (CH_4) is a gas formed as part of the process of coal formation. It is released from the coal seam and the surrounding disturbed strata during mining operations.

Methane is highly explosive and has to be drained during mining operations to keep working conditions safe. At active underground mines, large-scale ventilation systems move massive quantities of air through the mine, keeping the mine safe but also releasing methane into the atmosphere at very low concentrations. Some active and abandoned mines produce methane from degasification systems, also known as gas drainage systems, which use wells to recover methane.

As well as improving safety at coal mines, the use of coal mine methane improves the environmental performance of a coal mining operation and can have a commercial benefit. Coal mine methane has a variety of uses, including onsite or off-site electricity production (Gaohe coal mine case study), use in industrial processes and fuel for co-firing boilers.

GAOHE COAL MINE

Lu'an Group uses 99% of methane gas from the Gaohe coal mine in north China's Shanxi Province to operate a generator with a capacity of 30 MW. This new technology converts methane concentrations lower than 10%, which constitutes about 80% of the gas released during mining. Gas having a concentration level of more than 10% is transformed to methyl alcohol and utilised as fuel for internal combustion engines. Low concentration coal mine methane (CMM) has contributed majorly to China's environmental pollution. It is estimated that coal mines produces more than 10 billion m3/year of gas, leading to a massive GHG emissions. This is likely to help reduce 1.4 million tonnes of GHGs and produce 200 million kWh/year of electricity. This facility installed at Gaohe coal mine has attracted a number of interests from coal mining firms, as the industry develops emissions reduction initiatives in order to control carbon emissions.

Source: World Coal Association

COAL USE & THE ENVIRONMENT

Global consumption of energy raises a number of environmental considerations. For coal, the release of pollutants, such as oxides of sulphur and nitrogen (SO_x and NO_x), particulate matter and trace elements, such as mercury, have been a challenge. However, technologies have been developed and deployed to minimise these emissions.

The release of CO_2 into the atmosphere from human activities has been linked to global warming. The combustion of fossil fuels is a major source of anthropogenic emissions worldwide. While the use of oil in the transportation sector is the major source of energy-related CO_2 emissions, coal is also a significant source. As a result, the industry has been researching and developing technological options to meet this new environmental challenge.

Technological response

Clean coal technologies (CCTs) are a range of technological options which improve the environmental performance of coal. These technologies reduce emissions, reduce waste, and increase the amount of energy gained from each tonne of coal (Emissions reduction case study). Different technologies suit different types of coal and tackle different environmental problems. The choice of technologies can also depend on a country's level of economic development.

EMISSIONS REDUCTION INITIATIVES

Alstom saved 207 million tonnes of CO_2 from being emitted yearly for nine years (2002 – 2011). This was achieved by constructing new highly efficient plants and retrofitting new technology to existing plants. In Germany, the Rheinhafen Dampfkraftwerk 8 (RDK 8) coal-fired power station in Karlsruhe is one of the first new generation units adopting the ultra-supercritical technology. The 912 MW plant achieves 46% efficiency and even more when its district heating capabilities are taking into consideration (58% efficiency). RDK 8 emits 740gCO_2/kWh since its commissioning in 2012. A 1980s generation coal-fired power station emits 1200gCO_2/kWh which is about 40% improvement.

Source: World Coal Association

Steps have been taken to significantly reduce SO_x and NO_x emissions from coal-fired power stations. Certain approaches also have the additional benefit of reducing other emissions, such as mercury. The activated carbon injection (ACI) technology has demonstrated mercury removal rates of 70% to 90%. However, there is a huge difference in capital cost when considering different control technologies (ACI systems costs US$5-US$15/kW while fabric filters and carbon injection costs US$120 – US$150/kW).[55]

Sulphur is present in coal as an impurity and reacts with air when coal is burned to form SO_x. In contrast, NO_x is formed when any fossil fuel is burned. In many circumstances, the use of low sulphur coal is the most economical way to control sulphur dioxide. An alternative approach has been the development of flue gas desulphurisation (FGD) systems for use in coal fired power stations (unpolluted air case study).

UNPOLLUTED AIR

In South Africa, Kusile and Medupi power plants utilises supercritical technology with the incorporation of Alstom's wet flue gas desulphurisation system which removes 90% of the SO_X generated in the boilers. In sub-Saharan Africa, these are the most environmentally friendly plants and also the world's largest air-cooled coal power plants having six 800 MW turbines each. The use of air cooling is significant in water stressed areas which increases the local environmental sustainability.

[55] Natural Defence Council (2011): Evaluating mercury control technologies for coal power plants.

Source: World Coal Association

Oxides of nitrogen can contribute to the development of smog as well as acid rain. NO_x emissions from coal combustion can be reduced by the use of 'low NO_x' burners, improving burner design and applying technologies that treat NO_x in the exhaust gas stream. Selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) technologies can reduce NO_x emissions by around 80-90% by treating the NO_x post-combustion.

Fluidised bed combustion (FBC) is a high efficiency, advanced technological approach to reducing both NO_x and SO_x emissions. FBC is able to achieve reductions of 90% or more.

REDUCING CARBON DIOXIDE EMISSIONS

A major environmental challenge facing the world today is the risk of global warming. The IEA advocates a two-step process to reducing emissions from coal: firstly, by improving power plant thermal efficiency while providing meaningful reductions in CO_2 emissions and secondly, by advancing CCS technologies to commercial scale.

Energy efficiency

Improving efficiency levels increases the amount of energy that can be extracted from a single unit of coal. Increases in the efficiency of electricity generation are essential in tackling climate change. A single percentage point improvement in the efficiency of a conventional pulverised coal combustion plant results in a 2-3% reduction in CO_2 emissions. Highly efficient modern supercritical and ultra-supercritical coal plants emit almost 40% less CO_2 than subcritical plants.

Efficiency improvements include the most cost effective and shortest lead time actions for reducing emissions from coal-fired electricity. This is particularly the case in developing countries and economies in transition where existing plant efficiencies are generally lower and coal use in electricity generation is increasing.

The average global efficiency of coal-fired plants is currently 28% compared to 45% for the most efficient plants. A programme of repowering existing coal-fired plants to improve their efficiency, coupled with the newer and more efficient plants being built, will generate significant CO_2 reductions of around 1.8 Gt annually. Although the deployment of new, highly efficient plants is subject to local constraints, such as ambient environmental conditions and coal quality, deploying the most efficient plant possible is critical to enable these plants to be retrofitted with carbon capture technology in the future.

