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Promotion of Cleaner Energy Production for Meeting the Energy Security in the Indian Context

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ABSTRACT: The global energy requirement has grown at a phenomenon rate and the consumption of primary energy sources has been a very high positive growth. This paper focuses on the consumption of different primary energy sources and it identifies that coal will continue to remain as the prime energy in foreseeable future. It examines energy requirement perspective for India and demand of petroleum, natural gas, coal bed methane and underground coal gas in the foreseeable future. It discusses the state of present day petroleum and petrochemical industries in the country and latest advances in them to take over in the next few years. Economic development and poverty alleviation depend on securing affordable energy sources and for the country's energy security; it is necessary to adopt the latest technological advances in petroleum and petrochemical industries by supportive government policies. Attempts are made to lay a road map for these industries to benchmark themselves with the best practices employed in India and abroad. It discusses the strategies to be adopted for growth and meeting the energy demand. But such energy are very much concerned with environmental degradation and must be driven by contemporary managerial acumen addressing environmental and social challenges effectively. The paper concludes that energy security leading to energy independence is certainly possible and can be achieved through planed manner.

Keywords: Exponential, Consumption, Oil Equivalent, Utility, Power, Greenhouse.

INTRODUCTION

The requirement of primary energy sources is growing exponentially all over the world (Ghose, 2002a). The global primary energy requirement has grown from 6700 MtOE (Million tonne oil equivalent) to 10200 MtOE over the last 25 years. There has been a very high positive growth in consumption of all kinds of primary energy sources e.g. oil, natural gas, nuclear energy, hydro electricity and coal (Anon, 1988). If we look at the regional pattern of consumption of primary energy sources, we find that oil remains the largest single source of primary energy in most parts of the world. However, gas dominates as the prime source in some parts of world such as former Soviet Union and Middle East, coal enjoys the main primary energy source status in Asia Pacific, which comprises the largest population, and an economy that outperforms rest of the world in growth (Ghose, 2004). The reserve-to-production (R/P) ratio in respect of major regions of the globe describes the life of different fossil fuels on earth on the basis of current level of production (Barney, 1980). The fact remains that oil and gas have limited reserves to last 41 and 67 years respectively at current production level. In contrast, world has a coal reserve to last 190 years at the current production level.

As we know the energy sector plays a crucial role in the overall development of the economy. Of the total energy consumption of approximately 360 Mt of oil equivalent in the country, an estimated 35% is obtained from traditional sources such as fuel wood, agricultural waste, animal dung etc. and other 65%, termed as commercial energy, is obtained from coal, oil, gas hydel, nuclear and renewable sources. The share of various energy sources in the primary commercial energy consumption of the country in 1997–98 was, coal and lignite are mostly used in power stations (75%), steel plants (6.2%), cement plants (3.6%), other industries and brick-making plants (15.2%). Petroleum and natural gas are mostly used for the transportation sector although significant amounts are used in oil and gas fired power stations, fertilizer plants, other industries and in the domestic sector for cooking and lighting. There is a great demand and supply gap of energy in the country, which is widening every year. Energy security, which means ensuring that our country can supply lifeline energy to all its citizens, at affordable costs at all times, is a very important and significant need and is an essential step forward. Moreover, burning of fossil fuel is causing environmental degradation. Environment conservation is a significant priority of the society. Thus, there is an urgent need to find out alternative energy sources, which are environment friendly and to meet the demand and supply gap of the country.

INDIAN ENERGY PERSPECTIVE

More than 60 per cent of Indian households depend on traditional sources of energy like fuel wood, dung and crop residues for meeting their cooking and heating needs. Out of the total rural energy consumption, about 65 per cent is met from fuel wood. Fuel wood consumption during 2001–02 is estimated at 223 million tonnes, 180 million tonnes of which is for household consumption and the balance for cottage industry, big hotels etc. The consumption of animal dung and agro-waste is estimated at 130 million tonnes, which does not include the wet dung used for biogas plants. The projected requirement of commercial energy is estimated at about 412 MTOE and 554 MTOE respectively in 2007 and 2012 respectively (Anon, 2003–2004). The commercial energy demand is estimated to grow at an average rate of 6.6 per cent and 6.1 per cent respectively during the period 2002–07 and 2007–12 (Table 1). However, the demand may be less by 5 per cent and 10 per cent during 2006–07 and 2011–12 respectively.

