Report on

Advanced Coal Management

By

CGS Gunasekara

Electrical Engineer

Kothmale Power Station

Training Program held in Kolkata, India
01- 04 December 2009

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Preface

Energy is an essential item for today's society to maintain an acceptable standard of living and economic growth as economic development is directly proportional to the energy requirement. The steep rise of the oil prices, energy demand, depletion of fossil deposits and growing environmental concerns have focused the attention on alternative sources in fulfilling future energy demand. This has created awareness among stakeholders to explore new energy options.

As far as alternative sources are concerned future world trend focuses on liquid fuel, coal, natural gas, renewables and nuclear, while coal making a significant contribution approximately 50% of world energy usage. Considering the availability of coal deposits, economic and technical feasibility, Regional Corporation among nations, using coal for power generation creates a great opportunity as well as benefit for SAARC countries.

Toady, India is the world's third largest coal producer and user. During the training program it was in detail discussed and explored the experiences, problems and government policies developed and strategies adopted by India to over come the problems faced by them in coal industry, covering all the aspects such as land acquiescence, resettlement of people, social aspects of displaced families, environmental effects, logistics management, health and safety of mine workers etc. These experiences would greatly help other SAARC countries those who are in coal industry at present as well as those who intend enter into the field in the future to manage their activities in a better way.

And also, I take this opportunity to thank USAID and SARI/Energy for providing us, ;SAARC countries the opportunity to undergo this valuable training and share the experience of Indian academics and practicing experts in the Indian coal industry.

website ; http://www.mahawelicomplex.lk

1.0 Introduction

1.1 World Energy Scenario

Energy is essential item for today's society to maintain an acceptable standard of living and economic growth. History has proved that there is close relation between the population growth rate and the energy usage. [1]. As the energy intensive human activirties grow in future energy requirement increases with the growth of the population. Today there are nearly 6.5 billion population in the world. Out of that 20% live in developed countries and the remaining 80% in developing countries . But still there is 1.6 billion people do not have access to electricity and 2.4 billion use fire wood for cooking and heating [2]. Therefore, this gap also has to be filled in the future.

During the last forty years period, average per capita energy consumption per person has increased up to 1.5 TOE[6] . Further more due to world industrialization the average per capita energy consumption per person per year has reached to a average of 1.7 TOE in 1998 [1] . During this period world population has been doubled while tripling the energy consumption [3]. Figure 1.1 shows the rapid increase in the world primary energy consumption during the period 1980 to 2005 and the forecast up to 2030.

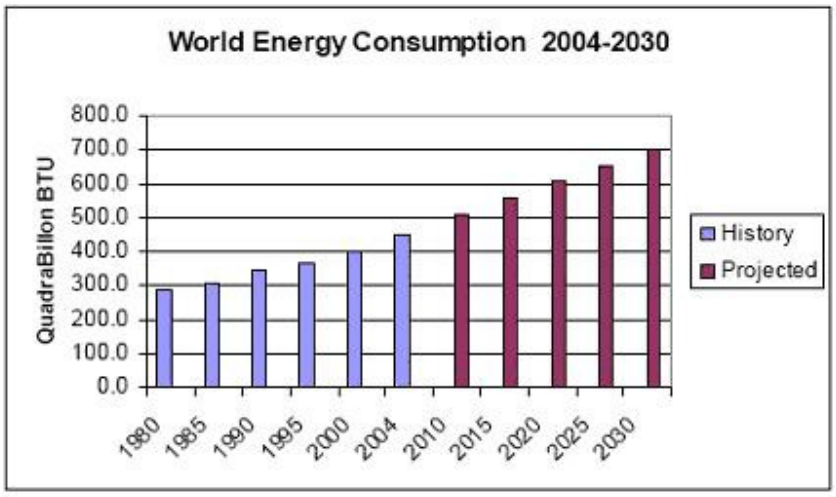

Figure 1.1 Total world Energy consumption (data Source EIA http://www.eia.doe.gov/oiaf/world.html)

The current world energy mix consists of oil (36%), natural gas (24%), coal (28%), nuclear (6%) , hydro (6%) , renewables (2%) [1]. Fig 1.2 and 1.3 shows the current energy mix and forecasted energy mix in 2050. Comparwing these two situations it can be seen that fuel proportions has been changed over the time.

As it can be seen that, fossil fuel makes the major contribution to the energy mix , but contribution of oil and natural gas has declined rapidly over the coming decades. The important contributors are, coal, oil, natural gas, hydro, nuclear and renewables making a significant contribution. Out of those coal makes a significant contribution nearly 50%, over the others in the years to come as clearly shown in fig 1.3 .

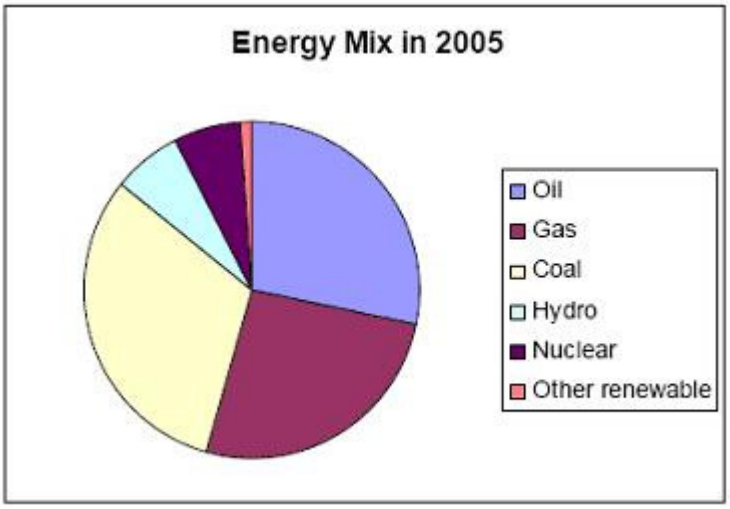

Figure 1.2 world energy mix in 2005 (data Source EIA http://www.eia.doe.gov/oiaf/world.html)

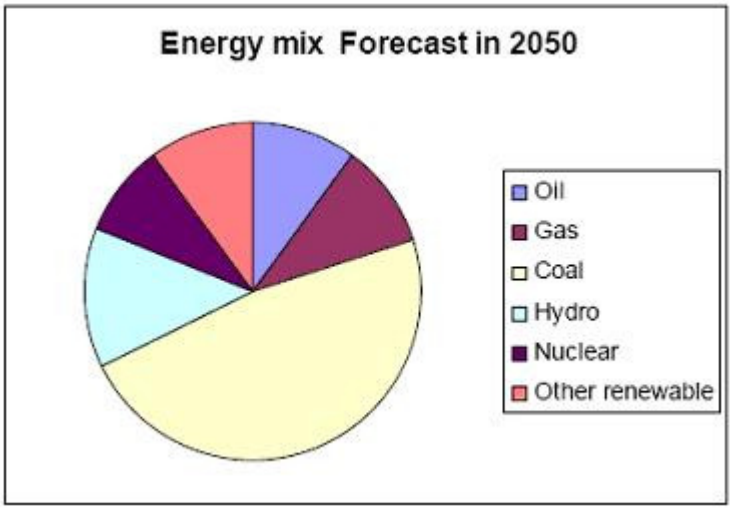

Figure 1.4 World projected energy mix in 2050, (data Source EIA http://www.eia.doe.gov/oiaf/world.html)

Figure 1.5 further illustrates that significant increase in fossil fuel usage in the decades to come, coal contributing as second largest fuel type in the future.

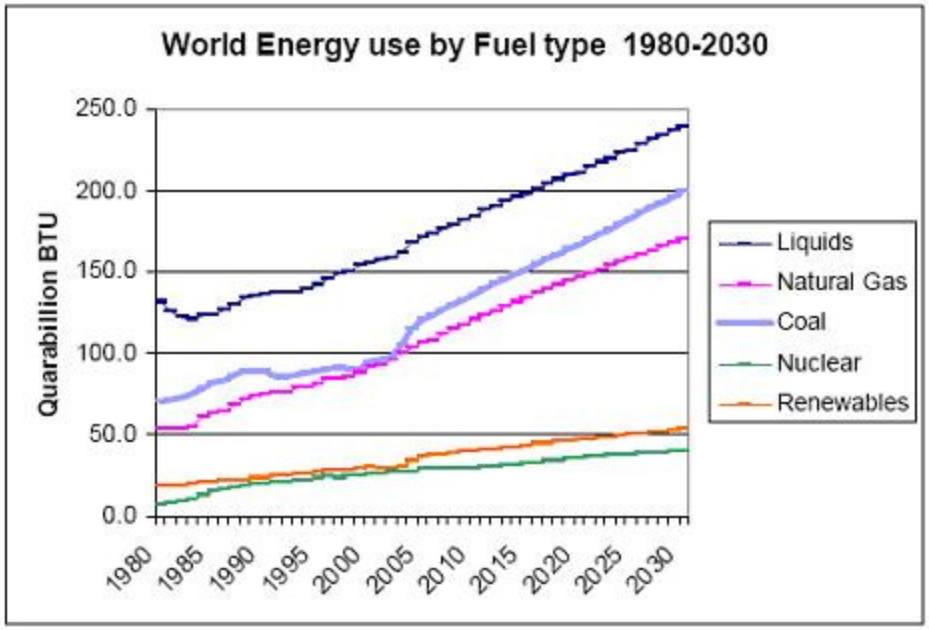

Figure 1.5 World projected energy use by source . (data Source EIA http://www.eia.doe.gov/oiaf/world.html)

1.2 Sri Lankan Energy scenario

Sri Lanka is an island country located in Indian Ocean to the south of India and separated from India by Palk Strait. It is also known as the Island of Serendipity. Sri Lanka lies just above the equator between 5° 55'N and 9° 55' N and between the eastern longitudes 79° 42' and 81° 52' . The maximum length and width of Sri Lanka is 435 km and 225 km respectively. Total area of Sri Lanka is 65610 sq km (Land area: 64740 sq km, Water area: 870 sq km), and has a population of over 18 million. Colombo, on the central west coast is the capital and largest city with a population of over 2 million.

The lowlands of the island are always hot, particularly from March to May. The highlands have a cooler climate. The southwest monsoon season is from mid-May to September, the northeast monsoon season from November to March, and the dry season from March to mid-May. Sri Lanka is mainly an agricultural country. Although rice is Sri Lanka's largest crop, tea, coconut, and rubber are the main economic agricultural crops. Approximately 29% of the land is used for agriculture and about 22% is forested. [4].

1.2.1 Current Energy supply

Energy supply in Sri Lanka is mainly based on three primary resources, namely ,biomass ,petroleum and hydroelectricity. In 2004, hydro-electricity production in the country accounted for 710.71 kTOE while the biomass-based energy supply was 4,513.3 kTOE. Approximately 4,131.9 kTOE was provided by imported crude oil and finished petroleum products such as diesel and liquefied petroleum gas (LPG). Additionally, the nonconventional resources (mainly wind) provided 3.6 kTOE of primary energy, giving an aggregate primary energy supply of approximately 9,359.5 kTOE. Primary energy contributions in 2004 to national energy supply were 48.2% from biomass, 44.2% from crude oil and petroleum products, and 7.6% from hydroelectricity and other renewable sources. The use of nonconventional energy resources in Sri Lanka is of a relatively smaller scale and therefore its contribution is presently of low significance in the macro energy picture [5].

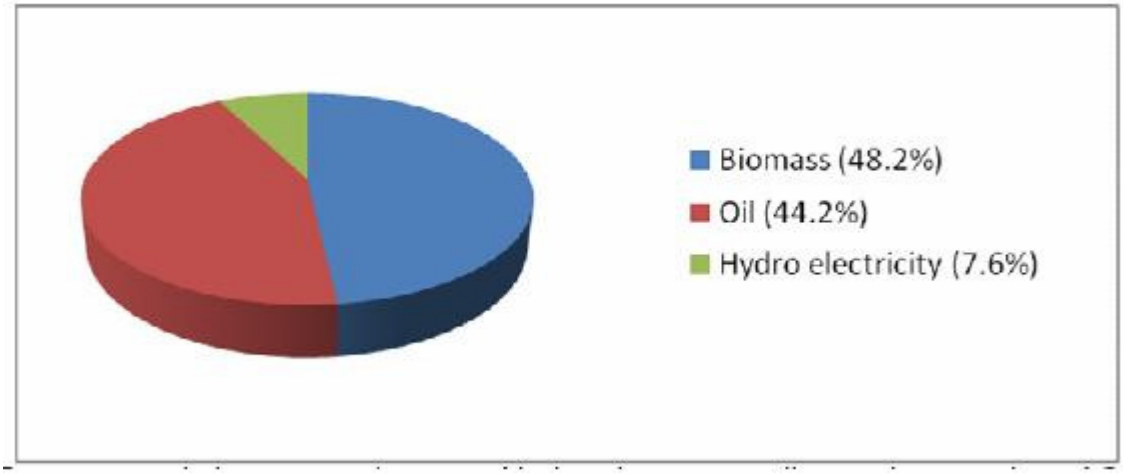

Figure 2 Energy supply by source (source; National energy policy and strategies of Sri Lanka, Ministry of power and energy, Government of Sri Lanka, October 2006)

The largest energy consuming sector is the household sector (45%) while transport is the second largest (25%), industry, non energy use and other consumption and commercial and public sector contribution are 23%, 4% and 3% as shown in figure 3.2.2 Future energy Demand growth With the ever increasing energy demand to cater the requirements of economic and social demand of the country total primary energy demand is expected to be rise up to 15000 KTOE by year 2020. It is approximately an average annual growth rate of 3% [5]. In

contrast Electricity and petroleum sub sectors would record a higher growth rate about 7-8% [5].

