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Coal as an Alternate Source of Energy-Prospect for Pakistan, Study of Thar Coal Sindh, Pakistan

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Abstract: The paper discusses about coal as an alternate source of energy and its prospects for Pakistan. In the study, world coal resources, production, consumption and cost have been discussed in detail. Coal reserves held in all the four provinces of Pakistan including Northern Areas and Azad Jammu &Kashmir. Specific mention of Thar coal reserves discovered in Sindh province has also been made. Details of various blocks handed over to various firms and future plans for remaining blocks were obtained from concerned authorities and have been included. Options to export the Thar coal were also studied. The discussion in the study then leads to various options available to make best use of Thar Coal. The options of mining and underground coal gasification (UCG) were studied in detail along with their merits and demerits. The underground coal gasification being new technology was given importance and UCG plants in use were evaluated. Finally, after complete analysis of the Thar coal, progress made so far and keeping other factors in mind, future prospects for Pakistan have been worked out. The information and data were vastly spread and not easy to collate. The research material used while writing this paper was taken from the open sources, newspapers, journals, printed books on the subject and long hours spent while surfing the internet. In addition, a detailed meeting was held in Planning Division with Dr Samar Mubarak on Underground Coal Gasification project (UCG). It helped to obtain first-hand knowledge on the UCG project and its progress. In addition, numbers of concerned personnel in the field of geology were consulted to clear the thought process on a very technical subject. The work is by no means exhaustive but just a humble effort to explore the subject.

Keywords: *Coal, Energy, Thar, Reserves, Thar coal fields, gasification, mining*

1. Introduction and Literature Review

Coal is a fossil fuel and is essentially a rock, which has composition of oxygen, carbon and hydrogen. By far it is much more plentiful than available reserves of oil or gas. It is estimated that existing world reserves of coal may last up to more than 200 years, if the current rate of consumption is maintained. The current reserves of coal are equitably around the world as compared to oil reserves which are concentrated in fewer areas. Review of available literature on the worldwide usage indicates that coal is generally less expensive as compared to other available energy sources. With heavy reliance of US and China, coal stands out as the largest energy source used for generation of electricity worldwide. Nearly 69% of electricity generated in China's and 46% of total power generation in USA1 comes from coal. However, the same remains to be an under exploited resource in Pakistan where less than 7% electricity needs are being met through Coal2. It is also an essential fuel for steel and cement production, and other industrial activities. In the context of Pakistan, economic development and national growth like any country of the world is mainly hinged on the assured availability of energy sources to meet its electricity needs. At present Pakistan is facing acute power outages. The main causes include increasing urbanization and industrialization is putting increasing pressure on the already fragile infrastructure. While Pakistan is spending huge amount of foreign exchange to produce electricity from oil. The cost of electricity is becoming unaffordable for industrial units to produce economically viable products. On the top, acute shortage of electricity is also greatly hurting the production output targets. Critical challenges being faced by energy sector of Pakistan‘s include:

a. Inherent deficiency of energy / power resources to the extent that the deficit of power reaches well over 25% at the time of peak demand.

b. 13% of households in Pakistan lack access to electricity (19% in rural areas which represent 2/3‘s of Pakistan‘s population.

c. To remain stable, increasing focus is required to maintain favorable energy balance in the back drop of declining gas supplies and greater dependency on oil imported from other countries.

d. Operation efficiency of thermal power plants (Gas / Oil Fired) is significantly low. The problem is compounded by theft and transmission / distribution losses which are presently more than 25% of the total generated electricity.

Rising energy costs, exacerbated by the high dependence on imported oil in Pakistan‘s energy mix, particularly in power generation, have adversely impacted the poor and the country‘s industrial competitiveness. Luckily Pakistan, a coal-rich country is abundantly blessed with the most important ingredient which can be utilized to meet the un-satiating needs of the country. As per current estimates, coal is available across Pakistan while the bulk of it is found in Thar desert of Tharparkar district in Sindh Pakistan. The Thar field has tremendous economic potential for Pakistan3. After discovery of lignite coal in Thar, Pakistan has now emerged as seventh amongst the top 20 countries of the world. Thar coal reserves comprise nearly 175 Bn tonnes of lignite and are spread over 9,000 km2. A lot has been written on the subject of Thar coal and its viability for Pakistan while applying different methods for its usage. A general agreement is observed on the quality and quantity of coal amongst scientist community. However, difference of opinion exists on its usage methodology. One school of thought considers that Underground Gasification (UCG) is the best option to produce electricity, while other supports the option of mining for its optimum utilization. Meanwhile Sindh Govt. till date has divided the area into 12 blocks. Five blocks have been handed over to various international companies for exploration and use of coal for generation of electricity. Blocks 7-12 have also been offered for bids by Govt. of Sindh.

2. Research Methodology

This study is followed the logical and scientific approach to collect and analyze the data. I have used mixed research method which covers both quantitative and qualitative methods. In quantitative method I collected all the statistical data and applied statistical analysis techniques to arrive at logical conclusions. In qualitative method, I collected data through interviews and studied geographical location and environment of Thar coal4. Option of using imported coal to meet the energy requirements has also been given due consideration. I collected the data from both the Primary and Secondary sources. Actual survey reports generated at various stages were consulted. Progress reports generated by Sindh Coal Authority were studied and analyzed. All contractual documents with Multinational firms were also studied and analyzed. Open source information such as articles, newspapers and internet has been used for the study. In order to fill voids in the available literature and to include views/experiences of relevant personnel, I interviewed Dr Samar Mubarakmand and other key personnel involved in the exploration of Thar Coal. A questionnaire for the areas of interest for study was accordingly prepared and relevant queries were posed to the concerned personnel being interviewed. The questionnaire is placed at Annex A. Study has been structured in a logical manner which would enhance understanding of reader on the subject. It includes best practices been adopted by the developed countries and their applicability in our environment were fully analyzed. Our previous experiences on ability to exploit mineral resources have also been given due consideration. Keeping all kind of factors and trends in mind, prospects for Pakistan in realistic terms have been determined in the study.

