COAL EXTRACTION AND USES

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Introduction

Coal has dominated the world energy scenario since the Eighteenth century, up to 1970 and in 2019 it accounts for approximately 26.8% of the primary consumption of energy (*Source: International Energy Agency (IEA) – Key World Energy Statistics 2021*). The greatest limit of coal is that it is the most polluting source of energy and it negatively affects the state of the climate. When compared to natural gas, production of one kilowatt-hour of electricity from coal generates more than twice the amount of nitrogen oxide, eight times the amount of heavy metals, ten times the amount of fine dust, and it also produces a large amount of sulphur oxides.

Extraction and uses

The set of operations leading to the identification of coalfields and to their assessment is called mining prospecting. As with oil, an analysis of airplane pictures is conducted to identify geologically interesting areas, then soil samples are studied to obtain more detailed information.
After having identified the coalfield and its position and shape, the mine building site is started. If the coal is found a at depth not exceeding 30 m, it is extracted in open pit mines, where the field is made accessible after the elimination of the top layers of rocks and soil by means of explosive charges. If the coal is deeper than 30m, the field is accessed by digging underground mines including at least two galleries to let miners and machines reach the coal.

Coal extraction

In open pit mines the coal is extracted after having removed the rocks above. In the case of underground mines, the extraction is carried out in two ways: the method of “abandoned pillars” and that of “long faces”. The first method consists in extracting coal while leaving “pillars” to support the roof of the mine. The second method envisages the use of a series of supporting structures called “scaffoldings” which can be easily removed and support the roof in the mining area. While the extraction goes on, the scaffoldings are removed and the roof collapses.
The two methods differ in terms of their impact on the ground. The removal of coal, if the mine is not supported, leads to a more or less gradual sinking of the ground above it. In environmentally valuable areas, the method of abandoned pillars is preferred. In other areas the preference goes to the long faces, which, thanks to a more intensive exploitation of the mine, lead to a coal output, which is 4/5 times greater. After being extracted, coal is processed in order to make it suitable for commercial needs. In particular, it is milled and riddled to obtain the size required on the market and is washed to remove impurities.

Treatment, transport and storage

The market requires coal to have a high quality and purity. The coal extracted from mines contains a mixture of fractions of different sizes, sometimes containing rocks or compost. Therefore, a

preparation stage is needed, called “beneficiation” and the raw coal is divided into a series of clean, uniform and classified products, ready to be sold. In some cases, raw coal has a high quality that satisfies consumers’ needs. In these cases, the “beneficiation” is not necessary and the coal can be simply broken into pieces and sieved in order to obtain a specific product.
A good preparation of coal before its combustion increases the homogeneity and efficiency of this combustible, reduces transport costs and its displacement inside the plant produces less dust and reduces the emission of sulphur oxides. Once coal has been extracted, it is necessary to transport it to the plants where it will be used. For short distances, trucks will be used, while for longer distances trains, barges and ships will be employed. Recently coal pipes have been tested: the mineral is pumped after being transformed into dust and mixed with water. Preventive measures are taken at any stage during transport and storage, in order to reduce any environmental impact. For example, the superficial flow of contaminated water is limited by the design of storage equipment and all waters are carefully treated before being re-used and disposed of. The dusts can be controlled by using water spray and compacting the coal to be stored.
Road or sea transport systems can be used to transport the coal from the storage place to combustion sites. However, more than 60% of the coal used to produce energy is consumed at 50 km from the extraction mine. Only around 14% of the coal production is traded at international level, although estimates say that this practice is destined to increase.

Electric plants with coal

Due to its wide availability, guaranteed supply, competitiveness and its very safe handling, transport and use (it is not inflammable, nor explosive, nor polluting for the soil or water), coal is the primary fuel for the creation of electric energy in the world and in Europe. The first step for energy creation in a coal plant starts in the steam generator area, where the burners are located for the combustion of coal fuel oil. The steam generator is generally made up of a furnace where air and fuel are inserted. When they burn, they heat and vaporize the water that runs in the pipes and serpentines that form the generator. In modern plants the coal is first grilled into very fine dust by increasing combustion speed; it is then driven to the kiln combustion chamber, where it is burnt at 1400°C. The high temperature of combustion gases determines the transformation of the boiler water contained in the pipes into steam.
The vapour, through big pipes, reaches the turbine and makes it turn at 3000 turns per minute. The turbine is a machine that converts the kinetic energy of a moving fluid (liquid or gas) into mechanic energy. With regard to coal plants, the fluid is superheated steam. The main element of the turbine is the rotor, made up of a wheel with “blades”. The mechanic energy is then transmitted, through an axle, from the rotor to an electric generator, called alternator. The alternator, connected to a turbine, produces electric energy. The fumes, once they have released their heat into the steam generator, are sent to the chimney after having passed through the denitrificators, dust collectors and desulphurizers in order to eliminate nitrogen oxides, dusts and sulphur dioxide. The steam, after transmitting a large part of its energy to the turbine, is driven to the condenser where, without ever getting in contact with it, transfers its residual heat to the seawater collected with adequate pumps.

