



Coal

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Strategic insight

1. Introduction

Coal in the global energy mix

Coal remains central to the global energy system. It is the world's largest source of electricity, accounting for around 40% of global electricity production. It is currently the world second largest source of primary energy, and is widely expected to replace oil as the world's largest source of primary energy within a few years. Coal's dominant position in the global energy mix is largely due to the fact it is abundant, widely distributed across the globe and affordable.

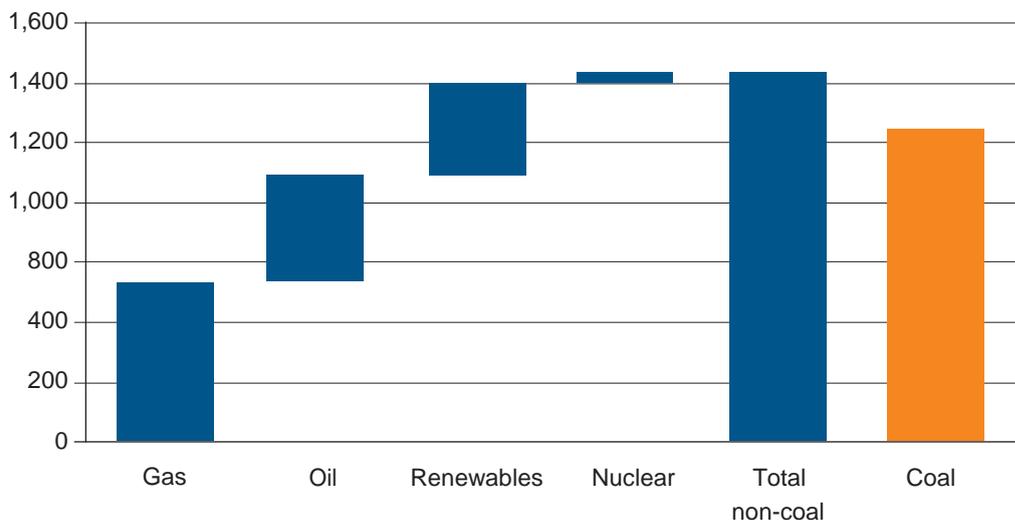
Wide distribution of coal is demonstrated in this report with major coal deposits existing on every continent. This report estimates there are 869 billion tonnes of coal reserves, which based on current production rates should last for around 115 years, significantly longer than conventional oil and gas reserves. Particularly important are the significant coal reserves in Asia and southern Africa, two regions of the world that face major challenges in providing energy to their populations

Unlike conventional oil and gas reserves, estimates of coal reserves can often be underestimated. Rather than a lack of coal resources, there is lack of incentive to prove up reserves. Exploration activity is typically carried out by mining companies with short planning horizons rather than state-funded geological surveys and there is no economic need for companies to prove long-term reserves. Coal resources are often estimated to be as much as 4-5 times

Figure 1.1

Incremental world primary energy demand by fuel, 2000-2010

Source: IEA, WEO 2011



greater than estimated reserves. This provides potential to increase coal reserves into the future. Furthermore reserve figures do not consider alternative ways of accessing energy from the coal resource, such as underground coal gasification.

China firmly holds the first place among coal producing countries. The United States remains the second largest coal producer, followed by India and Australia. Coal production increased significantly in Indonesia (15.8%), Colombia (12.7%), Ukraine (12.1%) and China (10.6%). Over three quarters of global coal consumption was accounted for by five countries: China, the United States, India, Russia and Japan. China alone accounted for over 48% of total global coal consumption. Coal consumption decreased by 2% on average across the OECD countries, however outside of the OECD, coal consumption increased by 8.6%, driven mainly by growing energy demand in China.

Despite projected declines in OECD countries, coal use is forecast to rise over 50% to 2030, with developing countries responsible for 97% of this increase, primarily to meet improved electrification rates.

Between 2000 and 2010 it is estimated that coal met around half of global incremental electricity demand (see figure below). Despite the rapid deployment of renewable energy technologies, particularly in the context of debates about climate change, it has been coal that has accounted for the largest increase in energy demand among the range of energy sources. The growth in coal usage, in both volume and percentage terms, was greater than any other fuel, including renewables. In fact, growth in coal consumption this century has almost equalled growth in oil plus gas plus nuclear plus renewables *combined*.

Coal has met this significant growth in energy demand because of its status as a reliable, widely distributed and affordable fuel, it is also the least subsidised of all fuel sources.

Coal's role in delivering energy access

As nations develop, they seek secure, reliable and affordable sources of energy to strengthen and build their economies – coal is a logical choice in many of these countries because it is widely available, safe, reliable and relatively low cost. One of the major challenges facing the world at present is that approximately 1.2 billion people live without any access to modern energy services. Approximately a further 1 billion have intermittent access to modern energy. Access to energy is a foundation stone of modern life and addressing the challenge of energy poverty is a major international priority and a key tool in eradicating extreme poverty across the globe.

Coal resources exist in many developing countries, including those with significant energy challenges. This report demonstrates that many countries with electricity challenges, particularly those in Asia and southern Africa, are able to access coal resources in an affordable and secure way to fuel the growth in their electricity supply. Coal will therefore play a major role in supporting the development of base-load electricity where it is most needed. Coal-fired electricity will be fed into national grids and it will bring energy access to millions and support economic growth in the developing world.

To demonstrate this fact, the International Energy Agency's World Energy Outlook 2011 highlights that "coal alone accounts for more than 50% of the total on-grid additions" required to achieve the its "Energy for All" case. This clearly demonstrates coal's fundamental role in supporting modern base-load electricity that is required to fuel economic development and alleviate poverty.

2 Technical and economic considerations

China, India and the developing world

The largest growing economies today are powered by coal and have significant coal reserves. The increase in coal consumption across the globe has predominantly been due to demand for greater electricity generation in China, India and other non-OECD countries which have seen total power generation double since 2000. Well over half of this new power generation has come from coal. China alone now uses as much coal as the rest of the world.

In 2012 it was announced that a key deliverable of the Millennium Development Goals – halving global poverty – had been achieved. However closer analysis shows that virtually all of the world's poverty reduction between 1981 and 2008 took place in China, 80% fuelled by coal.

World Bank estimates show that the percentage of those living below USD1.25 a day in China decreased from 84% to 13% between 1981 and 2008. During this time China lifted 662 million people out of poverty. Coal played a key role in achieving such a significant reduction in poverty in China. During the period 1980-2008 Chinese annual coal consumption increased by more than 400% from 626 million tonnes to 2.7 billion tonnes.

Electrification is a vital component of China's poverty alleviation campaign which has built up basic infrastructure and created local enterprises throughout China. As a result, from 1985 to 2003, electricity production in China rose by over 1500 TWh, of which around 80% is coal-fired.

It is clear that this development pathway is set to be repeated in other parts of developing Asia.

In India the increasing use of coal reflects significant growth in the economy which in turn increases demand for electricity as well as materials in which coal is a key component of production such as steel and cement. It is estimated that around 295 million people today still live in energy poverty in India. Although other energy sources will play a role, India's domestic coal reserves, relatively easy access to affordable imported coal and its ability to meet the sheer scale of demand mean that much of the future energy demand in India will be met by coal. The Indian Government anticipates an additional 60GW of coal-fired power generation to be built in the country by 2017 which would increase total coal-fired capacity to approximately 175GW.

A similar story will be told in elsewhere in South Asia, and southern Africa also provides another example. In South Africa coal is being used to bring electricity to some of the 12.5 million people – 25% of the South African population – who lack it. This electricity will help address the fact that half of South Africa's population lives in poverty. International support for the construction of modern, highly efficient coal-fired power plants in South Africa demonstrates the importance of coal in meeting the demand for reliable base-load electricity to help deliver economic development.

Cleaner energy from coal

With the ever-increasing demand for coal, particularly in the developing world, the use of low emission coal technologies becomes increasingly important if international targets on climate change are to be achieved. The two principal avenues for reducing carbon emissions from coal-fired power generation are through use of high efficiency, low emission power plants and carbon capture, use and storage.

High-efficiency, low-emission power generation

Efficiency in coal-fired power generation will play an important role in the future production of electricity. This is particularly the case with the potential of higher efficiency power generation to reduce CO₂ emissions.

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 one percentage point improvement in the efficiency of a conventional pulverised coal combustion plant results in a 2-3% reduction in CO₂ emissions. Highly efficient modern supercritical and ultra-supercritical coal plants emit almost 40% less CO₂ than subcritical plants.

In 2011 roughly 50% of all new coal-fired power plants used HELE technologies, predominantly supercritical and ultra-supercritical coal combustion units. However, about three quarters of all operating units today use non-HELE technology.

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 and transition countries where existing plant efficiencies are generally lower and coal use in electricity generation is increasing.

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 CCS in the future.

Efficient plants are a prerequisite for retrofitting with CCS – as capturing, transporting and storing the plant's CO₂ consumes significant quantities of energy. Highly inefficient plants will undermine capacity to deploy CCS technologies.

Improving the efficiency of the oldest and most inefficient coal-fired plants would reduce CO₂ emissions from coal use by almost 25% representing a 6% reduction in global CO₂ emissions. (By way of comparison, under the Kyoto Protocol, Parties have committed to reduce their emissions by “at least 5%”.) These significant emissions reductions can be achieved by the replacement of plants that are < 300 MW capacity and older than 25 years, with larger and significantly more efficient plants and, where technically and economically appropriate, the replacement or repowering of larger inefficient plants with high-efficiency plants of >40%.