2.1 Classification of Coal

Coal as an energy source has a historical precedence over all other fossil fuels. Coals can be classified in terms of their "rank" (level / degree of metamorphism), "type" (composition / constituent materials including plant) as well as "grade" (indicating calorific value / impurities). However, rank provides is universal to all classification schemes as it involves qualitative expression indicating coalification sequence. Parameters used by American standard for Testing Materials (ASTM) for classification of coals by rank are listed at Annex B. Brief description of coal ranking is as follows:

Peat. **Peat** is used as industrial fuel in various regions including Ireland and Finland. In dried form, it is an effective absorbent material and can be used to contain oil and fuel spillage on water and land. Peat can be utilized for conditioning of earth since it is capable to absorb / retain water and then release it slowly.

Lignite. **It** is also known as brown coal and is low in coal family. It can be used for fuel to generate electricity.
Sub-bituminous Coal. Sub-bituminous coal lies between lignite and bituminous coal. It is mainly used for generation of electricity.

Bituminous Coal. **It** is usually black or dark brown. It is mainly used as fuel in for heat and power applications. In addition, substantial quantities are used to make coke and for steam-electric power generation.

Steam Coal. Steam coal grade lies between bituminous and anthracite coal. Due historic use for powering steam locomotives, it is also called "sea-coal" in US.

Anthracite. Anthracite is high ranking coal. It is a black shining coal and is used primarily for heating commercial and residential areas.

Graphite. It cannot be ignited easily and is generally avoided for fuel usage. It is extensively used for lubrication and to make lead pencils.

Maturation5 of plants adds calorific value to the rank of coal.

2.2 World Coal Reserves

While coal reserves are known to be available around the world, recoverable reserves have been found in seventy countries with largest reserves in Russia, USA, China and India. Detailed status is placed at Annex C. Experts estimate that proven reserves of coal may last up to 147 years at current production levels. However, with ever increasing production driven by increased demands, peak coal production would reach in many countries with America and China set by 2030.

Usually the Reserves are mentioned as "Resources" ("measured" + "indicated" + "inferred" = "resources"). These can be defined as follows:

a. **Resource**. The total quantity of coal which exists in a coalfield or deposit without considering economic viability of mining the same. Thus, it can be understood that coal from all available resources are minable.

b. **Reserves**. Reserves are proved / probable reserves. Probable reserves are estimated with less confidence than proved reserves.

c. **Proved Reserves**. Proved Reserves indicates amount of coal that is economically / technically recoverable using current mining technology.

Assessment of coal reserves can be undertaken using the process developed by German Federal Institute for Geosciences and Natural Resources (BGR). This method is also used by IEA for determining the available coal

reserves. The other method is based on World Energy Council (WEC) process employed by BP Stat Review of World Energy.

2.3 Power Potential of Coal in Pakistan

~~After independence the Governmen~~t of Pakistan decided to develop the coal resources on permanent footings. Consultants from abroad and experts from Geological Survey of Pakistan (GSP) began evaluation of coal fields. Economic potential of these resources was however revealed in 80's with discovery of large reserves at Lakhra and Sonda areas in Sindh. Discovery of coal deposit of 175.5 billion tonnes at Thar provided a quantum increase in coal resources of Pakistan7. After this discovery, Pakistan has now the 6th largest resources of lignite in the world. Coal resources available to Pakistan exist in all four provinces and in AJK8. Major sites with coal reserves are indicated at Annex D. Coals of Pakistan have high contents of sulphur and ash. Percentage of moisture is also comparatively high in Sindh especially Thar. Rank of Pakistani coal ranges from lignite to bituminous9.

2.4 Sindh Coal Fields

Coal has been known to occur in Sindh for about 150 years. It is believed that Coal in Sindh was first discovered in 1853 when Baloch nomads reportedly struck a coal seam 2.43 meters thick at a depth of 125 m at Lakhra, a village in district Dadu. Sonda coal was discovered in 1980 while Thar coal was discovered in 1992. Identified coal potential has been indicated on map of Sindh placed at Annex E. Available / mineable coal reserves of Sindh, tentative estimate of power generation potential and their heating value is given in Table 8 below10.

Table 1: Shows the Sindh Coal Resources and their heating value

Coal Field	**Coal Resources (Million Tonnes)**	**Heating Value (Btu/lb)**	**Generation Potential (MW)**
Meting- Jhimpur	473	5,219 – 8,612	
Thar	175,506	6,244 – 11,045	100,000 MW
Lakhra	1,328	5,503 – 9,158	1,000 MW
Sonda-Jherruck	5,523	5,219 – 13,555	500 MW
Indus East	1,777	7,782 – 8,660	
Total	184,623		

2.4 Meting – Jhimpur Coal Field.

It was mapped in 1950 when GSP became involved in coal resources evaluation in Sindh.

a. Location and Accessibility. Meting-Jhimpur coal field lies approximately 125 km east of Karachi in the vicinity of Jhimpur and Meting Railway stations on the main railway line. The field total area is 218 square Km in Thatta.

b. Coal Geology. Only one coal seam is present which is generally thin and has thickness with an average of 0.6 m.

c. Coal Quality. Meting-Jhimpur coal field has a wide range of different constituents and heating values. The ash and sulphur contents are low as compared to Lakhra coal fields. Based on its calorific values, rank of coal can be classified as lignite B to sub-bituminous C11.

