TAKVEEN – KHWARZIMIC SCIENCE SOCIETY
http://www.khwarzimic.org/takveen/index.asp

Thar Synthetic Natural Gas: Converting Coal to Methane

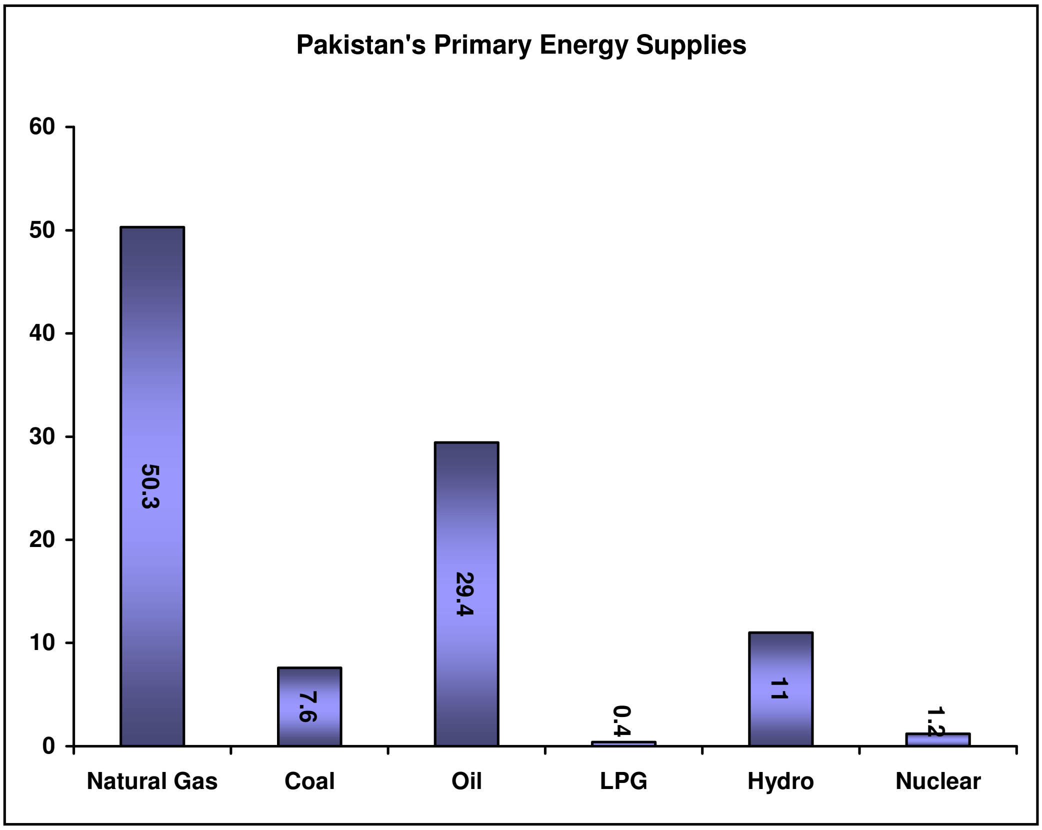
Rizwan Haider

Centre for Coal Technology, Faculty of Engineering and Technology, University of the Punjab.

to_alvi@hotmail.com

Coal is one of major energy source which is contributing in world's energy systems with the share of 23.80% and 23.75% of production and consumption respectively. But the utilization of coal as a fuel is a potential threat to the environment. Undesirable products, which are generated during the combustion, contaminate atmosphere, water and soil. In order to obtain clean fuels, the liquefaction and gasification of the world's mot abundant fuel i.e., coal, have gained increasing attention. The energy sector requires efficient and clean energy supplies. In case of coal, we would have to ensure higher efficiencies, environmental acceptance, prolonging its availability and proper replacement for oil and natural gas. This is only possible through sustainable development of new coal conversion technologies.

Pakistan has great potential in the shape of 185 billion tones coal reservoirs standing 18th in the world. These coal reserves are well developed in Punjab, Sindh, Balochistan and NWFP. Surprisingly, the share of coal in energy supplies for Pakistan is 7.6% during 2004-05. Coal consumption during 2004-2005 was: Brick Kilns (49.5%), Cement Industries (32.1%), Power (2.3%) and Coke use (16.1%).



The largest coalfield of Pakistan, Thar, is a resource potential of about 175 billion tonnes. The rank of Thar coal ranges form lignite-*B* to sub-bituminous-*A* with high moisture and low sulfur content. The average chemical analyses of the coal samples from the entire Thar coalfield are:

Moisture (AR)	46.77%
Volatile Matter (AR)	23.42%
Fixed Carbon (AR)	16.66%
Ash (AR)	6.24%
Sulfur (AR)	1.16%
Heating Value (Dry)	10,898 Btu/lb

- AR = as received basis

During recent years the interests in the use of low-ranked coals and lignite as energy sources have greatly increased. Investigations are being carried out for the possibility of the conversion of lignite into gaseous fuels. Biological gasification processes of coal and lignite will play an important role for energy requirements in future because these processes may offer potential advantages of lower cost and higher efficiencies than the various conventional thermal processes.