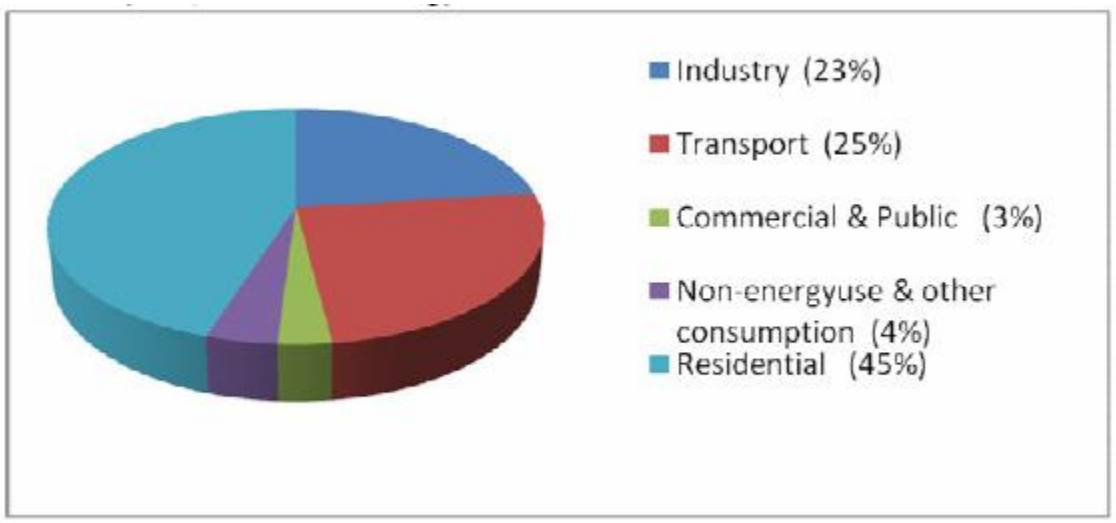

Figure 3 Energy Consumption by sector (source; The environmental information portal, http://earthtrends.wri.org/text/energy-resources/country-profile-167.html

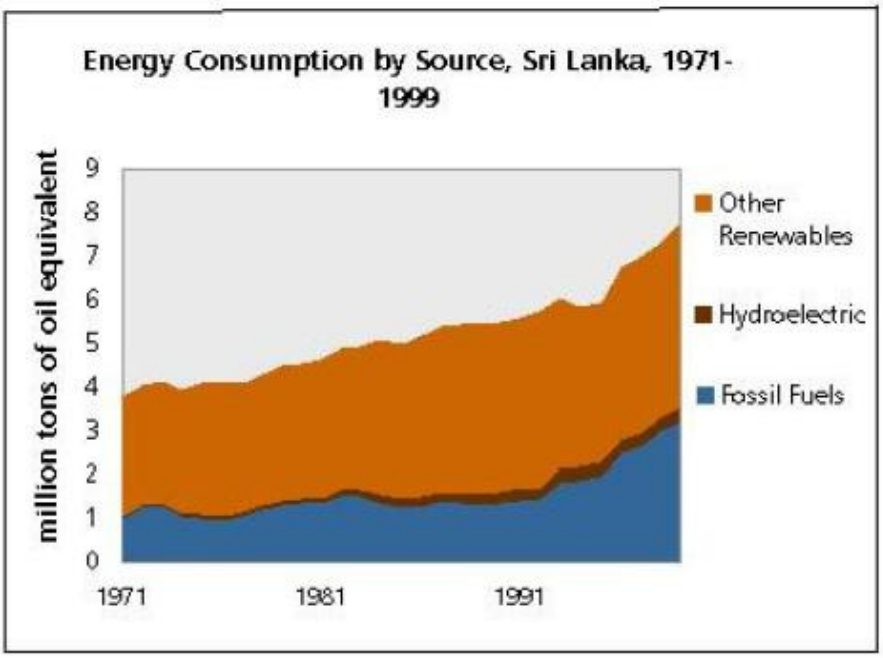

Figure 1.3 Energy consumption by source (source: The environmental information portal, http://earthtrends.wri.org/text/energy-resources/country-profile-167.html)

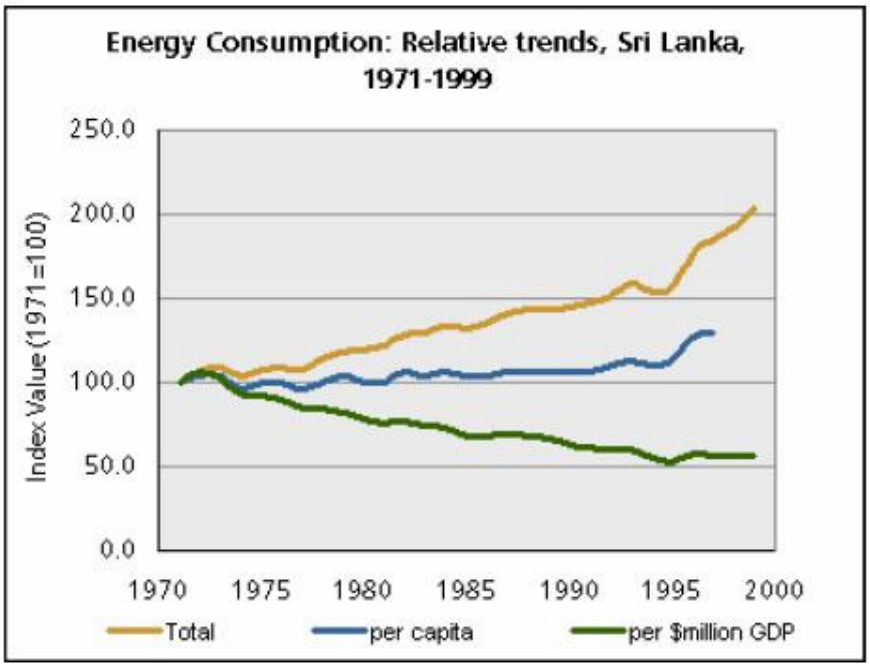

Fig 1.4 Energy consumption related trends (source: The environmental information portal, http://earthtrends.wri.org/text/energy-resources/country-profile-167.html)

1.2.1.1 Electricity supply

The generation of electricity using renewable energy sources in Sri Lanka has no long term plans at present set for the next ten years and power expansion is more towards the coal generation. Due to the increasing demand for electricity and scarcity of hydro power generation the move is towards the coal power generation. In figure 1.5 it is shown that the existing and proposed power generation options for the future

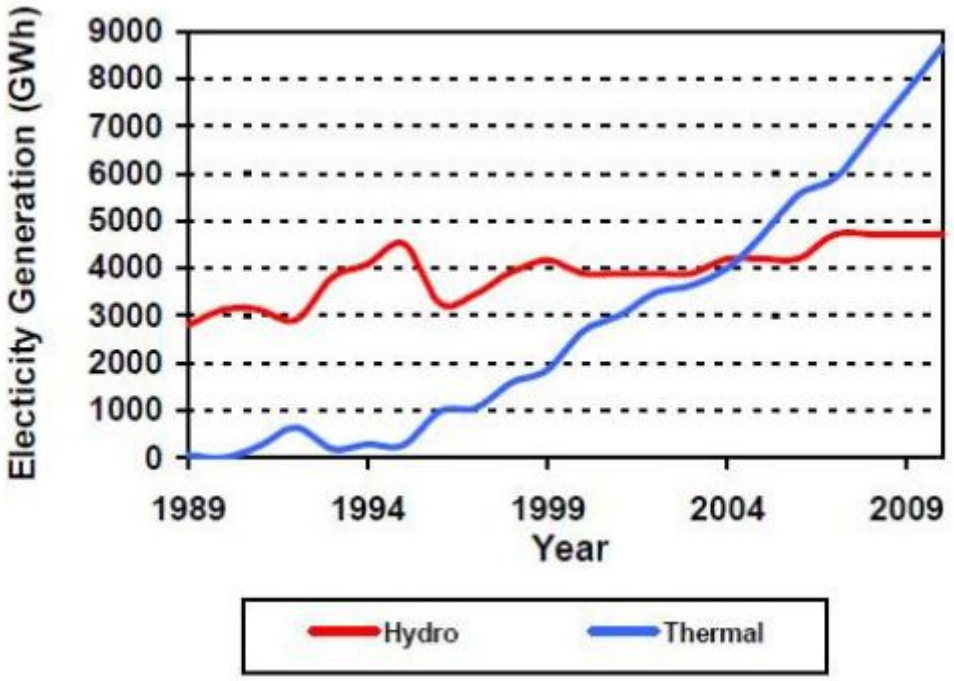

Fig 1.5: Existing and Proposed electric power generation capacities [3]

The main electricity producer of Sri Lanka is the government owned monopoly Ceylon Electricity Board (CEB) which has an installed capacity of around 1838MW comprising of 62% hydro, 37% thermal and 1% renewable (this includes small hydro plants and a 3 MW pilot wind farm) [6]. According to the predictions the future electricity demand growth will be around 10% annually increasing the household demand around 61%. [6]. The future power generation in the county will become predominantly fossil fuel based if appropriate action would not taken to exploit renewable sources. Fig 6, compares the hydro and thermal capacities growth so far [6]

1.2.2 Resources available for future development

1.2.2.1 Energy availability

Biomass, hydropower, and thermal power (fossil fuels), are the conventional large scale energy sources available in Sri Lanka in supplying energy. But, Hydro electricity production and biomass-based energy supplies, are expected to increase only marginally in the near future. This is mainly due to limitations in further hydropower development owing to lower economic viability of exploiting the remaining large hydropower sites and limited use of biomass with gradually increasing standard of living of the population. This means that the country's incremental primary energy requirements need to be supplied mainly by imported

fossil fuels in the medium term if immediate action would taken to develop alternative options.

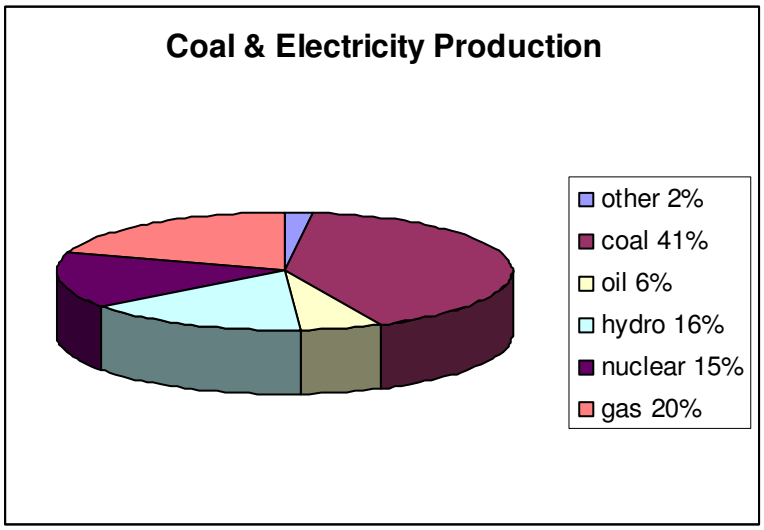

Figure 1.6 Global electricity generation by source
(Data source: http://www.worldcoal.org/coal/coal-mining/):

1.2.2.2 Suitability of coal as a primary energy source for future

In the view of above discussion as far as the availability of energy sources, life time of fossil fuel resources (oil), economy of energy resource, feasibility of technology available and the world trend are concerned coal is the next appropriate primary energy supply suitable in the future for a country like Sri Lanka who totally depends on imported fuel. Because, oil reserves all over the world will be ceased by 2100, but according to the estimations at present consumption level coal will sustain for about 135 years.

This is discussed in detail in chapter 2, in the context of SAARC region. related to all the countries belongs to SAARC group, pointing out the current status and the challenges and opportunities of coal..

2.0 Contemporary issues in coal and energy in SAARC

2.1 Opportunities and Challenges

SAARC is a diverse conglomerate of nations, mostly developing ones, where the demand for power has soared, propelled by the inexorable inertia of population explosion and aspirations for higher quality of life. There is no gain saying the fact that energy availability will be central to the development agenda in SAARC, as the catalyst for change for a better future. The *tsunami* wave of globalization, nay internationalization, has opened new windows for establishing increasing interdependence in the energy sector and this aspects will also deserve some consideration. The role of coal in the current and future energy landscape in SAARC will also be examined vis-à-vis SAARC observer countries- China and USA- to gain some insight into the prospects of energy development via coal in Bangladesh and Pakistan [7].

2.2 Energy sector in SAARC – The current status

The highlights of the energy sector in SAARC nations can be summarized as below:

- Economic growth has propelled energy consumption
- The growth is constrained by significant energy deficit
- India, Pakistan, Bangladesh , Sri Lanka and Afghanistan have energy demand surpassing their domestic supply
- Bhutan and Nepal have energy resources in hydropower far in excess of their domestic needs that can be traded within the region; Bangladesh, India and Pakistan have significant opportunities for electricity and gas traded within South Asia
- Recent escalation in world oil prices have placed an enormous burden on foreign exchange reserves in SAARC nation; Sri Lanka and Maldives, which lack indigenous fossil fuel resources, are especially hard hit while India, Pakistan and Bangladesh meet less of their demand with indigenous fuel resources and face thus mounting energy import bills.
- Energy security is an inevitable reality for vital economic development throughout SAARC nations.
- SAARC nations collectively had energy consumption of around 584.6 million toe, of which 420.2 million toe was commercial energy and the remaining share includes non-commercial sources like biomass. Some 38% of the total energy consumption came from non-conventional energy sources, animal waste, wood and biomass etc.
- Natural gas dominates Bangladesh energy mix accounting for 68% of the total energy consumption
- India depends heavily on coal that accounts for over 50% of total energy consumption
- Afghanistan, Maldives, Nepal and Sri Lanka rely heavily on oil products

- Bhutan has the highest share of hydropower, accounting over 70% of the total energy consumption
- Pakistan has a mixed bag of energy consumption which is diversified among oil products(27%), natural gas(55%) and primary electricity(12%)
- There is wide disparity amongst SAARC nations in terms of per capita energy consumption as is reflected in the following:

Afghanistan	-	16.00 toe
Bangladesh	-	89.00 toe
Bhutan	-	243.00 toe
India	-	335.0 toe
Maldives	-	759.0 toe
Nepal	-	44.00 toe
Pakistan	-	355.00 toe
Sri Lanka	-	200.00 toe

In terms of the proportion of population with access to electricity, the figures also reflect wide range- Afghanistan (26%), Bangladesh (38%), Bhutan(40%), India(55.8%), Nepal (40%), Pakistan(55%), and Sri Lanka (73.4%). The problems of access stem from high cost of electricity and poor quality. There are significant in transmission and distribution of electricity [7]

2.3 Energy endowment in SAARC nations

Fossil fuel resources are scarce in SAARC, barring India, which has over 260 billion tonnes of coal resources. Pakistan has some 60 million tonnes of sub-bituminous coal and over 2990 million tonnes of lignite. India holds a majority share of the region's oil resources, which was 5.7 million barrels Vis-à-vis natural gas, Afghanistan has 100 billion cubic metres, Pakistan 800, India over 750 and Bangladesh some 434 billion cubic .metres [7].

- Total recoverable reserves of Uranium aggregate to over 41,000 tonnes of uranium

- The nations have large renewable energy capacity, but high unit cost has been a road block In 2007, India's renewable capacity was distributed as follows: wind(70%), Small hydro(19%), cogeneration/ bagasse (8%) and Bio Power(5%)

- India is the 4thlargest producer of wind energy in the world with a capacity of over 7 GW and the capacity growth has now reached an annual rate of 40%.

2.4 Globalization, Liberalization and Technology

Since the fall of the Berlin Wall we have witnessed the strong influence of three powerful global forces: globalization, liberalization and technology which have necessarily had spread effects in SAARC nations too. Unless these three global forces are given a human face, especially in developing economies, we face a daunting challenge. It is in this setting that we need to address the question of co-operation.

2.5 Energy Trade and Future Prospects

Nepal imports 11% and Sri Lanka imports 45% of total energy requirements .Energy surplus and deficit nations of the region are not strongly linked. Hydropower potential of Nepal and Bhutan, which exceeds their domestic demand, and natural gas reserves of Bangladesh could be traded amongst the regional members to fulfill the energy requirements of India and Pakistan [7].

Abundant energy endowments of the neighbouring countries like Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, Kyrgyz Republic, Iran and Myanmar can become crucial for the region"s energy security.

- SAARC Working Group on Energy and SAARC Energy Centre are the key bodies overseeing the ways and means of energy integration amongst the SAARC nations.

- There is need for an agreement similar to the ASEAN Energy evelopment Agreement for SAARC nations too and we need to incentives and rewards to encourage energy efficiency and renewable energy development.

3.0 Strategic issues on Coal

3.1 Marketing and Management issues

In the present environment the rate at which business and industry change is exponential. This change started in eighties and caught up whole world in nineties. It changed the whole economic order of the world. Popularly called the Liberalization, Privatization and globalization regime (LPG) the globalization progress impacted the most of the world bringing about restructuring and liberalization in many countries. South Asian Nations were also influenced. The basic change was in the attitude and practice of governance, particularly with reference to business. Against this back drop nations started thinking in terms of energy security and enhancing power generation to catch-up with the growing demand as a result of rapid industrial and infrastructural development.