2.5. Thar Coal Field

Thar coalfield is located in the south-eastern part of Sindh. The first indication of the presence of coal beneath the sands of the Thar Desert was reported while drilling water wells by the British Overseas Development Agency (ODA) in coordination with the Sindh Arid Zone Development Authority (SAZDA), in 1991. On the basis of presence of coal in ODA2 water well, the U.S. Geological Survey (USGS) and Geological Survey of Pakistan (GSP) undertook a coal exploration and assessment program (COALREAP)12. COALREAP was undertaken under sponsorships of United States Agency for International Development (USAID) which started in 1985 and ended in Jun 93. The Thar coalfield, with a resource potential of 175.5 million tonnes of coal13, spread in area of 9,000 sq km in Thar Desert with dimensions of 140 km14 (north-south) and 65 km (east-west)15. The area has been divided into 12 distinct blocks. Map of the area indicating location of these blocks is placed at Annex F. The mineable coal reserves are estimated to be 1,620 million tonnes. The coal-bearing area is covered by stable sand dunes.

a. Location and Accessibility. About 410 km metalled road leads upto Mithi from Karachi via Hyderabad, Mirpurkhas, Naukot and is also connected by road via Thatta, Badin, Naukot to Mithi16. Rail link is also available from Karachi to Naukot via Hyderabad. To harness the potential of Thar coal for electricity, Japan has offered assistance in construction of transmission line17. Thar range is semi-arid, with scarce water resources due to meagre rainfall, averaging 200-300 mm.

b. Coal Geology. Thar coalfield is relatively shallow. Thickness of coal beds varies from 0.20 to 22.81 m and up to a max of 20 coal seams have been found in some of the drill holes. “Thar Coal Seam” is the thickest coal bed and is presentbetween 150 and 203 m

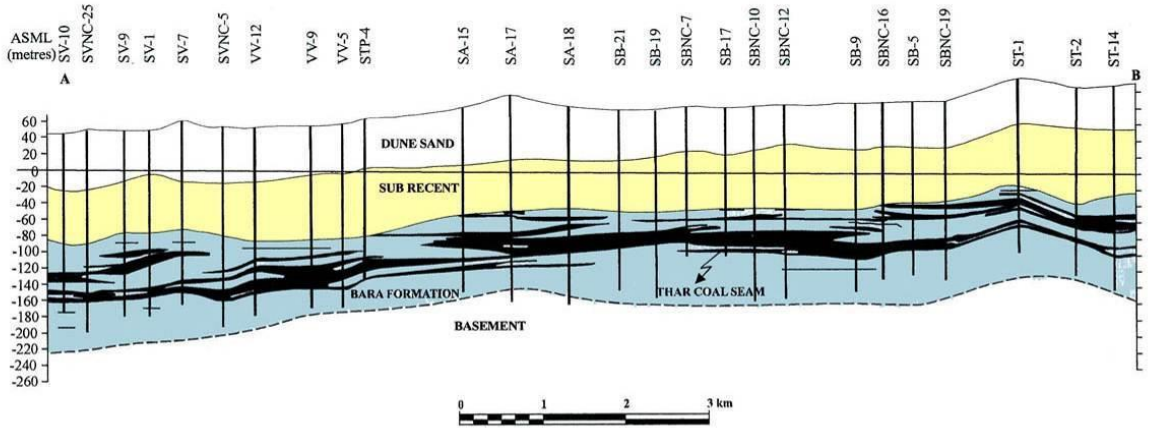


Figure 1. Cross-section - Thar Coalfield

c. Coal Quality. Thar coal can be classified as Lignite A/B. Moisture and ash contents of Thar Lignite deposits when compared with other reserves indicates that these are favourable for power generation. Another plus is its low sulphur contents18.

2.5 Sonda Coal Field

It was discovered in 1981 in Thatta district of Sindh. This coal field has total coal resource of 5.7 billion tonnes19. To increase share of coal in thr national energy mix of Pakistan, Government of Sindh (GoS) has engaged M/s China National Chemical Engineering Group Corporation (CNCEC) for mining in Sonda Jerrick coalfields and establishment of 250 MW coal-based power plant20.

a. Location and Accessibility. Sonda coal field is situated close to National highway linking Karachi with Hyderabad, about 80 km east of Karachi. It covers an area of 616 sq. Km on the east and west of River Indus.

b. Coal Geology. It has separate Coal beds 5 to 10 meters apart and thickness ranging from 0.5 to 15 m.

c. Coal Quality. Sonda coals are comparatively better than Lakhra coals as these have less ash and sulphur contents21. In Jherruck area, the coal is the thickest. It has coal resource of 1.8 billion tonnes22.