Carbon capture, use and storage

Carbon capture and storage technology will be a key technology to reduce CO₂ emissions, not only from coal, but also natural gas and industrial sources. Figures in the IEA's World Energy Outlook 2011 report estimate the potential for CCS to contribute 22% of global CO₂ mitigation through to 2035. Further analysis by the IEA in their Energy Technology Perspectives 2010 report also shows that climate change action will cost an additional USD4.7 trillion without CCS.

Like all new low emission energy technologies however, CCS will cost significantly more than conventional technology and requires extended development time. While available on a component-by-component basis, CCS has not yet been commercially proven on an integrated basis or at the scale required to meet global greenhouse gas concentration targets.

Once demonstrated, CCS will enable countries to rely on secure and affordable energy sources such as coal without compromising their environmental ambitions.

Key to operationalizing CCS however is establishing a sustainable business case and this is most likely to be met in the near term at least through the utilization of captured CO₂ and particularly through Enhanced Oil Recovery (EOR). CCUS and EOR can provide a pathway to two important energy goals of many countries – producing reliable and affordable electricity from coal power plants while reducing greenhouse gas emissions and producing more oil to meet growing demand and enhance national energy security. Utilising the CO₂ from the consumption of fossil fuels is a crucial step in economically reducing greenhouse gas emissions.

In its 2013 report, “Tracking Clean Energy Progress”, the International Energy Agency notes that patent applications that relate to CCS have increased by 45% since 2006, signalling commercial interest in the technology. However, the Agency estimates that around 75% of investments in CCS projects since 2007 have come from private financing and calls for greater public funding in this area.

Global trade in coal

Coal is a global industry, with coal found in over 70 countries and actively mined in 50 countries. Coal is readily available from a wide variety of sources in a well-supplied worldwide market. Coal can be transported to demand centres quickly, safely and easily by ship and rail. A large number of suppliers are active in the international coal market, ensuring a competitive and efficient market.

Coal is traded all over the world, with coal shipped huge distances by sea to reach markets Over the last twenty years:

- seaborne trade in steam coal has increased on average by about 7% each year
- seaborne coking coal trade has increased by 1.6% a year.

Overall international trade in coal reached 1142Mt in 2011; while this is a significant amount of coal it still only accounts for about 15% of total coal consumed. Most coal is used in the country in which it is produced.

Transportation costs account for a large share of the total delivered price of coal, therefore international trade in steam coal is effectively divided into two regional markets:

- the Atlantic market, made up of importing countries in Western Europe, notably the UK, Germany and Spain.
- the Pacific market, which consists of developing and OECD Asian importers, notably Japan, Korea and Chinese Taipei. The Pacific market currently accounts for about 57% of world seaborne steam coal trade.

Indonesia has overtaken Australia as the world's largest coal exporter. It exported over 300Mt of coal in 2011.

Australia remains the world's largest supplier of coking coal, accounting for roughly 50% of world exports.

Emerging coal technologies

In addition to improvements in the efficiency of coal-fired power stations and the deployment of CCS for electricity generation, the world's significant coal resources can also be deployed to support other energy needs.

Coal to liquids

Converting coal to a liquid fuel (CTL) – a process referred to as coal liquefaction – allows coal to be utilised as an alternative to oil.

South Africa has been producing coal-derived fuels since 1955. Not only are CTL fuels used in cars and other vehicles, but South African energy company Sasol's CTL fuels also have approval 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 now stands in excess of 160,000bb/d.

CTL is particularly suited to countries that rely heavily on oil imports and have large domestic reserves of coal.

Fuels produced from coal can also be used outside the transportation sector. In many developing countries, health impacts and local air quality concerns have driven calls for the use of clean cooking fuels. Replacing traditional biomass or solid fuels with liquefied petroleum gas (LPG) has been the focus of international aid programmes. LPG however, is an oil derivative – and is thus affected by the expense and price volatility of crude oil. 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 LPG.

Underground coal gasification

Underground coal gasification (UCG) is a method of converting unworked coal - coal still in the ground - into a combustible gas which can be used for industrial heating, power generation or the manufacture of hydrogen, synthetic natural gas or diesel fuel.

In the last few years there has been significant renewed interest in UCG as the technology has moved forward considerably. China has about 30 projects using underground coal gasification in different phases of preparation. India plans to use underground gasification to access an estimated 350 billion tonnes of coal.

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 under way in a number of countries, including the USA, Western and Eastern Europe, Japan, Indonesia, Vietnam, India, Australia and China, with work being carried out by both industry and research establishments.

3. Market trends and outlook

The road ahead

In its recent report *Time to get real – the case for sustainable energy policy*, the World Energy Council posed the energy trilemma of energy security, social equity and environmental impact mitigation. From the coal industry's perspective the trilemma is perhaps better described through the prisms of (1) energy access in the developing world, (2) energy security and affordability in the developed world and (3) environmental protection globally as being the main challenges that need to be addressed. These challenges can be addressed as integrated priorities.

As this report highlights the world benefits from abundant reserves of coal, much of it in regions that still have much work to do to improve access to energy and thereby help improve living standards. All energy sources will have a role to play in meeting this challenge however many countries will be looking to utilise their own natural resources to achieve that goal and affordable, reliable and accessible coal will be a key part of that development strategy.

Coal's wide availability in the developed world also proves to be a vital component in ensuring affordable fuel can contribute to limiting rising electricity prices, often brought about by poor economic decisions driven purely by environmental objectives.

An effective and sustainable response to the challenge of climate change must integrate environmental imperatives with the legitimate aims of energy security and economic development, including poverty alleviation.

Ensuring secure, affordable and sustainable energy requires a diverse energy mix. As this report shows, coal is a major economic and energy resource and will remain a key part of the energy mix well into the future.

Benjamin Sporton

World Coal Association

Reserves and production

1. Global tables

Table 1.1

Coal: proved recoverable reserves at end-2011 (million tonnes)

Sources: WEC Member Committees, 2011; data reported for previous WEC reports of Energy Resources; national and international published sources

	Bituminous including anthracite	Sub-bituminous	Lignite	Total
Afghanistan	66			66
Albania			794	794
Algeria	59			59
Argentina		550		550
Armenia	163			163
Australia	37 100	2 100	37 200	76 400
Austria			333	333
Bangladesh	293			293
Belarus			100	100
Bolivia	1			1
Bosnia-Herzegovina	484		2 369	2 853
Botswana	40			40
Brazil		6 630		6 630
Bulgaria	2	190	2 174	2 366
Canada	3 474	872	2 236	6 582
Central African Republic			3	3
Chile		155		155
China	62 200	33 700	18 600	114 500
Colombia	6 746			6 746
Congo (Democratic Rep.)	88			88
Croatia	4			4
Czech Republic	181		871	1 052
Ecuador			24	24
Egypt (Arab Rep.)	16			16
Georgia	201			201
Germany	48		40 500	40 548
Greece			3 020	3 020
Greenland		183		183
Hungary	13	439	1 208	1 660
India	56 100		4 500	60 600
Indonesia		28 017		28 017
Iran (Islamic Rep.)	1 122			1 122
Ireland	14			14
Italy		50		50
Japan	337		10	347
Kazakhstan	21 500		12 100	33 600
Korea (Democratic People's Rep.)	300	300		600

Korea (Republic)	–	126		126
Kyrgyzstan			812	812
Laos	4		499	503
Macedonia (Republic)			332	332
Malawi		2		2
Malaysia	4			4
Mexico	860	300	51	1 211
Mongolia	1 170		1 350	2 520
Montenegro	142			142
Morocco	82		40	122
Mozambique	212			212
Myanmar (Burma)	2			2
Nepal		1		1
New Caledonia	2			2
New Zealand	33	205	333	571
Niger	70			70
Nigeria	21	169		190
Norway		5		5
Pakistan		166	1 904	2 070
Peru	44			44
Philippines	41	170	105	316
Poland	4 178		1 287	5 465
Portugal	3		33	36
Romania	10	1	280	290
Russian Federation	49 088	97 472	10 450	157 010
Serbia	1	10	13 400	13 411
Slovakia	2		260	262
Slovenia		24	199	223
South Africa	30 156			30 156
Spain	200	300	30	530
Suriname	12			12
Swaziland	144			144
Taiwan, China	1			1
Tajikistan	375			375
Tanzania	200			200
Thailand			1 239	1 239
Turkey	322		8 380	8 702
Ukraine	15 351	16 577	1 945	33 873
United Kingdom	228			228
United States of America	108 501	98 618	30 176	237 295
Uzbekistan	47		1 853	1 900
Venezuela	479			479
Vietnam	150			150
Zambia	10			10
Zimbabwe	502			502
TOTAL WORLD	403 197	287 333	201 000	891 530

Table 1.2**Coal: 2011 production (million tonnes)**

Sources: WEC Member Committees, 2011; data reported for previous WEC reports of Energy Resources; national and international published sources