Table 1: Estimated Primary Energy Demand in India

Primary	*Unit*	*Demand (in Original units)*		*Demand (MtOE)*	
		2006–07	*2011–12*	*2006–07*	*2011–12*
Coal	Mt	460.50	620.00	190.00	254.93
Lignite	Mt	57.79	81.54	15.51	22.05
Oil	Mt	134.50	172.47	144.58	185.40
Natural gas	BCM	47.45	64.00	42.70	57.60
Hydro power	BKwh	148.08	215.66	12.73	18.54
Nuclear power	BKwh	23.15	54.74	6.04	14.16
Wind power	BKwh	4.00	11.62	0.35	1.00
Total commercial energy				411.91	553.68
Non-commercial energy				151.30	170.25
Total energy demand				563.21	723.93

(*Source:* ASEAN-India Business Portal*)

*The coal demand figures are under review and revision

India ranks sixth in the world in terms of energy demand accounting for 3.5 per cent of world commercial energy demand (Ghose, 2003). With a Gross Domestic Product (GDP) growth of 8 percent set for the tenth five-year plan (2002–07), the energy demand is expected to grow at 5.2 percent. Although, the commercial energy consumption has grown rapidly over the last two decades, a large part of India's population does not have access to it (Ghose, 2002b). At 479 kg of oil equivalent (kgOE), the per capita energy consumption is also low when compared to some of the other developing countries, like Thailand (1,319 kgOE), Brazil (1,051 kgOE) and China (907 kgOE). Primary commercial energy demand grew almost three-fold at an annual rate of 6 per cent between 1981 and 2001, to reach 314.7 million tonnes of oil equivalent (MtOE). India's incremental energy demand for the next decade is projected to be among the highest in the world, spurred by sustained economic growth, rise in income levels and increased availability of goods and services. India's commercial energy demand is expected to grow even more rapidly than in the past as it goes down the reform path in order to raise standards of living.

Energy security must be considered as a transition strategy, to enable us to achieve our real goal that is—energy independence or an economy, which will function well with total freedom from oil, gas or coal, imports. Energy Security rests on two principles. The first, to use the least amount of energy to provide services and cut down energy losses. The second, to secure access to all sources of energy including coal, oil and gas supplies worldwide, till the end of the fossil fuel era, which is fast approaching. Simultaneously, we should access technologies to provide a diverse supply of reliable, affordable and environmentally sustainable energy. Hence, Energy Independence has to be our first and highest priority. We have to critically look at the need for Energy Independence in different ways in its two major sectors—Electric power generation and Transportation. We also depend on oil to the extent of 114 million tonnes every year, 75% of which is imported, and used almost entirely in the Transportation Sector. Forecasts of our Energy requirements by 2030, when our population may touch 1.4 billion people, indicate that demand from power sector will increase from the existing 120,000 MW to about 400,000 MW. This assumes an energy growth rate of 5% per annum.

UNDERGROUND COAL GASIFICATION

India has relatively large reserves of coal compared to crude oil and natural gas. Hence, there is urgent need to explore for alternative methods for commercial extraction of those coal resources, which are presently not being mined through conventional mining. This will call for a focused attention towards non-conventional, sustainable and eco-friendly energy resource, like Underground Coal Gasification (UCG) which is the viable modem alternative for exploiting the deep seated, remotely located and uneconomical coal resources with lower cost. Apart *from* these, UCG also has the potential to work offshore coal reserves where the traditional mining methods are not suited.

Underground Coal Gasification (UCG) is a cost-effective environmental solution for resource recovery in areas beyond the technical and economic confines of conventional mining. Employing a series of wells, UCG converts *in situ* coal into product gas (syn gas), thus eliminating the expense of mining and reclamation. Technology is based on management of underground gasifier without making mines. The product gas composition is a mixture of H_2, CH_4, CO, CO_2, etc. with calorific value of 850 to 1200 $kcallNm^3$ underground gasifier, and its design is the most crucial part of a UCG operation.

In general terms, UCG uses adjacent boreholes drilled into a coal seam (typically > 100 m depth). The injection wells are used to feed a pressurised oxidant such as air or oxygen/steam into the coal seam and for down the hole ignition of coal seams. The production wells recover the product gases. Conceptually UCG is very attractive but the application of the concept as a large scale method of coal conversion has proved to be more difficult. It is clear from the tests with UCG application in the past that the natural permeability of the coal seam to transmit the gases to and from the combustion zone can be unreliable. For gasification over long distances in the coal seam, a properly constructed in-seam channel is preferred, before the coal seam is ignited and the gasification cavity is developed.

