

## COUNTRY NOTES

The following Country Notes on Coal have been compiled by the Editors, drawing upon a wide variety of material, including information received from WEC Member Committees, national and international publications.

Major international published sources consulted included:

- *Energy Balances of OECD Countries 2003-2004*; 2006; International Energy Agency;
- *Energy Balances of Non-OECD Countries 2003-2004*; 2006; International Energy Agency;
- *Energy Statistics of OECD Countries 2003-2004*; 2006; International Energy Agency;
- *Energy Statistics of Non-OECD Countries 2003-2004*; 2006; International Energy Agency;
- *Quarterly Statistics, Fourth Quarter 2006*; 2007; International Energy Agency;
- *Major coalfields of the world*; June 2000; IEA Coal Research.

### Argentina

Proved amount in place (total coal, million tonnes)	8 051
Proved recoverable reserves (total coal, million tonnes)	424
Production (total coal, million tonnes, 2005)	0.03

The principal coal-mining areas are located in the west of the country along the foothills of the Andes and in the Andes themselves, in the provinces of Catamarca, La Rioja, San Juan, Mendoza, Neuquén, Río Negro, Chubut and Santa Cruz, with smaller coalfields in Córdoba, the centre of Chubut and the Atlantic coast of Santa Cruz.

The biggest coalfield is Río Turbio, located to the west of the city of Río Gallegos in the southern province of Santa Cruz, close to the border with Chile. Río Turbio's coal is a steam coal with low sulphur content (down to 1%), falling into the sub-bituminous rank; it constitutes 99% of the hard coal resources of the country, and supports the only coal extraction activity in the Argentine Republic. The Río Turbio coalfield, including the concession for operating the associated railway and port facilities, was privatised in 1994 but is currently under administration by a Federal auditor.

The Argentinian WEC Member Committee has reported proved amounts in place of 697 million tonnes of sub-bituminous coal and 7 350 million tonnes of lignite, together with a minor quantity (4 million tonnes) of bituminous grade. For sub-

bituminous, the maximum deposit depth is 800 m, with seams ranging from 0.5 to 2.0 m in minimum thickness. The lignite resources are at a maximum depth of 680 m. The only proved recoverable reserves reported are 424 million tonnes of sub-bituminous.

Coal output from the Río Turbio mine is now very modest, at around 30 thousand tonnes per annum, and is used for electricity generation.

### Australia

Proved amount in place (total coal, million tonnes)	97 300
Proved recoverable reserves (total coal, million tonnes)	76 600
Production (total coal, million tonnes, 2005)	378.8

Australia is endowed with very substantial coal resources, with its proved recoverable reserves ranking 4<sup>th</sup> in the world. The major deposits of black coal (bituminous and sub-bituminous) are located in New South Wales and Queensland, especially in the Sydney and Bowen basins; smaller but locally important resources occur in Western Australia, South Australia and Tasmania. The main deposits of brown coal are in Victoria, the only State producing this rank. Other brown coal resources are present in Western Australia, South Australia and Tasmania.

The coal resource data included in the present *Survey* have been derived from *Australia's Identified Mineral Resources 2006*, published by

Geoscience Australia. The proved amount of coal in place (reflecting 'Economic Demonstrated Reserves (EDR)') comprises 55.8 billion tonnes of black coal, (including an estimated 3.3 billion tonnes of sub-bituminous) and 41.5 billion tonnes of brown coal/lignite. Within these tonnages, the proportion deemed to be recoverable ranges from 39.2 billion tonnes (70%) of the bituminous coal to 90%, 37.4 billion tonnes of the lignite. A little over half of the recoverable bituminous, and all of the recoverable lignite, are 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 108 billion tonnes, of which 68 billion tonnes is estimated to be recoverable. Comparable figures for brown coal are 174 billion tonnes and 156 billion tonnes, respectively.