Improving the efficiency of the oldest and most inefficient coal-fired plants would reduce CO_2 emissions from coal use by almost 25%, representing a 6% reduction in global CO_2 emissions. By way of comparison, under the Kyoto Protocol, parties have committed to reduce their emissions by "at least 5%". These emission reductions can be achieved by the replacement of plants that are < 300 MW capacity and older than 25 years, with larger and markedly more efficient plants and, where technically and economically appropriate, the replacement or repowering of larger inefficient plants with high-efficiency plants of >40%. The role of increased efficiency as a means to CO_2 mitigation is often overlooked in discussions about climate and energy. As the IEA notes "If the average efficiency of all coal-fired power plants were to be five percentage points higher than in the New Policies Scenario in 2035, such an accelerated move away from the least efficient combustion technologies would lower CO_2 emissions from the power sector by 8% and reduce local air pollution". It is also important to note that the cost of avoided emissions from more efficient coal-based generation can be very low, requiring relatively small additional investments. This is especially the case when compared to the cost of avoided emissions through deployment of renewables and nuclear.

WATER USAGE

A good start for efficient water consumption is by improving the washing rate of thermal coal[56]. This reduces net water consumption and removes ash which results in less waste and improves thermal efficiencies. It is estimated that if all thermal coal was washed and 10% of ash removed, overall water consumption would fall by 6-16%. However, in China the washing rate is below 40%[57] and this rate may be similar or lower in India where its coal is mainly low-grade, with a high ash content of around 40%. In China, steps are in place in order to conserve water in some regions, such as the requirement for new coal-fired power plants to have closed-cycle and air-cooling loops in the face of water scarcity. However, this cooling technology can reduce production efficiency by 3-10%, thus the need for more coal per unit of energy produced[58].

THERMOSYPHON DRY COOLING

Electric Power Research Institute (EPRI) is moving fast with the scale-up of thermosyphon cooling (TSC) by integrating this air-cooling technology with an experimental cooling tower at the Water Research Centre at Georgia Power's Plant Bowen. This is a dry cooling technology that transfers heat from hot condenser and returns water to a refrigerant and then to the ambient air without water evaporation. In 2015 a commercial demonstration of a 15 MW TSC dry cooling operation will commence. In retrofit applications with TSC, the annual water usage could reduce to about 75% with less energy penalty than present air-cooled technologies.

Source: EPRI (2014) Technology Innovation Prospectus

Water shortages are also experienced in developed worlds, such as the US where 52% of US coal-fired power plant utilises once-through cooling technology[59]. Due to extreme water

[56] Carbon Tracker (2014) The Great Coal Gap: China's energy policies and the financial implications for thermal coal, ibid.
[57] ibid. 56
[58] http://www.theguardian.com/sustainable-business/china-conflict-coal-fired-plants-water#
[59] EIA (2014) Many newer plants have cooling systems that reuse water.

shortages in western US many states could follow the footsteps of California. The once-through technology was not favoured in this state because 2010 witnessed the California State Water Resources Control Board approve a measure to ban this technology. This will force 19 plants to retrofit their cooling systems between 2010 and 2024, thus encouraging better water-efficient technologies[60]. A solution could be to incorporate dry cooling which could drastically reduce the amount of water use (Thermosyphon Dry Cooling case study).

At the power generation end of the coal-energy cycle, new technologies are also reducing coal's water footprint. As with other forms of thermal power generation, water in coal-fired plants is used in different ways depending on the type of cooling technology employed. Many technologies do not actually consume significant amounts of water but it is important to make sure that the extraction and return process minimises impacts on water temperature and wildlife.

Eskom, South Africa's largest electricity provider is a leader in dry cooling technology. This is crucial because South Africa is a water-stressed country. Eskom is currently constructing two new dry-cooled plants at Medupi and Kusile that are incorporating lessons learned from their older plants that already consume approximately 19 times less water than an equivalent wet-cooled power plant.

WASTE GENERATION

The combustion of coal generates waste consisting primarily of non-combustible mineral matter along with a small amount of unreacted carbon. The production of this waste can be minimised by coal cleaning prior to combustion. Waste can be further minimised through the use of high efficiency coal combustion technologies.

There is increasing awareness of the opportunities to reprocess power station waste into valuable materials for use primarily in the construction and civil engineering industry. In the year 2009-2011, slightly above half (53%) of the coal combustible products (CCPs) were utilised while the rest were transferred to storage or disposal sites (Table 10).

[60] California's Clean Energy Future (2011) Once Through Cooling Phase-Out

TABLE 10: ANNUAL CCPS PRODUCTION, UTILISATION RATE BY COUNTRIES 2010

Country/Region	CCPs Production (Mt)	CCPs Utilisation (Mt)	Utilisation rate %
Australia	13.1	6.0	45.8%
Canada	6.8	2.3	33.8%
China*	395.0	265	67.1%
Europe (EU15)	52.6	47.8	90.9%
India*	105.0	14.5	13.8%
Japan	11.1	10.7	96.4%
Middle East & Africa	32.2	3.4	10.6%
USA	118.0	49.7	42.1%
Other Asia*	16.7	11.1	66.5%
Russia	26.6	5.0	18.8%
Total/s	777.1	415.5	53.5%

Source: Heidrich, C. et al. (2013)[61] (* non-members of World Wide Coal Combustion Products Networks)

The fly ash, FGD gypsum, bottom ash and boiler slag generated from coal combustion are utilised in a variety of ways. A common global application is the substitution of Portland cement in concrete with fly ash, which improves performance of concrete because of its decrease in permeability and high durability[62]. In developed countries, FGD gypsum utilisation has progressed quite well and these are also adopted by the construction industries[63].

[61] Heidrich, C., Feuerborn, H., Weir, A. (2013) Coal Combustion Products: a global perspective.
[62] World Coal Association (2015)
[63] Jiabin Fu (2010) Challenges to increased use of coal combustion products in China.

5. OUTLOOK

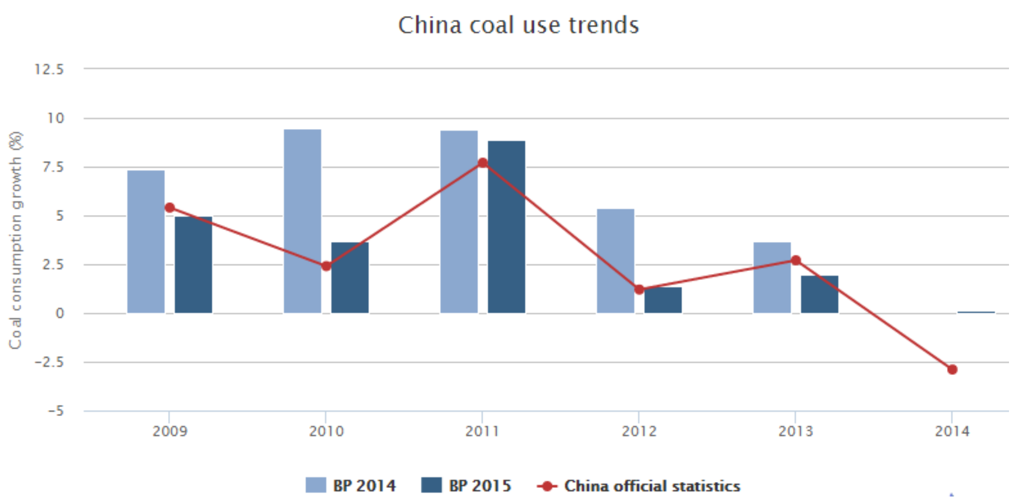
Thermal coal has been available for over nine decades, but this resource has been suffering from a supply surplus for years. It is no surprise that the price of thermal coal has reduced by half since 2011.