At the global level the structure of the world's coal industry has witnessed considerable change. European companies particularly multinational conglomerates are increasing their presence abroad. The removal of European coal subsidies has encouraged this trend. In the United States, the role of European companies has grown more pronounced and the U.S. based industry participants have reduced their role. Several of the smaller independent coal producers, major U.S. petroleum companies, electric utilities and domestic steel manufacturers are gradually reducing their roles. A considerable role is being played by foreign investment in Australia, the world's largest exporter of coal as in United States [8].

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3.2 The global scenario

Coal accounts for 25% of global energy consumption. This is less than crude oil (39%), but more than natural gas (22%). Up to 90% of coal production is consumed in the country of origin, primarily for the generation of electricity. Only about 10 percent of world coal production makes it way into export market. Still international trade in coal has grown significantly in recent years, particularly in case of steam coal. Around a decade ago international trade in steam and metallurgical coal were roughly equal. By 2010 steam coal trade is expected to be more than double the metallurgical coal trade. Between 1973 and 1994, international coal trade doubled and will increase by another 50 percent by 2010. Only a few nations and companies account for most of this trade Australia is the largest exporter of coal, the Unites States and South Africa been next to it. In 1994, Japan was the world's largest importer of coal followed by South Korea, Russia, Taiwan, Germany, the Netherlands and Great Britain. It is to be noted that though leading world coal producing companies include some state owned companies, a few multinational conglomerates are very prominent in worldwide coal trade and investment. These companies are largely from the United Kingdom, Germany, the United States, and Australia. Interestingly despite being

the largest importer of coal (and also of U.S. coal), Japanese companies have relatively minor investments in coal assets abroad. Many of the world's largest producers of coal are not publicly traded corporations. Neither are they multinational in outlook. For instance, among the world's largest producers of coal are the national coal companies of Russia, India, and Ukraine. Recently, the Indian giant CIL has started looking beyond shores through its Coal Videsh, the company's foreign venture arm [8].

UNITED STATES: Foreign investors have become increasingly important in U.S. coal over the past decade or so and the share of foreign affairs in U.S. coal production has grown from nearly zero in the late 1970's to 29 percent in 1990's, where three of the top five U.S. coal producing companies were foreign affiliated, accounting for more than one fifth of total U.S. production. The attractiveness of the U.S. coal industry as a target of foreign investment is for a number of reasons.

First one, the United States is the largest coal market open to foreign investors. In addition to being the second largest exporter of coal, it is the world's second largest coal consumer and producer. Most of the foreign investment in U.S. coal has been from Europe.
European coal companies are motivated to invest in U.S. coal for securing sources of coal in the face of declining European production.
Another possible motive for investing in U.S.coal are financial incentives. Largely due to several years of financial under performance among their coal segments, the majors' departed from U.S. coal. Only rarely in the last over two decades did the majors' profitability in coal exceed the profitability of their consolidated operations.
The key factor motivating UK and German investors is that many European mines got closed due to inefficiencies and multinational European coal producers had to move abroad in order to remain in the coal business. As a result, the United States and Australia (with their extensive coal reserve, established export market, and few impediments to foreign investors) gained prominence as a targets for coal investments.

EUROPE: In Western Europe, coal production is concentrated, with the United Kingdom and Germany which account for some four-fifths of total production while Spain and France account for most of the remainder. European coal producers benefitted until recently from protected markets and from an extraordinarily generous subsidies, that allowed their coal mines, to remain in operation despute inefficiency. In Germany, for instance, subsidies until recently were financed by a 7.5 percent levy on electricity bills. As a consequence, domestic coal prices in Germany were more than three times the import price.
Thus, electricity prices in Germany are the most expensive in Europe, and 70 percent more costly than in the United States. The German coal industry has

been shrinking in recent years in order to comply with European Union mandates and to remain competitive in international market.

Europe's coal industry is also restructured due to a shift to alternative fuels. Western Europe's energy consumption fueled by coal fell from around 80 percent in the 1950's to 25 percent in mines. The European utilities are expected to move toward greater usage of increasingly available North sea natural gas and away from coal.

This continued elimination of coal subsides and shift toward natural gas led to decline in European coal industry. In the meantime the coal production in the United Kingdom declined by over 60 percent from its 1980 level, and Germany experienced a decline of almost 40 percent in hard coal production. The reduction in coal output in the United Kingdom was in part due to the elimination of subsides undertaken by the British government. Germany has been behind schedule in removing coal subsidies. For OECD Europe, hard coal production is expected to fall from 187 million metric tons in 1992 to 80 million metric tons in 2010.

On the other hand U.S. coal production peaked in nineties, surpassing 1 billion short tons for the second time in history. U.S. production in nineties was 25 percent larger than in 1980. In future, the United States is expected to increase its coal output. Other countries expected to boost coal production and exports include, Australia and South Africa. Recent entrants into the global coal trade include Colombia and Venezuela.
Interestingly, with the exception of South Africa, all of the aforementioned nation's coal industries have seen increasing levels of foreign direct investment from a few multinational conglomerates.

AUSTRALIA: Till not very long ago the United States was world's primary source of coal exports. In 1970, the United States accounted for one-half of the international coal trade. Whereas U.S. share of world coal trade declined to 15 percent of the total.
Coal is Australia's number one export. Some companies most prominent in the U.S. coal industry are also significant in Australia's coal industry, particularly those directed towards export markets. Like United States, foreign investment plays a key role in Australia's coal industry, indicating how multinational in character the world coal investment has become. Australia consumes less than a third of its domestic production (contrast 90 percent in the United States).

Even though 70 percent of Australia's coal exports goes to Japan, its investment in Australian coal is comparatively small. Ownership of Australian coal assets is largely held by Australian, U.S., and European companies. The largest producer of coal in Australia is the Australian multinational conglomerate, Broken Hill Proprietary Company Limited (BHP). BHP is the 17^{th} largest coal producer in the United States, and also has coal mining interests in Indonesia.

SOUTH AFRICA: South Africa is the third largest exporter of coal, the mineral a accounting for 98 percent of its energy production and 78 percent of energy consumption. The country ranks seventh in coal reserves. For quite some time, United Nations' sanction restricted the flow of foreign direct investment to South Africa industries. In nineties, the sanctions were lifted, but foreign direct investment did not rise much. Though primarily domestically held corporations, South African coal mining companies are among the largest in the world. After lifting of the U.N. sanctions, South Africa coal mining could become a target of foreign direct investment and a growing source of coal exports.

CHINA: China is the world third largest coal producer as well as the consumer. In 90's, coal accounted for 75 percent of the country's total energy consumption. China's higher rate of economic development .has increased the it's heavy dependence of coal and petroleum fuel imports. Although china can easily export it's coal to near by countries who have high demand for electricity generation, it's high domestic consumption and poor infrastructure has hampered it. Some attempts have been made to reform the industry by removing the price control as well as by redistributing mine ownership to private sector, as the 50% of present mines are government owned. Further, industry is beginning, to attract foreign participation.

COLOMBIA AND VENEZUELA: Colombia and Venezuela. Are the largest producers of coal followed by Brazil and Venezuela. Colombia has Latin America's largest coal reserves, ranked ninth in the world in terms of coal exports, Colombia is expected to play an increasingly important role in world coal trade in the future. Moreover, several companies investing in Latin American coal mining also have coal investments in the United States and Australia. The Italian energy company AGIP mines coal in Venezuela, as does Royal Dutch / Shell and the German energy conglomerate Ruhrkohl. AGIP and Veba also have coal mining operations in the United States.

3.3 The Indian Scenario

Liberalization affected the India as well as other SAARC countries increasing the dependence on coal. The face this high demand and ensure the development of coal sector, India formed a government owned company called CIL Coal India limited, which is public sector under taking (PSU) consisting of eight subsidiaries in November 1979, which has the. world's largest corporate employers with more than 4.04 hundred thousand [8].

The CIL operates in 81 areas and 473 mines spread over eight States. Its products include raw coal (coking and non-coking), washed coal, middlings, soft coke and hard coke, coal tar, coal gas and coal chemicals.

The CIL has planned 134 projects that would produce a total of 285 million tones of coal at a cost of Rs.26,000 crore; 65 projects have already been approved and are under implementation. The company has set itself a target of producing 520.5 million tonnes in 2011-2012 and envisages reaching a production level of 664 million tones in 2016-2017. Around 86 percent of the CIL's coal comes from opencast mines. Though the technology for such mining remains unchanged, the CIL has brought in new equipment to enhance production [8].

Until 2006-2007, production from the CIL's underground mines had been decreasing. From 67 million tones in the mid 1970's, it had come down to a little over 43 million tones by 2006.

At present rate of production, there is a danger of the opencast mine reserves not lasting for more than 30 years; the CIL is refocusing on underground mining. The CIL is planning to develop abandoned mines. It has identified 18 such mines, with estimated reserves of over 1,600 million tones of high quality coal. It also plans to set up 19 washeries by the end of the next fiscal. India is currently the 11th largest energy producer in the world, accounting for 2.4 percent of the world's annual production, and the sixth largest energy consumer, accounting for about 3.3 percent of the world's annual energy consumption. The country's power sector is expected to grow exponentially with huge capacity addition. According to the New Coal Distribution Policy formulated by the government, the CIL has been given the mandate to meet the full demand for coal.

Although the total coal production for the present fiscal is targeted at 435 million tones, 437 million tones will be distributed; the additional two million tones are to come from the CIL's stocks. Of this, 313 million tones will go to the power sector – 306 million tones for the existing power houses and seven million tones for those power stations commissioned between April 2009 and March 2010.

The CIL recently invited expressions of interest to strike up joint venture with companies in the United States, South Africa, Indonesia and Australia that could eventually export coal to India. It bagged through competitive bidding two virgin coal blocks in Mozambique. Acquisitions are also on the anvil through International Coal Ventures Ltd, a special purpose vehicle between the CIL, Steel Authority of India Ltd, National Thermal Power Corporation Ltd, National Mineral Development Corporation and Rashtriya Ispat Nagam Ltd. The Company is also aware of the need to address the imbalance in the ratio between the increase in the rate of demand and increase in the rate of production. Major Marketing and Management Challenges of the coal industry post liberalization is increasing the competitiveness. The monopoly status that the company enjoyed has gone and competition from foreign coal is to be faced. Particularly in light of the fact that there is growing demand of coal to meet domestic development requirement, the CIL is planning to import Four million tones of coal. With liberalization import has become easier and cheaper and given the inherent weakness of Indian coal in terms of ash content many private consumers prefer foreign coal. So it is a

strange kind of a scenario you have to invite competition and you have to face it also. Moreover, certain logistical challenges also have to be coped with. Thus, the twin challenges of marketing and Management have to be coped with. Of late, CIL has embarked upon the strategies like out sourcing, e-auction and fuel sales agreement with its customers. But more needs to be done.In light of the above the coal industry in India is facing the following challenges [8]

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- **Quality:** Though underground coal is largely acceptable as its quality problem are more due to chemistry and seam related, still high ash content is to be contended with. The Indian coal produces, particularly the coking coal producing Bharat Coking Coal Limited is trying to send the coal to washeries first to that the beneficiation leads to improved quality. This adds to the cost and creates a problem for competitiveness. In the case of open cast coal that accounts for bulk of the production the situation is more of a human attitude and commitment. In open cast mined coal, the product gets mixed with overburden and other impurities and the company in its rush to dispatch more and more quantity compromises quality. This creates poor brand image and brand equity. Further, the Indian companies have not been able to shake off their monopoly status mind-set and are still focusing on sales rather than marketing. This is creating customer disaffection.

- **Production:** The output per man shift in India is rather low and the productivity poor. This is due to number of reasons one of the reasons is quality of man power and other related problems like absenteeism, alcoholism, stress and health etc. The safety standards and safety consciousness is also not of international class. In addition, technology up gradation, capacity utilization, management practices all need to be improved. A general improvement of the work culture is also required which will definitely add to the quality and productivity of the Indian coal industry.

- **R&D:** The investment and attitude towards R&D in the Indian coal industry is rather poor resulting in overall lack of competitiveness. There are though a few research agencies / organization which are engaged in research in coal quality, technology and management practices. The CIMFR (CSIR) and ISM (MHRD) are two world class organizations apart from the CMPDIL which is under CIL. But, the interface needs to be increased. One basic problem is the regimented approach towards HRD and sponsored research. In the twenty first century these efforts will have to be increased. More so, because the balance between environment and production enhancement needs to be met.

4.0 Social and Environmental concerns of coal industry

4.1 Introduction

Mining is an essential activity for industrial and social development. These are non-renewable and diminishing resource which is wide used for thermal power generation and and mining has to be done where the resource naturally exists. In most of the situations the minerals exist in forest and agricultural areas which invariably have low level of economic activities. The advent of mining brings about a marked change in the nature of activities taking place in these areas. The level of economic turn over increases manifolds [9].

Mining is generally considered as a socially and environmentally unfriendly activity as it causes several impacts on all the components of the environment including the society. The impacts are not restricted to the mining sites only but also can be experienced regionally as well as in some situations nationally. Keeping the importance of mining in view, the leading coal and mineral producing countries in the world have formulated various policies, legislation and procedures with a view to efficiently managing the societal and environmental aspects of mining and associated activities. In the South Asian region India is the most prominent coal and mineral producing country. The country stands third in the production of coal after China and USA, and is amongst the top ten mineral producing countries in the world. Nearly 70-75 percent of the coal produced is being used in thermal power generation [9].

Mining complexes present typical social and environmental dimensions, which need immediate attention. This is the only industrial activity which can be planned for reclaiming the land and developing the resources needed for the post mining land use. For efficient management of the societal and environmental issues in the mining sector the country has the Policies, Legislation and Procedures broadly outlined hereunder [9].

1	Policies	Mineral Policy
		Integrated Energy Policy
		Industrial Policy
		Environmental Policy
		Forest Policy
		Rehabilitation and Resettlement Policy
2	Legislation	Mining Legislation
		Environmental Legislation
		Civil Laws
		Land Acquisition Legislation
3	Procedures	For prospecting of minerals
		For the grant of mining leases
		For developing the mines
		For obtaining mining permissions
		For environmental clearance
		For diverting forest land for mining

Industrial and developmental projects require land for their establishment as these are land based activities. The land for these projects is acquired under the provisions in The Land Acquisition Act, or also purchased outright from the owners. Mining is a site specific industry and most of the minerals and fossil fuels exist in forest-cum-agricultural areas, which in general are socially and economically underdeveloped. Therefore, the mining companies besides taking care of the people directly involved in their activities have responsibility for making efforts for overall societal development of the mining complexes and surrounding areas as a part of their 'Corporate Social Responsibility (CSR) [9].

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For mining land is not only required for citing the mines but also for various other activities, e.g., coal/mineral preparation plants, dumps, colonies, workshop, etc. which facilitate mining. In the process of land acquisition and establishing the mines all the people living on the land used by mining and associated activities are displaced and those dependent on the land loose their livelihood. The families who are displaced and who loose their livelihood are called the P*roject Affected Families* (PAFs). These families are to be suitably taken care by re-establishing them at suitable locations and enabling them to live and earn their livelihood with honor and dignity [9].

In fact mining and associated activities cause several impacts on the society in and around the mineral/coal bearing areas and in the process of establishing the PAFs it is required to take care of these impacts also. Mining also causes several impacts on the other components of environment. Environmental issues are outlined below and a brief account of the impacts is given later.

4.2 Social dimensions

The total coal reserves available in India are amounting to 101.83 billion tones. It is estimated that present rate of consumption and production would last this for another 80 years. Coal supplie 55% of the energy need of the country [9].