2.6. Lakhra Coal Field

It was discovered in Dadu district of Sindh. This coal field has more than 1.3 billion tonnes of coal. Production of Sindh is mainly from Lakhra area23. Coal mining in the area is being done in a semi-mechanized manner. Location and Accessibility. Lakhra coal field is situated in Dadu district and is spread over 200 sq. Km24. It lies 16 km to the west of Khankot railway station on the Kotri Dadu section of Pakistan Railways. It is well connected with Karachi and Hyderabad through roads and railway. It is about 60 km NW of Hyderabad and about 217 km NE of Karachi. Coal Geology. Available at depth of 50 to 150 m from surface with thickness of 0.75 to 2.5 m and average thickness of 1.5 m. The Lakhra coal field has been extensively explored to find the behaviour and quality of coal25. Coal Quality. The Lakhra coals have undesirable contents of ash and sulphur. The coal has an apparent rank of lignite B to sub bituminous C. The coal is dull black and contains lots of resins. It is often susceptible to spontaneous combustion. Lakhra coal contains high sulfur. The feasibility study conducted by John T. Boyd & Co. of USA has confirmed mineability and suitability of Lakhra coal for power generation.

3. Thar Coalfield Blocks

Thar Coalfield has been divided into 12 blocks26. Geographical map indicating various blocks of Thar Coal Fields is placed at Annex F. Presently work is at advanced stages in four Blocks. Sindh Engro Coal Mining Company, Global Mining of China, and UK Oracle Coalfields have initiated Open Pit Coal Mining Projects. On the other hand, Dr. Samar Mubarakmand has initiated a pilot project of Underground Coal Gasification (UCG) in one Block. Project update on these Blocks is given in the ensuing paragraphs.

1) Block-I: Project of Global Mining Company China

Thar Block-I has been allocated to Global Mining China (CGM). The company plans to to produce 900 MW of electricity by mining coal upto 05 Mn tonnes / year. The same is planned to be increased to 2100 MW. In this regard concession for 30 years has been granted to a Sino-Sindh Resources, a well-known consortium under

Global Mining of China to cover total area of approximately 150 km2 with estimated reserves of lignite to be exceeding 3 bn metric tonnes. Bankable feasibility study was conducted through M/s RWE, Germany on Block-1 during 2004. The same was also made available to the consortium.

Table 2. Timelines for Thar coal field Block-1

Activity	**Timeline**
Allocated Block I	Sep 11
Start Pre-Mine Development	Jun 12
Power Generation (900 MW)	by 2015-16
Total Cost of Project	US$ 3 bn

2) Block-II: GoS - Engro Joint Venture Project

In order to undertake mining of coal from Thar Block II, Government of Sindh and Engro Powergen has formed a JV with name of The Sindh Engro Coal Mining Company Limited (SECMC). It is planned to mine 6.5 million ton of coal annually along with 1200 MW power generation project. To proceed with the project, Sindh Thar Coal Energy Board and Engro Power have approached China Coal Technology and Engineering Corporation Group (CCETG) for survey of Thar fields Block-2. China Investment Corporation has also been requested to undertake investments at Block – II in projects of coal-based power and coal mining.

3) Block III: Oracle Coalfields, UK

Thar Coalfield Block IV has been allocated to Oracle Coalfields, UK for open pit mining for 30 years with an option of another three decades. A MoU has been signed with Karachi Electric Supply Company (KESC) for the development of a 300MW mine-mouth power plant by 2015 which will be enhanced to the level of 1,100MW27.In order to develop open pit coal mine, it is in the plans of the company to make $610 million investments. The company has also earmarked $224 million for the purchase of equipment which will be used for the mining purposes.

4) Block IV: Underground Coal Gasification (UCG) Pilot Project

Planning Commission in Jul 09 engaged Dr. Samar Mubarak Mand to execute R&D Pilot Project for production of Syngas (Synthetic Natural Gas). In this connection, Dr. Samar has engaged Geological Survey of Pakistan (GSP) to undertake project of drilling for “Underground Coal Gasification” (UCG) in Thar. On June 23, 2010 an agreement was signed, which carried the approval from the Ministry of Petroleum28.Two rigs and engineers / staff has been placed at site by the GSP. Under the UCG project, GSP has successfully completed

drilling of 14 bore holes for the project at Thar Sindh till now for the purpose of gasification. Additionally, one bore hole at the depth of 83 meters has been drilled for ground water.29. Dr Samar Mubarakmand has confirmed that the Thar coal project will be operationalized by Dec 13. Additionally, a 50 megawatts (MW) gasified project was also been mostly completed. While mentioning about the cost of project, he gave the figure of Rs 8.898 billion and it had the share of foreign exchange to the tune of Rs 5.847 billion and the same carried approval of ECNEC30. One Gasifier has been Completed & Test Burn conducted in Dec 11. The appraisal of project was conducted by Planning Commission in Jun 12 and following decisions were taken:During time frame of 10-12 months, a pilot project consisting of one gasifire (36 wells) be made operational to generate 8-10 MWs of electricity. Requirement of funds to the tune of Rs 1.8 bn for the cost involved in the purification of gas plant to generate power units of (8-10 MW). After successful generation of the required electricity i.e 8-10 MW, the situation would be assessed based on which development of 100 MW power generation will be considered. Present progress of the project is as under:

Table 3: Timelines for Thar Coalfield Block-IV

Activity	**Timeline**
Open Pit Mining	5 million ton per annum
JDA signed with KESC	300 MW
IssuanceofMining Lease	Apr 12
Completion of Pre-Mine development	by Nov 12
Mine development phase	by early 13

4. Strengthening of Physical Infrastructure at Thar

Government of Sindh & Pakistan is committed towards provision of an enabling environment for mining. Therefore, great attention is being paid for the development of much needed projects related to infrastructure and those are: water supply, mine-water disposal, roads, and water supply, airport and transmission lines31.