	Bituminous	Sub-bituminous	Lignite	Total	R/P
Albania	0.1			0.1	> 100
Argentina		0.3		0.3	> 100
Australia	295.6	36.5	65.5	397.6	> 100
Bangladesh	0.6			0.6	> 100
Bosnia-Herzegovina			11.2	11.2	> 100
Botswana	0.9			0.9	7
Brazil		5.5		5.5	> 100
Bulgaria	0.0	2.7	34.5	37.2	64
Canada	34.6	22.8	9.7	67.1	98
Chile	0.2		0.3	0.5	> 100
China	3 236.8		146.9	3 383.7	34
Colombia	85.8	0.0		85.8	79
Congo (Democratic Rep.)	0.1			0.1	> 100
Czech Republic	11.3		46.6	57.9	18
Georgia	0.4			0.4	> 100
Germany	12.9		176.5	189.5	> 100
Greece			65.7	65.7	46
Hungary			9.4	9.4	> 100
India	483.7		32.1	515.8	> 100
Indonesia		353.3		353.3	79
Iran (Islamic Rep.)	2.3			2.3	> 100
Italy		0.1		0.1	> 100
Japan	1.3			1.3	> 100
Kazakhstan	116.3		8.4	124.7	> 100
Korea (Democratic People's Rep.)	26.0	7.4		33.4	18
Korea (Republic)		2.8		2.8	45
Kyrgyzstan	0.1		0.3	0.4	> 100
Laos	0.6			0.6	> 100
Macedonia (Republic)			7.3	7.3	45
Malawi		0.1		0.1	20
Malaysia		1.2		1.2	3
Mexico	2.0	13.7		15.7	77
Mongolia	0.2		9.6	9.8	> 100
Montenegro			1.7	1.7	84
Myanmar (Burma)			0.3	0.3	7
New Zealand	2.5	2.2	0.2	4.9	> 100
Niger	0.2			0.2	> 100
Norway		3.4		3.4	1
Pakistan	0.5	2.5	0.9	3.9	> 100
Peru	0.1			0.1	> 100
Philippines		3.6		3.6	88
Poland	67.6		62.9	130.5	42
Romania	2.8	0.6	31.8	35.2	8
Russian Federation	246.0		80.5	326.5	> 100
Serbia	0.0	0.7	40.0	40.7	> 100
Slovakia	3.9			4.0	66
Slovenia		0.5	4.0	4.5	50

South Africa	251.0		251.0	> 100
Spain	7.3	2.9	10.2	52
Swaziland	0.2		0.2	> 100
Tajikistan	0.2	N	0.2	> 100
Thailand			18.0	69
Turkey	2.6		74.3	> 100
Ukraine	59.5		0.2	> 100
United Kingdom	18.1		18.1	13
United States of America	500.5	510.5	81.0	1 092.0
Uzbekistan	0.1		3.0	> 100
Venezuela	6.4		6.4	75
Vietnam	39.8		39.8	4
Zambia	0.2		0.2	50
Zimbabwe	2.7		2.7	> 100
TOTAL WORLD	5 525.1	974.0	1 023.0	7 520.1

2. Regional tables

Table 1.3

Coal Regional Summary tables

Summary tables show top five countries per region only, ranked by reserves.

Country	Region	Coal Reserves Million tonnes	Production Million tonnes	R/P years
South Africa	Africa	30156	251	> 100
Zimbabwe	Africa	502	2.7	> 100
Mozambique	Africa	212		
Tanzania	Africa	200		
Nigeria	Africa	190		
Rest of region		357	2	0
Africa total		31617	255.4	
China	East Asia	114500	3 384.0	34
Korea (DRC)	East Asia	600	33.4	18
Japan	East Asia	347	1.3	> 100
Korea (Republic)	East Asia	126	2.8	45
Taiwan	East Asia	1		
Rest of region		0	0	
East Asia total		115574	3421	
Russian Federation	Europe	157010	327.0	> 100
Germany	Europe	40548	189.462	> 100
Ukraine	Europe	33873	59.7	> 100
Serbia	Europe	13411	40.687	> 100
Turkey	Europe	8702	76.9	> 100
Rest of region		20143	397	
Europe total		273 687.0	1 090.1	
Colombia	Latin America & The Caribbean	6746	85.5	79
Brazil	Latin America & The Caribbean	6630	5.505	> 100
Argentina	Latin America & The Caribbean	550	0.245	> 100
Venezuela	Latin America & The Caribbean	479	6.4	75
Chile	Latin America & The Caribbean	155	0.5	> 100
Rest of region		69	0	
LAC total		14629	99	

Iran	Middle East & North Africa	1122	2.3	> 100
Morocco	Middle East & North Africa	122		
Algeria	Middle East & North Africa	59		
Egypt	Africa	16		
Rest of region		0	0	
MENA total		1319	2	
Mexico	North America	1211	15.7	77
Canada	North America	6582	67.1	98
United States of America	North America	237 295.0	1 092.0	> 100
Rest of region		0.0	0.0	
North America total		245 088.0	1 174.8	
India	South & Central Asia	60600	516.0	> 100
Kazakhstan	South & Central Asia	33600	124.7	> 100
Mongolia	South & Central Asia	2520	9.8	> 100
Pakistan	South & Central Asia	2070	3.9	> 100
Uzbekistan	South & Central Asia	1900	3.1	> 100
Rest of region		1710	1	
South & Central Asia total		102 400.0	658.5	
Australia	Southeast Asia & Pacific	76400	398.0	> 100
Indonesia	Southeast Asia & Pacific	28017	353.3	79
Thailand	Southeast Asia & Pacific	1239	18.0	69
New Zealand	Southeast Asia & Pacific	571	4.9	> 100
Laos	Southeast Asia & Pacific	503	0.6	> 100
Rest of region		486	45	
Southeast Asia & Pacific		107216	819	
Total World		891530	7520.0	> 100

Country notes

The following Country Notes on Coal provide a brief account of countries with significant peat resources. They have been compiled by the Editors, drawing upon a wide variety of material, including information received from WEC Member Committees, national and international publications.

Argentina

Proved amount in place (total coal, million tonnes)	8 102
Proved recoverable reserves (total coal, million tonnes)	550
Production (total coal, million tonnes)	0.3

The Argentinian WEC Member Committee has reported proved amounts in place of 752 million tonnes of sub-bituminous coal and 7 350 million tonnes of lignite, which are found in two main deposits, Río Coyle with some 5 billion tonnes in place, and the middle course of the Río Santa Cruz, with 2.35 billion. Both these deposits lie in the Río Leona formation. The only proved reserves reported are 550 million tonnes of sub-bituminous. Undiscovered coal of this rank estimated to be in place amounts to 300 million tonnes, of which 100 million is regarded as recoverable.

Coal output from the Río Turbio mine is currently about 300 thousand tonnes per annum, and is used for electricity generation. A 240 MW coal-fired mine-mouth power plant, currently under construction, is scheduled to enter service in mid-2011. According to the Argentinian Member Committee, this development will require a quadrupling of Río Turbio's output.

Australia

Proved amount in place (total coal, million tonnes)	100 500
Proved recoverable reserves (total coal, million tonnes)	76 400
Production (total coal, million tonnes)	397.6

Australia is endowed with very substantial coal resources. Total production of raw black coal in Australia in financial year 2010-11 was 397 million tonnes (Mt.), down from 471 Mt. in 2009-10. This drop was largely as a result of the Queensland floods of January 2011 where production in that State fell by some 30% (see below).

After processing, 326 Mt. of black coal was available for both domestic use and for export in 2010-11. Again, this represented a drop in production of some 14% from the 366 Mt. produced in 2009-10.

New South Wales and Queensland remained the main producing states with around 97% of Australia's saleable output of black coal, and almost all of Australia's black coal exports.

Australia has USD26.5 billion in advanced coal mining projects and associated infrastruc-

ture, involving more than 74 million additional tonnes of coal production by 2014. 'Less advanced' coal mine and coal infrastructure projects have a potential capital expenditure of USD46.6 billion, if all projects were to proceed.

A little over half of the recoverable bituminous, and all of the recoverable lignite, have been reported to be surface-mineable. About 36% of Australia's massive reserves of bituminous coal are of coking quality. The maximum depth of the deposits ranges from 600 m in the case of bituminous coal to 200 m for sub-bituminous and 300 m for lignite. Minimum seam thicknesses are 0.3, 1.5 and 3.0 m, respectively.

'Subeconomic demonstrated resources' and 'inferred resources', additional to the proved amount in place, are vast: Geoscience Australia's current assessment puts those of black coal at 119 billion tonnes, of which 75 billion tonnes is estimated to be recoverable. Comparable figures for brown coal are 174 billion tonnes and 156 billion tonnes, respectively.

Brazil

Proved amount in place (total coal, million tonnes)	6 640
Proved recoverable reserves (total coal, million tonnes) (see remarks below)	6 630
Production (total coal, million tonnes)	5.5

Brazil has considerable reserves of sub-bituminous coal, which are mostly located in the southern states of Rio Grande do Sul, Santa Catarina and Paraná.

The Brazilian WEC Member Committee has reported that the remaining proved amount of sub-bituminous coal in place was 6 640 million tonnes. The same source assesses Brazil's proved recoverable reserves to be 6 630 million tonnes. This is higher than in the last report.

The maximum depth of the deposits is 870 m, whilst the minimum seam thickness is 0.5 m. It is estimated that 21% of the stated level of proved recoverable reserves could be exploited through surface mining.

The Member Committee quotes additional discovered amounts of coal in place at lower levels of confidence as approximately 10.8 billion tonnes classified as 'probable' and more than 6.5 billion tonnes as 'possible'. It also estimates that a further amount of around 8.3 billion tonnes of coal is recoverable from undiscovered resources.

Almost all of Brazil's current coal output is classified as steam coal, of which more than 85% is used as power-station fuel and the remainder in industrial plants. Virtually all of Brazil's metallurgical coal is imported: about 70% is used as input for coke production.