The social dimensions of coal mining can at best be assessed by knowing the total dependents on the sector and the existing quality of life of the families and complexes. The total employment in the coal sector is about 600,000 and hence the total dependents are about 6,000,000. For each person employed there are about ten dependents, which include five members of the families of the employee and another five supporting these families and the mining activities [9].

Some studies on the quality of life of the coal mining complexes have revealed that these areas have not socially and economically developed even though the levels of economic activities have increased manifolds. Out of eleven complexes studied only two had overall fair quality of life and the remaining nine had overall poor quality of life. None of the complexes had overall good quality of life.

The mining complexes in the country in general are seen to be having four distinct types of settlements. All of them develop in accordance with the level of economic assistance they receive from the mining companies. The contribution of the State Governments and other agencies is almost negligible in most situations.

1. *Colonies* – Officers, staff and workers colonies made by the mining companies with all the facilities provided by the companies.
2. *R&R villages* – The villages developed by the mining companies jointly with the PAFs with facilities as per the provisions in the rehabilitation and resettlement (R&R) packages.
3. *IPDP villages* – These are the villages within one kilometer distance of the mines with some facilities, e.g., water supply, roads, etc. provided by the mining companies.
4. *Native villages* – These are other nearby villages which do no receive practically any facility from the mining companies.

A study of the level of satisfaction of the emotional, mental and physical needs of the people residing in the four types of locations in two major coal mining complexes in the country revealed that it was different in these locations [10]. A general overview of the level of development of the mining complexes as a whole and the four types of locations in particular indicates that the areas do not represent the nature of development they should have with the level of economic activities taking place.

Another study of the community development [11], at two of the largest opencast coal mines in the country, namely, Gevra and Kusmunda, both in Korba coalfield, revealed the following. The total yearly turn over of the two mines was over Rs 300,000 million with profit of more than Rs 10,000 million. Before mining the area had mainly forest land and rain fed agriculture [9].

1. The mining and associated activities had brought about a marked change in the level of economic activities. But the benefits of the increase in the level of economic activities had not accrued to the entire cross section of the society.
2. The four types of localities in the two complexes developed differently in accordance with the magnitude of assistance they received from the mining company.
3. Only the colonies of the mining company had an overall fair quality of life of the families while the other three locations, namely, R&R villages, IPDP villages and native villages had overall poor quality of life. The percentage of poor families in the four locations was 6 in the colonies, >12 in R&R villages, 84.7 in IPDP villages and 86 in native villages.
4. The colonies and the R&R villages had >70% nuclear families while the IPDP and native villages had 80% combined families.

5. More then 60% of the people in the colonies and R&R villages were engaged in the works of mining and related activities. In the IPDP and native villages this percentage was 50-60.
6. The literacy level in the four locations, i.e., colonies, R&R villages, IPDP villages and native villages was 93.5, 64.6, 41.9 and 33.5 percent respectively with the percentage of non-matriculates being 2, 21.0, 39.4 and 79 respectively. This indicated that even with all the assistance from the Company the R&R villages had poor literacy and education.
7. The percentage of families having per capita income less then Rs 1,000/- per month was 15, 60.4, 83.8 and 87 in the colonies, R&R villages, IPDP villages and native villages respectively. Thus, the economic status of R&R villages, IPDP villages and native villages was no where near the level of the economic activities taking place in the complexes.
8. In the colonies all the families were using LPG as cooking fuel as this was being supplied by the Company. In the other three locations more than 75% families were using coal, wood, and cow dung for cooking.

A recent survey amongst the people resettled in the R&R villages in two coal mining complexes revealed that many people are not satisfied with their conditions of living and most of them do not wish to go back to their original place. This was mainly because they are not aware of the possibilities and future prospects as till now there are no such schemes developed for the coal mining areas.

Till a decade back almost all the coal mines in the country were in Public Sector except some operated by a private company for their own consumption. Coal India Limited (CIL) is the largest coal mining company. Recently about 200 blocks have been allotted to various public and private sector companies mainly for their captive uses. From the point of social dimensions of the Indian coal industry it would be appropriate to outline some details of one of the world's leading coal mining company, i.e., CIL. Salient features are given below.

- Total mines 473
- Underground mines 283
- Opencast mines 155
- Mixed mines 35
- Coal beneficiation plants 19
- Employees 412,350
- Total dependents 4,123,500
- Production in 2008-09 about 400 MT

CIL has its own Mission, Rehabilitation and Resettlement Policy and the company seriously takes its Corporate Social Responsibilities.

The *Mission* of the company is to produce the planned quantity of coal efficiently and economically with due regard to safety, conservation and quality.

As a part of the Corporate Social Responsibilities the company endeavors to uplift the social life and economic conditions of the people around the mines and projects operated by the subsidiaries. To meet the societal aspirations and needs of the people CIL has a well structured Community Development Activity program. Appropriate guidelines have been formulated for community development of the villages in the periphery of the coalfields. The guidelines include development of infrastructure facilities, health, education, social/cultural activities, and tree plantation and skill upgrading. Provisions also exist for institutional arrangements and for up keeping and maintenance of assets created.

The R&R Policy of the company is more Project Affected People (PAPs) friendly and aims at overall growth of the affected people while ensuring involvement of the PAPs.

CIL, the largest coal mining company in the country, has been implementing R&R of PAFs almost since the nationalization of the coal mines in early seventies. In fact, the company has a wealth of experience in this field. In order to fine tune its R&R efforts the company has been remodeling its R&R Policy and the latest one has been outlined earlier. For optimizing their R&R efforts CIL implemented a World Bank assisted Project, namely, Coal Sector Environment & Social Mitigation Project (CSESMP) in 25 mining projects. The salient features of the implementation of this Project are outlined hereunder. [12]

The *objective* of the Project was to strengthen CIL's capacity to deal more effectively with the environmental and social issues through implementation of *Environmental Action Plans* (EAPs), *Rehabilitation Action Plans* (RAPs) and *Indigenous People Development Plans* (IPDPs) to make coal production environmentally and socially sustainable. The Project was completed in June 2002.
The R&R of PAFs was taken up under the implementation of RAPs. The implementation of the project was adopted through a three pronged approach consisting of *Policy Support*, *Institutional Building* and *Implementation*.

Policy Support – Although CIL had an R&R Policy, which was facing many issues while implementing in the subsidiary companies, the Company after the inception of the Project adopted a comprehensive Corporate Resettlement and Rehabilitation Policy under the guidance of the World Bank. This Policy was reviewed from time to time and changes were brought in with the experience gained. The Policy is quoted below.

'*Earlier Practices in the subsidiaries of Coal India was to offer mine jobs to one member of the displaced family and found it relatively easy to acquire land. Further the standard of rehabilitation used to vary from subsidiary to subsidiary as well as mine to mine depending on the situation. Partly because of this practice and partly because of subsequent adoption of mechanized method of coal extraction, the subsidiaries had built up a labour force beyond their needs. This contributed to the heavy losses in many mines eroding competitiveness. On review of the situation, suitable resettlement and rehabilitation schemes for the affected people, in place of offering mine jobs, have been found to be the right solution to acquire land for developing mines. Considering all relevant aspects Coal India amended its existing policy of land acquisition and resettlement of the project affected persons. While Coal India's basic philosophy for compensating land losers remains substantially unchanged, the policy emphasized the need to cultivate and maintain good relation with the people actually displaced as well as the people whose livelihoods got affected. It also underscores that the subsidiaries have a responsibility towards the indigenous people who are not land losers but otherwise got affected due to the mining activities. Besides, the subsidiaries need to protect themselves more effectively against unjustified claims.*'

The company adopted a participatory approach towards implementation of the R&R for the PAFs. It was accepted that the PAFs are not only to be informed but also are to be consulted on matters of importance to the project and their entitlement or compensation and choice of R&R options.

Institution Building – With the R&R Policy in place the company needed to have a dedicated group of executives for implementing the project through formulation of RAPs. Hence, an organization was established covering the entire decision making and implementing issues. The organization consisted of the following.

The Project Officers of each Project was made responsible for the implementation of the project activities at their mine. In addition each Project was posted with one Community Development (CD)/Resettlement & Rehabilitation (R&R) officer with the responsibilities for implementing the project activities. Implementation of the project activities at the mines was monitored at the Area and Company level by Area General Manager and the Director (Technical) of the subsidiary companies respectively with assistance from the executives working under them. The project activities were also monitored by the CSESMP division of CIL.

Implementation - The *first step* towards implementation of the project was social impact assessment. This was done by assessing the socio-economic conditions of the PAFs and the impacts of land acquisition on them. The study of socio-economic conditions brought out details of social and economic status of the families who were to loose their means of livelihood and/or homestead. The data generated were reviewed yearly to update them and make them more realistic.

The *second step* consisted of the issue of photo identity cards to the PAPs/PAFs to facilitate implementation and monitoring of the R&R assistance being given to them.

The *third step* was the development of RAPs with focus on resettlement of the displaced PAFs and economic rehabilitation of the PAPs through income generating activities as pr income restoration plans to restore their income.

The *fourth step* was the implementation of resettlement as per RAPs. The total number of PAFs displaced as a result of land acquisition due to mine expansion was 2,129. All these families were provided with entitled resettlement benefits.

The *fifth step* consisted of implementation of the income generation plan. The total number of PAPs eligible for this purpose was 10,214. Attempts were made to rehabilitate them economically by employing them in the following activities. The reported monthly income of the PAPs in 2003 was about Rs 900-1,000/-.

1. Mine jobs
2. Jobs with contractors
3. Offering small contractual assignments after necessary training
4. Self employment through training
5. Arranging earning through land based income generation schemes

Social Benefits Achieved - The Company claims to have achieved the following *social benefits* by the implementation of the project at the 25 mines in its subsidiaries. [12]

1. 'Modified R&R policy brought a unified approach across the subsidiaries. It reduced the employment offer by the company to the land losers.
2. 'Skill training and subsequent self-employment reduced the social crimes and coal pilferage, etc. Hostile nature of the host community was also reduced.
3. 'Offer of monitory compensation for resettlement became a popular package. It reduced the time for resettlement and evacuation.
4. 'The IPDP approach helped developing the neighboring community and brought a cordial relation with the community. It minimized the interruption of normal mine operation by the host community. The principle of IPDP reduced the burden of the project towards the operation and maintenance of the infrastructure provided to the host community by the project. It helped the host community to

own the infrastructure as these were constructed and maintained by them.

5. 'Settled OB (overburden) dumps and unused mine land could be utilized for vegetation, plantation, etc. through Land Based Income Generation Schemes. This helped the host community to earn livelihood and at the same time helped the project to maintain a good environment and social relation.
6. 'Maintaining the social database helped to accurately quantify the total commitment of the project towards social mitigation. Continuous follow up was easier with up dated database.
7. 'Annual IPDP and RAP helped to mitigate the social problems in a more systematic way.'

Lessons Learnt - Following *lessons* were *learnt* from the implementation of the project at the 25 mines of the Company [12].

1. 'Resettlement and rehabilitation of the PAPs have to be done keeping in view the customs, habits and culture of the people.
2. 'It has been found that PAPs are more interested in getting the lump sum monetary compensation payment in lieu of plots in the resettlement sites. However, it is worthwhile to conduct a study to find out the ultimate plight of the PAPs who left the site after availing monetary compensation against land, against plot in the relocation site and employment in mines.
3. 'Technical assistance by NGOs greatly helped in formulating and implementing the RAPs. It would not have been possible by the CD/RR officers of the company to do the job as desired.
4. 'Transparency regarding the mining project construction to the PAPs is very much necessary for getting full cooperation for physical acquisition of legally acquired land.
5. 'The PAPs, being mainly agricultural workers, proved to be very difficult to train them in other trades and then develop entrepreneurship to make them capable of self-earning, particularly when they always dream of comparatively high salaried mine job. Thus, it was not possible to address the vast and complicated issues on social mitigation with complete success in the 25 geographically scattered opencast mines in such a short project implementation time. However, it was a good objective start in a planned manner.

6. 'While organizing training for the PAPs on skill development, the PAPs should be prioritized, so that only potential self employment interested persons are trained and not the persons who are interested only for the stipend during the training days.
7. 'The resettlement sites need to be identified with participation of the PAPs. Participatory method of dealing with the R&R issues is the best way to proceed with such projects.
8. 'Success of self-employment schemes depends highly on arranging seed money for the people from banks, funding through government schemes, or other philanthropic organizations, etc.
9. 'There is ample scope of implementing Land Based Income generation Schemes for the PAPs in the mining areas by utilizing the empty mine lands, reclaimed mine lands, and the discharges from the mines as well as sewage treatment plants for irrigating the plots identified for the schemes.
10. 'Certain aspects like mine closure planning and social impact assessment should be properly built in the Environmental Management Plan itself, including the cost estimates.'

4.3 Environmental Dimensions

Mining is considered as an environmentally unfriendly activity as it impacts all the components of the environment. The environmental issues in the various stages of mining and the impacts of the mining activities on the environmental components are subsequently.

4.3.1 Environmental issues in prospecting

The process of prospecting of minerals/fossil fuels involves various methods for the detection and assessment of the availability of the minerals/fossil fuels in terms of their geometry, quantity, location, etc. These details are used for ascertaining economic viability of exploitation of the minerals/fossil fuels. The environmental issues involved in the process of prospecting are as given below.

1. *Issues related to ecology* when prospecting is done in forest areas. This may involve restoring of the sites used for prospecting to the extent possible, minimization of noise and vibrations so that the wild life is not affected, effluent management so as not to pollute the water bodies and the soils, etc.
2. *Issues related to society* when prospecting is done near the villages and settlements. This may involve restoring of the sites used for prospecting to the extent possible, minimization of noise and

vibrations, effluent management so as not to pollute the water bodies and the soils, etc.

3. *Issues related to land* when prospecting is done in agricultural areas. This may involve reclamation and restoration of land for the uses nearly akin to the original status, effluent management so as not to pollute the water bodies and the soils, etc.
4. *Issues related to water regime* when prospecting is done by the methods which are likely to disturb the surface and underground water sources.

4.3.2 Environmental issues in exploitation

Mining of minerals and fossil fuels is a site specific unique industry with the following typical characteristics.

1. Fossil fuels and minerals invariably exist in forest-cum-agricultural areas, which are mostly dominated by tribal people.
2. Mining is only an intermediate use of land as before and after mining the land area is of no use to the mining companies.
3. Most of the mineral bearing areas have a low level of economic activities and majority of the living in these areas are dependent on agricultural and associated activities.
4. The advent of mining brings about a major jump in the level of economics.
5. The local people although own the mineral bearing land have no stake in the minerals and fossil fuels.
6. Most of the mining areas have not developed commensurate with the level of economic activities.

Exploitation/mining of the minerals either by opencast or by underground mining methods impacts all the components of environment. Some of the impacts are harmful and some beneficial. These impacts are discussed later in section 4.3.4 onwards.

4.3.3 Environmental issues in mineral preparation

Most of the minerals and coals can not be used in the industries in the state in which these are brought out from the mines. These resources have to be prepared so as to make them suitable for the intended uses. The coals having ash content more then the requirement of the thermal power plants, steel plants and other industries are washed to reduce the ash content to the desired limit. Similarly, minerals are prepared by various methods to make them suitable for the end use.

The environmental issues involved in the processes of coal washing and mineral preparation are as given below.