This steam is then transformed into water, which is taken back to the steam generator in order to repeat the cycle. The energy produced by the alternator is subject to a tension increase of up to 380 kilovolts in order to be introduced into the electric network.

Environment and territory

In certain production sectors coal is still an important energy source. At present 39% of the world-wide electric energy output is obtained by burning coal. Moreover coal plays a vital role in the production of steel. On the other hand, the size of its reserves still does not envisage any problems in terms of depletion in the future. Moreover, the use of coal was decisive in the past for the industrial development and the prosperity of European countries, whereas today it is questioned because of the high pollution level deriving from its use as a fuel.

Limits and advantages of coal

The combustion of coal generates great quantities of carbon dioxide (CO_2), greater than those produced by oil or natural gas. It should be remembered that carbon dioxide is the main culprit for the greenhouse effect, i.e. the increase of the earth's temperature. All fossil fuels produce greenhouse gas and coal contributes by slightly less than 20% to the greenhouse effect increase.
Other polluting gases generated by the combustion of coal are nitrogen oxides (NO_X) and sulphur oxides (SO_X) which, by combining in the atmosphere with steam, turn into nitric acid and sulphuric acid and cause acid rain, which damage the vegetation and surface water.
At the moment 100% of ashes and chalk produced from coal are recycled. In fact, they are used for the production of concrete, cement, road floors, and building products.

Mine rehabilitation

Coal mining has impacts on superficial and underground waters, soil, local land use and native flora and fauna. Each mine must have a reclamation or rehabilitation plan that covers all the phases of the mine lifecycle. The reclamation activities must be undertaken gradually: the land contour must be restored, the topsoil replaced and vegetation replanted on the mined out areas. Both before and during the mining activity, extreme care must be taken to preserve the wildlife, historical sites and all the resources of particular value to the territory. During mining operations, dust pollution, noise pollution and water contamination must be minimised. When mining activities have stopped, disused mine pits can be utilised to build tanks or for recreational activities using water. The reclaimed land can be put to use in different ways: for agriculture, forestry, recreation, building areas for industries or wildlife habitation and habitat. Today the coal industry is committed to protecting the environment and land rehabilitation is an integral part of most of the mining activities. Coal mining companies are investing a lot (in both expertise and financial resources) to restore the land to a condition that is equal to or better than the pre-mining one.

Clean technologies for coal

To achieve a less polluting use of this energy resource, over the last years technologies were developed leading to a reduction of the environmental impact in all the stages of the coal production cycle: from extraction to processing and combustion. These technologies reduce emissions, waste, and increase the quantity of energy that can be obtained from a ton of coal. Clean technologies today allow to reduce CO_2 emissions by more than 30% per unit of electric energy produced. For example, the "fluid bed" combustion consists of burning coal together with a mixture of salts absorbing part of the ashes and toxic gases. Thus, a smaller quantity of polluting gases is freed into the atmosphere (nitrogen oxides, sulphur oxides, carbon dioxide).

Similar results can be achieved through underground gasification processes envisaging the injection of air and steam into the coalfields until their partial combustion is achieved. Thus, only a mixture of fuel gases with no ashes reaches the surface and is then injected into traditional pipelines. There are also some hybrid systems that combine the best characteristics of gasification and combustion technologies, using coal in a two-phase process. The first phase consists of the gasification of most of the coal that produces steam and drives it to a turbine. The second phase is the combustion of coal residues to produce steam. With technique it is possible to reach an efficiency increase by 50%.

Moreover the co-firing can be applied to any generation system. It consists of burning biomass and waste together with coal. The advantages of this technique may include the reduction of CO_2, SO_X, NO_X emissions that are produced in coal traditional plants. Moreover in this way it is possible to obtain a large energy efficiency from biomass and waste, without having to build new specific plants. From coal gasification it is possible to obtain hydrogen, which can be used to produce energy (for example in fuels cells) at "zero emissions".

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