For a variety of reasons (e.g. environmental restrictions, government policies, military lands), not all of the tonnages classified as EDR are currently accessible: black coal reserves are only slightly affected, but the 'Accessible EDR' of brown coal are put at 30 billion tonnes, significantly lower than the quoted level of EDR, although still massive in tonnage terms.

In 2005 Australia produced 308 million tonnes of saleable black coal (bituminous and sub-bituminous) and 71 million tonnes of brown coal. The major domestic market for black coal is electricity generation: in 2004, power stations accounted for 85% of total black coal consumption, with the other major consumer being the iron and steel industry. Brown coal is used almost entirely for power generation.

Australia has been the world's largest exporter of hard coal since 1984: in 2005, it exported 233 million tonnes. About 54% of 2005 exports were of metallurgical grade (coking coal), destined largely for Japan, the Republic of Korea, India and Europe.

### Botswana

Proved recoverable reserves (total coal, million tonnes)	40
Production (total coal, million tonnes, 2005)	1.0

Vast deposits of bituminous coal have been located in Botswana, principally in the eastern part of the country. The only mine to have been developed so far is at Morupule, near the town of Palapye, where Morupule Colliery Limited (controlled by Anglo American Corporation) commenced coal extraction in 1973.

For the present *Survey*, the resource data reported for the 2004 edition by the Botswana WEC Member Committee have been retained. Proved recoverable reserves were given as 40 million tonnes, of which 50% could be mined by

open-cast methods. The reported tonnages related solely to the economically recoverable reserves that were being exploited at the Morupule Mine. With cumulative output to the end of 2005 amounting to some 20 million tonnes, Botswana's remaining proved amount of coal in place was reported to be 3 340 million tonnes.

All of Botswana's current coal production (985 thousand tonnes in 2005) is of power generation quality, none of coking quality. The Morupule mine's chief customers are the Botswana Power Corporation, the copper/nickel mine at Selibe-Phikwe and the soda ash plant at Sua Pan. The BPC power station at Morupule (net capacity 118 MW) generates about half of Botswana's electricity supplies, the balance being provided by imports from South Africa.

### Brazil

Proved amount in place (total coal, million tonnes)	17 017
Proved recoverable reserves (total coal, million tonnes)	7 068
Production (total coal, million tonnes, 2005)	6.3

Brazil has considerable reserves of subbituminous coal, mostly located in the southern states of Rio Grande do Sul, Santa Catarina and Paraná.

For the present *Survey*, the Brazilian WEC Member Committee has reported a virtually unchanged level for the proved amount in place,

at just over 17 billion tonnes, of which almost 42% is categorised as proved recoverable reserves. The maximum depth of the deposits is 870 m, whilst the minimum seam thickness is 0.5 m. There is estimated to be some 15.3 billion tonnes of additional coal in place, of which 50% is considered to be recoverable.

With respect to the stated level of proved recoverable reserves, it is estimated that 21% could be exploited through surface mining, and that 7% is considered to be of coking quality. In 2005, 65% of Brazilian coal production was obtained by surface mining.

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

#### Canada

Proved amount in place (total coal, million tonnes)	8 723
Proved recoverable reserves (total coal, million tonnes)	6 578
Production (total coal, million tonnes, 2005)	67.5

Canada has considerable coal resources, with proved reserves, according to the Geological Survey of Canada (GSC), of about 6.6 billion tonnes. Bituminous coals (including anthracite) are evaluated as 3.5 billion tonnes, sub-

bituminous grades are put at approximately 0.9 billion tonnes; and lignite at 2.2 billion tonnes.

Estimates of the tonnages of coal that are considered to be additional to the 'proved' amounts of each rank total almost 190 billion tonnes. While these figures are approximate, they do serve to underline Canada's large coal endowment.

Canadian coal reserves are mainly located in the western provinces of Saskatchewan, Alberta and British Columbia, with smaller deposits in the eastern provinces of Nova Scotia and New Brunswick. Bituminous deposits are found in the two eastern provinces together with Alberta and British Columbia; Alberta also possesses sub-bituminous grades, while lignite deposits are found only in Saskatchewan.