Countries need to meet their electricity needs and this will be possible with low-cost electricity, which in turn points to the role coal has played and what it would play in the future. Coal is abundant, accessible, secure, reliable and affordable, and has a substantial existing infrastructure. However, despite these attributes the leverage for coal seems uncertain in light of growing CO_2 emission levels and increasing competitiveness of non-coal power sources in China, the US and the EU.

CHINA

China, the key market driver experienced an unexpected decline of 2.7% in 2014 (Figure 14).

FIGURE 14: CHINA COAL USE TRENDS

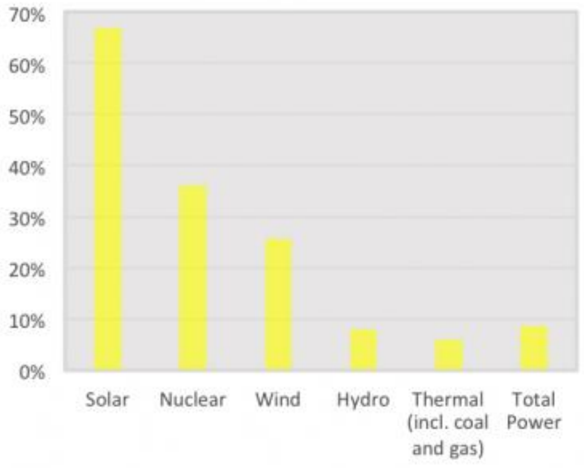


Source: China National Bureau of Statistic, BP Statistical Review (2015)

Essentially, not only is the decline due to a fall in demand but also on tougher regulations that do not favour low quality coal imports from some producers like Indonesia and Australia. The reduction in coal importation would favour China as larger volumes of coal exportation are expected due to the domestic coal oversupply and the export tax reduction from 10% to 3% which was effective since January 2015[64].

China continues to tackle its severe air pollution and it is likely that the share of primary energy consumption from renewables such as solar and wind will continue to increase up to 15% in 2020[65]. It is important to note that coal will not be completely phased out because it would be needed as base load to secure supply. However, China will target to reduce its consumption from coal to below 62% by 2020[66]. In 2014, coal had less than 10% of growth capacity, this means there is growth, but in modest level (Figure 15).

FIGURE 15: 2014 GROWTH OF POWER GENERATION CAPACITY IN CHINA

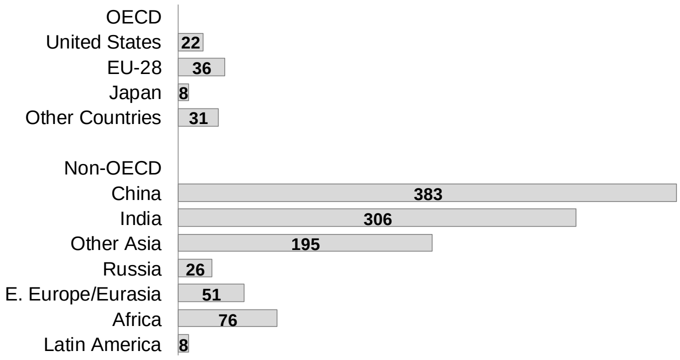


Source: National Bureau of Statistics of China

China added 39 GW of coal-fired capacity in 2014 which was 8.3% increase from the previous year[67]. Only about 60% of the new plants are built using ultra supercritical technology which produces efficiency as high as 44%, meaning CO_2 emissions can be cut by more than a third compared to plants with efficiency between 27% - 36%[68]. It is likely to see this trend progressing in the future as under the IEAs New Policies Scenario, China is seen to cumulatively have 383 GW of coal based power generation between 2014-2015, as the usage of coal as an enabler for economic growth persists (Figure 16).

[64] China coal Resource, http://en.sxcoal.com/111509/NewsShow.html
[65] Climate News Network (2015) China's investment in renewables soars by a third.
[66] South China Morning Posts (2015) China aims to reduce coal reliance in next five-year plan.
[67] Institute for Energy Research
[68] Office of Chief Economist (2015) Coal in India

FIGURE 16: CUMULATIVE COAL BASED POWER PLANT ADDITION BY



COUNTRIES/REGIONS 2015-2040 IN GW

Source: IEA World Energy Outlook (2015)

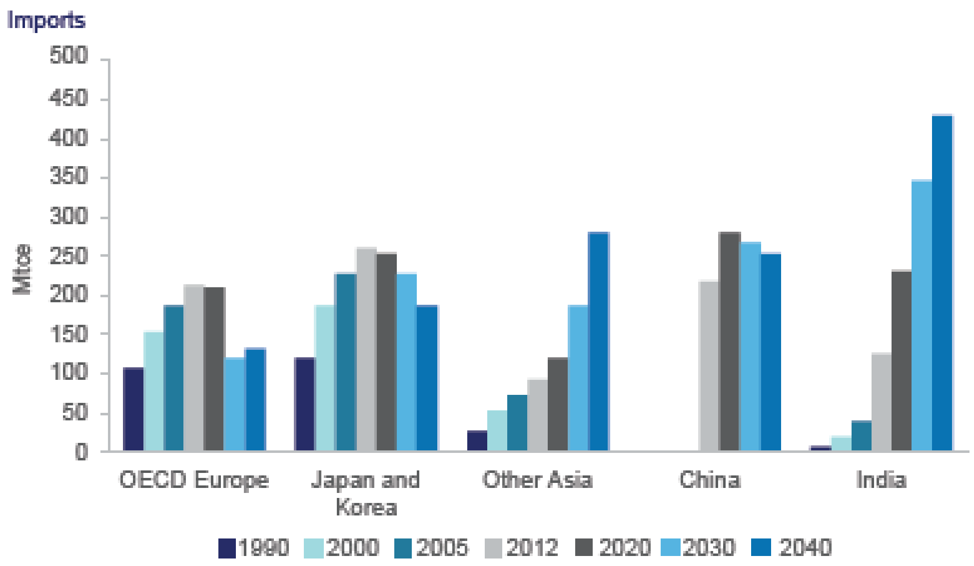
INDIA

Since China's cut on coal importation, it seems India is set to overtake them as the biggest importer of thermal coal. IEA new policies scenario which takes into account announced policies that are yet to be enacted illustrated that by 2025 or sooner, Indian thermal coal imports would surpass China's[69] (Figure 17).