In Brazil, coal's share in the energy mix is about 5% and only 1.3% in the electricity generation. The main uses of coal are in the steel industry and for power generation. Brazilian coal is considered to be low quality, with high ash content and low carbon content, which makes its use outside the coal deposit regions unviable. As such, more than 98% of coal is imported.

In 2010 Brazil consumed around 20 million tonnes of coal, of which 14.2 million tonnes was imported. Of this 20 million tonnes, 4.4 million tonnes (22%) was used in electricity generation and the remainder was used in industry.

Canada

Proved amount in place (total coal, million tonnes)	22 022
Proved recoverable reserves (total coal, million tonnes)	6 582
Production (total coal, million tonnes)	67

Coal is by far Canada's most abundant fossil fuel, with 6.6 billion tonnes of recoverable coal reserves. Canada has anthracite, bituminous, sub-bituminous, lignite coal deposits. More than 90% of Canada's coal deposits are located in western provinces which provide a strategic advantage because of the close proximity of west coast ports.

Canadian coal production has been around 60 million tonnes over the last decade however in 2012 coal production increased to 67 million tonnes. 38 million tonnes (56%) was thermal coal produced mainly in the prairies and 29 million tonnes was metallurgical (steel-making) coal, produced in Western Alberta and B.C.

To meet its rapid infrastructure growth and consumer demand for things such as vehicles and home appliances, Asia has turned to Canada for its high-quality steel-making coal. As Canada's largest coal trading partner, coal exports to Asia accounted for 73% of total exports in 2010.

40% of the coal produced in Canada is exported. In 2010, exports totalled 33 million tonnes, a 22% increase from the previous year. The majority of the coal exported was steel-making coal.

The Canadian WEC Member Committee has reported the following estimates of recoverable reserves (in millions of tonnes), as provided by Natural Resources Canada: bituminous coals (including anthracite) 3 474; sub-bituminous grades 872; and lignite 2 236. The corresponding amounts of coal remaining in place from which these tonnages could be extracted are (respectively) 4 651, 3 430 and 13 941 million tonnes.

Estimates of the remaining tonnages of coal in place that are considered to be additional to the 'proved' or 'measured' amounts of each rank total more than 300 billion tonnes. Within this enormous in situ figure, remaining discovered resources add up to 176.5 billion tonnes, of which 'probable/indicated' resources total 50.6 billion tonnes and 'possible/inferred' 125.9 billion. Undiscovered resources ('hypothetical/speculative') are estimated to add another 126 billion. While these figures are necessarily highly approximate, they do serve to underline Canada's massive coal endowment.

Around 88% of Canadian coal consumption is used for electricity generation, 7% in the steel industry and 5% in other industries. Alberta is the largest coal-consuming province, Ontario the second. Ontario and Nova Scotia rely on coal imports.

The Canadian coal industry is privately owned. Output is mainly from surface mines: there are two operating underground mines, Campbell River, British Columbia and Grande Cache, Alberta. Production from these operations is relatively small, about 1 million tonnes of coal annually. The potential exists to reopen the underground mine at the Donkin coal resource in Nova Scotia.

China

Proved amount in place (total coal, million tonnes)	NA
Proved recoverable reserves (total coal, million tonnes) (see remarks below)	114 500
Production (total coal, million tonnes)	3 384

Coal still is The King in China with vast reserves located within economic reach of the energy consumer. The recent announcements about Chinese coal consumption indicate that China alone accounts for more than 50% of the global total annual coal consumption. China is a major force in world coal, standing in the front rank in terms of reserves, production and consumption. In the continued absence of reliable published information regarding China's coal resources and reserves, compounded by problems of definition and terminology, there has been a considerable amount of controversy over the best level to quote for proved recoverable reserves. Not infrequently, commentators appear to confuse in-place amounts with recoverable tonnages.

The levels of proved recoverable reserves as at end-1990, originally provided by the Chinese WEC Member Committee for the 1992 Survey, have been retained for each successive edition. In billions of tonnes, they amount to: bituminous coal and anthracite 62.2; sub-bituminous coal 33.7 and lignite 18.6, implying a reserves-to-production ratio of 38.

The same figure for total proved reserves (114.5 billion tonnes) was quoted at the 11th Session of the UN Committee on Sustainable Energy (Geneva, November 2001), in the context of an estimate of 988 billion tonnes for China's coal resources. This reference, in a paper co-authored by Professor Huang Shengchu, a vice-president of the China Coal Information Institute, indicated a degree of continuity in the official assessments of China's coal reserves and supported the retention of the level originally advised by the Chinese WEC Member Committee in 1991.

Further confirmation that the level of proved reserves used in the present and previous Surveys is of the right order is provided by the Chinese Statistical Yearbook, published by the National Bureau of Statistics. Since 2002, this publication has specified China's 'ensured reserves' of coal which, according to the Ministry of Land and Natural Resources, have an average recovery ratio of 35%. Applying this rate to the 'ensured reserves' quoted for 2008 in the Yearbook (326.1 billion tonnes) produces 114.1 billion tonnes, a figure almost identical to the level of proved recoverable reserves adopted for this Survey.

Coal deposits have been located in most of China's regions but three-quarters of proved recoverable reserves are in the north and northwest, particularly in the provinces of Shanxi, Shaanxi and Inner Mongolia.

Colombia

Proved amount in place (total coal, million tonnes)	NA
Proved recoverable reserves (total coal, million tonnes)	6 508
Production (total coal, million tonnes)	85.8

Colombia's vast coal resources are located in the north and west of the country. Data on 'measured reserves', published in 2004 by the Instituto Colombiano de Geología y Minería (Ingeominas), Ministerio de Minas y Energía, indicate a total of 7 064 million tonnes, of which

the Cerrejón Norte, Central and Sur fields in the department of La Guajira accounted for 56% and fields in the department of Cesar for 29%. For the present report, the WEC Member Committee for Colombia has reported proved recoverable reserves of 6 508 million tonnes based on the Ingeominas end-2003 measured reserves, adjusted for cumulative coal production in 2004-2011, inclusive. 'Indicated reserves' quoted by Ingeominas in the afore-mentioned publication were 4 572 million tonnes, whilst 'inferred' tonnages were 4 237 million and 'hypothetical' resources 1 120 million. The 'indicated' and 'inferred' levels are reported by the Member Committee under the headings of 'probable' and 'possible', respectively.

Virtually all Colombia's coal resources fall into the bituminous category: the reserves in the Alto San Jorge field in Córdoba, with an average calorific value in the sub-bituminous/lignite bracket bituminous in Table 1.1. The measured reserves of Alto San Jorge were 381 million tonnes at end-2003 and annual output is approximately 350 000 tonnes, implying end-2008 reserves of about 380 million tonnes.

Development of Colombian coal for export has centred on the Cerrejón deposits which are located in the Guajira Peninsula in the far north, about 100 km inland from the Caribbean coast. The coal is found in the northern portion of a basin formed by the Cesar and Rancheria rivers; the deposit has been divided by the Government into the North, Central and South Zones.

Exports account for more than 90% of Colombia's coal production; Cerrejón North remains one of the world's largest export mines.

Colombia is the world's tenth largest producer of hard coals and the fourth largest exporter of coal, based on 2009 data. The U.S. Geological Survey states that Colombia is the largest coal producer in South America and has the largest reserves in the region. It also states that coal mining for export is booming in Colombia, with production having increased by 80% since 1999.

The majority of Colombia's coal exports are shipped to European markets due to shorter distances and lower freight costs compared to the rapidly growing Asian markets. Colombia is considered to be a low-cost producer with its coal highly sought after due to its low sulphur content.

In Colombia, the state owns all hydrocarbon reserves and private companies operate coal mines under concession contracts with the state.

Czech Republic

Proved amount in place (total coal, million tonnes)	4 336
Proved recoverable reserves (total coal, million tonnes)	1 052
Production (total coal, million tonnes)	57.9

The Czech Republic WEC Member Committee has reported coal resources and reserves provided by the Czech Geological Survey (Geofond). The remaining discovered amount in place (in Czech terminology, 'economic explored reserves') are quoted as 1 519 million tonnes of bituminous coal and 2 362 million tonnes of brown coal/lignite, of which respectively 181 and 871 million tonnes are classed as recoverable ('exploitable') reserves.

In addition to the proved amounts, the Member Committee reports substantial quantities of probable ('economic prospected') and possible ('potentially economic') reserves: in millions of tonnes, these are quoted as respectively 5 999 and 8 821 for bituminous and 2 663 and 4 523 for brown coal/lignite. Total known resources remaining in place are thus some 16.3 billion tonnes of bituminous and 8.9 billion tonnes of brown coal/lignite.

The maximum depth of deposits varies from 1 600 m in the case of bituminous to 500 m for brown coal/lignite; minimum seam thicknesses range from 0.6 (for bituminous) to 1.5 for brown coal/lignite.

Bituminous coal deposits are mainly in the Ostrava-Karviná basin in the east of the country, and lie within the Czech section of the Upper Silesian coalfield. The principal sub-bituminous/lignite basins are located in the regions of North and West Bohemia, close to the Krusne Hory (Erzgebirge or Ore Mountains), which constitute the republic's north-western border with Germany. Currently all Czech output of bituminous coal and lignite is deep-mined.

The Czech WEC Member Committee points out that Czech coal statistics now show brown coal (previously classed as sub-bituminous coal) with lignite.

