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ENERGY CRISES AND SOLUTIONS

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Abstract

Energy consumption is one of the parameters for measuring the prosperity of a country. Energy situation of Pakistan has been critical for the last few years as the reserves of natural resources of energy are depleting at a very fast rate, resulting in the current energy crises and load shedding, badly affecting industrial and agricultural growth. Based on the observations and experience, energy resources of the country have been discussed, emphasising on the utilisation of indigenous resources, particularly, coal and hydel resources for minimising dependence on imported energy. Research and development work, carried out in the country on various fuels, has been discussed. Among them coal briquetting, coal carbonization (coking) of Sharigh coal, extraction of chemicals and desulphurisation of Pakistani lignites have been discussed. Studies on alternate/renewable and non-conventional sources of energy have also been presented with special reference to bio-gas, solar and wind energies, etc.

Keywords: Energy, Coal briquetting, Hydel power.

Introduction

Coal played a significant role till 1951 in the scenario of energy consumption of the country with a 60% share. Now, this figure has reduced to less than 2%. Railway engines were converted to consume fuel oil instead of mineral coal. Similarly, boilers and power plants were converted to use more convenient fuels, like, oil and natural gas, as the latter were more easily available at the most competitive prices. Most of the domestic houses have been using natural gas as fuel for the last fifty-five years. The beauty of natural gas is that it is ashless and smokeless, creating minimum environmental threats and storage problem.

It is suggested/proposed and recommended that there are only two options, i.e., hydel and indigenous coal, to combat against energy crises and loading/ignoring political pressure and environmental threats by installing coal fired plants at mine-head to minimising transportation and environmental problems.

An assessment of the energy consumption of the country has been for the last fifty is presented in the Table 1.

First ever coal based industry was set-up by the Pakistan Industrial Development Corporation (PIDC) in mid-fifties at Dawood Khel, using Makerwal/Gulla Khel coal as raw material for the production of energy and fertilisers, including, ammonium sulphate. The factory switched over to natural gas in late sixties and then coal was no more in use there.

In spite of huge deposits of coal in all the provinces of Pakistan, only 3 million tonnes of coal is annually mined (Government of Pakistan, 1988-89). Some of deposits of are projected in the Table 3. The most general analysis of Pakistani lignites is given in Table 4.

Table 1. Sources of Energy and Annual Consumption for the last 50 years.

Energy	% consumption
Oil	40
Natural Gas	40
Others (Coal < 5 %, Nuclear, Biomass (Wood, Bagasse, etc.), Hydel, LPG, etc.)	20

Table 2. Percent Share of Generation of power from Coal in selected countries.

Countries	Percent Share
Poland	90
South Africa	90
China	79
USA	60
India	50
Germany	48
Pakistan	0.1
Globally	38

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Table 3. Coal Fields in Pakistan

Fields	Estimated Reserves
Thar	185 Billion Tonnes
Lakhra	1.0 Billion Tonnes
Sharigh	0.5 Billion Tonnes
Sonda Thatta	0.5 Billion Tonnes
Sor-Range	0.3 Million Tonnes
Mach	22.5 Million Tonnes
Pir Ismail Ziarat	11.0 Million Tonnes
Dukki	49.6 Million Tonnes
Chamlang	5.0 Million Tonnes
Salt Range	61.1 Million Tonnes
Makerwal/Gullakhel	19.5 Million Tonnes
Jhimpir Metting	25.0 Million Tonnes

Source: Government of Pakistan 1992-93.

Table 4. Most general analysis of Pakistani coal

Constituents	Percent
Ash	15 – 40
Volatile Matter	30 – 40
Fixed Carbon	20 – 38
Sulpher	05 – 15
Energy Content	15 –20 MJ/Kg

Source: First International Coal Conference, February 22–26, 1986.

Pakistan Steel imports about one million tonne of bituminous coal from Australia among other locations for coking purposes. Coke in steel mills is used for the reduction of iron ore for purification (enriching) of iron. More than one million tonne of lignites is imported by private parties from South Africa and Indonesia for cement industries replacing furnace oil. Lignites from these countries contain less than one percent sulphur. Pakistani lignites are mostly rich in sulpher and mineral matter.

Presently, brick kilns are the major consumers of indigenous coal, using 97% of coal mine (Government of Pakistan, 1988-89). Minimum environmental problems are created as the kilns are normally situated away from human dwellings.