India's dependence on imported coal will continue to increase (Figure 14) because the quality of domestic product is considered inferior, with a high ash content of over 30%. Furthermore, given the slow rise in domestic production in the past few years, the Government estimates that imports could almost be a third of its total coal or up to 350 million tonnes by 2016-2017[70]. The rising prediction of imports associates coal to remain the primary energy supply for the nation.

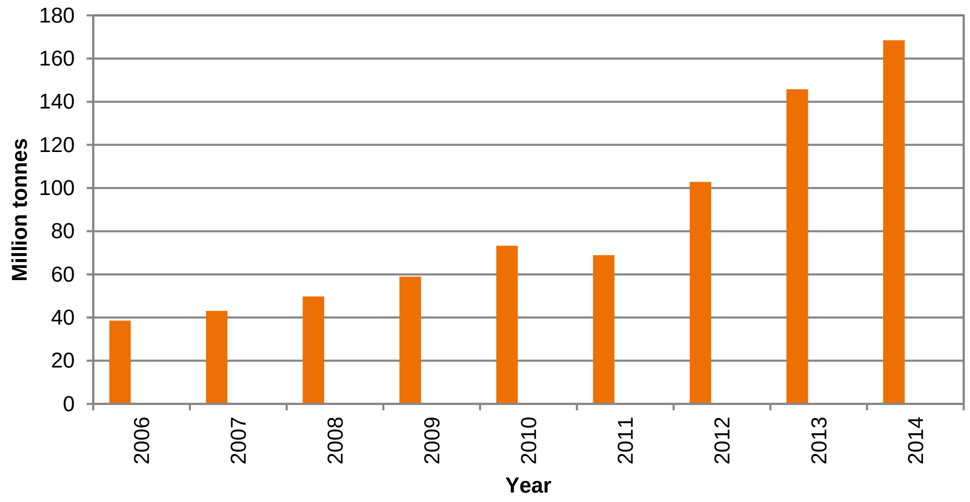
[69] Office of Chief Economist (2015) Coal in India
[70] Coal India Limited (2015) About Us

FIGURE 17: WORLD COAL IMPORTS, NEW POLICIES SCENARIO



Source: Office of the Chief Economist, Australian Government (2015) Coal in India Report

FIGURE 18: INDIA'S GROWING COAL IMPORTS



Source: Central Statistical Office, India

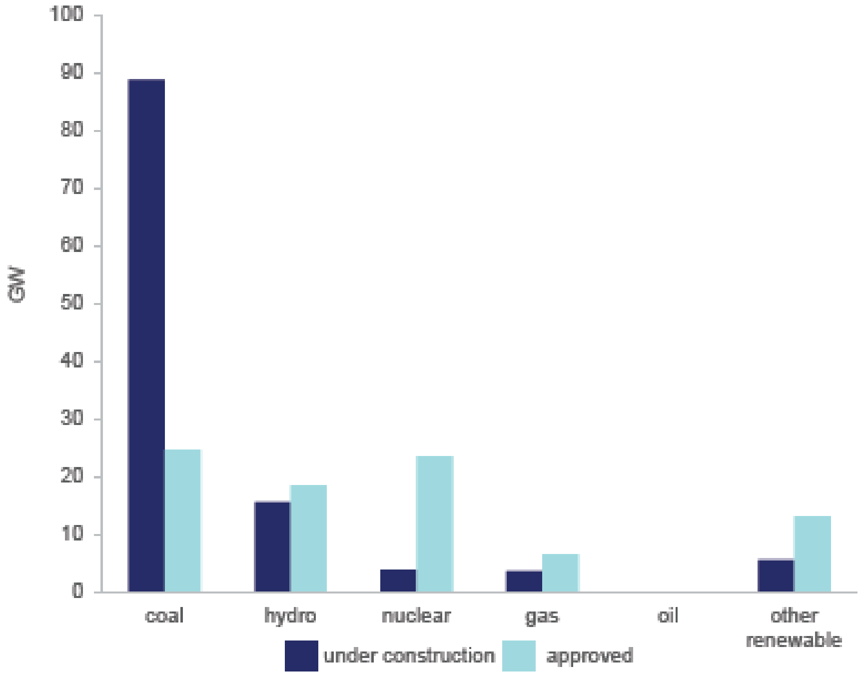
India like most nations is diversifying its generation sector, however coal is projected to remain in dominance and also coal-fired power is projected to more than double with an increasing rate of 3.3% per year, from 840 TWh to about 2,100 TWh before 202571.

[71] Coal India Limited (2015) About Us

Currently there are plans for coal in this nation's generation capacity as a majority of new plants under construction are mainly coal-fired (Figure 19).

Over the past decade about 90% of India's coal-fired capacity was based on subcritical technology. With global talks on CO_2 emission mitigations, the proportion of subcritical coal-fired technology commissioned in the next five years will decrease. In the next five years it is expected that supercritical technology will be 36% of total coal-fired plants[72].

FIGURE 19: INDIA'S ELECTRICITY GENERATION CAPACITY UNDER DEVELOPMENT > 50MW



Source: Coal in India 2015 Report, Office of the Chief Economist, Australian Government

Overall, electricity generation from coal is expected to grow with increasing focus on improved coal-fired power plant efficiency because the cost competitiveness of coal is driven primarily by low coal prices and limited availability of alternative fuels.

SOUTHEAST ASIA

In the New Policies Scenarios, the total primary energy demand in Southeast Asia remains heavily reliant on fossil fuels with their share of 74% in 2013 expanding to 78% in 2040.

In Southeast Asia the demand for coal is expected to more than triple from 2013 to 2040 growing at an average of 4.6% per year (Table 11). The need to provide electricity to 120

[72] Enerdata (2015)

million people in the region that still lack access all contributes to coal's expanding role in the fuel mix, especially in Indonesia, Malaysia, Philippines, Thailand and Vietnam.