Apart from its coking coal, which is consumed by the iron and steel industry, most of the republic's bituminous coal is used for electricity and heat generation, with industrial and private consumers accounting for relatively modest proportions. This pattern of utilisation also applies to brown coal/lignite, which is still the main power station fuel.

The Czech Republic is heavily dependent on coal for its energy needs and relies mostly on extensive reserves of brown coal or lignite in north Bohemia, in the northwest of the country, and of hard coal in the east of the country, where the Upper Silesian Basin falls within Czech territory. Between 1993 and 2003 coal consumption decreased by 26 per cent, mainly due to the commissioning of two new units at the Temelin nuclear power station. In 2004, in line with EU regulations, the Czech government lifted quotas on coal imported from Poland and Ukraine.

The Czech Republic's coal industry consists of six companies: three hard coal (black) mining companies (Ostrasko-Karvinske Doly; Ceskomoravske Doly; and Zapadoceske Uhelne Doly); and three lignite (brown) mining companies (Mostecká uhelná společnost, Severoceske Doly, and Sokolovska uhelna).

According to the State Energy Policy, coal will remain the country's primary energy source in the future in spite of the increased use of nuclear energy and natural gas. The government expects coal to account for 30.5 percent of consumption in 2030.

Germany

Proved amount in place (total coal, million tonnes)	NA
Proved recoverable reserves (total coal, million tonnes)	40 548
Production (total coal, million tonnes)	189.5

The German WEC Member Committee has reported coal reserves on the basis of data provided by the German Federal Institute for Geosciences and Natural Resources (BGR).

Proved recoverable reserves are given as 40 548 million tonnes, almost all of which is lignite. The level of hard coal reserves in this category is confined to the projected amount of the (highly subsidised) German hard coal production until 2018, when subsidised hard coal mining is due to be phased out. The hard coal component has a maximum deposit depth of 1 500 m below the surface, and a minimum seam thickness of 0.6 m, whilst the corresponding parameters for lignite are 500 and 3 m, respectively.

In previous reports only the proved recoverable amount of lignite reserves in existing and planned surface mines was reported. For better comparability with reserve data from other countries the present numbers report the entire German lignite reserves.

BGR's category 'resources' (using its own definition, which differs from WEC usage) amounts to around 82.9 billion tonnes of hard coal and 36.5 billion tonnes of lignite. These levels convey an indication of the enormous size of the additional amounts of coal 'in place', over and above the in situ tonnages hosting the recoverable reserves.

Over three-quarters of German hard coal production is derived from the Ruhr Basin (Ruhr and Ibbenbüren mining districts). The coal qualities range from anthracite to high-volatile, strongly-caking bituminous coal. The second largest German coalfield is situated in the Saar Basin, with substantial deposits of weakly-caking bituminous coal. All German hard coal is deep-mined from seams at depths exceeding 900 m.

The lignite deposit in the Rhineland region is the largest single formation in Europe in terms of lignite production. In the former East Germany there are major deposits of lignite in the Central-German (at Halle/Leipzig) and Lusatian mining districts, which have considerable domestic importance. Germany is still the world's largest lignite producer.

The principal markets for bituminous coal are electricity generation, iron and steel, and cement manufacture: other industrial and household uses are relatively modest. The bulk of German lignite is consumed in power stations, although a considerable tonnage (over 11 million t/y) is converted into lignite products such as briquettes, dust, coal for fluidised circulating beds and coke for the industrial, residential and commercial markets.

Germany has considerable reserves of hard coal (48 million tonnes) and lignite (40,500 million tonnes), making these the country's most important indigenous source of energy.

Germany's primary energy consumption amounted to 480 Mtce in 2010. Oil accounted for the largest share (33.6%), followed by coal (22.8 %), natural gas (21.8 %) and nuclear energy (10.9 %). Renewable energy reached 9.5 %. Within coal, hard coal accounted for 12.1 % and lignite for 10.7 % of primary energy consumption. Germany is dependent on energy imports to a large extent, except in the case of lignite. About 77% of hard coal was imported, in comparison with 98% of oil and 87% of gas. The power generation structure is characterised by a widely diversified energy mix. In 2010, gross power output was as follows: 42.4% from coal (of which 23.7% was from lignite and 18.7 % from hard coal), 22.6 % from nuclear, 13.6 % from natural gas, 16.5 % from renewable energy sources and 4.9% from other sources. This means that hard coal and lignite, as well as nuclear energy, are the mainstays of the German power industry.

Greece

Proved amount in place (total coal, million tonnes)	5 800
Proved recoverable reserves (total coal, million tonnes)	3 020
Production (total coal, million tonnes)	65.7

Coal resources are all in the form of lignite. According to the Ministry of Development's Energy Outlook of Greece total 'remaining exploitable deposits' of lignite in 2008 were 3 020 million tonnes. Apart from a very small amount of private mining, all production is carried out by the mining division of the Public Power Corporation (DEI). There are two lignite centres, Ptolemais-Amynteo (LCPA) in the northern region of Western Macedonia, and Megalopolis (LCM) in the southern region of the Peloponnese. These two centres control the operations of five open-cast mines; LCPA mines account for nearly 80% of DEI's lignite output.

In the lignite-mining areas, there are eight dedicated power stations (total generating capacity: 5 288 MW), which produce more than two-thirds of Greece's electricity supply. Greece is the second largest producer of lignite in the European Union and the 6th largest in the world. Greece has no hard coal reserves, and consequently imports hard coal from South Africa, Russia, Venezuela, and Colombia.

Greece is second only to Germany in the EU for lignite coal production. Greece had 2011 coal production of 57.5 million tonnes, 0.18% of the world total. Domestic production has been partly opened to private companies, but the Public Power Corporation (PPC) remains the largest producer with the right to exploit 63% of known reserves.

Coal is Greece's single most important local energy source. Lignite and low quality black coal is used to generate power. Greece had 2011 coal consumption of 7.32 million tonnes oil equivalent, a change of -0.4% on 2010 and equivalent to 0.19% of the world total.

The Public Power Corporation (PPC) is Greece's main electricity provider, producing 95 % of Greece's total electricity supply. Lignite - fired generation accounts for 70% of total output. Exclusive rights for production of electricity from lignite are granted to the PPC, now a public company traded on the Athens and London stock exchanges, but in which the Greek Government retains a 51% share. PPC has undertaken an expansion programme to facilitate the increase in production.

India

Proved amount in place (hard coal only, million tonnes)	105 820
Proved recoverable reserves (total coal, million tonnes)	60 600
Production (total coal, million tonnes)	515.8

Coal is the most abundant fossil fuel resource in India, which is the world's third largest coal producer. The principal deposits of hard coal are in the eastern half of the country, ranging from Andhra Pradesh, bordering the Indian Ocean, to Arunachal Pradesh in the extreme northeast: the eastern States of Chhattisgarh, Jharkhand, Orissa and West Bengal together account for about 77% of reserves. The Ministry of Coal (quoting the Geological Survey of India) states that at 1 April 2009, India's geological resources of bituminous coal comprised 105.8 billion tonnes of 'proved resources', 123.5 billion tonnes of 'indicated resources' and 37.9 billion tonnes of 'inferred resources'. Coking coals constitute 17% of the tonnage of

proved resources. The resources quoted are the result of exploration down to a depth of 1 200 m.

Considerable uncertainty remains regarding India's coal reserves, particularly as to (i) whether they represent remaining tonnages or need to be reduced by the subtraction of past years' production, and (ii) whether it is appropriate to assess coal resources down to a depth of 1 200 metres, when current coal mines in India do not generally exceed 300 m. Although it is not possible to draw definitive conclusions from the information available, the downside implications of these considerations should be borne in mind.

Lignite deposits mostly occur in the southern State of Tamil Nadu. All-India resources of lignite are quoted in the 11th Five Year Plan as 38.27 billion tonnes as at 1 April 2006, with proved reserves put at 4.5 billion tonnes. About 2.4 billion tonnes in the Neyveli area of Tamil Nadu have been stated to be regarded as 'mineable under the presently adopted mining parameters'. Annual production of lignite is currently in the region of 32 million tonnes, almost all of which is used for electricity generation.

Although India's coal reserves cover all ranks from lignite to bituminous, they tend to have a high ash content and a low calorific value. The low quality of much of its coal prevents India from being anything but a small exporter of coal (traditionally to the neighbouring countries of Bangladesh, Nepal and Bhutan) and conversely, is responsible for sizeable imports., mainly from Australia, China, Indonesia and South Africa.

Coal is the most important source of energy for electricity generation in India: about three-quarters of electricity is generated by coal-fired power stations. In addition, the steel, cement, fertiliser, chemical, paper and many other medium and small-scale industries are also major coal users.

Indonesia

Proved amount in place (total coal, million tonnes)	24 100
Proved recoverable reserves (total coal, million tonnes)	28 017
Production (total coal, million tonnes)	353.3

Indonesia has substantial coal resources released according to the annual report of the Ministry of Energy and Mineral Resources as published in 2012. This report indicates a total resource base of nearly 120 billion tonnes, with measured resources totalling 24.1 billion, indicated 27.0, inferred 35.6 and hypothetical 33.5. Within these tonnages, total coal reserves are put at 28 017 million tonnes. It is noteworthy that the proved in place coal resources and recoverable reserves have increased from their 2008 reported levels.

According to the same source 353 million tonnes of coal was produced in 2011 a significant increase from the last report (240 Mt for 2008). Indonesian coals in production generally have medium calorific values (5 000 - 7 000 kcal/kg or 21-29 MJ/kg), with relatively high percentages of volatile matter; they benefit from low ash and sulphur contents, making them some of the cleanest coals in the world.