Western Canada dominates coal production, accounting for over 95% of the total. Alberta is the largest coal-producing province, mainly of thermal grades. British Columbia is the second largest, producing mainly metallurgical coals. Saskatchewan produces lignite. About 40% of Canadian coal production, principally metallurgical, is exported.

Around 90% of Canadian coal consumption is used for electricity generation, 7% in the steel industry and 3% 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 recoverable reserves (total coal, million tonnes)	114 500
Production (total coal, million tonnes, 2005)	2 190.0

China is a major force in world coal, standing in the front rank in terms of reserves, production and consumption. 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. The level of proved reserves retained for the present *Survey* implies a coal R/P ratio of 52, on the basis of 2005 production.

It is interesting to note that the same figure (114.5 billion tonnes) for total proved reserves 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, indicates a degree of continuity in the official assessments of China's coal reserves and supports the retention of the level originally advised by the Chinese WEC Member Committee in 1991.

Information received in mid-2007 in a private communication from an expert Chinese source confirms a level of approximately 1 000 billion tonnes for China's 'demonstrated' or 'explored' reserves, including all grades from proved to prospective, on an in-situ basis.

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.

After more than 20 years of almost uninterrupted growth, China's coal production peaked at nearly 1.4 billion tonnes in 1996, followed by 4 years during which output was constrained by the closure of many small local mining operations. Annual output has followed a steep upward path since 2002 and reached a new peak in 2005. By far the greater part of output is of bituminous coal: lignite constitutes only about 3%.

The major coal-consuming sectors are power stations (including CHP), which accounted for 56% of total consumption in 2004, the iron and steel industry with a 17% share, and other industrial users with about 21%.

Coal exports have fallen back sharply in recent years, dropping from 95 million tonnes in 2003

to 87 million in 2004 and 72 in 2005: data for the first three quarters of 2006 indicate a continued decline.

### Colombia

Proved recoverable reserves (total coal, million tonnes)	6 959
Production (total coal, million tonnes, 2005)	59.1

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, 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 *Survey*, proved recoverable reserves have been based on this level, adjusted for cumulative coal production in 2004 and 2005. 'Indicated reserves' quoted in the same publication are 4 572 million tonnes, whilst 'inferred' tonnages are 4 237 million and 'hypothetical' resources 1 120 million.

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, are shown under sub-bituminous in Table 1-1.

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. In October 1975 the Government opened international bidding for the development of El Cerrejón-North Zone reserves and in December 1976 Carbocol (then 100% owned by the Colombian State) and Intercor (an Exxon affiliate) entered into an Association Contract for the development and mining of the North Zone. The contract has three phases and covers a 33-year period with the production phase scheduled to end early in 2009.

Carbocol was privatised in October 2000, the purchasers being a consortium of Anglo-American, Billiton and Glencore; in early 2002 the three partners acquired the whole of Intercor's interest.

Coal exports from Colombia totalled 55 million tonnes in 2005, equivalent to over 90% of its coal production. Cerrejón North remains one of the world's largest export mines.

### Czech Republic

Proved amount in place (total coal, million tonnes)	8 808
Proved recoverable reserves (total coal, million tonnes)	4 501
Production (total coal, million tonnes, 2005)	62.0

The Czech Republic possesses sizeable coal resources, with a proved amount in place of nearly 9 billion tonnes, of which just over half is reported to be economically recoverable. In terms of rank, 37% of the proved reserves are classified as bituminous, 58% as sub-bituminous and 5% as lignite. The tonnages reported by the Czech WEC Member Committee for the present *Survey* show fairly considerable changes from those advised for the 2004 *Survey* in 2003: a 19-20% decline in proved reserves of both bituminous and sub-bituminous, and an overall 9% fall in the proved amount of coal in place, with bituminous dropping 18% and sub-bituminous increasing by 19%. The maximum depth of deposits varies from 1 600 m in the case of bituminous to 500 m for sub-bituminous and only 130 m for lignite; minimum seam thicknesses range from 0.6 (for bituminous) to 1.5 (lignite) and 2.0 m for sub-bituminous.

