India is one of the world’s fastest growing economies and its demand for energy is ever increasing. The security of India’s energy supply is one of the country’s major challenges. Besides energy security, there is also the need to develop and harness environmentally-friendly, greenhouse gas (GHG) reducing clean energy resources in line with the global trend. In this area, coal-based unconventional energy resources can play a vital role.

The coal sector has been helping to secure the Indian energy sector by playing a dominant role in meeting the country’s energy requirements, contributing to about 50% of India’s primary energy requirement and about 66% of its electricity generation. Coal’s dominance is likely to continue in view of the uncertainties of the global supply of hydrocarbons and their soaring prices, which are driven more by geopolitical forces than markets. The Government of India’s Integrated Energy Policy acknowledges the importance of coal in the coming years and stresses the need to augment coal production from its present level of more than 530 million tpa to meet the estimated requirement of 2 billion tpa by 2030 – 31. To sustain a GDP growth of 8 – 10%, the coal sector will need to grow at the same pace. But growth in the production of
coal in India is constrained by growing land acquisition problems and stringent environmental laws. The use of coal in its present form is also not environmentally friendly.

Underground coal gasification (UCG) requires less surface area than traditional coal mining, and therefore represents a potential method to extract energy from India’s deep and isolated coal and lignite deposits. If UCG technology is perfected, it could supplement the country’s underground coal mining and help address its energy security. It would also strengthen the national policy for the development of sustainable energy resources based on clean coal technologies, such as coalbed methane (CBM), coal mine methane (CMM) and UCG.

Underground coal gasification

UCG refers to gasifying a coal seam in situ under controlled combustion and bringing the resulting synthetic gas (syngas) to the surface. The syngas is a mixture of hydrogen, carbon monoxide, methane, CO₂, and higher hydrocarbons, and has a calorific value in the range of 850 – 1100 kcal/m³ for air injection. This syngas has great downstream utilisation potential, such as for power generation through integrated gas combined cycle (IGCC) or as feedstock in the fertilizer and chemical industries. Syngas can also be converted to liquid hydrocarbon.

UCG development in India

In India, UCG was taken up in the 1980s by Oil and Natural Gas Corp. Ltd (ONGC) and Coal India Ltd (CIL), the country’s two major public sector companies, with technical assistance from the then-USSR. ONGC drilled two wells during 1984 – 86 to study the prospect of UCG in deep lignite/sub-bituminous coal deposits in the state of Gujarat. It could not proceed further because the project did not have access to the appropriate technological support. Under the initiative, Soviet experts selected three out of 13 coal/lignite blocks for the generation of additional geological, geophysical, hydro-geological and geotechnical data. On the basis of additional data, only one block – Merta Road lignite deposit – was found to be technically feasible for UCG. A UCG project was taken up by the Central Mine Planning and Design Institute (CMPDI), with technical support from the USSR, to acquire more geological and hydro-geological data at Merta Road to enable a pilot-scale study. Although found suitable, pilot appraisal for UCG could not be taken up at the Merta Road lignite deposit due to concerns about the contamination of ground water.

With new advancements in technology, UCG is again in focus and a number of companies – Neyveli Lignite Corp. (NLC) and Rajasthan State Petroleum Corp. Ltd (RSPCL), ONGC and CIL/CMPDI – are pursuing its development on a limited scale to prove the viability of the process in Indian geology. Recently, CMPDI has generated UCG-specific data through exploratory drilling in Kastha block in the Raniganj coalfield under a joint venture project with ONGC. In addition, ONGC has also generated additional data on the Vastan lignite block, Gujarat, for taking up pilot-scale studies. It is reported that ONGC will carry out pilot-scale studies in near future.

Challenges for UCG development in India

CIL/CMPDI and ONGC’s attempts to carry out pilot-scale studies for the development of UCG in 1980s were marred by a number of constraints.

Technological and environmental challenges

Despite successful trial burns and technological advancements, fully-fledged commercial-scale UCG operation is not on the near horizon. There are many technological challenges that need to be addressed through continued R&D:

- **Environmental.** The risk of contaminating groundwater aquifers with the products of coal pyrolysis and ground subsidence is a major environmental concern. However, current technological knowledge can eliminate or reduce these environmental risks.

- **Controlled combustion.** UCG operations cannot be controlled to the same extent as surface gasifiers. Many important process variables, such as the rate of water influx, the distribution of reactants in the gasification zone and the growth rate of the cavity, can only be estimated from measurements of temperatures and gas quality and quantity.

- **Suitable coal deposits.** While UCG may be technically feasible for many coal resources, the number of deposits that are suitable may be much more limited as some may have geological and hydrological features that increase environmental risks to unacceptable levels.

- **Inconsistent supply of syngas.** UCG is an inherently unsteady-state process, and both the flow rate and the heating value of the gas product will vary over time. Any operating plant must take this factor into consideration.

- **Economies of scale.** The economics of UCG operation have major uncertainties that are likely to persist until a reasonable number of UCG-fired power plants are built and in operation.

However, these challenges can be addressed and controlled with the application of the proper technology. Encouraged by recent trials, interest in UCG has been revived in India. The Ministry of Coal (MoC) has taken keen measures to overcome the regulatory issues for commercial exploitation of the vast coal and lignite resources that may be suitable for UCG.