Competitive quality characteristics have secured substantial coal export markets for Indonesia: it is now the world's second largest coal exporter, after Australia. In 2011, approximately 272 million tonnes of coking coal and steam coal were shipped overseas, representing 82% of hard coal production.

Within Indonesia, coal's main market is power generation, which accounted for 56% of internal consumption in 2011.

Kazakhstan

Proved amount in place (total coal, million tonnes)	62 200
Proved recoverable reserves (total coal, million tonnes)	33 600
Production (total coal, million tonnes)	124.7

The Kazakhstan WEC Member Committee reports that at end-2011 the remaining discovered amounts of coal in place were (in billions of tonnes): 24.7 of bituminous coal and 37.5 of lignite, within which the estimated recoverable amounts were 21.5 and 12.1, respectively. It has also provided the following notes on Kazakhstan's coal endowment:

The greater part (63%) of counted (i.e. measured) reserves consists of bituminous coal, found in the Karaganda, Ekibastuz and Teniz-Korzhankol basins, the Kushokinsk, Borly, Shubarkol and Karazhyr deposits, and elsewhere. The remainder (37%) consists of lignite, mainly from the Turgay, Nizhne-Ilyyskiy and Maikuben basins.

Kazakhstan coal is characterised by a wide range of metamorphism stages, from gas bituminous coal (GB) up to forge coal (F).

The Karaganda, Ekibastuz and Maikuben basins, and Kushokinsk, Borly, Shubarkol and Karazhyr deposits, as well as some other (small) deposits in various regions of the Republic (where coal mining is presently of insignificant volume, to meet local requirements), are developed and operating.

Distribution analysis of coal reserves and forecast coal resources in regions of the Republic shows that the main part of balance reserves is located in Central Kazakhstan (Karaganda Oblast) and North Kazakhstan (Pavlodar and Kostanay Oblasts). The eastern, western and southern regions of the Republic are in deficit of coal.

After a period of decline in the 1990s, total national output of coal has advanced strongly in recent years. Kazakhstan is a major coal exporter, with Russia and Ukraine as its main customers. The prime internal markets for Kazakh coal are power/CHP plants and the iron and steel sector.

Kazakhstan contains central Asia's largest recoverable coal reserves, 3.69% of the world total. is the former Soviet Union's 2nd largest producer, after Russia. According to the Kazakh Ministry of Energy and Natural Resources, the country aims to be producing 100 – 105 million tonnes annually by 2015.

The country has more than 400 coal deposits of which a third are classified as brown coal or lignite deposits. Most coal production is sourced from two main basins, the Karaganda Basin, which supplies coking coal from underground mining operations and the Ekibastuz Basin (the third largest coal basin in the FSU) which supplies coal to the power generation sector. Bogatyr Access Komir, LLP is the largest open cast mining company in Kazakhstan.

The Karazhir deposit is one of Kazakhstan's higher grade coal deposits containing more than 1 billion tonnes of reserves, with a large proportion being open pittable. Several foreign companies are investing in some of Kazakhstan's coal industries.

MMRC owns 32.8 % of the Eurasian Energy Corporation, with the remaining 24.3% by the government and the balance as public and corporate shares.

Ispat-Karmet, Kazakhstan's biggest steel producer, operates several coal mines to feed its steelworks, producing just over 7 Mt from the Karaganda region. Another major producer in Kazakhstan, Bogatyr Access Komir, or BAK, which is wholly owned by the US' Access Industries Inc., owns the Bogatyr mine. The mine has a projected capacity of 50 Mt/y.

New Zealand

Proved amount in place (total coal, million tonnes)	2 719
Proved recoverable reserves (total coal, million tonnes)	571
Production (total coal, million tonnes)	4.9

New Zealand has extensive coal resources, mainly in the Waikato and Taranaki regions of the North Island, and the West Coast, Otago and Southland regions of the South Island. Total in situ coal resources are estimated at around 15 billion tonnes, more than half of which is potentially recoverable. New Zealand coal production in 2010 was 5.33 million tonnes (Mt), 17% up from 2009 production of 4.6Mt. Of this production, approximately 2.60Mt was bituminous, some 2.44Mt was sub-bituminous, and approximately 0.295Mt was lignite. Opencast mines supplied 3.98Mt, with the remaining 1.35Mt from underground mines. Production is centred on the Waikato (2.04Mt), the West Coast (2.71Mt), and Otago/Southland (0.54Mt). Over 59% of national production was from two large opencast operations, at Rotowaro and Stockton.

In 2010, New Zealand consumed some 2.7Mt of coal, again down on the usage of the previous year due to reduced coal-fired generation at Huntly (New Zealand's only one coal-fired power station - The use of this had been scaled back in 2007 in favour of gas; however, the plant was pushed into use again by a particularly dry winter in 2008 impacting on hydroelectricity production). Just over 0.25 million tonnes of coal were imported, mainly for use by Genesis for electricity production, with the remainder coming from local production.

Coal supplied around 5% of New Zealand's consumer energy demand. The biggest domestic users are again the Glenbrook steel mill (0.8 Mt) and the Huntly power station (0.6 Mt). Electricity generation (including cogeneration) accounted for 37.5% of domestic coal use and transformation (mainly steel making) accounted for 19%. The industrial sector, mainly cement plants (Golden Bay Cement near Whangarei and Holcim's plant at Westport), lime and plaster, meat, dairy factories (particularly those at Clandeboye in South Canterbury and Edendale in Southland), wool, timber, and pulp and paper products, accounted for 37% of coal use, and the commercial sector - heating accommodation and service buildings in central and local government, hospitals, rest homes, and educational institutions – accounted for 2.5%. The remaining 4% was used by the agricultural, transport, and residential sectors.

Pakistan

Proved amount in place (total coal, million tonnes)	3 451
Proved recoverable reserves (total coal, million tonnes)	2 070
Production (total coal, million tonnes)	3.9

Pakistan's total coal resource is reported as some 185 billion tonnes, within which 'measured reserves' are 3.45 billion tonnes, 'indicated reserves' nearly 12 billion tonnes, 'inferred reserves' 57 billion and 'hypothetical resources' 113 billion. Clearly a high proportion of the quoted total resource has, at this point in time, a relatively low degree of geological assurance, being comprised of inferred reserves (lying within a radius of 1.2 to 4.8 km from a point of coal measurement) and hypothetical resources (undiscovered coal, generally an extension of inferred reserves in which coal lies more than 4.8 km from a point of measurement). A recovery factor of 0.6 has been applied to the measured reserves, resulting in estimated recoverable amounts (in million tonnes) of 166 of sub-bituminous and 1 904 of lignite.

The bulk (around 99%) of Pakistan's huge coal resource, notably the Thar field, is located in the province of Sindh. The economic coal deposits of Pakistan are restricted to Palaeocene and Eocene rock sequences only.

The coals of Pakistan are high in sulphur and ash contents. The moisture percentage is also high in Sindh coal, especially in the Thar coal. The ranks of Pakistani coals range from lignite to high-volatile bituminous. The demonstrated Thar coalfield has the largest resources (over 175 billion tonnes in situ) and out of that about 12 billion tonnes are 'demonstrated reserves' (of which 2.7 billion classed as 'measured'). Small tonnages of indigenous coal are used for electricity generation and by households, but by far the largest portion is used to fire brick kilns.

Poland

Proved amount in place (total coal, million tonnes)	19 274
Proved recoverable reserves (total coal, million tonnes)	5 465
Production (total coal, million tonnes)	130.5

The Polish WEC Member Committee reports that at end-2011 Poland's remaining discovered amount of bituminous coal in place was 17 606 million tonnes, of which 4 178 million tonnes were estimated to be recoverable. The corresponding tonnages for lignite are reported as 1 668 million tonnes in place, of which 1 287 is regarded as recoverable. In both cases the recoverable tonnages relate to established amounts in developed deposits.

The proved amount of hard coal in place is based on a maximum deposit depth of 1 000 m and a minimum seam thickness of 1 m; the corresponding parameters for lignite are a maximum deposit depth of 350 m and minimum seam thickness of 3 m.

Over and above the tonnages quoted above, the Member Committee has advised substantial amounts of both ranks of coal at lower levels of probability, on the basis of a 2009 study. Additional known in situ resources of bituminous grades comprise 26 906 million tonnes classified as 'probable' and 9 193 million tonnes in the 'possible' category, with a further total of some 25.5 billion tonnes potential additional recovery from known resources. Supplementary in situ resources of lignite are reported as 20 995 million tonnes in the 'probable' category and 26 541 million tonnes in the 'possible' category.

Poland's hard coal resources are mainly in the Upper Silesian Basin, which lies in the south-west of the country, straddling the border with the Czech Republic: about 80% of the basin is in Polish territory. Other hard-coal fields are located in the Lower Silesia and Lublin basins. There are a number of lignite deposits in central and western Poland, with four of the larger basins currently being exploited for production, virtually all through surface mining.

The quality of the Upper Silesian hard coals is generally quite high, with relatively low levels of sulphur and ash content. Of Poland's proved reserves of hard coal, 42.5% is reported to be of coking quality.

Although output of hard coal has declined during the past twenty years, and especially since 1997, Poland is still one of the world's major coal producers (see Table 1.3), with a 2008 output of some 84 million tonnes of hard coal and 60 million tonnes of lignite.