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.

Since 1990, Czech output of bituminous coal has fallen by 41%, to 13.3 million tonnes in 2005, whilst sub-bituminous/lignite has declined by 39%, from 80 million tonnes in 1990 to 48.8 million tonnes in 2005. Over half of the republic's

bituminous coal production consists of coking coal. In 2004, total exports of coal amounted to 6.7 million tonnes, equivalent to nearly 11% of production.

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 sub-bituminous coal, which is still the main power station fuel.

### Germany

Proved amount in place (total coal, million tonnes)	7 455
Proved recoverable reserves (total coal, million tonnes)	6 708
Production (total coal, million tonnes, 2005)	202.8

The German Federal Institute for Geosciences and Natural Resources (BGR) has reported coal reserves on behalf of the German WEC Member Committee. Proved recoverable reserves are given as 6 708 million tonnes, most 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 2012, there being no clear governmental position (in particular, re financing) regarding output after 2012. The proved amount in place is also based on BGR

data; 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.

BGR's category 'resources' (using its own definition, which differs from WEC usage) amounts to around 8.4 billion tonnes of hard coal and 76.4 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.

Germany's output of hard coal has fallen from 76.6 million tonnes in 1990 to 24.9 million tonnes in 2005, whilst lignite production has virtually halved, from 357.5 to 177.9 million tonnes over the same period. Germany is still the world's largest lignite producer.

The Ruhr coalfield produces over three-quarters of German hard coal. The coal qualities range from anthracite to high-volatile, strongly-caking bituminous coal. The Saar is the second largest coalfield, 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 Rhine region is the largest single formation in Europe. In the former East Germany there are major deposits of lignite at Halle Leipzig and Lower Lausitz; these have considerable domestic importance.

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 tonnes in 2004) is converted into brown coal briquettes for the industrial, residential and commercial markets.

### Greece

Proved recoverable reserves (total coal, million tonnes)	3 900
Production (total coal, million tonnes, 2005)	70.6

Coal resources are all in the form of lignite. 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 2005, LCPA produced 55.45 million tonnes of lignite, LCM 14.44 million tonnes.

A new 330 MW lignite-fired power station at Florina in Western Macedonia came into operation in June 2003. In the lignite-mining areas, there are now 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 5<sup>th</sup> largest in the world.

#### India

Proved amount in place (total coal, million tonnes)	100 124
Proved recoverable reserves (total coal, million tonnes)	56 498
Production (total coal, million tonnes, 2005)	428.4

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 north-east: 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, in addition to 95.9 billion tonnes of 'proved resources' of bituminous coal, there are 119.8 billion tonnes of 'indicated resources' and 37.7 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.

The Indian WEC Member Committee reports proved recoverable reserves as 52 240 million tonnes of bituminous coal at end-2005 and 4 258 million tonnes of lignite at end-2004.

Lignite deposits mostly occur in the southern State of Tamil Nadu. India's geological

resources of lignite are estimated to be some 36 billion tonnes, of which about 2.4 billion tonnes in the Neyveli area of Tamil Nadu are regarded as 'mineable under the presently adopted mining parameters'. Annual production of lignite is currently in the region of 31 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 (around 20 million tonnes/yr of coking coal and 17 million tonnes/yr of steam coal) 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)	12 466
Proved recoverable reserves (total coal, million tonnes)	4 328
Production (total coal, million tonnes, 2005)	152.2

Indonesia possesses very substantial coal resources: according to the data reported by the Indonesian WEC Member Committee for the purpose of this *Survey*, the proved amount in place is nearly 12.5 billion tonnes, within which proved recoverable reserves amount to around 4.3 billion tonnes. Sub-bituminous coals account for 40% of the tonnage in place, with lignite 32% and bituminous grades 28%. On a proved recoverable basis, however, bituminous and sub-bituminous each has a share of around 40%.