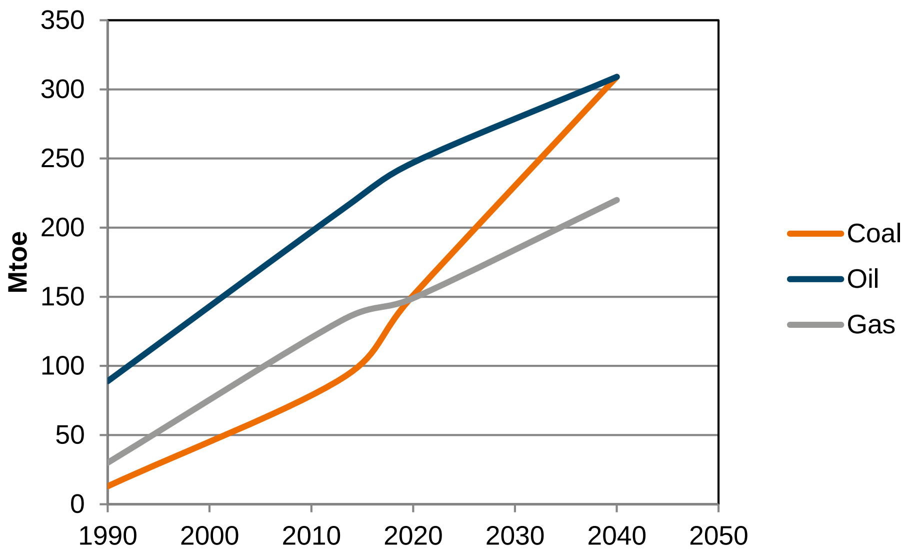
TABLE 11: PRIMARY ENERGY DEMAND IN SOUTHEAST ASIA (MTOE)

Fuel					Shares	
	1990	2013	2020	2040	2013	2040
Fossil fuels	**131**	**437**	**547**	**838**	**74%**	**78%**
Coal	13	91	151	309	15%	29%
Oil	89	213	247	309	36%	29%
Gas	30	133	149	220	22%	21%

Source: IEA (2015)

Southeast Asia is one of the regions in the world where coal's share of the energy mix is projected to increase. The coal share is to rise in 2020 overtaking natural gas (Figure 20). This trend is underpinned by the price advantage and relative availability of coal versus gas in the region.

FIGURE 20: PRIMARY ENERGY DEMAND BY FOSSIL FUEL IN SOUTHEAST ASIA, 1990-2040



Source: IEA (2015)

By 2040, Southeast Asia's total electricity generation will almost triple from 789 TWh in 2013 to 2200 TWh in 2040. Coal use increases its share in power generation from 32% to 50%, while the share of natural gas declines from 44% to 26% (Table 12). Southeast Asia's electricity depends largely on fossil fuels, especially coal where countries such as Indonesia, Malaysia and Thailand intend to expand their use of coal.

TABLE 12: ELECTRICITY GENERATION BY FOSSIL FUELS IN SOUTHEAST ASIA (TWH)

					Shares	
	1990	2013	2020	2040	2013	2040
Fossil fuels	**120**	**648**	**925**	**1699**	**82%**	**77%**
Coal	28	255	482	1097	32%	50%
Oil	66	45	36	24	6%	1%
Gas	26	349	406	578	44%	26%

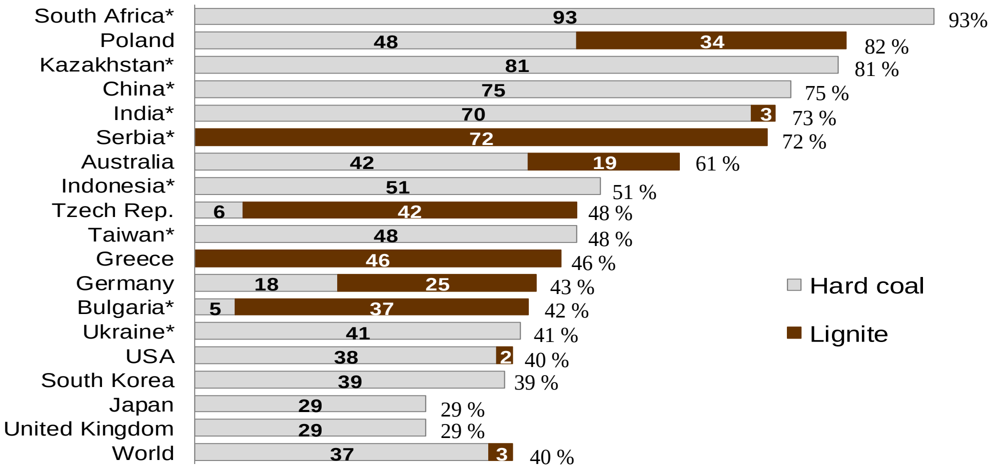
Source: IEA (2015)

SOUTH AFRICA

More than 85% of South Africa's electricity is generated from coal and about 90% of the supply is provided by Eskom, the nation's electricity public utility[73] (Figure 21). In early 2015 the company was forced to implement three stages of load shedding which reduced supply by up to 4 GW because of years of under investment in new generation capacity and insufficient maintenance[74].

[73] Burton, J.& Winkler, H. (2014) South Africa's planned coal infrastructure expansion: Drivers, dynamics and impacts on greenhouse gas emissions
[74] Wood Mackenzie (2015)., South Africa's power supply crisis

FIGURE 21: COAL SHARE IN POWER GENERATION IN 2014



Source: IEA, Electricity Information, Paris 2015 (* for Non-OECD-countries numbers for 2013)

There could be a challenge for South Africa's electrification as the available coal reserve is expected to be in mass shortage in the 2020s[75]. With this in light, the government and major players in the supply chain industry have implemented a plan called "coal roadmap". It is expected that provision will be made to supply higher grade coal to the older Central Basin power stations from the Waterberg and also rail infrastructure are likely to be available in the early 2020s to facilitate transport of coal to overcome shortfalls in local utility supply[76].

As the nation is struggling to meet its demand as it upgrades aging plants and builds new generating capacity, including coal-fired power plants such as Medupi Power Station which will produce 4.8 GW when completed in 2019[77], it is likely that electricity importation from neighbouring Mozambique could increase by as much as 40%[78]. The building of non-coal-fired new generation capacity is already a challenge, for example the first new nuclear power stations which are projected to be operational in 2023 are facing severe financial constraints. However, this will aid in rebalancing the mix of power generation[79].

EUROPE

The pace of closure in the coal sector is accelerating because of ample supplies of gas and environmental policies to cut GHG emissions, but this does not mean coal-fired power generation will completely disappear.

In Germany, its energy policy points to a 2.7 GW capacity reserve for lignite plants which will pay plant operators to put their power stations on standby and subsequently shut them

[75] Christian, S. (2015) Eskom South Africa: A case of planning failure
[76] Ibid 75
[77] Business Day live (2015) Medupi finally produces first power
[78] Bloomberg (2015) Eskom Sees Power Supply from Mozambique up by up to 40%
[79] World Nuclear Association (2015) Nuclear Power in South Africa

down after 202080. In the UK's electricity mix, in 2014, it provided 35.4% of UK's electricity generation, but the capacity of UK's coal-fired stations could fall by 66% by 2021 and disappear altogether by 2030 with gas, nuclear and renewable power expected to pick up what's left81.

