Coal is the largest and most widespread fossil fuel resource providing 23% of the world’s energy. However, widespread concern about environmental emissions from coal has started to limit the growth in use of this important energy source.

What is Coal?

HOW COAL IS FORMED

Coal is a combustible carbonaceous rock, formed from accumulated vegetable matter that has been altered by decay and various amounts of heat and pressure over millions of years. Inter-layered with other sedimentary rocks, it forms beds ranging from less than a millimetre to many metres thick known as seams. It is classified by rank, which is a measure of the amount of alteration it has undergone during formation. Consecutive stages in evolution of rank, from the initial peat stage are: brown coal (lignite), sub-bituminous coal, bituminous coal, and anthracite.

Sub-bituminous coal, bituminous coal and anthracite are together known as black coal or hard coal. Brown coal (lignite) is a relatively soft material that has a heating value only about one-quarter that of black coal. It has lower carbon content and higher moisture content than black coal.

CHEMICAL COMPOSITION OF COAL

Coal varies widely in its composition. It is composed chiefly of rings of six carbon atoms joined together in an extremely complex composition of layered arrangements that have in them, not only hydrogen but significant amounts of oxygen and nitrogen. The structure also includes varying amounts of sulphur and other environmental pollutants. Up to one tenth of the total mass of coal can be material with no fuel value.

Coal is usually analysed for moisture, volatile matter fixed carbon and ash (proximate analysis - Figure 1). The sulphur and nitrogen content are important as emissions of their chemical oxides during coal burning can cause acid rain. Uncontrolled emissions resulted in widespread damage to forests and lakes in Europe, the USA and Canada in the 1960s.
COMBUSTION PROPERTIES

The combustion of coal is a more complex process than that of oil or gas. It can best be described as a series of processes:

- All coal contains some moisture. During the early stages of combustion this moisture is evaporated using some of the coal's energy in doing so.

- As the temperature increases, a range of gases including carbon monoxide, methane, and a variety of hydrocarbons, is given off from the coal. However, all of these gases are fuels and carry as much as
half of the energy of the coal. They comprise the volatile matter which can be captured and used.

- The remaining fixed carbon is effectively charcoal and burns with oxygen from the air to create carbon dioxide; and
- With all the fuel burnt out, anything left over is ash.

**Coal Mining**

Coal mining has been carried out for over a thousand years, but only on a large scale since the 18th century. Coal is mined by two main methods - surface or open-cut mining and underground or 'deep' mining. There are two main methods of underground mining: 'room-and-pillar' and 'longwall' mining.

With the room-and-pillar approach, coal is mined by cutting a network of 'rooms' into the coal seam and leaving behind 'pillars' of coal. Recovery rates are about 50% to 60%. The longwall approach uses mechanical shearsers to cut and remove the coal at the face (100m to 250m in breadth). Self advancing hydraulically powered supports temporarily hold up the roof while the coal is extracted. The roof area behind the face is then allowed to collapse. Recovery rates are over 75%.

Surface mining is economical only when the seam is near the surface. It recovers a higher proportion of the coal than underground methods but degrades the value of the land for subsequent uses.

**Coal Processing**

Black coal may be used without any serious processing: other than crushing and screening to reduce the rock to a useable and consistent size. However, it is often washed to remove pieces of rock or mineral that may be present. Washing reduces ash and improves the overall quality of the coal.

Coking coal is heated in the absence of air to produce gases and coke. Coal can also be further processed to produce oil and petroleum products.

**Coal Resources and Production and Consumption**

The amount of coal produced is usually measured in tonnes. Because the energy content of coal varies so widely (Figure 1) global and national production figures are sometimes stated in energy units such as million tonnes of oil equivalent (mtoe) or Petajoules.

**GLOBAL RESOURCES**

There is much more coal than any other fossil fuel. The World Energy Council listed the proven recoverable reserves of coal in 1999 at around one million million tonnes. This is enough to sustain present production for more than 200 years.
Coal is more evenly distributed around the world than is oil or gas (Figure 2) although there is very little in South America and virtually none in the Middle East.