1. *Issues related with the society* – For establishing the coal/mineral preparation units land is required for various uses and the people living on this land will need to be displaced.
2. *Issues related to ecology* - The preparation plants established in forest areas or very close to the forests will disturb both the terrestrial and aquatic fauna. When established in agricultural land plants will tend to disturb the characteristics of top soil.
3. *Issues related to land* – In the preparation plants land is not only required for the plant but also for the storage of coals/minerals to be prepared and the washed coal and prepared minerals. These plants also required to use land for storage of tailings and in some cases the middlings. Thus, the preparation plants contribute to the changes in the land use pattern in the mining areas.
4. *Issues related to water regime* – The effluents discharged by the preparation plants tend to pollute the surface and underground water bodies and soils.
5. *Issues related to atmosphere* – The dust generated in various parts of the preparation plants if allowed to get into the atmosphere will tend to increase the SPM concentration. The noise and vibrations generated in the plants will tend to disturb the people living nearby and also the fauna.

In India Environment has been defined in The Environmental (Protection) Act, 1986 *as to include water, air and land, the inter-relationship which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organisms and property*, and it is commonly understood as our surroundings which support the life and the human activities. On the basis of this understanding the five components of the environment have been defined as given below.

1. Society, i.e., human beings and their activities.
2. Ecology, comprising of various species of terrestrial and aquatic flora and fauna and their interdependence.
3. Land, which provides support to the society and the ecosystems in various ways.
4. Water regime, which sustains life and is an important resource to both the society and the ecology.
5. Atmosphere, which also sustains life and is also an important resource to both the society and the ecology.

For effective planning and implementation of CSR, R&R and Community Development in mining areas it is necessary to understand these impacts and then devising the corrective requirements to be incorporated in mine planning as well as in the development of CSR, R&R and Community Development

packages/schemes. The impacts of mining start with the declaration of finding the mineral/fossil fuel reserves. People from outside, in anticipation of the financial gains, etc., start buying land, establish shops, business, etc. in and around the mineral/fossil fuel bearing areas.

4.3.4 Impact on society

Among the environmental components society is the most important because it directly affects to the environment. The impacts of mining and associated activities on society are as follows.

Changes in population – Minerals invariably exist in forest-cum-agriculture areas, which are generally sparsely populated, and the people living in such areas do not possess necessary skills for mining. Hence, most of the population for mining and associated activities comes from outside. Initially outside people come in anticipation of economic gains for establishing business and buying land, etc. Then they come for establishing the mining and associated activities. But, when the minerals get exhausted and the mining activities come to an end the population of the mining complexes decreases rapidly. The density of the population remaining in the areas after mining depends on the extent to which the land in the post-mining period can support the human economic activities.

Displacement of people – Land is acquired for establishing mining and associated activities. Hence, all the people living on the land acquired are displaced. These people are called the '*project affected people* (PAPs)' and their families are called as the 'project affected families (PAFs)'. For the rehabilitation of the PAPs/PAFs separate arrangements are made as per the '*Rehabilitation and Resettlement* (R&R)' policies/schemes chosen for implementation In some European countries due to efficient implementation of R&R and mine closure including reclamation of the mined out areas it has been possible displace the PAPs/PAFs only for a limited period of time and after the land has been suitably prepared the PAFs are brought back to their original site. In India this concept is still not in practice. This is the most important part of R&R in the mining complexes.

Losses of livelihood – Due to acquisition of land for establishing mining and associated activities the people directly and indirectly dependent on the land loose their livelihood. Such people are also called the PAPs/PAFs. Resettlement of PAPs/PAFs is done as per the provisions in the agreed R&R packages/scheme.

Decrease in sex ratio (number of females per 1,000 males) - It has generally been noticed that, mining being a male dominated activity, the sex ratio in the mining complexes is much lower then the normal agriculture-cum-forest areas. One of the reasons for this is that the people coming from outside for working

and establishing business, etc. for economic gains do not always bring and keep their families with them in the complexes. Another reason that can be attributed to this is the lack of family facilities, e.g., education, transportation, etc. in the mining complexes. *Proper Community Development and R&R planning to some extent can address and arrest this trend of marked decrease in the sex ratio*.

Increase in the cost of living – Before the advent of mining the mineral bearing areas, in forest-cum-agricultural land, have low level economic activities based on forest and agriculture products. Hence, the overall availability of money is limited. Mining brings with it much higher level of economic activities with more money availability. At the same time the change in land use from forest/agriculture to mining causes the loss of the local products. For meeting the requirements of consumable goods for the increased population in the mining complexes about 90% of consumable goods are brought from outside. This causes a marked increase in the overall cost of living in the mining areas.

Development of civic facilities – Advent of mining activities and consequent in-migration of people from outside tends to improve the civic facilities, i.e., housing, water supply, sanitation, etc., in the mineral bearing areas. These facilities are developed for the employees and migrating population the ethnic population also use the facilities.

Changes in income pattern – As stated earlier the mining activities bring in additional supply of money in originally low level economic activities in forest-cum-agriculture land. This increase in the level of economic activities causes a marked change in the overall income pattern. Those associated with the mining and related activities generally earn more then the ones engaged in their original

Urbanization – With most of the people involved in the mining and associated activities belonging to the outside areas the mining complexes develop on the urban pattern in the form of well organized colonies, busties, townships, market places, etc

Education and medical facilities – With the advent of mining and associated activities education and medical facilities develop in the complexes mainly for the benefit of the people directly and indirectly associated with the mining activities. When developed, these facilities are also availed by the population not associated with the mining activities.

Infrastructure facilities, i.e., roads, railways, transport and communication facilities – These facilities in the mining complexes are developed by the mining companies for facilitating the activities related to mining but are also availed by all the people living in the complexes. However, when the level of economic activities in the complexes after the mine closure decrease along with the decrease in the overall population the entire network of the facilities developed may not be suitable for use in the post mining period. Hence, in R&R and mine

closure planning assessment of the actual requirement of these facilities during the post-mining period is necessary.

Aspirations of the society – With the increase in the level of the economic activities and mixing of the people from various walks of life the ethnic people are exposed to many new and modern things. This tends to increase their aspirations. Sometimes it may be advisable to intentionally increase the aspirations of the ethnic people so as to encourage them to accept the new and improved ways of life with various facilities and new things brought about into the areas with the advent of the mining and associated activities

Safety of the people and property – In the mining complexes the safety of the people and their properties during the period of mining is ensured by taking various safety measures. *Similarly, it is necessary to ensure that there is no danger to life and properties during the post-mining period, i.e., after the mines have been closed*.

Societal costs of environmental pollution - The society in and around the mining complexes bear the costs of measures taken for protection against the impacts and dangers due to pollution. Briefly societal costs of environmental pollution are outlined below. *Community development, R&R and mine closure planning need considerations for minimizing the societal costs of environmental pollution to the extent possible for the benefit of the people residing in the areas after the closure of the mines*.

4.3.4.1 Societal costs of environmental pollution

Although most of the industrial and developmental activities are supposed to have built-in pollution control and mitigative measures, the society has to compulsorily bear the cost of various degradations and pollution, directly as well as indirectly. Direct costs being those which the society bears on its own account and the indirect costs are those that the society pays through various taxes, etc. Discussed below are the various costs the society bears due to impacts of the mining and associated activities on the environmental components.

Societal costs of socio-economic impacts **-** All the developmental activities invariably involve various impacts on the society and the society has to bear the costs of mitigating these impacts. These are outlined below.

1. *Compensating for loss of livelihood* **-** Developmental activities, e.g., mining, setting-up a thermal power plant, etc., cause displacement of the people living in the designated areas. As a result many people loose their livelihood. Depending upon the R&R packages various industries provide compensatory measures to the PAFs. Invariably it is noticed that a sizeable percentage of PAFs fight for their livelihood as they may be required to change their trade and thus learn the new trade(s) and develop suitable skills.
2. *Taking care of increased cost of living* **-** In an underdeveloped area industrial development increases the economic activities and at the

same time due to land being occupied by mining and associated activities the land's production declines. The PAFs and other indigenous people in and around the areas whose income does not increase correspondingly have to bear the burden of the increased cost of living.

3. *Disintegration of societal structure* **-** Industrial and infrastructural development including mining in countries like India demand inflow of population from other areas as the manpower suitable for taking up the assignments is usually not available locally.
4. *Dilution of culture* - In India most of the mineral bearing areas are in forest-cum-agricultural land and over 70% of the nation's population lives in the villages. These people have their distinct culture. Mixing of people from other regions/areas makes a distinct impact on the ethnic cultures as the people from different cultural background come together. As a result there is invariably a change in the ethnic culture and the people have to adjust to such changes.
5. *Taking care of displacement* **-**When land is acquired for any mining, industrial and developmental activity the people living in the designated areas are required to shift. Although most of the industrial and developmental activities usually carry with them R&R packages, the displaced people have to bear the various costs as they have to adjust their living in the new surroundings.
6. *Meeting increased aspirations* **-** When people from different walks of life come together and are exposed to the various developments their aspirations increase. The society has to bear the cost of fulfilling the aspirations.

Societal costs of ecological impacts **-** The society bears the various costs with respect to the ecological impacts of mining, industrial and developmental activities, some of which are outlined hereunder.

1. *Compensating for the loss of ecological products* - The human beings utilize various ecological products from the forests and water bodies, e.g., wood/timber, fruits, medicinal herbs, fishes, etc. Any impact on the sources of these products, i.e., deforestation, pollution of water bodies, etc. results in the loss of the products. To make-up for the requirement of these products the society has to bear extra burden.
2. *Losses due to ecological imbalances* - Generally speaking the terrestrial as well as the aquatic ecologies/ecosystems are complex with various species being interdependent. Any change in the ecosystems, e.g., deforestation, blocking of corridors, water pollution, etc., causes disturbances which may result in imbalances of overall system. Such situations may lead to wild animals disturbing the surrounding areas and damaging the agricultural crops, migration of fishes, killing of fishes, diseases from consumption of fishes, etc.
3. *Possible changes in climate*- Large-scale deforestation can cause changes in climatic pattern, including rainfall. This may also in some situations aggravate flooding. In the efforts to adjust to these changes the society bears extra burden.

Societal costs of land degradation - Land degradation due to mining, industrial and developmental activities causes the society to bear additional burden. Some of which are discussed below.

1. *Compensating for loss of production and productivity* - Invariably some portions of the land in and mining areas loose their agricultural production and whatever percentage is used may suffer the loss of productivity. The society dependent on those products is required to compensate for them from other sources, which imposes additional burden.
2. *Compensating for soil pollution and soil erosion* - The mining activities cause soil pollution and soil erosion, e.g., discharge of effluents on land, leachate from overburden dumps in opencast mining areas, erosion of topsoil due to changes in surface topography and the drainage pattern, etc. In order to bring the land thus affected into uses it becomes necessary to take various corrective measures the cost of which has to be borne by the society.
3. *Costs as a result of the changes in land use* - Developmental and industrial activities, e.g., mining, establishing steel plants, etc., cause marked changes in the land use in the areas not only for establishing these activities but also for developing supporting infrastructure, e.g., colonies, roads, railway lines, etc. These land use changes generally cause loss of land based production of consumable goods, which are then required to be brought in from the other areas adding to the cost structure.

Societal costs of water regime disturbances - Air and water are the lifelines of the society. In fact it is due to water that the human society has developed as it is used in almost every human activity. Therefore, the disturbances in the water regime make the society to bear extra burdens some of which are outlined below.

1. *Management of water due to its loss from surface and underground sources* - Some of the developmental and industrial activities, e.g., underground and open excavations for mining and other purposes, etc., cause damage to the surface as well as underground water bodies and thus the availability of water from the sources decreases not only in the areas of activity but also in the surrounding areas. As a result it becomes necessary to manage water from nearby sources, which involves extra burden.
2. *Management of disturbances in surface drainage pattern* - The industrial and developmental activities cause changes in surface drainage pattern, which, if not managed properly, can be expected to cause severe problems, e.g., water logging and associated hazards, flooding, excessive erosion, etc. The costs on the management of the surface drainage are directly or indirectly borne by the society. If drainage management is not done, then the society bears the costs on mitigation of the hazards and the problems.
3. *Losses due to flooding* - Flooding of surface areas due to disturbances in surface drainage pattern and land subsidence, etc., causes various hazards and problems and the society bears extra burden.

4. *Losses due to leaching* - There is always a chance of leaching of toxic elements with water from the various solid wastes generated in various industries, e.g., overburden dumps, coal combustion residues, spent pot liners, tailings, etc. The leachates tend to pollute not only the water bodies but also the soils around. Thus, there may be loss of products from the water bodies and the land if suitable mitigative measures are not taken. The loss of products and the cost of mitigative measures are borne by the society.
5. *Water poisoning* - Discharge of some toxic elements in various forms from the mines and related industries, e.g., mercury, arsenic, cadmium, lead, etc., into the water bodies can cause the water to become poisonous leading to loss of aquatic life as well as poisoning of the people consuming this water and fishes. The costs on the loss of life and reduction in the efficiency of the human beings as well as the loss of products from the water bodies are to be borne by the society.
6. *Water borne diseases* - Many commonly occurring diseases are water borne, e.g., cholera, dysentery, etc., which cause not only loss of life but also the loss of efficiency of the survivors and the society pays for it.
7. *Increased consumption of fuels, soaps and detergent* - Supply of hard water for domestic consumption causes an increase in the consumption of fuels, soaps and detergents. This can also cause choking of pipelines.
8. *Domestic water purification* - Majority of households in mining areas use various domestic water purification systems, e.g., boiling, filters, aqua-guard, etc., involving additional costs on the households.
9. *Acidic rain and acid mine drainage* - Acidic rain and other corrosive effects of rain cause impacts on the household areas exposed to the rain necessitating frequent maintenance. Acid mine drainage from the mines and release of acidic effluents on the surface and in the water bodies cause pollution/damage to the soils as well as water.

Societal costs of air pollution and noise - Air is lifeline for human beings as it provides oxygen. Air pollution, i.e., the presence of undesirable gaseous and particulate matter in the atmosphere, has been attracting global attention due to its impacts on the ozone layer and being responsible for causing green house effect. On the household level the impacts of air pollution and their costs to the society are the matters of common man's interest. Similarly, excessive noise levels are also matters of concern. Discussed below are some of the costs the society bears as a result of noise and air pollution.

1. *Loss of life* - Excessive air pollution can cause loss of life due to CO poisoning, choking, etc.
2. *Expenditure on taking care of diseases* - Inhaling polluted air can cause various diseases depending upon the nature and extent of pollution, e.g., pneumoconiosis due to inhaling of dust; lead poisoning due to inhaling of air borne lead from the exhausts of petrol vehicles, etc.; throat and bronchial problems due to inhaling of SO_2 and NO_x; viral problems; etc. The society not only bears the cost of taking care of these diseases but also the loss of man-days and efficiency.
3. *Acid rain* - Presence of some air pollutants, e.g., SO_2, can cause acid

rain.

4. *Maintenance of in-house cleanliness* - With the increase in the presence of particulate matter the requirement on maintaining in-house cleanliness also increases in terms of more frequent de-dusting of floors, washing and cleaning of curtains, window pans, etc.
5. *Maintenance of personal cleanliness* – The people working in dusty conditions spend more time and money on maintaining personal cleanliness.
6. *Costs on health impacts of noise* - Exposure to excessive ambient noise levels can cause various health related problems, e.g., sleeplessness, irritation, loss of hearing, etc. Taking care of these problems and associated loss in working efficiency puts an extra burden on the society.
7. *Costs on the ambient noise management* in various situations, including soundproofing are directly or indirectly borne by the society.