The Member Committee also reports an estimated additional amount in place of 44.7 billion tonnes, within which 6.0 is classified as bituminous, 27.6 as sub-bituminous and 11.1 as lignite.

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 2005, 108 million tonnes were shipped overseas, representing 71% of total coal output. Asian customers take a large part of Indonesia's coal exports.

Within Indonesia, coal's main market is power generation, which accounted for 63% of internal consumption in 2004.

### Kazakhstan

Proved recoverable reserves (total coal, million tonnes)	31 300
Production (total coal, million tonnes, 2005)	86.6

Reported recoverable reserves of some 31 billion tonnes indicate that Kazakhstan has the third largest coal endowment in Asia. Most of these reserves are said to consist of anthracitic and bituminous grades. In the absence of any further data, lignite has, for the purpose of this *Survey*, been assumed to represent 10% of the republic's total proved reserves.

The major coal-producing areas are the Karaganda Basin towards the centre of the country and the Ekibastuz Basin in the northern province of Pavlodar. Bogatyr Access Komir, Kazakhstan's largest coal producer, is developing the Bogatyr and Severny fields in the latter basin.

Total national output of coal exhibited a declining trend after independence in 1991, but has recovered some lost ground since the turn of the century. Production in 2005 was 86.6 million tonnes, marginally less than in 2004, with hard coal grades accounting for some 95%. Kazakhstan is a major coal exporter (26 million tonnes in 2004), 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.

### Pakistan

Proved amount in place (total coal, million tonnes)	3 303
Proved recoverable reserves (total coal, million tonnes)	1 982
Production (total coal, million tonnes, 2005)	4.6

At the request of the Pakistan WEC Member Committee, the Geological Survey of Pakistan (GSP) has provided details of coal resources and reserves as at 30 June 2005 (detailed data on reserves/resources 'as on June 30, 2006' issued by the GSP are unchanged from the year before). The total resource is put at more than 186 billion tonnes, within which 'measured reserves' are 3.3 billion tonnes, 'indicated reserves' about 12 billion tonnes, 'inferred reserves' 56 billion and 'hypothetical resources' 114 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 1 bituminous, 167 sub-bituminous and 1 814 lignite.

The WEC Member Committee reports that the bulk (around 98%) of Pakistan's huge coal

resource is found in Sindh Province, in particular the Thar coalfield. 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 rank of Pakistani coals ranges from lignite to high-volatile bituminous. The demonstrated Thar coalfield has the largest resources (over 175 billion tonnes) and out of that about 12 billion tonnes are 'demonstrated reserves' (2.7 billion 'measured' and about 9.3 billion 'indicated'). The documented production of coal is 4.59 million tonnes for the year 2005.

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. Just over 1 million tonnes of Australian coking coal is imported each year for use in the iron and steel industry.

### Poland

Proved amount in place (total coal, million tonnes)	17 169
Proved recoverable reserves (total coal, million tonnes)	7 502
Production (total coal, million tonnes, 2005)	159.5

The Polish WEC Member Committee has been able to provide revised coal resource assessments, of improved relevance. The proved amounts in place and the corresponding

tonnages recoverable now refer solely to those in 'developed deposits', rather than being based on ultimately recoverable amounts.

The latest figures show the proved amount of hard coal in place in 'developed deposits' as 15.3 billion tonnes, on the basis of a maximum deposit depth of 1 000 m and a minimum seam thickness of 1 m; the corresponding level for lignite is about 1.9 billion tonnes, at a maximum deposit depth of 350 m and minimum seam thickness of 3 m. Proved recoverable reserves in such developed deposits consist of 6 billion tonnes of hard coal and 1.5 billion tonnes of lignite.

The estimated additional amounts in place have been derived from Poland's total geological resources of coal (called in Polish terminology 'documented geological resources - category A, B and C'), by deducting the in-place and recoverable amounts in developed deposits specified in the previous paragraph, and adding on forecast additional resources of coal, which are in unexplored extensions of known deposits below 1 000 m and inferred amounts estimated on the results of geological information. The resulting additional tonnages are around 27 billion tonnes of hard coal and 12 billion tonnes of lignite.