Apart from Russia, Poland is the only world-class coal exporter in Europe. However its 2008 exports fell sharply to less than 8 million tonnes, of which steam coal accounted for 80% and coking coal for 20%. Germany, the Czech Republic and Austria were Poland's largest export markets for coal.

About 63% of inland consumption of hard coal goes to the production of electricity and bulk heat, industrial uses account for 24% and residential/commercial/agricultural uses 13%. Almost all lignite production is consumed in CHP plants.

Poland consumes 77 million tonnes of coal per year, which makes it the 10th largest coal consumer in the world and the 2nd largest in the EU, after Germany. 92% of electricity and 89% of heat in Poland is generated from coal and according to the official Polish Government Energy Policy Strategy, coal will remain the key element of the country's energy security until at least 2030.

Although Poland's electricity mix is expected to become more diversified over the coming years, with the first nuclear power plant scheduled for 2022 and rising interest in shale gas exploration, coal is perceived by policy makers as a strategic energy resource for the country's energy security and its consumption is not expected to decline over the next two decades.

According to the "Energy Policy of Poland until 2030" coal is expected to be used as the main fuel for electricity generation. The document envisages a reduction in the energy consumption of the Polish economy and a 19 % share of renewables in total energy consumption by 2020. Nevertheless, electricity consumption in 2030 is expected to increase by 30%, gas consumption by 42% and petroleum products consumption by 7%.

Russian Federation

Proved amount in place (total coal, million tonnes)	194 000
Proved recoverable reserves (total coal, million tonnes)	157 010
Production (total coal, million tonnes)	326.5

The proved amount of coal in place reported for end-1996 comprised 75.8 billion tonnes of bituminous coal, based on a maximum deposit depth of 1 200 m and a minimum seam thickness of 0.6-0.7 m; 113.3 billion tonnes of sub-bituminous grades (at depths of up to 600 m and minimum thickness 1.0-2.0 m); and 11.5 billion tonnes of lignite (at 300 m and 1.5-2.0 m, respectively).

Proved recoverable reserves were reported as just over 49 billion tonnes of bituminous coal,

of which 23% was considered to be surface-mineable and 55% was suitable for coking. Of the 97.5 billion tonnes of proved recoverable reserves of sub-bituminous coal, 74% was suitable for surface mining, while all of the 10.5 billion tonnes of recoverable lignite reserves fell into this category. Overall, about 94 billion tonnes of Russia's proved reserves were deemed to be recoverable by opencast or strip mining.

Russian coal reserves are widely dispersed and occur in a number of major basins. These range from the Moscow Basin in the far west to the eastern end of the Donetsk Basin (most of which is within Ukraine) in the south, the Pechora Basin in the far northeast of European Russia, and the Irkutsk, Kuznetsk, Kansk-Achinsk, Lena, South Yakutia and Tunguska basins extending across Siberia to the Far East.

The principal economic hard coal deposits of Russia are found in the Pechora and Kuznetsk basins. The former, which covers an area of some 90 000 km², has been extensively developed for underground operations, despite the severe climate and the fact that 85% of the basin is under permafrost. The deposits are in relatively close proximity to markets and much of the coal is of good rank, including coking grades. The Kuznetsk Basin, an area of some 26 700 km², lies to the east of the city of Novosibirsk and contains a wide range of coals; the ash content is variable and the sulphur is generally low. Coal is produced from both surface and underground mines.

Lying east of the Kuznetsk and astride the trans-Siberian railway, the Kansk-Achinsk Basin contains huge deposits of brown (sub-bituminous) coal with medium (in some cases, low) ash content and generally low sulphur; large strip-mines are linked to dedicated power stations and carbo-chemical plants. The vast Siberian coal-bearing areas of the Lena and Tunguska basins constitute largely unexplored resources, the commercial exploitation of which would probably be difficult to establish.

From a peak of around 425 million tonnes in 1988, Russia's total coal production declined dramatically following the disintegration of the USSR, reaching a low point of around 232 million tonnes in 1998, since when output has regained an upward trajectory, totalling about 326 million tonnes in 2008.

Serbia

Proved amount in place (total coal, million tonnes)	20 858
Proved recoverable reserves (total coal, million tonnes)	13 411
Production (total coal, million tonnes)	40.7

Serbia has Europe's largest proven deposits of lignite. The Serbian WEC Member Committee reports that the proved amount of coal remaining in place is nearly 21 billion tonnes, of which by far the greater part (98%) is lignite. Within the other ranks, 9 million out of the 22 million tonnes of bituminous coal in place (41%) is deemed to be recoverable, while the corresponding figures for sub-bituminous are 361 million out of 436 million (83%). The recovery factor attributed to the lignite reserves is approximately 66%. Lignite deposits have been assessed to a maximum depth of 380 metres, with a minimum seam thickness of 10.6 metres.

The pattern of Serbia's coal reserves is replicated in its current production levels: lignite (all of which is surface-mined) accounted for nearly 98% of total output. Most of the lignite is used for electricity generation, with minor quantities being briquetted or directly consumed in the industrial and residential sectors.

Lignite production is estimated at around 5.5 Mt and bituminous coal production at around 3.6 Mt. The underground Raspotocje Mine at Zenica is one of the larger mines. Lignite, mined in opencast pits, remains one of the main fuels for power generation within the long-term development plans of EPS. In 2010, total power generation in Serbia reached 35.9 TWh of which 25 TWh was based on lignite (69%).

South Africa

Proved amount in place (total coal, million tonnes)	NA
Proved recoverable reserves (total coal, million tonnes)	30 156
Production (total coal, million tonnes)	251

Assessments of South Africa's coal resources remain a moving target. While a number of surveys (e.g. de Jager, 1983; Bredell, 1987; and later studies by the Minerals Bureau) have attempted to quantify the reserves present in each of South Africa's many coalfields, there is not yet total consensus in respect of the tonnages that are currently economically and technologically recoverable.

The figure of 30 156 million tonnes has been adopted as basis for further calculations, based on advice from an expert South African source. This level is derived from the de Jager report, with the individual coalfield reserves adjusted by subtracting cumulative coal production over the period 1982-2008, and then a view being taken of the mineability of coal in major prospective producing areas, in particular the Waterberg coalfield, but also the Springbok Flats, Limpopo and parts of the Free State coalfields. The net outcome is a total for South Africa's proved recoverable coal reserves that is more than one-third lower than the level reported for the 2007 Survey, but that is arguably more realistic in the present circumstances.

Coal occurs principally in three regions:

1. the shaly Volksrust Formation, which covers most of central and northern Mpumalanga province (formerly the Transvaal). The coal is found in isolated basins and troughs which results in the fields being disconnected and widely separated;
2. the sandy Vryheid Formation of the northern part of the main Karoo basin (northern Free State, northern Kwazulu-Natal and southern Mpumalanga): this generally continuous area is probably the most important economically;
3. the Molteno Formation, which is confined to the north-eastern Cape. It is of minor economic importance compared to other coalfields in South Africa.

Some lignite deposits are known along the Kwazulu-Natal and Cape coasts, but are considered to be of scant economic importance.

Coal occurrences have been divided into 19 separate coalfields, 18 of which are located in an area extending some 600 km from north to south by 500 km from east to west. The Molteno field lies some 300 km south of the main coal-bearing region.

South Africa's coals are generally low in sulphur but high in ash. Beneficiation is essential for export-quality coal. Lower-quality coal is for the local power generation market.

Eskom, the South African electric utility, accounts for about 65% of coal consumption. A further large slice is consumed by the Sasol plants in making synthetic fuels and chemicals from coal. The third main user is the industrial sector, including the iron and steel industry. Coal use in residential and commercial premises is relatively small, while demand by the railways has virtually disappeared.

Coal exports are equivalent to about 27% of South African output and are mainly destined for Europe and Asia/Pacific. The main route for exports is via Richards Bay, Kwazulu-Natal, where there is one of the world's largest coal-export terminals.

Thailand

Proved amount in place (total coal, million tonnes)	2 075
Proved recoverable reserves (total coal, million tonnes)	1 239
Production (total coal, million tonnes)	18

At the end of 2011 Thailand is reported to have proved coal reserves of 1 239 million tonnes. In that same year Thailand had total coal production of 18.0 million tonnes.

Banpu, Thailand's largest coal producer, has entered into a 50:50 joint venture with CLP Powergen Southeast Asia to build a 1,400 MW coal-fired power station at Rayong. The total cost is estimated at USD1.3 billion and Banpu is reported to be seeking to reduce sell off 15-25% of its interest. The company produced 2.5 Mt of lignite in 2003, with sales to the cement industry and power generation utilities.

Thailand is a significant producer of lignite, which is used almost exclusively for power generation. Total national lignite production is around 21 Mt/y. The country currently also imports some 5-6 Mt/y of bituminous coal and some coke for industrial use. The 2,400 MW lignite-fired Mae Moh power plant is the largest source of electricity in the country, generating around 13% of Thailand's electric power production, and also one of the largest point sources of atmospheric pollution in Southeast Asia. The total cost of the project has been estimated at USD1.3 billion, and USD1.1 billion has been received in debt financing from a consortium of financing institutions. Construction began during 2003 and is scheduled for completion in 2006. The project will rely on imported coal. Banpu's mines in Thailand and Indonesia currently have a combined capacity to produce 14.5 Mt/y, with a reserve base of 170 Mt and resources of 139 Mt.