Addressing regulatory issues

To address the regulatory issues, the MoC formed a multi-organisational committee to draft a regulatory framework for the development of UCG. The committee submitted its recommendations to the MoC in August 2006. To further expedite UCG development, the MoC issued a Gazette Notification in July 2007, which specifies: “Production of syngas obtained through coal gasification (underground and surface) and coal liquefaction to be end uses for the
The purpose of Coal Mines Nationalization Act, 1973. This notification has paved the way for investment in UCG by public and private entrepreneurs. The MoC also issued guidelines in July 2009 for carrying out commercial exploitation of UCG, which includes:

- Guidelines for the allocation of blocks.
- Guidelines for carrying out UCG.

The Gazette Notification and the guidelines issued by the MoC are a step forward and will become a milestone in the history of the commercial development of UCG in India. Commercial development is currently under active consideration by the Government because of its ability to extract energy from unmineable coal seams.

**Opportunities for UCG development in India**

UCG offers a potential economic means of extracting energy from deep deposits, which are not economically viable for physical extraction at present by conventional methods, irrespective of the rank of the coal. Indian coal resources are largely dominated by low rank coals (about 80%), and therefore UCG could be more relevant to India, if the technology is perfected. The medium heating value gas produced from UCG can be used for power generation and as a feedstock in the manufacture of methanol or gasoline. It finds its relevance at a national level primarily on account of two basic premises:

- Coal demand/supply scenario.
- Conservation and optimisation of resource utilisation.

**Identifying coal/lignite blocks for UCG development**

The MoC entrusted CMPDI to fix criteria for the selection of suitable coal/lignite reserves for the application of UCG development, in consultation with NLC, Singareni Collieries Co. Ltd (SCCL), the Geological Survey of India (GSI), and the Directorate General of Mines Safety (DGMS). CMPDI was also entrusted to identify coal/lignite blocks within and outside the CIL command area that would be suitable for the commercial development of UCG in consultation with GSI, SCCL and NLC.

Seven blocks (five in lignite and two in coal) were deemed suitable for the commercial development of UCG. CMPDI also identified two coal blocks - Kaittha block in Ramgarh coalfield and Thesgora “C” block in Pench-Kanhan coalfield – within the CIL command area.

**Techno-economics of coal mining in India**

With present day economics, it is generally agreed that coal deposits occurring beyond 300 m in depth are not economically viable for mining.

**Indian resources**

India’s large bituminous coal and lignite resources play a dominant role in providing energy security to the country. Coal is the cheapest source of primary energy and will remain so for the foreseeable future. India has the fifth largest global coal resources, with an estimated 60.6 billion t of proved recoverable reserves - 7% of world reserves – and a reserve-to-production (R/P) ratio of 106 (Figure 1).

**Coal resources**

India has substantial deep non-metallurgical coal reserves that may not be techno-economically amenable to conventional mining. In Q2 2011, India’s coal resources were estimated at 285.86 billion t (Figure 2). Some 88% - or 250.89 billion t - of Indian coals are non-metallurgical coals, which are mainly used for power generation. Only 14% of non-metallurgical coals are of superior grade, occurring within a depth range of 0 – 1200 m. The remaining 86% non-metallurgical coals are high-ash, inferior and thermal grade coals, which are suitable only for power generation (Figure 3). Around 88.65 billion t (35%) non-metallurgical coals occur at a depth range of 300 – 1200 m (Figure 4).
Lignite resources

India has extensive lignite deposits of around 40.9 billion t (Figure 5), which can mainly be used for power generation.

The mining of lignite deposits is mainly confined to within 0–150 m of the surface, but this accounts for just 21% of the total resource. Figure 5 shows that the majority of the lignite resource occurs between 150–300 m (27%) and >300 m (46%). Apart from the resource given in Figure 5, 60 billion t of lignite occurs within 800–1400 m depth in the Kalol basin in Gujarat, as estimated by ONGC. Shell Oil Co. has also indicated the presence of substantial lignite resource at deeper levels in the Barmer and Sanchor basins in Rajasthan state.

Availability of coal and lignite resources for UCG development

India has 88.6 billion t (31%) of non-metallurgical coal reserves occurring at a depth of 300–1200 m and a further 29.6 million t of the lignite reserves—constituting 72.4% of the total lignite resource—occurring at >150 m. At first appearance, these would not seem to be technically or economically amenable to mining at present; however, these provide a target area for UCG.

Conclusion

India is well positioned to take up UCG for extracting energy from the isolated and geologically-difficult areas in which mining is not technically or economically feasible. The Government's Gazette Notification and the issuing of guidelines for the commercial development of UCG has paved the way for initiating UCG development on a commercial scale.

Recent advancements in technology and the results of the pilot scale/commercial development have proven that UCG technology could be applied with minimal environmental impact. A successful trial of this technology in Indian conditions will further eliminate doubts about the adverse impact on the environment, specifically in terms of ground water contamination. Several companies are working on this aspect.

CMPDL, on behalf of CIL, has taken the lead in commercial development of UCG in a number of identified areas. The tender floated for the purpose received a positive response, which indicates the industry's interest in this new technology area. The successful implementation of commercial UCG projects will be helpful in bridging the gap between the demand and supply of energy resources in India.

Sources

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