The society invariably does not realize that how much cost it is bearing due to the impacts of the mining and associated activities on the environmental components. There is no indigenous methodology available at present to account and assess the costs. Only a rough idea can be had from the data on

1. expenditures on taking care of occupational or pollution based diseases,
2. accounting for man-days and efficiency lost as a result of pollution and the loss of production and productivity, and
3. comparison of per capita consumption of soaps and detergent, etc.

The costs the society bears can be minimized by proper Community Development and R&R planning, management of the impacts of the various activities on the environmental components along with the development of the hazard mitigation plans. The Community Development should be planned in such a manner that there are minimum costs on the society on account of the pollution due to mining and associated activities during the life of the mine and due to the remnants after mine closure.

4.3.5 Impact on ecology

The ecology of the areas having mineral wealth and hence mining activities is affected by the mining and associated activities. In many areas the minerals exist in forests and ecologically fragile/sensitive areas and mining in such places can severely affect the ecology. The Government of India (GOI) has identified ecologically sensitive /fragile areas and in such areas mining is seldom permitted. The impacts of mining and associated activities on the ecology of the mineral bearing and surrounding areas and their implications in Community Development and R&R planning are discussed briefly hereunder.

Clearing of all vegetation - For the preparation of land for mining activities all the vegetation is cleared from the areas designated for mining, dumping of soils and overburden, and various constructions. If proper care is not taken in preservation the typical flora of the area may be lost. Hence, it is advisable to develop a *flora bank* for this purpose. The preserved flora can be used for improving the ecological status of the areas during mine closure activities. The plants, etc. removed from the designated areas should be suitably replanted to augment Community Development and R&R efforts. *Mine closure should be planned in such a manner that sufficient space is available for greening the areas and restoration of the ecological status to the extent possible*.

Deforestation in the forest areas for the mining activities – When mining is planned in forest areas it is necessary to deforest the areas required for mining and essential activities. Only the essential activities should be planned in the forest areas. When forest land is diverted for non-forest purposes under The Forest (Conservation) Act, 1980 it is stipulated that the mining companies will arrange at their own cost for afforestation of an equivalent areas of non-forest land. If such a land is not available double the area in degraded forest land shall be afforested. The forest land diverted for non-forest purposes reverts back as forest land when its intended use for mining and associated activities is over. *These stipulations require that the closure of the mines should be planned in such a manner that it is possible to afforest the forest land that was used for mining and associated activities. In most of the opencast mining areas it will be necessary to prepare the land for the purpose of afforestation in mine closure*. This will also help in proper rehabilitation of tribal people.

Disturbances to the wild life and other fauna – Due to clearing of the vegetation and deforestation for facilitating the mining and associated activities the wild life and the animal kingdom of the areas are disturbed. Invariably mining activities not only in the forest areas but also in the vicinity of the forests tend to drive away the wild animals and birds not only from the mining areas but also from the surrounding areas. Noise, vibrations, dust and water pollution due to mining and related activities disturb the fauna, which are sensitive to these elements. *It is a known fact that some impacts on the wild life and animal kingdom cannot be avoided in the mining areas, but efforts can be made in planning and implementation of the mine closure to make conditions suitable for the animal kingdom to come back and establish in the areas after the closure of the mines*.

Retardation in the growth of vegetation **-** The pollution of water and air caused due to mining and associated activities in the mining complexes causes slowing of the growth of vegetation in and around the areas. Deposition of dust on the leaves and presence of SO_2 and NO_x in the atmosphere can cause retardation in the growth of the vegetation. Presence of heavy metals and toxic elements in water allow the plants to uptake these metals and elements and accumulate them in the parts consumed by the animals and human beings causing toxic and poisonous effects. During mining taking care of the air and water pollution helps

in proper implementation of Community Development and R&R as pollution control will minimize the impacts and hence the societal costs of environmental pollution. *Mine closure planning should therefore be done to ensure that there are no further chances of air and water pollution once the mining and related activities are closed. The underground and surface water bodies developed as a part of mine closure should be designed in such a manner that their water is not polluted in any manner in future*.

Degradation of aquatic flora and fauna – Discharge of polluted water in nearby surface water bodies from mining and associated activities including the domestic activities pollute the water in the water bodies, which affects their flora and fauna. Proper management of effluents will help in better management of surface water resources for overall Community Development and R&R. *But, after closure of the mining and associated activities it should be ensured that there is no further chance of any impact on the flora and fauna of the surface water bodies so that these are useful as resources for the people and their activities. Hence, suitable provisions should be made in mine closure planning*.

4.3.6 Impacts on land

Opencast and underground mining both cause severe impacts on the land. Since mining is only an intermediate use of land the impacts on land are to be taken seriously and suitable measures are to be incorporated in the mine plan and its implementation so that during mining and mine closer the land can be developed for suitable economic uses. The various impacts on the land and the measures to be incorporated for effective Community Development and R&R in the mine plan are briefly outlined hereunder.

Changes in topography - In opencast mines changes in surface topography take place due to formation of pit itself and surrounding external dumps/stacks of overburden and soils. In the underground mining areas surface topography changes due to subsidence movements. The nature and extent of the changes in the topography depend upon the magnitude of the subsidence movements and their impacts on the surface. *In addition some changes in the topography also take place due to preparation of the land for other mining related uses. For effective Community Development and R&R the mine plan should, besides causing minimum changes in the topography, aim at brining the changed topography as close to the original topography. If restoration of topography not possible it should be modified to suit the intended post mining land uses. All attempts should be made to design the post mining topography so as to suitably merge with the surrounding topography*.

Changes in land use pattern – Mining is only an intermediate use of land as before and after mining the land is of no use to the mining companies. Mining activities both opencast and underground tend to change the original land use of

the areas as the land is brought into the use for mining and associated activities. When mining activities come to an end this use of land ceases and if proper care is not taken the land is wasted. Mine planning should aim at minimizing impacts on land use for effective Community Development planning and design. In addition, mine closure plan should aim at bringing the land, after the mining use is over, into suitable economic uses. Generally the post mining use of the land is for agriculture, plantation, forestry, etc.

Changes in surface drainage pattern – The alterations in the surface topography due to mining and associated activities make a marked change in the surface drainage pattern. This may cause serious problems due to water logging and erosion. During the period of mining it is necessary to canalize the water to avoid these problems and after the mining has come to an end it is necessary to prepare the surface topography to achieve a surface drainage pattern such as to merge with that of the surrounding area. At the same time it should not cause any problem of water logging and erosion of soils. Proper management of surface drainage pattern is essential for overall Community Development planning and hence for R&R also. In mine closure planning and implementation due attention is to be given to this aspect of impact on the land. The mining activities should be planned in such a manner that proper drainage of the area is maintained and surface water resources to be used for mining and associated activities and also by the people living in the area are suitably maintained during and after mining.

Alterations in the characteristics of top soils - Mining activities call for the removal of soils and their proper storage and management so that they can be re-laid during the process of reclamation. In addition, the discharges from the mines and run-off from the dumps may cause some alterations in the characteristics of the soils in the surrounding areas. This may affect the land use of such areas. In view of this mine planning calls for proper management of the soils so that these are available with proper characteristics for relaying during reclamation and proper management of run-off and effluents from the mining and associated activities to minimize the impacts on the soils of the surrounding area.

4.3.7 Impact on water regime

The water regime in the mining complexes comprises of surface and underground water sources and their interconnectivity. This is true in the mining areas having sedimentary deposits, e.g., coal and limestones. Before the onset of the mining activities water from these sources is generally used for various purposes, i.e., agriculture, industries, domestic consumption, forestry, etc. Mining activities cause the loss of available water from these sources affecting the activities dependent on the resource.

Removal of all water bodies in the areas designated for opencast mining, dumping, etc. in opencast mines – For establishing the opencast mining

operations it is necessary to remove all the surface water bodies from the areas designated for opencast mining, dumping of overburden, storage of soils, development of infrastructure, etc. In some situations it may be necessary to divert surface streams for facilitating mining. This results in the loss of available water from these resources and disturbances in surface drainage and hydrological pattern and overall water balance.

In the underground mining areas also it is necessary to remove all the surface water bodies for permitting surface subsidence and resulting cracks. Otherwise it is required to restrict the subsidence movements in such a manner that the tensile strains caused by underground mining are less then the permissible limits for the water bodies.

Water is an important resource for the society of the mining areas and water management is necessary for effective Community Development and R&R planning of the complexes. In addition, water is also required for mining and associated activities. It is difficult to reactivate the underground water bodies once these are damaged due to mining. In the post mining period water is required to sustain the human activities taking place in the areas. This calls for mine closure planning in such a manner that to the extent possible the surface water resources of the areas are restored.

Damages to the underground water sources – Both the underground and opencast mining damage the water table and underground aquifers which causes loss of underground water availability not only in the mining areas but also in the surrounding areas. In many areas the society depends on the water from these sources and hence the loss of this water can be expected to pose serious problems to the people living in the areas after the mines have been closed and even during the period of mining. Restoration of the underground water sources though theoretically possible has not been attempted in the mining areas in the country. Considering the importance of underground water sources for the society it is necessary to incorporate necessary measure in mine planning so as to minimize the damages to these water sources as well as, if possible, restore the underground aquifers and water table to the extent possible. In the situations where it is not possible it will be advisable to consider incorporating development of surface and underground water bodies in the mine closure plan.

Management of surface drainage pattern – Both surface and underground mining and associated activities alter the surface topography and hence the surface drainage pattern. This may cause water logging in some of the areas and excessive soil erosion in some other areas. For effective management during the mining period and also in the post mining period it is necessary that the drainage system of the mining area merges with the drainage pattern of the surrounding area and also there are no chances of undesired water logging. Hence, mine plan as well as the mine closure plan should be drawn in such a manner that this aspect of water management is given due attention.

Management of acid mine drainage - In some of the mines having rocks containing sulfides and pyrites there are chances of acid mine drainage when these rocks come in contact with other acid forming minerals, oxygen, water, ferric ions and iron oxidizing bacteria. The acidic mine water can be formed due to both biological and non-biological oxidation of sulfur and iron sulfide in the presence of moisture and oxygen. Microbial oxidation plays a more important role than non-biological oxidation. The impacts of acid mine drainage are well known to the mining community and hence during mining all efforts are made to tackle this problem. It is necessary to incorporate appropriate measures in the mine plan to avoid occurrence of acid mine drainage during mining and also in the post mining period as this may cause serious problems not only to the people but also in the intended post mining land use.

Pollution of water in the surface and underground water bodies – The water available in the surface and underground water bodies in and around the mining complexes can get polluted due to discharge of mine water and also due to discharge of effluents from other activities taking place in the complexes. During the period of mining measures are taken to avoid/minimize/control this pollution not only for facilitating mining but also for meeting the requirement of the people living in the areas. After the closure of the mines there will be no body to take such measures. *Hence, it is appropriate to incorporate suitable measure to ensure that pollution of the water available from these sources is avoided so that the people living in the areas after the mines have been closed do not face any problem.*

4.3.8 Impact on atmosphere

Mining and associated activities in the mineral bearing areas cause air pollution and the most important pollutants are suspended particulate matter (SPM) and respirable particulate matter (RPM). The other pollutants contributed to the atmosphere are NO_x and SO_2. The explosives used in the mines may contribute some chemicals depending upon their composition. The coals and rock masses having CH_4 when exposed to the atmosphere may contribute this gas to the air. The mineral processing plants depending upon the nature of processing and the characteristics of the products may contribute some other gases to the air in the surroundings.

During the period of mining various measures are taken for controlling the emissions so as to maintain an acceptable quality of air for the mining and adjoining areas. After the closure of the mines the chances of air getting polluted are only from the remnants of the mining activities and the post mining human activities. Control and management of air pollution is essential for the overall community development of the complexes. Hence, in the mine plan provisions should be made to minimize air pollution potential of the remnants of the mining and associated activities.

Mine fires in coal mines and in the mines having carbonaceous shales in the overburden are a major source of air pollution. Planning of the mines should be done in such a manner that the chances of the occurrence of the mine fires are minimum and if fires do take place these should be mitigated at the earliest. When closing the mines efforts should be made to mitigate all the mine fires and to ensure that there is no further chance of any more mine fire in the area.

4.4 Ingredients of sustainable mining

Mining is an intermediate use of land and mining and associated activities impacts all the five components of environment. It is necessary look into prospects of development of sustainable mining practices (SMPs), which are not only technologically sound but are also human and environmentally friendly. The objectives should be to achieve an overall societal development of the mineral bearing areas with an improved environment. The practices should also achieve zero accident potential with appropriate conservation and utilization of the mineral resources. The ingredients among others, include establishment of a national data bank, creation of awareness among masses, achieving active participation of all concerned, environmentally and human friendly mine planning and design including the care that is required to be taken for societal impacts, suitable mine closure planning and design, and self regulatory mining and environmental management.

Objectives

1. The benefits of the economic activities as a result of advent of mining should accrue to almost the entire cross-section of the society of the complexes.

2. The activities should be safe and environmental friendly, i.e., they should tend to improve upon the pre-mining environment.

3. The selection of the technologies for the exploitation of the minerals, either by underground or opencast methods, should be appropriate for achieving maximum possible conservation and optimal utilization of resources for given geological and structural settings.

4. The SMPs should be designed for zero accident potential not only during mining but also in the post mining period.

5. The overall activities of mining operations inclusive of implementation of mine closure should be economically viable.

Ingredients

- *Establishment of a national data bank*
- *Creation of awareness among masses*

- *Achieving active participation of all concerned*
- *Amending the land acquisition legislation*
- *Environmentally and human friendly mine planning and design including the care that is required to be taken for societal impacts*
- *Suitable mine closure planning and design*
- *Realistic EIA and EMP*
- *Technical audit of the mining and environmental management activities*
- *Self regulatory mining and environmental management*
- *Establishment of separate central funds for R&R, reclamation and mine closure*

Establishment of national data bank

The first step towards the development of SMPs is establishing a national data bank for the mining sector having the following data accessible on line to all concerned.

1. Maps of all mineral bearing areas overlain by surface features (topography, land use, drainage pattern, soil types, etc.), structures (villages, townships, canals, railway lines, roads, pipe lines, underground cable layout, overhead transmission lines, etc.), and special features (places of religious, cultural, historical, archeological, and ecological importance).
2. Geological and exploration data including geological maps and sections, macro structure, micro structure, reserve quality and quantity, etc.
3. Hydro geological data and models of the areas.
4. Environmental settings of the mineral bearing areas including the status of social, ecological and land environment, water regime, and atmospheric environment.
5. Legislative frame work for establishing and operating a mine and the roles of various state and central governmental agencies and other associated bodies. The legislative frame work should include all the mining legislation, environmental legislation, civil laws, etc.
6. Inventory of the characteristics of the minerals, coal seams and surrounding rock mass including the hazardous characteristics, e.g., fire potential, explosion potential, etc.
7. Inventory of all the methods of mining that have been adopted with comprehensive details including the geological settings in which the methods were tried, problems and constrains faced, equipment used, manpower deployed, production achieved and economics of the operations. Inventory all the types of equipment being used in the mines and also being manufactured in the country.
8. Inventory of equipment available globally and that which has been imported in the recent past.

9. All the data and findings of all the completed sponsored and grants-in-aid projects and the results of their implementation in the actual situations.
10. Inventory of all the accidents including the disasters that have taken place in the country with the causes and possible measures that could have been taken to avert them.
11. Inventory of all the books, journals, etc. related with mining and associated activities being published in the country and abroad with abstracts and highlights available on line.
12. Inventory of all the web-sites which can be visited for information on mining and associated topics.
13. Inventory of all the method of working permissions and the environmental clearances granted by the Directorate General of Mines Safety (DGMS) and the Ministry of Environment and Forests (MoEF) respectively.
14. Any other data that is required for mine planning and design including planning and implementation of mine closure.