Further details of these projects are presented in the ensuing paragraphs.

Table 4: Funding status- Thar Infrastructure Project

Name of Scheme	**Total Cost Rs (Bn)**	**CFY Allocation Rs (Bn)**
Improvement of Road from Thatta to Thar	6.4	3.5

(335 KM)		
Supply of water from LBOD to Thar Coalfield	9.1	3.0
50 Cu DrainageEffluent Channel Construction	3.6	2.0
Thar Airport at Islamkot Construction	0.972	0.65
110 Reverse Osmosis Plants Installation	3.2	0.73
Total	23.27	9.89

Provision of Road Network
Approved schemes for road network include improvement of roads from Thatta to Wango More Badin and from Wango More to Thar.

Construction of Thar Airport
GOS has approved a scheme costing Rs 972 million for construction of Thar Airport. In this regard an amount of Rs. 317.94 million had already been provided to Civil Aviation Authority (CAA) while an allocation of Rs. 654.12 million has been made for year 2012-13. CAA has awarded the contract and work on the project has been initiated with an EDC of Jun 13.

Prospect for Pakistan

Pakistan has no shortage of energy resources which can be exploited at the commercial level. These include the gas, oil, coal, hydropower and nuclear power. The country has also got a large quantity of traditional fuels which are available in the shape of fuel wood, agricultural and animal wastes. If we study and analyze the Pakistan's energy supply market, it becomes very much evident that the country undertakes huge imports in the energy sector.

The present energy supply matrix is composed of number of technologies. The major portion of primary commercial energy supply mix of Pakistan is in Oil and gas which contributes 82.5% (gas:

43.8%, oil: 38.3%, LPG: 0.4%). In other options, we have contributions of coal: 5.4%, hydro-electricity:

11.3% and nuclear electricity: 0.9%. Pakistan has very low domestic oil production and it only meets one sixth part of the total requirement of the country. Pakistan is largely dependent on the imported oil which forms almost one-third of her total energy requirements. Therefore, Pakistan has energy shortage and its own resources are presently been able to meet a very small percentage of her requirements. The oil and gas reserves presently available in the country would not go beyond 12 and 21 years respectively. The severe shortage in the gas reserves is posing threat to the National Security of the country. The situation is becoming more complex with every passing day. In order to address the severe shortages of energy, options to exploit potential of renewable sources (incl wind &solar) and coal needs special attention at all levels. Pakistan has in fact no shortage of resources, and their potential need to be combined and efforts are to be synergized to exploit the potential. Wind

and Solar energy technologies are being exploited gradually and it can be said that these are indeed at their primitive stages of exploitation in the country. If we compare the solar and wind energy, it can be easily deduced that solar energy has clear advantage over the wind as it is a much more cost effective. Respective costs for solar and wind energy are (US cents/kWh) 20 and 77 respectively. Further, in Pakistan, the availability of solar energy is comparatively is sufficient all-round the year. While the wind energy is not uniformly available round the year.

Presently only 5.4% of the Pakistan's primary energy requirements are being met from the coal. The coal reserves of Pakistan are considered to be approximately 187 billion tonnes, out of which around 175 billion tonnes are present in Thar Desert in Sindh province. The quality of coal has been found to be ranging from sub-bituminous to lignite. Historically the reduction in the consumption of coal in Pakistan was observed as the gas reserves were found and made available. However, still scope for the use of coal for the purposes of power generation is considered to be great. Coal offers numerous advantages, and it's a cheap option for the energy and can become a primary source for power generation which would help to produce uninterrupted power supply benefitting numerous industries particularly fertilizer, cement, and chemical industries and: Savings of foreign exchange as requirement to import oil would be greatly reduced. The savings in foreign exchange would help to develop the country reserves and strengthening of Pak Rupee.

Job opportunities would be created as the economic activity would greatly pick up due to turning of wheels in the mills. The country would be required to handle less oil and therefore, traffic on roads and efforts required for the movement of oil to various power houses in the country would be greatly reduced. The country would be able to gain and learn latest techniques in the field of mining and sectors of power generation through coal. The Petro-chemical industries would gain a boost in the process. Coal can take the shape of an energy resource which is Strategic in nature and can ensure energy security for Pakistan in the coming decades.

It may be a matter of national pride for the nation. The exploration of coal would help to reduce poverty particularly in the province of Sindh. It will also help to improve the quality of life especially of the people living in Thar Desert. Availability of jobs for the people living in Thar Desert would become a reality. Prospects of Thar Coal for Pakistan definitely exists, however, following conditions are mandatory: In order to generate electricity at the mine mouth, large quantity of water is a mandatory requirement. Presently, the water is not available abundantly as required. UCG Plants are few in the world and technology is yet not well practiced. The foreign exchange requirements to set up the coal fired plants are huge and investors would need certain Govt guarantees. Consistent policies by the Govt. and investor friendly environment. Coal creates pollution. Lignite has low calorific value; hence more coal is required to be burnt as compared to its better versions. Its effects on the environment would require a separate detailed study.

Lignite is generally not transported to long distances. Export options therefore are minimal and it should be preferably consumed at the mine mouth. The waste water generated by the coal-based power plants has its effects on the damaging to landscapes, water supplies, and ecosystems. "Coal in a Changing Climate" shows that coal produces large amounts of toxic chemicals which have detrimental effects on the health of human beings.