Underground Coal Gasification (UCG) is one of the viable modern alternative for exploiting the deep seated and uneconomical coal resources with lower cost. It is a process by which coal is converted *in situ* to combustible gas for recovering energy contents of coal. The product synthetic gas (Syngas) is brought to the surface for use as fuel or chemical feed stock. Integrated Gasification Combined Cycle (IGCC) is an alternate to pulverized coal combustion for power generation. In pulverized fuel (PF) combustion, coal is milled to powder and blown into the boiler with air. The powdered coal having a large surface area gets easily combusted in burners. This provides the heat that is used to produce superheated steam to drive turbines and hence generate electricity. In the future power plant cycles like IGCC, coal is brought into contact with steam and oxygen and thermo chemical reactions produce a fuel gas largely hydrogen and carbon monoxide, which when combusted can be used to power gas turbines. IGCC systems give increased efficiencies by using waste heat from the product gas 209 *Underground Coal Gasification-Application in the country* to produce steam turbine, in addition to a gas turbine. IGCC systems also produce less solid waste and lower emission of SOx, NOx and CO_2. A combination of UCG and IGCC is technically feasible. First IGCC project based on UCG has taken shape at commercial scale in Chinchilla, 350 km west of Brisbane, Queens land, Australia. The project operation at Chinchilla has been discussed in brief in this paper. Prospects of development of UCG in India have also been outlined.

Indian Effort for UCG Development

In India, a UCG National project was taken in early 80's. A protocol for UCG development was signed between Indian Govt. and Govt. of erstwhile USSR in 1981. A core group consisting of CMRS, CFRI, IIT Kharagpur, CIL /CMPDI and ONGC was formed. It was also decided that UCG prospect evaluation for coal seams less than 300 m depth would be handled by CIL/CMPDI and more than 300 m depth will be handled by ONGC. In 1983, a S&T scheme was taken by CMPDI evaluation of UCG prospects of shallow lignite deposits of Paina-Merta Road with Soviet collaboration after consultation with CMRS, CFRI and ONGC. Soviet experts visited India in 1986 and examined the available geological reports of 13 coal/lignite blocks offered to them and they selected (a) South Sayal & Madni Rai block CCL in Thakhand (b) Palna-Merta Road lignite block of Rajasthan. Soviet experts concluded that UCG technology is technologically feasible at Merta Road and techno-economics could be worked out only after the pilot plant studies. Pilot plant study at Merta Road lignite block was not recommended at this stage due to pollution of existing limited ground water resources in the area. During the same period 1984–86, ONGC drilled 2 pilot boreholes UCG-l & UCG-3, 10 km. north of Mehsana city in Gujarat, to know the nature of the rocks, sub-surface strata conditions and the nature, quality and properties of coal to see the suitability of application of UCG techniques. Coal cores thus derived were subjected to various analysis in CSL Nagpur. However further studies on the subject have not been made since then.

NATURAL GAS HYDRATES

Oil and gas account for over 42% of the country's energy basket and it is projected that the share of natural gas would go up from 8% to over 20% in the next decade. This clearly brings out the fact that our energy security in the years ahead would primarily mean "hydrocarbon security". The dependence on imported oil to meet the domestic demand has already exceeded 75% in the year 2004–05. During 2005–06, country's total crude oil consumption was 129.84 Mt, out of which 32.20 Mt (24.8%) was domestic production and the balance 97.64 (75.2%) was met through imports. The experts in this field have projected that this dependence, despite the projected growth in indigenous crude production, could increase to over 85%.