Creation of awareness among masses

Minerals and fossil fuels in the country generally are in forest and agricultural areas which have traditional society with a low level of economic activity status. Mining brings about a marked change in the nature of activities and at the same time causes several impacts on the society. The local people in most situations are not fully aware of the things to come when mining activities take place. In order to gain the confidence of these people it would be appropriate to make the people aware of what they should expect when mining starts and what will be their gains and loses, and how the losses will be compensated. The awareness campaign should contain the environmental aspects also.

Land acquisition

For the purpose of mining the land is acquired under the Land Acquisition Act, 1894 and the Coal Bearing Area (Acquisition and Development) Act, 1957 (both amended up to date). In addition the mining companies buy land directly from the owners.

The land acquired under the two Acts reverts back to the State after the use for mining is over and the mining companies invariably can not sell this land although they pay compensation for the acquisition. The land directly purchased can be sold. This is one reason due to which the mining companies are reluctant to reclaim the mining degraded land for suitable economic uses after mine closure. The laws should be suitably amended to encourage the mining companies for suitably reclaiming the land used for mining and other purpose and recover the costs incurred. This has a direct bearing on the development of SMPs.

Environmentally and human friendly mine planning and design

Perhaps the most important part of human friendly mine planning and design is the management of land for mining and associated activities. The authors feel that management is land is key to mine planning as with this the impacts on the other environmental components can also be minimized. The following suggestions are being made for the management of societal and land impacts and selection of the mining methods.

1. A large component of cost of the mines goes for acquisition of land. Hence, mining and associated activities should be designed in such a manner that the land requirement for them is minimum possible. This not only tends to minimize the cost of the mining projects but also the number of people likely to be affected.
2. The land acquisition laws should be suitably amended to encourage the mining companies for suitably reclaiming the land used for mining and other purpose and recover the costs incurred. This has a direct bearing on the development of human friendly R&R package as well as on the management of land environment. In most situations this will tend to reduce the costs of mining projects.
3. The underground mines should be designed with appropriate layouts for subsidence management. The subsidence movements and hence the impacts on the surface can be minimized by suitably designing the layout of the panels/stopes.
4. In case of opencast mines it is necessary to optimize the pit slopes considering the characteristics of the overlying rock mass. Thus, the land requirement for the mine can be minimized. Similarly the land requirement for the formation of external stacks of soils and overburden dumps should be optimized.
5. As far as possible the mines should be planned with concurrent reclamation so that temporary displacement of the project affected families (PAFs) can be planned. Such a planning will require minimum formation of external dumps and hence the land requirement will be minimized. The optimization of land requirement for the mine and planning with reclamation will help in minimizing the number of PAFs and planning for their temporary displacement.
6. The overburden rock mass and the soils should be treated as resources and not wastes as these are required for reclamation of the mined out land both in the mines designed with concurrent reclamation as well as the ones to be reclaimed after finishing mining.
7. In most opencast mining situations it will not be possible to restore the surface topography because either the solids available for backfilling will be less or in excess. Restoration can

only be planned in the mines having a mineral-overburden ratio of 1:6.7. Hence, in general it will be necessary to redesign the surface topography to be achieved during reclamation. This should, while merging with the surrounding topography, match with the intended use of land and minimization of erosion of soils.

8. The land for the activities and facilities outside the mine should be chosen in such a manner that the impacts on the land use are minimum. This measure will also tend to minimize the number of PAFs.
9. The mines which can not be planned with concurrent reclamation should have a provision of post mining reclamation with development of a suitable land use to support the population which will be living in the areas after the mines have been closed while having a fair quality of life (QoL).
10. While planning and implementing the reclamation process care should be taken that as far as possible the resources, land and water, necessary for agriculture and plantation are adequately developed.
11. The selection of the method of working and hence the equipment to be used should be done on the basis of well defined criteria and suitability for the geo-mining conditions. *In fact based on the macro and micro structure the mineral bearing areas should be categorized for their suitability for various mining methods*.
12. The methods of working selected should be proven and should be implemented in total packages with comprehensive monitoring to obtain data which can be used for refining and modifying the methods and also as guidelines for the selection of the methods for other similar conditions.

For the management of other environmental components, namely, ecology, water regime, and atmosphere, the following measures can be incorporated in the mine plan. The design of the measures will need comprehensive knowledge of the prevailing environment.

1. ***Ecology*** – Most of the mineral and fossil fuel deposits in the country are in forest and agricultural areas. In these areas the management of ecological environment assumes a great importance. The following measures can be incorporated in the mine plan.

    - The inventory of the soil types and premining flora and fauna is useful in designing the post mining land use for forestry. Legally all *forest land* areas revert back to forest when their non-forest use is over. Hence, all the forest land that is diverted for mining purposes will revert back to forest after mining.

- For developing forests it is not necessary to specifically design the surface topography. But care is required to be taken in the reuse of soils so that the original species of the trees, shrubs and grasses can be replanted.
- Since due to mining water regime is disturbed it is necessary to plan for the development of water resources for affecting the desired land use.
- The *agricultural* land that is diverted for mining is required to be reclaimed so that it can be reused. This requires specific knowledge of premining land and soil types, topography, water resources, and drainage pattern.
- For reclaiming mined out land for agricultural use in case of underground mines not much efforts are necessary because the subsided land can be easily brought back to this use by suitably affecting the drainage and managing water. This can be achieved by prediction of subsidence movements and assessing the post mining surface contours. The cracks developing due to subsidence on the surface can be suitably filled.
- In the case of opencast mines it will be necessary to preserve the soils so that they can be reused during reclamation. The surface topography is to be designed to suit drainage and to minimize soil erosion. During backfilling for reclamation all precautions are required to be taken to minimize shrinkage of backfilled material and seepage of water into the backfilled rock mass.
- The rock masses which can cause mine fires and acid mine drainage are required to be managed appropriately during reclamation.
- In many a situations the solids available for backfilling are not in sufficient quantity for the restoration of the surface topography. In such situations some voids will remain, which can be developed into surface water bodies.
- During reclamation planning can be done so that surface can be prepared for various uses, e.g., agriculture, water body, road making, building construction, etc.

2. ***Water regime*** - Both opencast and underground mining disturb surface as well as underground water bodies. Mining also causes a marked reduction in the availability of water from underground sources in the surrounding area within a radius of about 1-1.5 km. In order to carefully plan mining and associated activities it is necessary to have a thorough knowledge of the hydrogeology and water regime of the area. For the development of the post mining land use and for meeting the water requirement during mining the

following measures can be incorporated in the mine plan on the basis of the premining water regime scenario.

- The mine water being pumped out of the mines should be suitably treated and used for various purposes. If necessary it may be made available to other users in the nearby areas.
- The mine plan should incorporate formation of underground water bodies after the closure of underground mines and surface water bodies in the opencast mines.
- Water is an important resource for post mining land use development. Therefore, it should be ensured that adequate quantity of water of suitable quality is available from surface and underground sources.

3. ***Atmosphere*** - From the point of view of management of atmospheric environment the knowledge of the following parameters of premining scenario is necessary.

    - *Micro-meteorological parameters*, i.e., maximum and minimum temperature, humidity, wind speed and direction including the wind-rose diagram, etc.
    - Stability class of the area.
    - Rain fall data including the total rain and its pattern.
    - Inventory of all the sources of *air and noise pollution.*
    - Air and noise pollution control measures being adopted.
    - Status of air pollutants and noise levels, vis-à-vis, the permissible ranges.

    The data on the above parameters is useful in many ways in planning and designing the mining and associated activities. Some of the suggestions are given hereunder.

    - Designing the surface layouts with special reference to the locations of colonies and townships. These should be on the up wind side of the predominant wind direction.
    - Prediction of the air and noise pollution potential of the mine and hence design of the control and prevention measures.
    - Deciding the locations and designs of greenbelts and acoustic barriers.

Mine closure

This is a legal requirement but is yet to be suitably addressed in actual planning and execution. Mine closure planning at the initial mine planning stage itself is an important aspect which helps in the development of the R&R packages as is evident from its objectives mentioned below.

1. Bringing the land back to proper economic uses with suitable resource development for the population expected to live in the areas after the closure.
2. Ensuring that the land use merges with the surrounding area and it affords the desired QoL for the residents.
3. Ensuring safety of the living beings and the property in the post-mining period.
4. To alleviate or eliminate environmental damages and thereby encouraging environmental sustainability.
5. Management of surface drainage pattern and control of soil erosion.
6. To reduce the need for long-term monitoring and maintenance by ensuring physical and chemical stability of the mined out areas and the adjoining areas disturbed by mining.

The Indian Bureau of Mines (IBM) has issued guidelines for Mine Closure Plan which call for development of progressive mine closure plan and final mine closure plan. Though, the guidelines are explicit a lot of work is required to be done for developing comprehensive mine closure plans. Under the World Bank aided Environmental and Social Mitigation Project (ESMP) Coal India Limited a Manual was developed for the preparation of mine closure plans. The authors feel that mine closure should not be looked in isolation and it should be a part of the mine plan itself.

Realistic EIA and EMP

In the country after the issuance of the EIA notification it has become mandatory for all new mines and those undergoing modification, up gradation, reorganization, and renewal of lease to get environmental clearance from the MoEF. Here the concern is the EIA and formulation of EMP. Often at various forums it is debated that EMP is a part of EIA or vice versa. The authors suggest that EIA should be a part of EMP. The MoEF has brought out a Manual for conducting EIA exercise, which is also applicable to the mining sector. It is generally felt that the EIA/EMP exercise in the country for the mining areas lacks the realistic approach due to the following reasons.

- There is a need for separate guidelines for underground and opencast mines, and small mining sector for different locations/regions in the country.
- There has not been any effort for the development of *models for the population dynamics* of the mining complexes.
- The societal impact mitigation measures designed and implemented so far in general have been lacking the *human touch* as there has not been any involvement and participation of the PAFs.
- The concepts of the *QoL based development planning* and taking care of the emotional, mental and physical needs of the affected people has not been incorporated so far.

- The overall QoL of the mining complexes has not improved to the extent of the level of economic activities and the people in the mineral bearing areas are reluctant to part with their land.
- The present practice of *public hearing* of the EMP will have to be modified to *public participation* in the preparation of the plans and the mitigative measures.
- Most of the minerals in the country are in forest and agricultural areas. There has not been any effort for the development of *models for reclamation of mined out land* for post mining economic uses.
- Also, there is no practice of the development of *alternative scenarios*. The selection of *preferred scenario* should be done in consultation with the local people.
- There has not been any effort to develop the *mined out areas akin to forests*. Invariably for the management of ecology plantation is done. There is an urgent need for the development of models for *ecological reclamation* of the mining areas.
- As stated earlier the design of the mining complexes should be done by *using minimum possible land* for mining and associated activities and the selection of land for non-mining uses should be done in such a manner so as to cause *minimum changes in the land use*. This has not been a common practice.
- In both the underground and opencast mines *reclamation and economic rehabilitation of land* degraded due to mining activities should be compulsory as an integral part of the EMPs. This should also include dismantling of constructions and structures not required after their uses are over.
- Similarly *mine closure* should be an integral part of mine planning and EMPs with a provision of developing the most appropriate economic use of the reclaimed and rehabilitated land. Though this is a legal requirement this has not found due attention.
- Reclamation and rehabilitation of the mined out areas besides developing appropriate land use should also address the development of *drainage pattern* and minimization of *soil erosion*.
- *Hydrological models* are being used in the EMPs but the total water management including the development of surface and underground water bodies for post mining land uses and if possible for reactivation of the damaged water table and underground aquifers have so far not been done. Water balance has also not been given due attention.
- *Water pollution and water quality management models* for different types of terrain, rock characteristics and structures need development.
- *Acid mine drainage* (AMD) is a serious problem in some of the mines in the country. Suitable modeling needs to be done for dealing with the situations in both underground and opencast mines.
- *Mine fires* take place in the coal mines and also in the mines having carbonaceous shales and coal bands in the overlying or underlying rock mass. The knowledge of the prevailing environmental parameters

and micro characteristics of the overlying and underlying rock mass may help in better design of mine workings with least possible chances of the fires.

- For the assessment of *stability class* of the atmosphere in the mining areas the meteorological data is generally taken from the nearest weather station, which in many cases are more then 100 km away. It is advisable to establish weather monitoring stations in the complexes so that accurate data is available for this purpose and also for air pollution management.
- *Air pollution modeling* should be done on the basis of the *emission factors* of various mining and associated activities. Although some studies have been done in the country the necessity of developing this knowledge is still felt.
- *Noise pollution modeling and management* system though well defined need refinements and orientation to suit various mining situations.

In many a mining situations after getting the clearance the EMPs are cold stored. In addition the original mine plan is altered to suit the production demand and working conditions met in underground and opencast mines. In fact the action plan for the implementation of the mining activities should include the measures to be taken for the management of environment including the social impact mitigation measures.

Self regulatory mining and environmental management

It is not possible for the regulatory agencies, i.e., DGMS, MoEF, SPCBs, etc., to look after day to day mining and environmental management efforts in the entire mining sector in the country. Hence, mining and environmental management in this sector should be self regulatory and the total responsibility should rest with the mining companies. Though, there is legislative requirement of submission of the annual statement, e*nvironmental statement and quarterly reports,* etc. which call for development of self regulatory systems, the mining industry is yet to properly achieve it. The following measures are being suggested for the system to become a day to day affair in the mining sector.

- Environmental management should not be looked in isolation and it should be integrated with mine planning and implementation of mining and associated activities.
- The system of implementation of the methods of working and environmental management measures should have checks at appropriate times and levels so as to remind the implementers of any shortcoming, etc.
- All the officials including the workers at all the levels should be suitably trained to not only make them environmentally aware but also to make them understand their roles in the implementation of the activities while taking care of the environment. They should be fully aware of their social and legal obligations in environmental and mining legislation.

- There should a periodic, preferably monthly, review of the achievements and implementation of the activities so as to evaluate the effectiveness of the mining methods and environmental management measures.
- The knowledge and skills of the officials should be regularly updated with respect to the latest technological and legislative developments.
- There should be internal system of reward and punishment for the implementation of the integrated activities.
- Each mining company should develop their own data bank and think tank to assist the efforts at the mine level. There should be no bar in inter-company data flow for the benefit of the other companies.
- The regulatory agencies should make sample review of the activities and make suggestions for improving the method of working and environmental status. Their roles should also be of advisory nature.

Technical audit

Many a times it is seen that the mines, when in production stage, do not correspond to the original plan because in the process of construction and development several deviations are made. In many a situations even the basic methods of working had to be changed. In some situations this happens due to lack of detailed geological details of the formations and the minerals/coal seams. This leads to re-planning of the mine workings as well re-defining the targets, etc. For the mines having environmental clearance there should be a provision of technical audit to ensure that the deviations form the planned path are the least. All the deviations should have appropriate reasons and justifications. The technical audit should also evaluate the performance of the implementation of the mining methods as well as the environmental protection and management measures. The audit process should be dynamic so that the deviations are detected as soon as they occur.

Establishment of funds

The country has a long history of mining and the past mining practices have damaged a large number of areas. In addition the current mining practices are causing impacts on land, which need immediate attention. In many a situations the implementation of R&R packages has not been as per the emotional, mental and physical needs of the PAFs. To take care of the back log and future shortcomings in R&R, reclamation and mine closure implementation it would be appropriate to establish separate funds with a system of reward and punishment. The funds to be managed by suitable agencies can be developed out of the contributions from the mining companies and charging a nominal cess on the minerals.