5. Conclusion

Even though UCG has a number of advantages, the technology has several limitations and potential concerns:

Siting and operation of UCG have environmental consequences, including groundwater impacts and ground subsidence. Current knowledge and practice can eliminate or reduce these environmental risks. UCG operations cannot be controlled to the same extent as conventional Gasifiers. Many important process variables, such as the rate of water influx, the distribution of reactants in the gasification zone, and the growth rate of the cavity, can only be estimated from measurements of temperatures and product quality and quantity.

a. While UCG economics appear promising, uncertainties in capital and operating costs are likely to persist until such time as a reasonable number of UCG-based power plants are built and operated.

b. UCG is not a steady-state process, and both the flow rate and the heating value of the syngas will vary over time.

c. While UCG may be technically feasible for many coal resources, a number of deep seams may be limited by geologic and hydrologic hazards.

Coal Pollution

The term pollution refers to the act of contaminating ones environment by introducing certain hazardous contaminants that disturb the ecosystem and directly or indirectly affect the living organisms of that ecosystem. Pollution in general is the activity of disturbing the natural system and balance of an environment.

The burning of coal creates some of the most damaging impacts32. This may seem paradoxical in light of current efforts to reduce greenhouse gas emissions, knowing that the combustion of coal emits 1.3 times more CO2 than oil and 1.7 times more than gas. In addition to contributing to global warming through substantial emissions of carbon dioxide, coal plants give off the following pollutants:

a. Sulfur dioxide, which produces acid rain. Coal combustion is the leading source of sulfur dioxide emissions.

b. Nitrogen oxides, key contributors to ground-level ozone (smog) and respiratory illnesses.

c. Particulate matter (soot), which produces haze and can cause chronic bronchitis, aggravated asthma, and premature death. (Both sulfur dioxide and nitrogen oxides transform into particulates in the atmosphere).

d. Mercury, a neurotoxin that can contaminate waterways, makes fish unsafe to eat, and cause birth defects. As with sulfur dioxide, coal burning is the leading source of mercury emissions.

e. Hydrocarbons, carbon monoxide, volatile organic compounds (VOCs), arsenic, lead, cadmium, and other toxic heavy metals.

f. After combustion, the remaining coal ash and sludge is often disposed of in unlined and unmonitored landfills and reservoirs. Heavy metals and toxic substances contained in this waste can contaminate drinking water supplies and harm local ecosystems. Even worse, failed reservoirs can flood coal waste into surrounding areas.

Coal Pollution in USA. A typical (500 megawatt) coal plant burns 1.4 million tons of coal each year. As of 2012, there are 57233 operational coal plants in the U.S. with an average capacity of 547 megawatts. Additionally, a 500 megawatt coal-fired electricity plant in the United States puts out each year:

a. 3,700,000 tons of carbon dioxide (CO2), the primary human cause of global warming - as much carbon dioxide as cutting down 161 million trees.

b. 10,000 tons of sulphur-dioxide (SO2)34, which causes acid rain that damages forests, lakes, and buildings, and forms small airborne particles that can penetrate deep into lungs35.

c. 500 tons of small airborne particles36, which can cause chronic bronchitis, aggravated asthma, heart disease37 and premature death, as well as haze obstructing visibility.

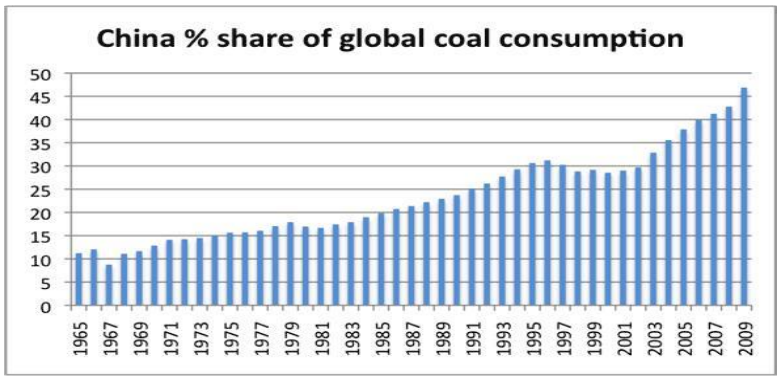
d. 10,200 tons of nitrogen oxide (NOx), as much as would be emitted by half a million late-model cars. NOx leads to formation of ozone (smog) which inflames the lungs, burning through lung tissue making people more susceptible to respiratory illness.

e. 720 tons of carbon monoxide (CO), which causes headaches and place additional stress on people with heart disease.

f. 220 tons of hydrocarbons, volatile organic compounds (VOC), which form ozone.

Future Suggestions

Since 1965, China has steadily increased its percentage share of global coal consumption and now accounts for 50% of global coal consumption:



Unless China finds a way to clean up its coal plants and the thousands of factories that burn coal, pollution will soar both at home and abroad. The increase in global-warming gases from China's coal use will probably exceed that for all industrialized countries combined over the next 25 years, surpassing by five times the reduction in such emissions that the Kyoto Protocol seeks.

The sulfur dioxide produced in coal combustion poses an immediate threat to the health of China's citizens, contributing to about 400,000 premature deaths a year. It also causes acid rain that poisons lakes, rivers, forests and crops. Coal has become China's double-edged sword - the new economy's black gold and the poor environment's dark cloud. Already, China is using even more coal than the US, the EU and Japan combined. China has increased her consumption of coal by 14 percent in the past two years in the expanded industrialization ever. Every week to 10 days, one coal-fired power plant is inaugurated somewhere in China that is big enough to serve all the households in Dallas or San Diego.

