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Fact Sheet

THE FORMATION OF COAL

What is Coal?
Coal is a combustible, sedimentary, organic rock formed from ancient vegetation, which has been consolidated between other rock strata and transformed by the combined effects of microbial action, pressure and heat over a considerable time. This process is referred to as 'coalification'.

Layered between other sedimentary rocks, coal is found in seams ranging from less than a millimetre, to several metres, in thickness.

Coal is composed of the following main elements:

N- Nitrogen
O- Oxygen
C- Carbon (50% – 98%)
A- Ash
S- Sulphur
H- Hydrogen (3% - 13%)

It furthermore contains smaller amounts of water and grains of inorganic matter that remain as a residue known as ash when coal is burnt.

How was Coal Formed?
Initially peat, the precursor of coal, was converted into lignite or brown coal – a coal type with low organic 'maturity'. Over many millions of years, the continuing effects of temperature and pressure produced additional changes in the lignite, progressively increasing its maturity and transforming it into the range known as sub-bituminous coals.

As this process continued, further chemical and physical changes occurred causing these coals to become harder and more mature, at which point they are classified as bituminous or hard coals. Under the right conditions, the progressive increase in the organic maturity continued to ultimately form anthracite.

Coal Rank
The degree of 'metamorphisrn' or coalification undergone by a coal, as it matures from peat to anthracite, has an important bearing on its physical and chemical properties, and is referred to as the 'rank' of the coal.

Low rank coals, such as lignite and sub-bituminous coals, are typically softer, friable materials with a dull, earthy appearance; they are characterised by high moisture levels and a low carbon content, and hence a low energy content.

Higher rank coals are typically harder and stronger and often have a black glasslike lustre. Increasing rank is accompanied by a rise in the carbon and energy contents and a decrease in the moisture content of the coal. Anthracite is at the top of the rank scale and has a correspondingly higher carbon and energy content and a lower level of moisture.
Between anthracite and peat, there are three broad coal rankings.

Bituminous coals are dense black solids, frequently containing bands with a brilliant lustre. The carbon content of these coals ranges from 78 to 91 percent and the water content from 1.5 to 7 percent.

Non-coking bituminous coals are used for power generation, cement making and to provide heat and steam in industry.

Sub-bituminous coals usually appear dull black and waxy. They have a carbon content of between 71 and 77 percent and a moisture content of up to 10 percent, and are used for electricity generation or can be converted to liquid and gaseous fuels.

The lower ranked coals are browner and softer. ***Brown coals*** or lignite have a high oxygen content (up to 30 percent), a relatively low carbon content (60-75 percent on a dry basis), and a high moisture content (30-70 percent).

Coal in South Africa

Coal reserves in South Africa were formed 250 to 300 million years ago, when South Africa was still attached to the super-continent known as Gondwanaland. The super-continent, which comprised Africa, South America, India, Australia and Antarctica, has since fragmented into the continents that we know today. Our coals are moderately young (the age of the coal being referred to as its rank) and mostly classified as "bituminous" coals, with coals in other parts of the world varying from "brown" (very young) to "anthracite" (very old). The anthracite used to heat our homes in this country are most often not really anthracite, but rather bituminous coals that have been heat-treated to devolatilise them and give them similar properties to true anthracite coals.

South African coal reserves were formed in fresh water swamps, and on the banks of a huge inland-sea that covered much of what we now today know as Mpumalanga. By international standards, our coal deposits are relatively shallow with thick seams, which naturally make them easier, and most often cheaper, to mine.

South African power stations generally use low-grade coal for steam production. Eskom has succeeded at many of its power stations, specifically at Lethabo, to use coal which is of a very low grade, a Calorific Value of 15-16Mj/kg also with a very high ash content, ±42%. This is strategically significant as it effectively extends the country's coal reserves by using what was previously regarded as "real estate" to generate power.

The Future

Coal reserves are the world's most significant fossil fuel resource. Currently, coal provides some 37% of the world's electricity, without which there cannot be economic development. It is also essential to the iron and steel industry. Coal will continue to be an important source of primary energy, relative to both oil and gas, and to non-fossil fuels, with new technology ensuring its global importance well into the 21st Century.

Because of continually improving clean coal technologies, coal will be used more and more efficiently. These technologies will also allow coal-fired power stations to meet the increasingly stringent environmental regulations in force worldwide. Coal is being burnt cleanlier today than ever before. The diversity and abundance of global coal reserves mean that coal can meet the strategic challenge of energy security. Coal can also meet the economic challenge - a competitive fuel for the generation of electricity and a vital input to the steel industry.

Clean Burn Coal Technology

Advanced Pulverised Fuel (PF) Combustion

Industry continuously strives to increase efficiencies of conventional plant; for example, the average thermal efficiency of power stations has increased from 5% in 1900, to around 35% currently. Application of new advanced materials to Pulverised Fuel (PF) power plants should enable efficiencies of 55% to be achieved in the future. This results in corresponding reductions in CO_2 emissions as less fuel is used per unit of electricity generated.

Fluidised Bed Combustion (FBC)

Fluidised bed combustion is a method of burning coal in a bed of heated particles suspended in a gas flow. At sufficient flow rates, the bed acts as a fluid resulting in rapid mixing of the particles. Coal is added to the bed and the continuous mixing encourages complete combustion and a lower temperature than that of PF combustion. The advantages of fluidised beds are that they produce less NO_x in the outlet gas due to lower combustion temperatures, and they produce less SO_x when limestone is continuously added to the coal. They can also use a wider range of fuels than PF combustion. The efficiency of most fluidised beds used for power generation is similar to that of conventional plant. However, use of this technology has been stimulated by its better environmental performance when utilising lower grade fuels. Pressurised fluidised beds, which can achieve efficiencies of up to 45%, are now in commercial operation.

Gasification and IGCC

An alternative to coal combustion is coal gasification. When coal is brought into contact with steam and oxygen, thermochemical reactions produce a fuel gas, largely carbon monoxide and hydrogen, which when combusted can be used to power gas turbines. Integrated Coal Gasification Combined Cycle (IGCC) power generating systems are presently being developed and operated in Europe and the USA. These systems give increased efficiencies by using waste heat from the product gas to produce steam to drive a steam turbine, in addition to a gas turbine.

In addition, IGCC systems produce less solid waste and lower emissions of SO_x, NO_x and CO_2. Over 99% of the sulphur present in the coal can be recovered for sale as chemically pure sulphur.

Hybrid and Advanced Systems
Hybrid combined cycles are also under development. These combine the best features of both gasification and combustion technologies, using coal in a two-stage process. The first stage gasifies the majority of the coal and runs a gas turbine, the second stage combusts the residual 'char' to produce steam.

In addition to these CCTs, a development which can apply to all of the generating systems is the co-firing with coal of biomass or wastes. This involves burning or gasifying such materials together with coal. Benefits can include reductions in CO_2, SO_x and NO_x emissions relative to coal-only fired plants, and recovery of useful energy from biomass and wastes at high efficiencies can be achieved, without the need for building dedicated plant. Hence, the coal-fired power industry can support the renewable energy and waste industries.

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