5.0 Safety and Health

5.1 Safety and Health Performance in Indian Coal Mining

Minerals though depleting assets constitute the backbone of economic growth of a nation. Extraction of the same from below the surface of the earth is fraught with innumerable dangers and is therefore hazardous. In India safety, welfare and health of workers employed in mines are concern of the Central Government. The objective is regulated by the Mines Act, 1952 and the rules and regulations framed there under. These are administered by the Directorate General of Mines Safety under the Union Ministry of Labour & Employment. Our endeavour to bring down hazards by all available means to an acceptable level is continuing. Human efforts are being directed to reduce the risk so as to keep the work force not only safe but healthy and happy too [13].

India has a unique blend of big and small, manual and mechanized, opencast and underground mines. The number of working coal mines are 575, in oil sector there are 50 projects excluding Off-shore beyond territorial water. The number of metal mines submitting returns stands at about 2000. However there are many more mines which are small in size, seasonal in nature and are not submitting returns and their numbers can be estimated to be around 5000. The total size of workforce on any day on an average is of the order of one million [13].

5.2 Growth in Coal Sector

Keeping with the spirit of industrial policy, ambitious programs were launched to increase production for meeting ever growing demand of coal and other minerals. In the last three decades, coal mining has witnessed a phenomenal growth in production from 75 million tones in 1971-72 to 429 million tone in 2005-2006 and had touched about 490 million tones during 2007-2008. Coal vision 2025 estimates the demand of coal for future up to 2024-25 for different sectors based on the forecast made by TERI considering the coal demand and the change in the GDP. The adopted approach indicates that the overall growth in coal demand is expected to be 5.62% with 8% GDP growth scenario and 5.04% with 7% GDP growth. Sector wise coal demands as assessed with the above approach for two scenarios are given in Table 1. Table 2(a), Table 2(b) and Table 2(c) indicates breakup of production from underground mining and opencast mining in projection of coal production, share of coal production from underground and opencast and projected share of coal production from underground and opencast up to terminal year of XIVth Plan respectively. Considering the high growth in coal demand either as per assessment of Coal Vision 2025, or as per the estimates of the Administrative Ministries of coal consuming sectors, there is a need to increase the availability of coal from indigenous sources. With this in mind coal production program in different ‘plan periods’ have been worked out. Coal demand as envisaged in the Coal Vision 2025 document, is expected to rise to 1267 million tones per annum by 2024-25. [13]

Table 1
Sector-wise demand for coal
(in Million tones)

Consumer	Terminal Year of five yearly plan								
	Xth Plan 2006 - 07	2011-12		2016-17		2021-22		2024-25	
		7%	8%	7%	8%	7%	8%	7%	8%
Power utilities	317	412.69	427.16	517.31	552.56	635.46	698.53	718.94	804.03
Power Captives	28.26	43.26	44.33	59.89	62.96	83.50	90.04	101.93	111.60
Steel	42.7	53.13	54.24	66.57	69.49	83.87	89.52	96.54	104.50
Cement	25.40	38.40	39.39	58.18	61.06	88.16	94.12	113.13	123.41
Bricks and others	59.82	63.52	64.51	79.57	82.11	100.72	105.62	116.54	123.41
Total	473.18	611.45	629.63	781.52	828.16	991.70	1078.54	1147.54	1267.01

Table 2(a)
Breakup of Production from underground mining and opencast mining in projection of coal production

Company	Xth Plan (06-07)			XIth Plan (11-12)			XIIth Plan (16-17)			XIIIth Plan (21-22)			XIVth Plan (26-27)		
	OC	UG	Total	OC	UG	Total	OC	UG	Total	OC	UG	Total	OC	UG	Total
CIL	321.8	51.2	373	448.5	59.5	508	568	80	648	655	100	755	715	124	839
SCCL*	25.8	11.9	37.7	28.7	12.3	41	31.5	13.5	45	32.9	14.1	47	32.9	14.1	47
Others**	19	2.0	21	39.6	4.4	44	67.5	7.5	75	112.5	12.5	125	157.5	17.5	175
Captive															
TISCO/															
IISCO															

Total	36 6.6	95 .1	43 1.5	51 6.8	76 .2	59 3	66 7.0	10 1	76 8	80 0.4	12 6.6	92 7	90 5.4	15 5.6	10 61

Table 2(b)
Share of Coal Production from Underground and Opencast

Year	Underground		Opencast		Total
	Production (Mt)	% Share	Production (Mt)	% Share	
1951	30.19	86.32	4.19	13.68	34.38
1971	58.55	77.41	17.09	22.59	75.64
1991	70.73	29.75	167.06	70.25	237.79
2001	64.13	18.78	277.37	81.22	341.50
2006	63.00	14.93	359.00	85.07	422.00
2007	63.01	12.50	359.99	87.50	423.00

Table 2(c)
Projected Share of Coal Production from Underground and Opencast

Terminal year of five yearly Plan	Underground		Opencast		Total
	Production (Mt)	% Share	Production (Mt)	% Share	
XI (11 – 12)	76.2	12.85	516.8	87.15	593
XII (16 – 17)	101	13.07	667	86.85	768
XIII (21 – 22)	126.6	13.65	800.4	86.35	927
XIV (26 – 27)	155.6	14.69	905.4	85.33	1061

5.3 Accident Experience

Just like any other industrial accident, unsafe act and unsafe conditions of work leads to accidents in mines and most of them are preventable – they do not happen they are caused. Accident causation has three main factors namely the work environment, machine and worker and can mostly attribute to directly or indirectly to human failings.

Incidence of accidents being an important indicator of the status of safety, it is pertinent to examine the accident scenario. Table – 3 shows the trend of fatal accidents and fatality rates per 1000 persons employed and per million tones of coal produced. Table – 4 shows major accidents and disaster from 1901 to 2007 [13].

Table 3
Trend in Fatal Accidents and Fatality rates per 1000 person employed and per million tones coal produced

Year	No. of Fatal Acc.	No. of Killed	D. Rate / 1000 Pers.	D. Rate Mill. Te.
1951	278	319	0.91	9.3
1961	222	268	0.65	4.81
1971	199	231	0.60	3.05
1981	165	184	0.36	1.045
1991	138	143	0.26	0.60
2000	117	144	0.31	0.43
2001	105	141	0.32	0.41
2002	81	97	0.23	0.27
2003	83	113	0.27	0.30
2004	87	96	0.24	0.26
2005	96	117	0.29	0.29
2006	79	138	0.36	0.34
2007	77	79	0.20	0.19
2008	87	100	0.25	0.24

Table 4
Analysis of major accident and disaster from 1901 to 2007

Year	Number of (Persons killed)				
	Explosion	Inundation	Fall of roof	Side fall	Fire/Gas
1901 -2007	37 (1258)	33 (829)	136 (840)	23 (147)	8 (125)

In coal mines there has been a sharp decrease in ten yearly average figure of 295 fatalities from 223 accidents in 1951-60 to 170 fatalities from 140 accidents in 1991-2000. The average annual figure is 110 fatalities from 88 accidents for last eight years [13].

Ten yearly average death rate per 1000 persons employed has also come down from 0.91 to 0.32 from 1951-60 to 1991 -2000 with current average figure of 0.27 up to 2008 [13].

Main factor behind this achievement is shift of production technology from conventional underground to mechanized opencast in mining of coal. In coal mines major concern is occurrence of disasters at regular intervals mostly in underground mines. The frequency of disasters due to inundation in underground coal mines have alarmingly increased in the recent past. Disasters due to explosion have been controlled in the last two decades, but there have been a number of cases of ignition of inflammable gases including an explosion claiming 50 lives in last four years. For fatal accidents involving four or less fatalities per accidents roof fall continues to be area of major concern followed by dumpers in

coal mines.In the last couple of years there have been cases of dump failure in opencast mines, which were unheard of during nineteen nineties bringing in focus requirement of proper design and maintenance of OB dumps. Non availability of adequate land for creation of such dump calls for immediate due attention.

Cause wise fatal accidents in coal mines in belowground, opencast and above ground during 1995 – 2005 is shown in Table - 5

Table 5
Cause wise fatal accident in coal mines in belowground opencast and aboveground during 1995 – 2005

Cause	B/G	O/C	A/G	Overall
Fall of roof	306	0	0	306
Fall of side	97	9	0	106
Other ground movement	4	4	0	8
Transportation machinery	16	0	0	16
Rope haulage	116	0	4	120
Wheeled trackless transport	0	146	64	210
Other transportation machinery	18	5	22	45
Machinery other than transportation machinery	17	54	25	96
Explosives	30	4	1	35
Electricity	7	14	21	42
Gas, dust and other combustible material	9	10	5	24
Fall of Person	37	12	25	74
Fall of object	10	8	6	24
Other falls	1	2	0	3
Irruption of water	11	0	0	11
Flying pieces	1	0	1	2
Miscellaneous	6	7	4	17
Total	**686**	**275**	**178**	**1139**

5.4 Occupational Safety and Health in days to come

Need for substantial increase in production of coal particularly for energy security is a must for the country with production coming from highly mechanized and high capacity open cast and underground mines with due attention to changing scenario of health and safety issues. The future mining has to address the following.

(a) Mining in an eco friendly manner;
(b) Produce mineral / coal at an economic price with high capacity mechanized operation;

(c) Increase in standards of occupational health and safety;
(d) Greater concern to the society in and around mining projects
(e) Developing clean technology for Coal Bed Methane, Underground Coal Gasification etc,
(f) Waste management, suitable end use of waste generated from beneficiation plant / power house.

5.5 Analysis and suggested measures to prevent accident

Underground Mining

Below ground accidents contributes 60% of the total accidents in coal mines
In below ground mines roof fall contributes 44.6%of total accidents in coal mines
Fall of roof and fall of sides together contributes contribute about 60% of the accidents

From analysis of disaster it can be seen that fall of roof though it is not generally considered as contributory to major accident / disaster yet it has killed 840 persons in 136major accident / disaster which is more than the persons killed due to inundation. If we add other accidents up to four fatalities roof fall / side fall it will become single major contributing cause of underground accidents.

- Phasing Out of manual loading by mechan9ized loading
- Use of mass production technology like continuous miners – shuttle car
- Increase in powered support long wall in dipper horizon
- Introduction of short wall mining with powered support to extract already developed pillars
- Use of road headers for faster development of headings
- Replacement of conventional bolting by mechanized roof bolting machine.

Opencast Mining

Opencast accident contributes 24% of total accidents in coal mines.In opencast mines wheeled trackless transport contributes 54% accidents and machinery other than transportation machinery contributes 19% accidents. Together they cause 73% of accidents in opencast mines [13].

- It is necessary to control the movement of machineries by introducing and implementing traffic rules, standard operating procedures, maintaining proper haul roads, lighting, dust free environment, designing suitable cabins and maintaining the machinery in safe working order

Above Ground

Above ground accident contributes 16% [13] of total accidents .

In above ground wheeled trackless transportation contributes 28% accidents. Causes like other transportation machinery, machinery other than transportation

machinery, electricity contributes 16%, 15% and 15% accidents respectively [13].

About 60% accidents are caused by all types of machinery in above ground.

- Development and adoption of safe operating procedures for various activities and machineries along with training and retraining of workers can help in reduction of such accidents.

Accident to Contractors Workers

Outsourcing of non-core job is likely to go up substantially thereby exposing workers employed through these agencies to various hazards. In this context employer's responsibilities, contractor's responsibilities as well as employee's responsibilities needs to be clearly defined

- Provision of statutory manpower for effective supervision
- R&D input for improving safety
- Training and IME/PME and refresher training
-

Strategies for improvement

Production of clean coal with integrated plan for waste management and harnessing for non conventional and clean technology for tapping coal based energy. Integration of issues of Occupational safety and health with that of environment in order to have integrated plan for SHE for overall production system

Development of flexible regulation, shift from prescriptive legislation to goal setting legislation and formulation of safety , health and environment management plan based on built in risk management mechanism. Standard of safety and health needs to be optimal beyond minimum regulatory requirements.

Advance planning for emergency and suitable emergency response system have to be developed.Application of electronics and communication technology in field of Occupational Safety and Health and applied research by professional bodies in the field of hazard surveillance and other geo technical issues with adequate funding needs focus for progressive development.

Occupational health, ergonomics and workplace design needs to be given due importance besides occupational safety issues.Development and extraction plan have to match long-term need of environment management and management of reclamation, rehabilitation and resettlement ensuring post mining best use of land and mine closure plan.

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standard of excellence, comparative advantage following and cost effective. Besides conversion of economic agenda and political will there will be transparent administrative approach with quality people in every walks of life who can think global and try to learn from overseas experiences.

Due to increasing pressure from government, employees and community groups, the need to improve safety, health and environment function is emerging as a top priority for the senior executives of the mining industry. New trend in mining coupled with social demands have created the need for managers to redefine the way in which safety and health functions in Indian mine are performed and structure it to meet the challenges of the day and beyond.

I am sure that the discussion on the training on energy option available to the SAARC countries, aspects of coal power management, energy security, efficient use of energy, understanding the concept of cost consciousness, social and environmental effects and other related issues will definitely help in sustainable economic development at faster rate. It will create macro economic impulse which will move through down the fabrics of society and touches the level which it is aimed at.

7.0 References

[1] World Energy to 2050, A half Century Decline, available at http://www.paulchefurka.ca/WEAP/WEPA2.html as accessed at 10/12/2009, as accessed at 12/12/2009

[2] Tomorrow's Energy Journal , available at http://www.exxonmobil.com/corperate/files/corperate/tomorrow_energy.pdf , as accessed at 12/12/2009

[3] Nuclear energy today, Nuclear energy organization for economic corperation and development, available at http://www.nea.fur/html/pub/nuclearenregytoday/ net/nuclear_energy_today.pdf, as accessed at 15/12/2009

[4] Climate of Sri Lanka, Climate in Sri Lanka, Weather in Sri Lanka, http://www.eixis.net/travel-tourism/sri-lanka-tourism/climate-of-sri-lanka.html

[5] National energy policy and strategies of Sri Lanka, Ministry of power and energy,Government of Sri Lanka, October 2006,

[6] Sustainable Electricity System for Sri Lanka, J.B.Ekanayaka et al , Tyndall Centre for Climate Change Research, U.K. and Department of Electrical and Electronic Engineering, University of Peradeniya, Sri Lanka.October 2002

[7] Contemporary Issues – Challenges and Management challenges, A.K.Ghose, FNAE, December 2009

[8] Strategic Issues- Marketing and management challenges, P.Pathak, 2009

[9] Social and Environment Dimensions of the Coal Industry, N.C.Saxena,

[10] Rehabilitation and resettlement of project affected persons(PAPs) in Kusmanda and Gerva Projects of SECL, Tripathi, MTech Dessertation, ISM, Dhanbad (unpublished)

[11] Investigations into the development of a model for community development planning for coal mining complexes, Tripathi R.N. ,Phd thesis ISM Dhanbad, 2004 (unbuplished)

[12] Rehabilitation and resettlement of project affected persons(PAPs) in India under CSESMP, Proc 19th world mininng con, New Delhi, Btattacharya, 2003

[13] Safety and Health performance, R.B.Chakraborty, 2009

8.0 Photos

Fig 8.1 Opening ceremony of the program

Fig 8.2 Participants and resource personnel

Fig 8.3 Participants from Afganistan

Fig 8.4 Participants from Sri Lanka, Nepal and India

Fig 8.5 Discussion with resource personnel