Coal Pollution in India. The most problems in India are related to the environment and are enhanced due to its heavy reliance on the coal for the purposes of power generation. India’s environmental problems are enhanced by its heavy reliance on coal for power generation38. IMF Chief Christine Lagarde on July 10, 2012 said that pollution from coal generation plants cause about 70,000 premature deaths in India every year. Indian Coal-fired power plants are generally less efficient in comparison with the similar power plants in China and US39. The average net efficiency of coal-fired power plants in India is presently below 28%40. The higher average operating heat rates of plants in India are due to the poor quality of Indian coal and also due to the inefficiencies in management processes. It is clear that plants in India would require more coal to produce a kWh of electricity than 5 similar plants in US.

The heating value of Indian coal is much lower than coal mined in the China or US. The coal which is used to produce electricity in India is being produced locally to the tune of almost 90% and has got the heating value from 2,700 and 4,400 kcal/kg.

Risk Associated with Coal Mining

While Pakistan is all set for major mining operations in Thar, it must be noted that around the globe, coal fires are burning in thousands. If these fires start, it is almost next to impossible to reach these fires and turn them off by extinguishing. These fires may pose danger to roads and towns, pollute the air and add to the global warming. he United States, has the largest coal reserves and hundreds of fires are burning continuously from Alabama to Alaska.41. Few of the fires which are lit underground happen in a natural manner. In this process coal which has been exposed or is closer to the surface due to erosion, interacts with oxygen, and as a result of a chemical reaction produces heat. The process can develop in number of years; low-grade, soft coals brittle and which are low in carbon can suddenly catch fire, at low temperatures as 104 degrees Fahrenheit. At times lightning or a fire in the bush at times can also ignite soft coal. A fire which is burning underground can burn for many years and even for decades without being visible on the surface of the earth.

Annex A

RESEARCH QUESTIONS

- How energy requirements are presently being met in the country?
- Exactly quantify the energy shortages being faced in country?
- What are the Statistics of total coal held with various countries?
- What are the different types/quality of coal available in the world?
- What is the dependence of countries on coal energy?
- What are the Country-wise usage details of coal in the world?
- What are the worldwide trends on usage of coal vis-a-vis other options?
- What are the worldwide coal trade statistics?
- What are the options available for export of coal to different countries?
- Identify International concerns on pollution due usage of coal?
- What is the cost comparison of coal energy with other options?
- What is the estimated quantity/quality of coal discovered in Pakistan?
    - What is the estimated quantity of Thar coal?
    - What are the exact coordinates of area where coal has been discovered in Thar?
    - Find details of area w.r.t

- o Demography
- o Road/Rail Links
- o Proximity to Indian border
- o Distance from main grid station
- o Environmental conditions/ wind direction o Availability of water against requirement

- Which Govt. bodies are responsible to monitor and develop Thar coal?
- What has been the progress made since discovery of Thar coal?
- What amount has been spent so far to manage pilot projects?
- What has been the division and allocation of Blocks in Thar for exploitation of coal?
- What are the future plans to exploit Thar coal reserves?
- What is the estimated time and finances required to develop Thar coal field?

- What are the available options to use coal in an effective manner?
- What are the advantages/disadvantages of various options for usage of coal?
- How the world is using coal as a source of energy?
- Determine cost/benefit analysis of various options for usage of coal?
- What are the possible effects of pollution and the measures required to control?
- Study how the world is controlling pollution.

Annex B

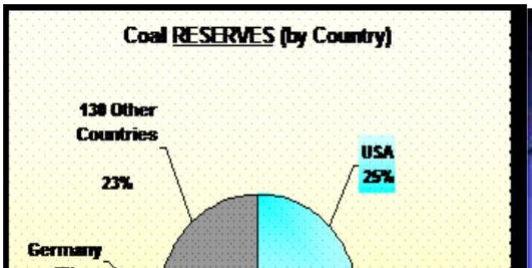
PARAMETERS USED BY ASTM FOR CLASSIFICATION OF COALS BY RANK

Class/group	Fixed Carbon Limits (dry mineral-matter-free basis) %		Volatile Matter Limits (Dry, Mineral-matter-free Basis) %		Gross Calorific Value Limits (Moist, mineral-matter-free Basis)			
					Btu/lb		Mj/kg	
	Equal or Greater Than	Less Than	Equal or Greater Than	Less Than	Equal or Greater Than	Less Than	Equal or Greater Than	Less Than
Anthracite:								
Meta-anthracite	98	---	---	2				
Anthracite	92	98	2	8				
Semianthracite	86	92	8	14				
Bituminous:								
Low Volatile	78	86	14	22				
Medium Volatile	69	78	22	31				
High Volatile A	---	69	31	---	14,000	---	32.6	---
High Volatile B					13,000	14,000	30.2	32.6
High Volatile C					11,500	13,000	26.7	30.2
Subbituminous:								
Subbituminous A					10,500	11,500	24.4	26.7
Subbituminous B					9,500	10,500	22.1	24.4
Subbituminous C					8,300	9,500	19.3	22.1
Lignite:								
Lignite A					6,300	8,300	14.7	19.3
Lignite B					---	6,300	---	14.7