Poland's hard coal resources are mainly in the Upper Silesian Basin, which lies in the southwest 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.

The quality of the Upper Silesian hard coals is generally quite high, with relatively low levels of sulphur and ash content. One-third of Poland's proved reserves of hard coal are regarded as of coking quality.

Although output of hard coal has declined during the past 17 years, and especially since 1997, Poland is still one of the world's major coal producers (see Table 1-3), with a 2005 output of 98 million tonnes of hard coal and 62 million tonnes of lignite. The decline in hard coal production reflects a deep restructuring of the industry, with the aim of eliminating the non-profitable mines by a reduction in excess production potential, substantially lower employment levels, elimination of government subsidies, etc.

Apart from Russia, Poland is the only world-class coal exporter in Europe: its total exports in 2005 were nearly 21 million tonnes, of which steam coal accounted for 84% and coking for 16%. Germany, Austria, the United Kingdom and France are currently Poland's largest export markets for coal.

About 64% 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 12%. Almost all lignite production is used for base-load electricity generation.

### 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, 2005)	299.3

The only data on coal resources that the Russian WEC Member Committee was able to provide for the present *Survey of Energy Resources* is based on information released by the Ministry of Natural Resources in May 2006: 'discovered' reserves of 194 billion tonnes, which are equated with the proved amount in place of all ranks of coal, and 'balance' reserves of more than 200 billion tonnes, which are taken to correspond with the additional amount in place. As the WEC Member Committee has been unable to obtain any more coal resource data, for reasons of confidentiality, the levels adopted for proved recoverable reserves in the present instance are unchanged from those given for end-1996 in the 1998 *Survey of Energy Resources*,

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 Donets 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 km<sup>2</sup>, 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 km<sup>2</sup>, 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, attaining almost 300 million tonnes in 2005. In 2004, around 70% of Russian consumption was accounted for by power stations and district heating plants; the iron and steel industry and the residential sector were the other main centres of coal usage.

### Serbia

Proved amount in place (total coal, million tonnes)	21 176
Proved recoverable reserves (total coal, million tonnes)	13 885
Production (total coal, million tonnes, 2005)	35.0

Serbia has Europe's largest proven deposits of lignite. The Serbian WEC Member Committee

reports that the proved amount of coal in place is over 21 billion tonnes, of which by far the greater part (97%) is lignite. Within the other ranks, 6 million out of the 27 million tonnes of bituminous coal in place (22%) is deemed to be recoverable, while the corresponding figures for sub-bituminous are 379 million out of 571 million (66%). The recovery factor attributed to the lignite reserves is also approximately 66%.

The pattern of Serbia's coal reserves is replicated in current production levels: lignite (all of which surface-mined) accounted for more than 98% of total output in 2005. Most of the lignite is used for electricity generation, with minor quantities being briquetted or directly consumed in the industrial and residential sectors.

### South Africa

Proved amount in place (total coal, million tonnes)	115 000
Proved recoverable reserves (total coal, million tonnes)	48 000
Production (total coal, million tonnes, 2005)	245.0

The South African WEC Member Committee has reported coal resources for the present *Survey* based on an assessment published in 1987, adjusted for cumulative production; they thus differ only marginally from those reported for the 2004 *Survey*.

The proved amount in place relates to a maximum deposit depth of 350 m and a

minimum seam thickness of 1 m. The reserve is based on a previous study by the Geological Survey of South Africa (now the Council for Geoscience), completed in 1972 but not published until 1987. While there have been later recalculations of the reserve, these are not yet finalised. If the re-evaluations are found to be correct, the current proved recoverable reserves would be 31 022 mt. However, it is known that significant resources in the Waterberg coal field need to be evaluated and redefined as reserves. These are included as reserves in the 48 000 mt given above but excluded from the figure of 31 022 mt.