Naturally occurring gas hydrates are ice like compounds in which gas molecules, methane in most cases, are en-caged in interstices for hydrogen bonded water lattices at low temperature and high pressure. The first evidence of such naturally occurring gas hydrate deposits was found in Messiyokha field in Russian permafrost region. Subsequently gas hydrates were also found in shallow marine sediments of arctic region during various ODP legs in tropical deep-water areas where water depth exceeds 650–750 meters, the pressure, temperature conditions are favourable for formation of gas hydrates. Gas hydrates accumulation in deep-water areas is believed to be due to accumulation of biogenic methane generated in shallow sediments. Area with higher sedimentation rates is thus favourable for such accumulation as the organic carbon is preserved due to its rapid burial. The fact those 164 cubic meters of methane gas is trapped in one cubic meter of gas hydrate and large area of deep water have favourable conditions of formation for gas hydrate makes it a suitable candidate as an alternative source of energy. In view of this goal, in 1997 a Natural Gas Hydrate Programme was launched for exploration and development of gas hydrates resources of the country by MOP&NG. Simultaneously ONGC, GAIL and DGH started in house studies for evaluation of gas hydrates in Indian offshore areas. In India, ONGC is the only agency equipped with the capability for evaluation of gas hydrate potential due to its inherent strength in terms of expertise on acquisition, processing and interpretation of seismic data. Realizing its national obligation and possibility of exploitation of gas hydrates as a future business opportunity. ONGC has taken up the job of detailed planning/implementation of various aspects of gas hydrate exploration and exploitation. The first step towards such studies was initiated in 1996. Preliminary analysis of seismic data along the Eastern and Western deep water area of India has brought out the potential areas for gas hydrate occurrence which includes the area of Andaman-Nicobar, Krishna-Godavari, Konkan and Kutch offshore up to a bathymetry 00000 meters.

HYDROGEN ENERGY

Hydrogen has the potential to replace liquid fossil fuels in the future. In recent years, significant progress has been reported by several countries, including India, in the development of hydrogen as an alternative fuel. Serious concerns' relating to energy security are driving this global transformation towards a hydrogen economy. India is one of the few developing countries, which has strong RD&D (research, development, and demonstration) programmes on hydrogen energy. There is a need to accelerate the development of hydrogen energy. Technologies in India through research organizations and industry for making it a viable substitute for petroleum products in the long run.

Electrolysis using electricity from renewable sources is considered as the long-term solution and is a technology favored by environmentalists. However, the capital costs of renewable energy technologies need to be reduced significantly for electrolysis to emerge as an important hydrogen production method. Such technologies would lead to large-scale application of decentralized hydrogen production methods. No single production technology is likely to meet the requirement of hydrogen for the new and emerging applications in power generation and the transport sector in the near and medium term. Therefore, all possible options would have to be pursued in a prioritized manner. Research efforts also need to be unmeet the requirement of hydrogen for the new and emerging applications in power generation and the transport sector in the near and medium term. Therefore, all possible options would have to be pursued in a prioritized manner. Research efforts also need to be undertaken for large-scale and cost-effective production of hydrogen based on coal and nuclear energy.

For a hydrogen-based economy, the key economic determinants would be the cost and safety of the fuel distribution system. This is true of any fuel, but hydrogen presents unique challenges because of its high diffusivity, extremely low density as a gas and liquid, and its broad flammability range. These unique properties present special cost and safety considerations at every step of distribution, from manufacture to, ultimately, on-board vehicle storage. Also critical is the form in which hydrogen is being shipped and stored. It can be transported as a pressurized gas or a cryogenic liquid; combined in an absorbing metallic alloy matrix or absorbed on or in a substrate; or transported in a chemical precursor form such as lithium, sodium metal, or chemical hydrides.

Apart from its existing uses in industry, hydrogen can be used for a wide range of applications, including power generation and transportation. It is possible to use hydrogen directly in IC (internal combustion) engines, mix it with diesel and CNG (compressed natural gas) and also use it as a fuel in fuel cells to directly produce electricity. It is also used as a fuel in spacecrafts. MNES has been supporting a broad-based RD&D programme on different aspects of hydrogen including its production, storage, and utilization as a fuel for transport and power generation. Several research, scientific, and educational institutions, laboratories, universities, and industries are involved in implementing various projects on hydrogen energy technology. The emphasis of the research has been on further improvement in renewabie energy-based hydrogen production methods, its storage, and materials used for storage and utilization of hydrogen energy as a fuel.

CONCLUSIONS

The global energy demand is on the rise, more so in the case of developing countries like India. Though conventional fossil fuels that provide primary energy have limited resources, coal will maintain its dominance in international energy scenario because of its huge reserves that will last for two centuries. Due to environmental concerns, various other energy options including renewable, are being tried globally but they have failed to provide bulk energy at competitive cost. Environmental laws for the abatement of environmental degradation are discussed. It is concluded that energy security leading to energy independence is certainly possible and can be achieved through planed manner.

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