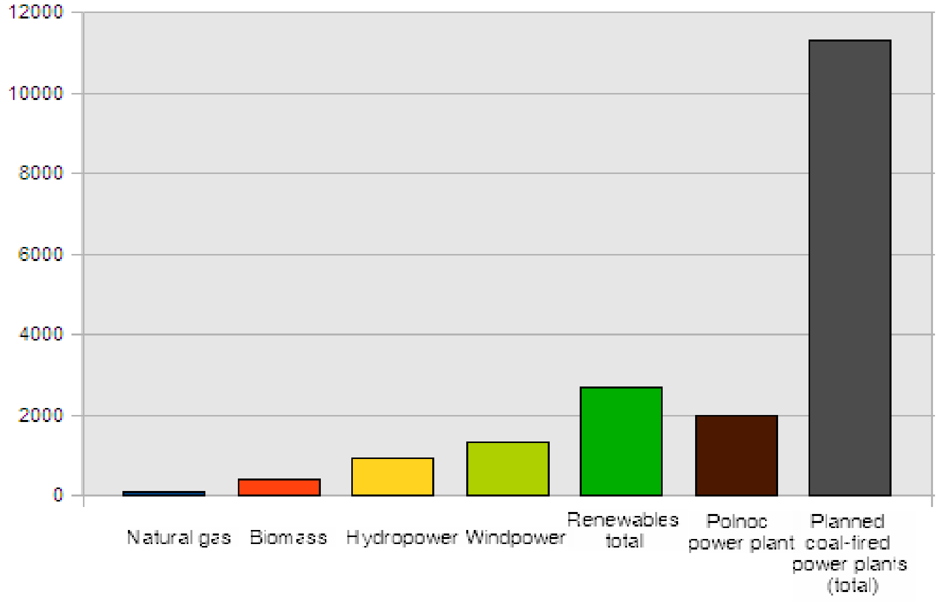
As with other hydrocarbons, Russia has a rich supply of coal reserves. According to BP's Statistical Review of Energy 2015, Russia had 157,010 million tonnes of coal reserves or 17% share of global reserves. In 2014, Russia produced 334,058 tonnes of coal, with 74,995 tonnes coking coal. Major coking coal export destinations include: China, Ukraine, Japan and Korea. Major steam coal export destinations include: UK, Japan, Korea, China and Germany. The 'Coal Industry' was identified in the 'Energy Strategy of Russia for the Period up to 2030' as a priority area for scientific and technological progress. A key element of this programme will be driving efficiencies in coal-fired power generation. Average efficiency of coal-fired power plants is planned to reach 41% by 2030, with the most advanced coal-fired stations having electricity production net efficiency between 45% and 47%.

Countries with growing economies and abundant coal reserves, such as Poland, plan to increase their installed capacity with coal. However, this task is challenging as there is a cross road, the huge investments into energy generation are needed as well as phasing out 7GW of its current coal-fired generation capacity by the end of 2015[82], despite the reality that 85% of electricity is from coal.

Amid climate change talks, Poland will still remain clear on fossil fuels being its main energy source, with this, the nation plans to construct a capacity of 11,300 MW of coal power by 2020 (Figure 22)

[80] Financial Times (2015) Germany –decision means the coal industry lives on
[81] Financial Times (2015) British coal-fired power plant bows to the inevitable,
[82] Bank watch (2015) Coal-fired plant in Poland

FIGURE 22: MW OF GENERATION CAPACITY IN POLAND BY 2020



Source: Bank watch (2015)

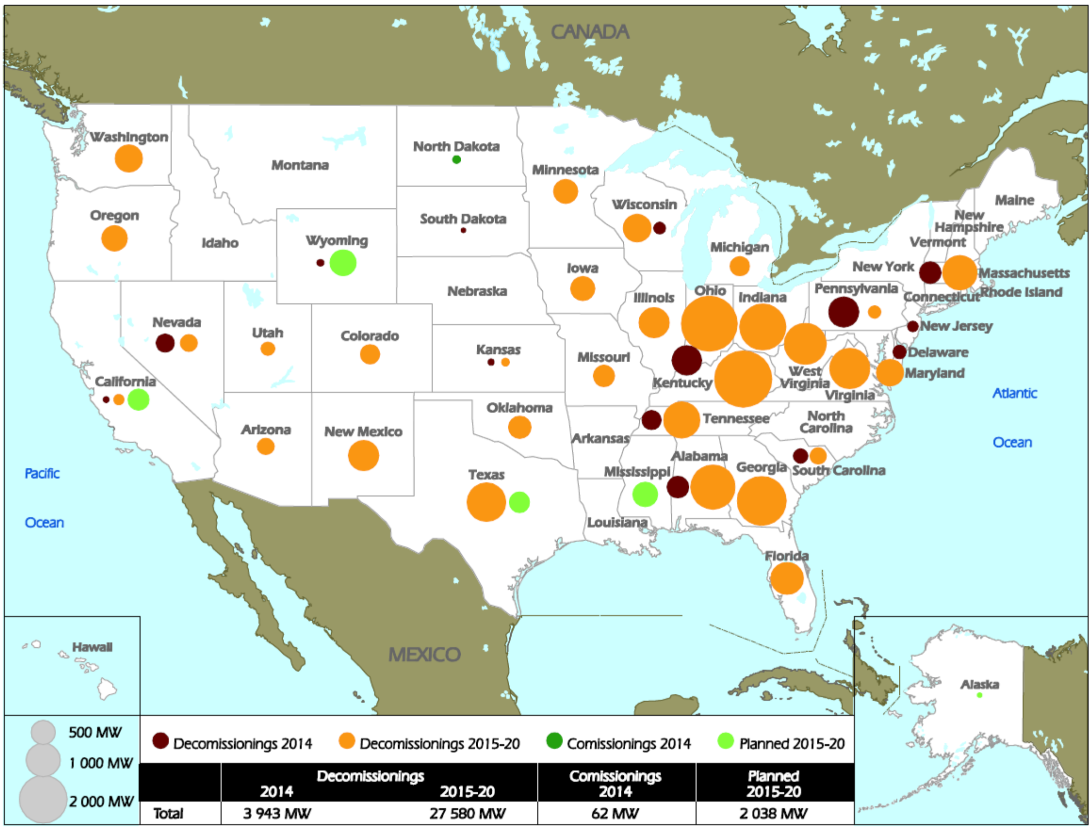
"Black gold" or "Polish gold" as supporters call this energy source is believed to be significant in avoiding dependence on Russia's natural gas[83]. It is projected that coal will remain Poland's primary fuel for electricity generation because it is an affordable option for a nation that cannot afford a quick transition to cleaner alternatives. As the EU puts in tougher rules, it is expected that coal's share from Poland's electricity generation will slowly decline. Polish mining companies will have to adjust its production level to the economically profitable demand, but coal is expected to remain the primary electricity generation source. Despite the current economic slowdown, coal companies and other investors, both national and international are interested in making investments in new Polish coal mines[84].