ASTM The American standard for Testing Materials

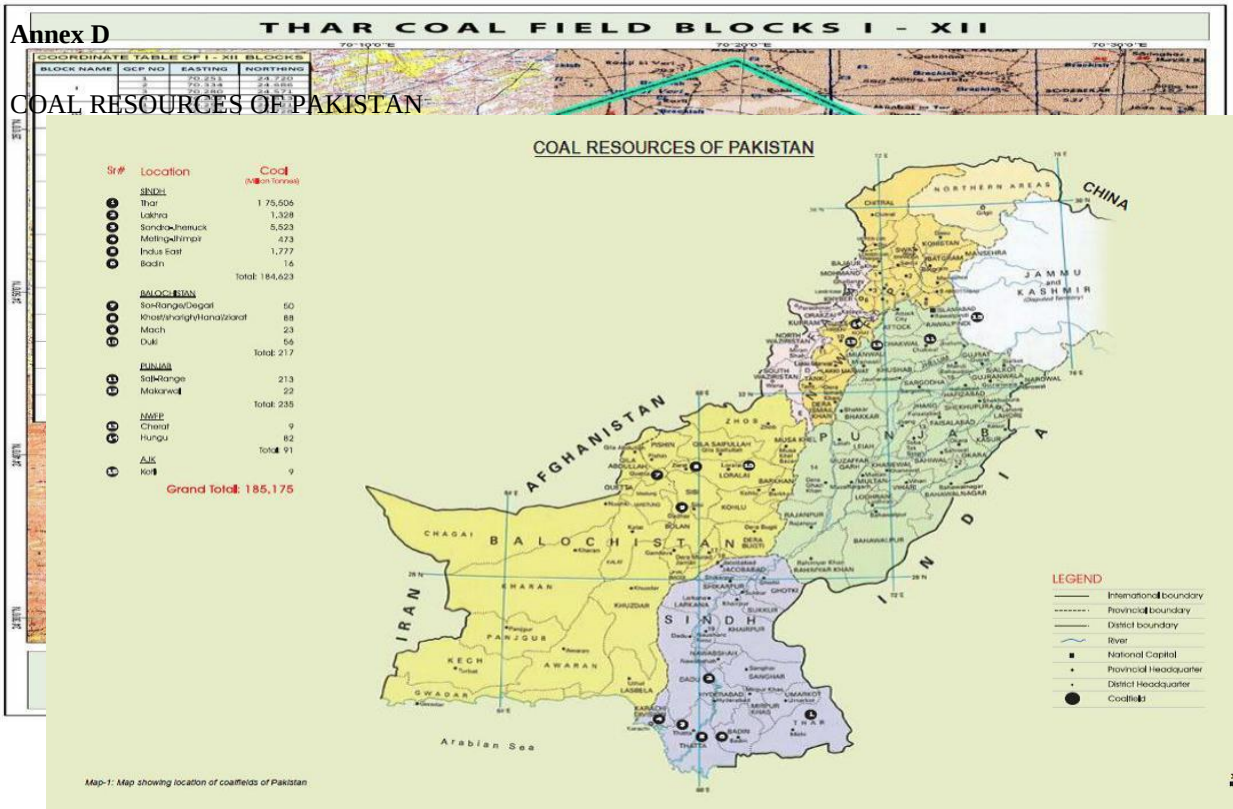
Annex C

COAL RESERVES BY COUNTRY



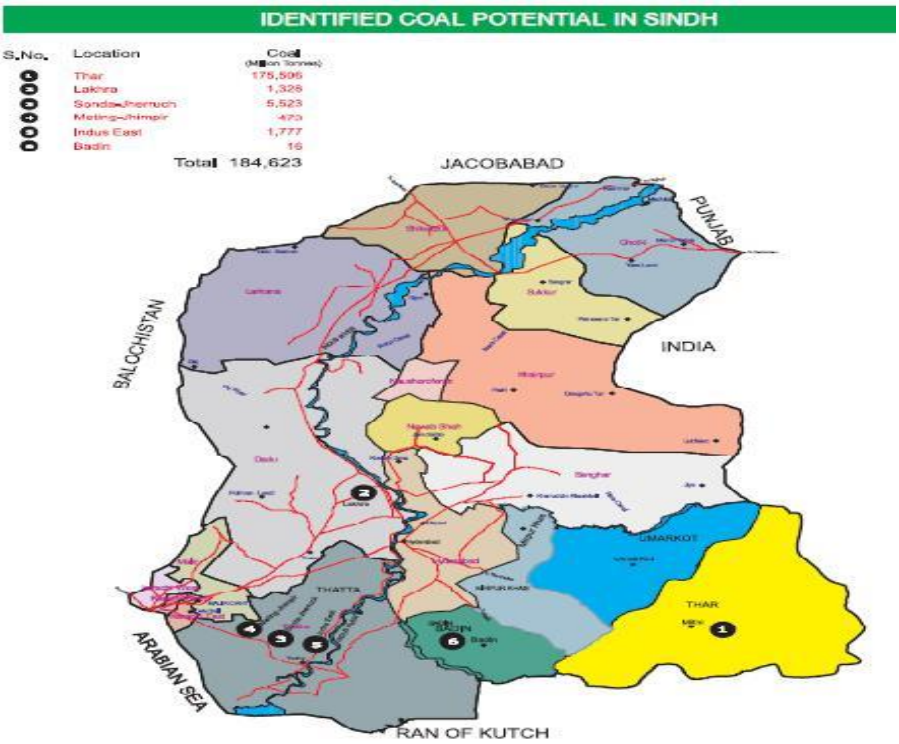
Annex D

COAL RESOURCES OF PAKISTAN



Annex E

SINDH COAL RESERVE



Annex F Thar Coal

File

Figure 1: Thar Coal Field Blocks I - XII

Annex G

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