One of the possible ways for the utilization of Thar coal is its conversion into methane gas which can be used as *Thar Synthetic Natural Gas (TSNG)*. Biogasification of Thar coal is favored for several reasons. First, it has high moisture content which makes it unsuitable and expensive for use in more conventional thermal processes. For biogasification process the moisture content is an advantage, because aqueous systems are necessary for microorganisms. Proximate analysis of Thar coal shows that it has moisture content of 46.77%. Second, it is being considered a young or immature coal which has not undergone a great deal of polymerization and oxygen loss. It is much closer in structure to the original biological components than a higher rank coal.

Mainly, two approaches for the synthesis of methane from the coal have been developed. In the first one, the coal is subjected to the gasification process using conventional coal gasification technologies for the production of gaseous mixture which is upgraded to almost pure methane through anaerobic fermentation.

The second approach can be applied to the low-ranked fuels, municipal waste, peat, lignite or coals with high moisture content. In this technique, lignite is oxidized or depolymerized biologically (using microbes) or chemically (with the help of aqueous alkali and hydrogen peroxide). Sometimes both procedures can be used to facilitate the degradation of lignite. Then the solubilized lignite undergoes fermentation. The second approach is well-suited for the production of methane from Thar coal.

Methane production from lignite or low ranked-coal involves three stages of degradation. First, a complex substrate such as coal, biomass or peat–all of which can be considered as polymers–must be broken down to smaller organic compounds. This stage is called pretreatment process. In lignite, a large portion of the matrix is composed of single-ring aromatic hydrocarbons/compounds joined in a network of carbon-carbon and carbon-oxygen bonds. The purpose of pretreatment process is to break the bonds and produce single ring aromatic compounds. For the increase in effectiveness of degradation alkali and hydrogen peroxide are also added. Alkali is used to break carbon-oxygen bonds while addition of hydrogen peroxide promotes the breakage of carbon-carbon bonds. This pretreatment process can be called, in some sense, decoalification because it is the reverse process of coalification (the process in which plant remains become coal).

In the second stage the smaller organic compounds obtained from first stage are fermented to acetate and carbon dioxide which are substrate for methanogenesis. Finally the acetate and carbon dioxide are converted to methane using methanogens. A different population of microbes is required for each stage.

For the early stage of degradation a complex mixture of fermentative bacterial species is used. Most of these organisms are obligate anaerobes which are poisoned by presence of oxygen. Some microbes, including fungi, bacteria and protozoa, have been found to degrade lignin, the lignite precursor, to smaller polymeric and monomeric units. The most notable of these are the *basidiomycete* fungi, which include some of the agarics, and the white-rot fungi, such as *Phanerochaete chrysosporium. P. chrysosporium* is a white-rot fungus which is naturally found in forests and have the ability to degrade lignin in wood and lignocellulose pulps under certain conditions.

The second stage is dominated by the acetogenic bacteria. These organisms ferment fatty acids, alcohols and aromatic acids to acetate, hydrogen and carbon dioxide. The partial pressure of hydrogen is critical at this stage because an increase in partial pressure will prevent the formation of desired products. The methanogens take either carbon dioxide and hydrogen or acetate and produce methane. This reduction of carbon dioxide is necessary to the energy metabolism of the organism, as carbon dioxide serves as the main electron acceptor for the organism. These are the only organisms that can convert acetate and hydrogen to methane without light or electron acceptors other than carbon dioxide.

Methanogenic bacteria are very different from most other species of bacteria. The major differences are the lack of peptidoglycan cell wall, the presence of polyisoprenoid ether-linked lipids in the cell membranes and immunologically unique transfer and ribosomal RNA. They are also slow growers, requiring 1 to 9 days for doubling time depending upon species and growth conditions. Their optimum temperatures are in ranges of 35 – 40°C. The optimum pH is in the range of 6 – 8. Methanogens are strict anaerobes, requiring the redox potential of the medium to be below −300mV. This, as well as other factors, such as a tendency to flocculate, hinders the isolation of organisms for pure culture.

All methane bacteria can convert carbon dioxide and hydrogen to methane. The number that can convert acetate to methane is much more limited. Both *Methanosarcino* sp. and *Methanothrix soehngenii* have this capability. These organisms can be isolated from sewage sludge, where 80% of methane is derived from acetate. Optimum temperatures for these bacteria are in the range of 30 to 37°C.

The process variables, which can affect the yield of methane gas from lignite, such as pH, nutrient level, temperature, inoculum size, effect of sulfur gases on organism toxicity and agitation rate of reactor should be studied in order to make the process efficient, feasible and favorable economically.

The process scheme involves an aqueous alkali pretreatment of the lignite followed by anaerobic fermentation of the hydrolysate in large underground caverns. Fermentation might also be used for the production of intermediate for organic synthesis or for the production of liquid fuels. The gas evolved from the process will contain methane and carbon dioxide. Gas purification is used to split the gas into its two components. The methane produced will be of sufficient quality to be injected into a gas pipeline. The carbon dioxide side stream will be sold for the use in tertiary oil recovery.

In view of large indigenous reserve of Thar coal deposit, Pakistan should lead to novel conversion technologies for the best utilization of coal. The novel technologies include biogasification bioliquefaction of coal, ethanol and hydrogen production from coal. These approaches provide several roadways for the high-throughput and environment friendly use of coal and enable us to consume it as raw material to improve our economics by co-generation and or co-production of power, electricity and chemicals.