All of Mae Moh's production is consumed by the adjacent power plant (2 625 MW). On the other hand, most of the lignite produced by other Thai mines is used by industry, chiefly in cement manufacture. Imports of bituminous coal are mostly destined for consumption in the iron and steel sector.

Ukraine

Proved amount in place (total coal, million tonnes)	45 164
Proved recoverable reserves (total coal, million tonnes)	33 873
Production (total coal, million tonnes)	59.7

Ukraine holds the 7th largest coal reserves in the world about 34 billion tonnes and 3rd largest anthracite coal reserves – 5.8 billion tones. Most of the country's coal deposits are located in Donbas basin, Eastern Ukraine. In 2010, Ukraine was the 13th largest coal mining country in the world. Out of 82 mmt of coal mined in 2011, steam coal volume amounted to 62% of total output.

The Majority of produced steam coal in Ukraine is consumed domestically for electricity

production. Coal comprised 43.7% of fuel for energy generating companies in 2011, which makes it second most important fuel after nuclear.

Increased demand for steam coal is supported by underutilized capacity of coal-burning TPPs, implementation of pulverized coal injection (PCI) technology at metallurgical plants and increasing export volumes. However, currently Ukraine has a surplus of anthracitic coal, which is mainly exported to Turkey, Bulgaria and Western Europe countries.

Coal production in Ukraine halved over the last 20 years on the back of low demand in the mid-1990s and on a lack of investments into sector's development. Ukraine has a chance to restore former potential implementing successful reforms. In recent years, coal production has increased by 14% – from 72 mmt in 2009 to 82 mmt in 2011 mainly from increased production from private mines. Further increase in mining output is expected after the privatization and modernization of nearly 100 state mines.

Over and above the massive tonnages reported as proved, the WEC Member Committee quoted estimated additional amounts in place totalling more than 11 billion tonnes, with a broadly similar breakdown by rank as for the proved component, and the same implied recovery factor of 75%.

United Kingdom

Proved amount in place (total coal, million tonnes)	386
Proved recoverable reserves (total coal, million tonnes)	228
Production (total coal, million tonnes)	18.1

The country has significant, potentially economic, hard coal resources estimated at 3,000 million tonnes. About 600 million tonnes of reserves are available in existing deep mines or in shallow deposits capable of being extracted by surface mining. In addition, currently inaccessible resources have the potential to provide many years of future production at present levels. There is also about 500 million tonnes of lignite resources, mainly in Northern Ireland, although none is mined or consumed at present.

The UK consumed 64.1 million tonnes of coal in 2012, including 54.9 million tonnes in power stations.

Coal imports to the UK were 44.8 million tonnes, a large increase (+37.7%) on the previous year's amount, mainly as a result of a dramatic increase in electricity generated from coal. Indigenous production was 9.9% less than the previous year at 16.8 million tonnes. (Over the year, 3.0 million tonnes was lifted from stock, compared to 0.8 million tonnes in 2011.)

Coal-fired power stations provided 41% of the UK's electricity (gas 26%, nuclear 20%, others (including renewables) 13%).

Production rose to a peak of nearly 300 million tonnes/yr during World War I and thereafter did not fall below 200 million tonnes/yr until 1960. Output began a long-term decline in the mid-1960s, falling to less than 100 million t/year by 1990.

The UK coal industry was privatised at the end of 1994, with the principal purchaser being RJB Mining (now UK Coal plc), which acquired 16 deep mines from British Coal. There is now virtually no UK production of coking coal..

The decline of the British coal industry has been accompanied by a sharp decrease in economically recoverable reserves. This assessment, and all other UK coal resources/ reserves data reported by the Member Committee, have been supplied by the Coal Authority, the body which regulates the licensing of British coalmines and performs the residual functions of the former British Coal.

The amount of coal in place that hosts the proved recoverable reserves is put at 386 million tonnes, implying an average recovery factor of 0.59. At lower levels of confidence are a 'probable' amount in place of 262 million tonnes, of which 155 is deemed to be recoverable (also with a recovery factor of 0.59), and a 'possible' in situ tonnage of 2 527 million tonnes, of which 1 396 (55%) is classed as recoverable. A further amount of 1 636 million tonnes is reported by the Member Committee as representing potential additional recovery from known resources. The UK's known resources of coal are dwarfed by its undiscovered resources, with nearly 185 billion tonnes estimated to be in place, of which about 41 billion is deemed to be recoverable.

United States of America

Proved amount in place (total coal, million tonnes)	442 414
Proved recoverable reserves (total coal, million tonnes)	237 295
Production (total coal, million tonnes)	1 092

The United States coal resource base is the largest in the world. The US WEC Member Committee last report states a proved amount in place of some 442 billion tonnes (based on the Energy Information Administration's 'Demonstrated Reserve Base'). This total is comprised of 241.6 billion tonnes of bituminous coal (including anthracite) with a maximum deposit depth of 671 m and minimum seam thickness of 0.25 m; 161.8 billion tonnes of sub-bituminous (at up to 305 m depth and 1.52 m minimum seam thickness) and 39.0 billion tonnes of lignite (at up to 61 m depth and 0.76 m minimum seam thickness).

The reported proved recoverable reserves amount to 237.3 billion tonnes, equivalent to about 28% of the global total. They comprise 108.5 billion tonnes of bituminous coal (including anthracite), 98.6 billion tonnes of sub-bituminous and 30.2 billion tonnes of lignite. The overall ratio of proved recoverable reserves to the proved amount in place is 0.54. This ratio varies widely from one rank to another, reflecting relative degrees of accessibility and recoverability: bituminous deposits average 0.45, sub-bituminous 0.61 and lignite 0.77. Open-cast or surface mining techniques can be applied to 27.6% of bituminous reserves, to 42.8% of the sub-bituminous and to 100% of the lignite.

On top of the tonnages summarised above, the US WEC Member Committee reports enormous quantities of coal as inferred resources, being the difference between Remaining Identified Resources and the Demonstrated Reserve Base: in total these come to well over a trillion tonnes, composed of 418 billion tonnes of bituminous, 268 billion sub-bituminous and 391 billion lignite. These estimates are derived from a US Department of the Interior study of coal resources as at 1 January 1974, but are regarded as still providing valid indications of the magnitude of the USA's additional coal resources. Assuming a similar recovery ratio for such resources as for those reported as proved, the US Member Committee estimates the recoverable portion as amounting to some 653 billion tonnes, comprised of 188 bituminous, 163 sub-bituminous and 302 lignite.

Enormous additional (hypothetical) coal resources are also reported. These represent

deposits that extend deeper than the proved amount in place, include thinner beds in some areas, and are based on older source data in many cases. The amounts involved comprise 698 billion tonnes of bituminous coal, 1 036 billion tonnes of sub-bituminous and 296 billion tonnes of lignite, giving a total of some 2 trillion tonnes.

The USA's coal deposits are widely distributed, being found in 38 states and underlying about 13% of the total land area. The Western Region (owing largely to Montana and Wyoming) accounts for about 47% of the EIA's 'Demonstrated Reserve Base', the Interior Region (chiefly Illinois and western Kentucky) for 32% and the Appalachian Region (chiefly West Virginia, Pennsylvania and Ohio) for 21%. Bituminous coal reserves are recorded for 27 states, whereas only 8 states have sub-bituminous reserves, of which 90% are located in Montana and Wyoming, and 10 have lignite reserves, mostly in Montana and Texas.

US coal output is the second highest in the world, after China, and accounted for about 16% of global production. Coal is the USA's largest single source of indigenous primary energy, although running neck-and-neck with natural gas.

Uzbekistan

Proved amount in place (total coal, million tonnes)	3 000
Proved recoverable reserves (total coal, million tonnes)	1 900
Production (total coal, million tonnes)	3.1

Uzbekcoal, the republic's major coal company, quotes Uzbekistan's explored reserves as 1 853 million tonnes of brown coal and 47 million tonnes of black coal. Total coal resources are put at more than 5.7 billion tonnes.

Two coal fields are presently being developed: the Angren brown coal field in the Tashkent region (being exploited by the Uzbekcoal and Apartak companies via open-pit mining) and the Shargun anthracite deposit in the Surkhandarya region. Some bituminous coal is produced from the Baysun field, also in the southern region of Surkhandarya. Reflecting a modernisation programme at Angren, Uzbekistan's lignite production has increased in recent years to over 3 million t/year. According to Uzbekcoal, over 85% of lignite production is consumed by the electric power sector, some after being processed by underground gasification. Bituminous output remains on a very small scale (around 70 000 t/year).

Uzbekistan has listed commercial coal reserves of approximately 3,000 Mt, including 1,000 Mt of bituminous coal. The Angren field contains a proven 1,900 Mt. Uzbekistan's current annual coal requirement is 4 Mt. At present, all of Uzbekistan's coal is produced by JSC Ugol, with over 80% of the production coming from the Angren deposit, situated in the Tashkent oblast. JSC Ugol also has a mining operation at the Shargun mine in the Sukhardaryinskaya oblast. About 70% of Uzbekistan's coal reserves are brown coal/lignite with the remainder bituminous. Coal resources are estimated at over 5 000 Mt, of which 3 000Mt are classified as reserves. Reserves at Angren alone are estimated at over 2 000 Mt, of which most is classified as lignite. Completion of a third mining operation at Baisun could ensure that Uzbekistan has a surplus of coal for export in the future.

Ugol is currently developing two coal deposits, Angren in the Tashkent region and the Shargun pit in Surkhandarya. It is also involved in exploration in the Baisun field in Surkhandarya region.