The South African Department of Minerals and Energy has initiated a comprehensive survey to re-evaluate the reserve but no report has yet been issued. No information is available as to the progress of the study. What is clear is that South African reserves require an urgent and comprehensive re-evaluation. Alternative exploitation techniques (such as in-situ gasification) may open up currently non-economic resources and thus change the reserve base.

Coal occurs principally in three regions:

- 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;
- 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;
- 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 60% 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 30% 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)	2 056
Proved recoverable reserves (total coal, million tonnes)	1 354
Production (total coal, million tonnes, 2005)	21.4

Thailand has sizeable resources of lignite, notably at Mae Moh in the north of the country. For the 2004 SER, the Thai WEC Member Committee reported proved recoverable reserves of 1 354 million tonnes; the maximum deposit depth taken into consideration was approximately 700 m, while the minimum seam thickness was 0.30 m. In respect of the present *Survey*, the Member Committee has reported a proved amount in place for lignite of 2 056 million tonnes, and an estimated additional amount in place of 2 857 million tonnes.

The 2005 edition of the annual publication *Thailand Energy Situation*, issued by the Department of Energy Development and Promotion, quotes total lignite reserves as 2 870 million tonnes. In this context, the reserves are defined as including 'the remaining reserve from produced area as well as the measured and indicated reserve from undeveloped area'.

Annual output of lignite increased by almost 90% between 1990 and 1997, but has since levelled off. All of Mae Moh's production is consumed by the Mae Moh 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, 2005)	78.4

Ukraine's coal endowment is one of the largest in Europe. The WEC Member Committee for Ukraine reports that the proved amount of coal in place exceeds 45 billion tonnes, of which 45% ranks as bituminous, 49% as sub-bituminous and about 6% as lignite. The reported mining parameters associated with these resource assessments are (respectively) maximum depths of 1 800, 1 800 and 400 metres, and minimum seam thicknesses of 0.55, 0.60 and 2.7 metres.

A recovery factor of 75% is attributed to all three ranks, implying proved recoverable reserves of some 15 billion tonnes of bituminous, 17 billion of sub-bituminous and 2 billion of lignite. Most of the bituminous and sub-bituminous deposits are located in the Donets Basin in eastern Ukraine.

Over and above the massive tonnages reported as proved, the WEC Member Committee quotes 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%.

Coal production in 2005 is reported by the Ministry of Coal Industry as just over 78 million tonnes, but without a breakdown by rank. The principal outlets for Ukrainian coal are the iron and steel industry (51% in 2004) and power stations (37%).

### United Kingdom

Proved recoverable reserves (total coal, million tonnes)	155
Production (total coal, million tonnes, 2005)	20.5

Coal deposits are widely distributed and for many years the UK was one of the world's largest coal producers, and by far its largest exporter. 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 tonnes/yr by 1990. Reflecting continued competition from natural gas and imported coal, UK coal production sank to just over 20 million tonnes in 2005, including coal/slurry recovered from non-mine sources such as dumps, ponds, rivers, etc.

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. At 31 March 2006 there were 7 major deep mines, 5 smaller deep mines and 35 open-cast sites in production. Deep-mined coal output in 2005 was 9.56 million tonnes and open-cast sites produced 10.45 million tonnes – the first year that the output from UK deep mines had fallen below that of open-cast sites. Production from slurry etc. amounted to 0.49 million tonnes. There is now virtually no UK production of coking coal – output in 2005 was only 274 000 tonnes.

The decline of the British coal industry has been accompanied by a sharp decrease in economically recoverable reserves. The figure reported by the United Kingdom WEC Member Committee for the purpose of the present *Survey* is 155 million tonnes, reflecting the 2006 level (comprising 110 in deep mines and 45 in surface mines), quoted in Chapter 4 of *The Energy Challenge: Energy Review Report 2006*, published by the UK Department of Trade and Industry in July 2006. The DTI figures are described as 'estimates of deep and surface mine reserves identified in reviews commissioned by DTI in 1998-2004 adjusted to reflect subsequent mine closures and production and the uprating of newly proved reserves at ongoing mines'. The report goes on to say that 'in addition to this, there is thought to be in the order of 400 million tonnes of recoverable coal at other prospects, most of which would require either new mine developments or significant investment at existing or former mines'.