UNITED STATES

In the US, the coal industry is declining as a result of the Environmental Protection Agency (EPA) policies and low natural gas prices[85]. The EPA will require existing power plants to cut carbon emissions by 30% by 2030. Since 2010, utilities have formally announced retirement of substantial amounts of coal-fired generating units (Figure 23) and it is expected to see more coal-fired stations closed or substituted with natural gas by 2020, with the majority of generating capacity retiring by end of 2016[86].

[83] New York Times (2015) Coal in Poland lowering life spans
[84] EURACOAL (2015)
[85] Coal Unit Shutdowns, American Coalition for Clean Coal Electricity (ACCCE)
[86] Coal Unit Shutdowns, American Coalition for Clean Coal Electricity (ACCCE)

FIGURE 23: COAL-FIRED POWER PLANT PROJECTS AND DECOMISSIONINGS IN THE UNITED STATES



Source: IEA (2015)

A good example is PacifiCorp, the Berkshire Hathaway controlled utility laid out plans to retire nearly 3,000 MW of capacity by 2029 and to add more renewable energy resource[87].

Overall, there is demand for coal but the growth in demand will slow over the long-term. However, coal will continue as a major part of the US energy mix. It is expected to account for about one quarter of the countries generation capacity in 2030[88]

[87] Utility dive 2015
[88] http://www.whitecase.com/publications/insight/power-dynamics-forces-shaping-future-coal-united-states

6. GLOBAL TABLE

2014/2015 COAL RESERVES, RESOURCES AND REMAINING POTENTIAL

Source: BP Statistical Review of World Energy 2016, BGR Energy, WEC, and IEA

Hard coal - energy content of ≥ 16,500 kJ/kg comprises sub-bituminous coal, bituminous coal and anthracite.

Lignite - possess lower energy content (< 16,500 kJ/kg) and higher water content

Million Tonnes	RESERVES 2014*			RESERVES 2015**	RESOURCES 2014*		REMAINING POTENTIAL 2014*	
Region	Hard coal	Lignite	Total	Total	Hard coal	Lignite	Hard coal	Lignite
Afghanistan	66		66		n.s.		66	
Albania		522	522			205		727
Algeria	59		59		164		223	
Argentina	500		500		300	7300	800	7300
Armenia	163		163		154		317	
Australia	62095	44164	106259	76400	1536666	399267	1598761	443431
Austria						333		333
Bangladesh	293		293		2967	3	3260	3
Belarus						1500		1500
Belgium					4100		4100	
Bhutan	n.s.				n.s.		n.s.	
Bolivia	1		1		n.s.		1	
Bosnia & Herzegovina		2264	2264			3010		5274
Botswana	40		40		21200		21240	
Brazil	1547	5049	6596	6630	4665	12587	6212	17636
Bulgaria	192	2174	2366	2366	3920	2400	4112	4574
Canada	4346	2236	6582	6582	183260	118270	187606	120506
Central African Rep.		3	3			n.s.		3
Chile	1181	n.s.			4135	7	5316	7
China	124059	7555	131614	114500	5338613	325097	5462672	332652
Colombia	4881		4881	6746	9928		14809	
Congo DR	88		88		900		988	
Costa Rica					17		17	
Croatia		n.s.				300		300
Czech Republic	1107	2604	3711	1052	15419	7163	16526	9767
Dominican Rep.						84		84
Ecuador		24	24			n.s.		24
Egypt	16		16		166		182	
Ethiopia		n.s.				n.s.		n.s.
France		n.s.			160	114	160	114
Georgia	201		201		700		901	

Germany	21	36300	36321	40548	82961	40500	82982	76800
Region	**Hard coal**	**Lignite**	**Total**	**Total**	**Hard coal**	**Lignite**	**Hard coal**	**Lignite**
Greece		2876	2876	3020		3554		6430
Greenland	183		183		200		383	
Haiti						40		40
Hungary	276	2633	2909	1660	5075	2704	5351	5337
India	85562	4714	90276	60600	174981	37932	260544	42645
Indonesia	17394	8274	25668	28017	92431	32365	109825	40639
Iran	1203		1203		40000		41203	
Ireland	14		14		26		40	
Italy	10	7	17		600	22	610	29
Japan	340	10	350	347	13543	1026	13883	1036
Kazakhstan	25605	n.s.		33600	123090	n.s.	148695	n.s.
Korea DPR	600	n.s.			10000	n.s.	10600	n.s.
Korea Rep.	326		326		1360		1686	
Kosovo		1564	1564			9262		10826
Kyrgyzstan	971	n.s.			27528	n.s.	28499	n.s.
Laos	4	499	503		58	22	62	521
Macedonia		332	332			300		632
Madagascar					150	37	150	37
Malawi	2		2		800		802	
Malaysia	141	39	180		1068	412	1209	451
Mali						3		3
Mexico	1160	51	1211	1211	3000	n.s.	4160	51
Mongolia	1170	1350	2520	2520	39854	119426	41024	120776
Montenegro	142	n.s.			195	n.s.	337	n.s.
Morocco	14		14		82	40	96	40
Mozambique	1792		1792		21844		23636	
Myanmar	3	3	6		248	2	252	5
Namibia					350		350	
Nepal	1		1		7		8	
Netherlands	497		497		2750		3247	
New Caledonia	2		2		n.s.		2	
New Zealand	825	6750	7575	571	2350	4600	3175	11350
Niger		6	6		90	n.s.	90	6
Nigeria	287	57	344		1857	320	2144	377
Norway	2		2		90		93	
Pakistan	207	2857	3064	2070	5789	176739	5996	179596
Peru	102		102		1465	100	1567	100
Philippines	211	105	316		1012	912	1223	1017
Poland	16203	5429	21632	5465	162709	222458	178913	227886
Portugal	3	33	36		n.s.	33	3	66
Romania	11	280	291	291	2435	9640	2446	9920
Russia	69634	90730	160364	157010	2658281	1288894	2727915	1379623
Serbia	402	7112	7514	13411	453	13074	855	20186