Nevertheless, the top ten countries (see Figure 3) accounted for 95% of the reserves of bituminous coal – which was equal to 53% of total coal reserves. These same ten countries also held over 85% of the sub-bituminous and lignite reserves. In total, these top ten countries on a reserves basis held just over 90% of the total reported coal reserves at the end of 1999.

GLOBAL COAL PRODUCTION

There has been a slow and steady rise in the use of coal in the last 28 years with a total increase of around 56%. By 2002 the USA and the People’s Republic of China together accounted for almost half the coal
produced in the world. Chinese coal production is growing fast with a doubling over the last 20 years. The production of coal from the former USSR has decreased over the same period.

Australia is by far the world’s biggest coal exporter accounting for some 30% of the trade. The biggest importers are Japan, Korea and Chinese Taipei.

**AUSTRALIAN COAL PRODUCTION AND CONSUMPTION**

Coal supplies approximately one third of Australia's energy needs, with black coal providing the bulk of this. New South Wales and Queensland produce 95% of the total production of raw black coal (345 Mt in 2001-2002). After processing, 272 Mt of metallurgical and thermal black coal were available for both domestic use and export. Brown coal or lignite (around 66 Mt/annum) is mined in Victoria for use in electricity generation. Western Australia and South Australia have considerable reserves of sub-bituminous coal, which is suitable for local electricity generation and industrial uses but is not exported.

Black coal is Australia’s largest commodity export with a value of around $13.5 billion in 2001-2002. It represented around 25 per cent of Australia's mineral and energy exports ($54.7 billion) and just over 11 per cent of total Australian merchandise exports ($121.2 billion) (Australian Coal Association).

Coal accounts for about 75% of Australia’s electricity generation (Figure 4) with black coal accounting for about 50% of this.

![Fuel use in thermal electricity generation in Australia](image)

*Figure 4.* Fuel use in thermal electricity generation in Australia.
(From Australian Energy News, April 1997)

While there is growing concern about the greenhouse gas emissions generated by coal burning, coal remains the most available fossil fuel source.
**Uses of Coal**

The major use of coal is for generating electricity in power stations. Coal used for this purpose is called steaming coal. Some types of black coal are suitable for coke-making and are known as coking coals. Coke is a porous solid composed mainly of carbon and ash and is used mainly in blast furnaces that produce steel. Black coal is also used as a heat source in the manufacture of cement and in mineral and food processing.

Many chemicals, including tars and feedstock for making various plastics, can be prepared from the by-products of coke and gas production. Some coal is used primarily to make these products.

![Figure 5. Global uses of coal in 1997](from Power for Progress 4th Ed, World Coal Institute)

**Coal and the Environment**

The key environmental challenges facing the coal industry are related to both coal mining and the use of coal. These issues, which can be both local and global in their impacts, include:

- Greenhouse gas emissions;
- Acid rain, ground level ozone and other toxic emissions;
- Disturbance of land and the local environment by coal mining;
- Acid mine drainage; and
- Waste and waste disposal.

The coal industry is striving to minimise its environmental footprint. In developed countries there are strict environmental and health and safety
laws. Since 1980 global emissions of sulphur dioxide have halved in spite of an increase in the amount of coal burnt. This is because of the introduction of flue gas desulphurisation and greater use of lower sulphur coal. Australian coal is generally low in sulphur.

Reducing emissions can be expensive. Developing countries, where there may be a huge demand for cheap electricity together with shortage of capital and few environmental laws, may need help to reduce their emissions. Coal burning produces more carbon dioxide per unit of energy than other fossil fuels. Much research effort is being put into methods of capturing this gas and storing it underground in a process referred to as carbon geosequestration. Viable methods for doing this have not yet been found.

Abbreviations

Mj – mega joules
Mj/kg – megajoules per kilogram
Mt – million tonnes
PJ – petajoules

References

Australian Energy News April 1997

For More Information

RE-Files
International Energy Agency
World Coal Institute

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