The coal resources of the UK are, of course, considerably larger than the comparatively modest levels of recoverable reserves quoted for existing deep mines and opencast sites. The Coal Authority, the body responsible for directing the British coal industry, has indicated that in 2005 coal resources at existing deep mines and existing, planned and known potential surface-mining sites were in the order of 900 million tonnes, with approximately one-third in deep mines and two-thirds at surface-mining sites. Additional recoverable tonnages considered to be potentially available from new or expanded deep-mining operations amounted to almost 1.4 billion tonnes.

The Government White Paper, *Meeting the Energy Challenge* (May 2007) states that, 'Making the best use of UK energy resources, including coal reserves, where it is economically viable and environmentally acceptable to do so contributes to our security of supply goals. The Government believes that these factors reflect a value in maintaining access to economically recoverable reserves of coal'.

#### United States of America

Proved amount in place (total coal, million tonnes)	447 183
Proved recoverable reserves (total coal, million tonnes)	242 721
Production (total coal, million tonnes, 2005)	1 038.6

The United States coal resource base is the largest in the world. The US WEC Member

Committee reports a proved amount in place at 1 January 2006 of some 447 billion tonnes (based on the Energy Information Administration's 'Demonstrated Reserve Base'). This total is comprised of 244.3 billion tonnes of bituminous coal (including anthracite) with a maximum deposit depth of 671 m and minimum seam thickness of 0.25 m; 163.6 billion tonnes of sub-bituminous (at up to 305 m depth and 1.52 m minimum seam thickness) and 39.3 billion tonnes of lignite (at up to 61 m depth and 0.76 m minimum seam thickness).

The reported proved recoverable reserves amount to 242.7 billion tonnes, equivalent to about 29% of the global total. They comprise 112.3 billion tonnes of bituminous coal (including anthracite), 100 billion tonnes of sub-bituminous and 30.4 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 0.46, sub-bituminous 0.61 and lignite 0.77. Open-cast or surface mining techniques can be applied to 27% of bituminous reserves, to 43.4% of the sub-bituminous and to 100% of the lignite.

Data for proved amount in place and recoverable reserves are measured and indicated (proved and probable), in a commingled data base. The data cannot be separated into 'proved only' and 'probable only'.

On top of the tonnages summarised above, the US WEC Member Committee reports enormous

quantities of coal as 'estimated additional amounts in place': in total these come to well over a trillion tonnes, composed of 445 billion tonnes of bituminous, 274 billion sub-bituminous and 394 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. Data on the estimated additional amount in place are primarily inferred. These resources 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 estimated additional amount in place has been adjusted only to indicate the arithmetic difference with proved amount in place.

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 18% of global production in 2005. Included in the USA's 2005 coal production of 1 038.6 million

tonnes is 12.1 million tonnes of recovered waste coal. Coal is the USA's largest single source of indigenous primary energy; power stations, CHP and heat plants accounted for 82% of domestic coal consumption in 2004. Coal exports amounted to 45 million tonnes in 2005: the USA remains a leading supplier of coking coal and other bituminous grades.

### Uzbekistan

Proved recoverable reserves (total coal, million tonnes)	3 000
Production (total coal, million tonnes, 2005)	3.2

Most of the republic's coal resources are classed as brown coal or lignite. Uzbek sources quote the proved (sometimes referred to as 'commercial') coal reserves as approximately 3 billion tonnes, of which 1 billion is classed as bituminous (or 'fossil') coal.

Two lignite fields are presently being developed: the Angren strip-mine in the Tashkent region and the Shargun 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, exceeding 3 million tonnes in 2005. Bituminous output remains on a very small scale (around 70 000 tpa). In 2004, about 82% of lignite production was consumed in power stations and CHP/heat plants.