Million Tonnes	RESERVES 2014*			RESERVES 2015**	RESOURCES 2014*		REMAINING POTENTIAL 2014*	
Region	Hard coal	Lignite	Total	Total	Hard coal	Lignite	Hard coal	Lignite
South Africa	9893		9893	30156	203667		213560	
Spain	868	319	1187	530	3363	n.s.	4231	319
Swaziland	144		144		4500		4644	
Sweden	1		1		4		5	
Taiwan	1		1		101		102	
Tajikistan	375		375		3700		4075	
Tanzania	269		269		1141		1410	
Thailand		1063	1063	1239		826		1889
Turkey	380	12466	12846	8702	802	362	1182	12828
Turkmenistan					800		800	
Uganda					800		800	
Ukraine	32039	2336	34375	33873	49006	5381	81045	7717
United Kingdom	70		70	228	186700	1000	186770	1000
USA	222641	30483	253124	237295	6457688	1367877	6680329	1398360
Uzbekistan	1375	n.s.		1900	9477	n.s.	10852	n.s.
Venezuela	731		731	479	5981		6712	
Viet Nam	3116	244	3360	150	3519	199876	6635	200120
Zambia	45		45		900		945	
Zimbabwe	502		502	502	25000		25502	
Total Africa	13151	66	13217		283611	402	296762	468
Total Asia Pacific	296416	77627	374043	288328	7224567	1298505	7520985	1376131
Total CIS	130363	93066	223429	227833	2872736	1295775	3003099	1388840
Total Europe	20255	77365	97620		471820	317713	492077	395077
Total Middle East	1203		1203	1122	40000		41203	
Total North America	228330	32770	261100	245088	6644148	1486147	6872478	1518917
Total S. & Cent. America	8943	5073	14016	14641	26491	20118	35434	25191
World	698660	285964	984624	891531	17713376	4418658	18412036	4704622
Sierra Leone						2		2
Slovakia		135	135		19	938	19	1073
Slovenia	56	315	371		39	341	95	656

*BGR

** BP Statistical Review of World Energy 2016

2014 COAL PRODUCTION

Source: BP Statistical Review of World Energy 2016, BGR Energy, R/P (reserve to production ratio)

Million Tonnes	PRODUCTION			
Region	Hard coal 2014*	Lignite 2014*	Total production 2014*	Total production 2015**
Afghanistan	0.7	-	0.7	
Albania	-	< 0.05	-	
Algeria	-	-	-	
Argentina	0.1	-	0.1	
Armenia	-	-	-	
Australia	441.3	62	503.3	485
Austria	-	-	-	
Bangladesh	0.9	-	0.9	
Belarus	-	-	-	
Belgium	-	-	-	
Bhutan	0.1	-	0.1	
Bolivia	-	-	-	
Bosnia & Herzegovina	-	6.3	6.3	
Botswana	0.8	-	0.8	
Brazil	4.5	3.4	7.9	8
Bulgaria	-	31.3	31.3	36
Canada	60.5	8.5	69	61
Central African Rep.	-	-	-	
Chile	4	0.2	4.2	
China	4	145	4	3747
Colombia	88.6	-	88.6	86
Congo, DR	0.1	-	0.1	
Costa Rica	-	-	-	
Croatia	-	-	-	
Czech Republic	8.3	38.3	46.6	46
Dominican Rep.	-	-	-	
Ecuador	-	-	-	
Egypt	0.3	-	0.3	
Ethiopia	-	< 0.05	-	
France	0.3	-	0.3	
Georgia	0.4	-	0.4	
Germany	8.3	178.2	186.5	184
Greece	-	48	48	48
Greenland	-	-	-	
Haiti	-	-	-	
Hungary	-	9.6	9.6	9
India	612.4	47.2	659.6	677
Indonesia	410.8	60	470.8	392

Iran	2.8	-	2.8	
Million Tonnes	**PRODUCTION**			
Region	**Hard coal 2014***	**Lignite 2014***	**Total production 2014***	**Total production 2015****
Ireland	-	-	-	
Italy	0.1	-	0.1	
Japan	1.3	-	1.3	1
Kazakhstan	109.0	6.6	115.6	106
Korea, DPR	33	7	40	
Korea, Rep.	1.7	-	1.7	
Kosovo	-	7.2	7.2	
Kyrgyzstan	0.3	1.3	1.6	
Laos	0.2	0.5	0.7	
Macedonia	-	6.5	6.5	
Madagascar	-	-	-	
Malawi	0.1	-	0.1	
Malaysia	2.5	-	2.5	
Mali	-	-	-	
Mexico	14	-	14	14
Mongolia	18.1	6.3	24.4	24
Montenegro	-	1.6	1.6	
Morocco	-	-	-	
Mozambique	6.1	-	6.1	
Myanmar	0.5	< 0.05	0.5	
Namibia	-	-	-	
Nepal	< 0.05	-	-	
Netherlands	-	-	-	
New Caledonia	-	-	-	
New Zealand	3.7	0.3	4	3
Niger	0.3	-	0.3	
Nigeria	< 0.05	-	-	
Norway	1.7	-	1.7	
Pakistan	1.9	1.2	3.1	3
Peru	0.2	-	0.2	
Philippines	8.1	-	8.1	
Poland	73.0	63.9	136.9	136
Portugal	-	-	-	
Romania	-	23.6	23.6	25
Russia	287	70	357	373
Serbia	0.2	29.9	30.1	38
Sierra Leone	-	-	-	
Slovakia	-	2.2	2.2	
Slovenia	-	3	3	
South Korea				2
South Africa	253.2	-	253.2	252
Spain	3.9	1.24	3.9	3

Swaziland	0.2	-	0.2	
Million Tonnes	**PRODUCTION**			
Region	**Hard coal 2014***	**Lignite 2014***	**Total production 2014***	**Total production 2015****
Sweden	-	-		
Taiwan	-	-	-	
Tajikistan	0.6	-	0.6	
Tanzania	0.2	-	0.2	
Thailand		18	18	15
Turkey	1.8	60	61.8	
Turkmenistan	-	-	-	
Uganda	-	-	-	
Ukraine	65	0.2	65.2	38
United Kingdom	11.6	-	11.6	9
USA	835.1	71.8	906.9	813
Uzbekistan	< 0.05	4.4	4.4	4
Venezuela	2	-	2	1
VietNam	41.7	-	41.7	42
Zambia	0.4	-	0.4	
Zimbabwe	4	-	4	4
Total Africa	265.7	-	265.7	266
Total Asia Pacific	5,303.9	347.5	5,651.4	5440
Total CIS	462.3	82.5	544.8	527
Total E.U.	7,262.2	2	8,795.2	528
Total Middle East	2.8	-	2.8	1
Total North America	909.6	80.3	989.9	888
Total S. & Cent. America	99.4	3.6	103	98
World	7,153.0	1,023.4	8,176.4	7861

*BGR

** BP Statistical Review of World Energy 2016

LIST OF TABLES AND FIGURES

FIGURES

TABLES

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