As far as research and development work on lignites in Pakistan is concerned, washing, coking, extraction of chemicals, briquetting and atmospheric fluidised bed combustion (AFBC) of Lakhra lignites were carried out.

Washing: Washing of Pakistani lignites is not recommended as these are heavier than water and do not float on water; hence hydrocycloning of these coals is not possible. Pakistani lignites are rich in mineral matter, hence heavier than water. A washing plant for hydrocycloning of Sharigh coal for steel mills was installed in seventies at Sharigh near Quetta but the plant could not produce the desired results.

Coking: Coking of sharigh coal at Sharigh, in bee-hive ovens and in vertical retorts at Karachi using internal partial combustion of sharigh coal by counter-current flow of hot gases produced from the combustion of natural gas and steam was carried out but the results were not found encouraging (Ali, 2006). Coking of bituminous coal is carried in steel mills for the production of coke. Results of these studies have been reported (Ali, 2006).

Extraction of chemicals: Humic acids have been extracted from Lakhra lignites for better agriculture crops. Extraction of humic acids is carried out from weathered coal or coal wastages of low grade coal–lignites rich in mineral matter. It is observed that the composition of humic acids is not in uniform as it is a mixture of humic acids. Hence results on various agricultural products may not be identical.

Briquetting: Briquetting of Pakistani coal is also one of the easiest methods of coal utilisation with some reservations, like, ignition/combustion of briquettes, storage and environmental issues. Briquetting is a centuries old method for using solid fuels. Coal briquetting material was moulded by hand for spherical shape. Coal briquettes were found ideal for space heating, particularly, in poultry farms but not recommended for domestic purposes from environmental point of view (Ali, 1993, 1994, 1996).

AFBC of Lakhra lignites: Atmospheric fluidised bed combustion (AFBC) of Lakhra lignites was carried using lime stone as sorbent for fixing sulphur of coal as calcium sulphate. The results were found encouraging up-to four percent sulphur content of coal. Coal and lime stone are fluidised in a bed of sand at 800^{o}C to minimise agglomeration (melting of mineral matter) of coal (Gvay, 1986).

About eight years back, some experts on the subject have tried to convince for the gasification of coal. A project of about 200 million cubic ft. per day of synthetic fuel gases was prepared for

Bakhar, Punjab. It was to be sponsored by, most probably, a natural gas company. Unfortunately, the proposal was dropped because gasification of Pakistani coals is neither technically possible nor economically and thermally feasible. The energy potentials of fuels are presented in Table 5.

Good quality coal (Table 6) or coke is required for gasification for production of synthetic fuel gases.

There is no comparison of these synthetic fuel gases with natural gas with respect to potency (Table 7) in general, and on economic basis, in particular. The gas produced from coal and any other source will be too expensive to generate power for power plants or combustion purposes. However, it could be used for the preparation of value added chemicals as was produced by the Pakistan Industrial Development Corporation (PIDC), at Dawood Khel.

Table 5. Energy Potentials of Fuels

Fuel	Energy Potential (MJ / Kg)
Hydrogen	142.00
Methane	55.53
Ethane	51.92
Propane	50.40
Butane	49.60
Octane (petrol)	48.00
Kerosene	45.94
Furnace oil	42.33
Charcoal	31.30
Anthracite	29.54
Bituminous	27.33
Lignite	26.55
Biogas	22.40
Wood	20.37
Biomass	15.55

Source: Culp, 1991. Principle of Energy Conversion, Archie W. Culp, Jr. McGraw Hill Inc.

Table 6. Classification of coal

Constituents	Peat	Lignite	Bituminous	Anthracite
Carbon	60.0	67.0	88.4	94.1
Hydrogen	5.9	5.2	4.6	3.4
Oxygen	34.1	27.8	7.0	2.5
Heating value (MJ/kg)	21.8	25.27	26.3	34.0

Source: Perry, 1963. Chemical Engineers' Handbook, 4th Edition.

Table 7. Energy Potentials of various synthetic fuel gases

Synthetic fuel gases	Energy Potential	
	(btu/ft^3)	(Mega Joules/m^3)
Anthracite producer gas	134	4.99
Bituminous producer gas	150	5.59
Blast furnace gas	102	3.80
Blue water gas	308	11.47
Carburreted water gas	536	19.67
Coke oven gas	588	21.90
Oil gas	575	21.42
Retort coal gas	575	21.42
Water gas	325	12.10
Bio-gas	600	22.35
Natural gas	1000	35.37

Source: Perry, 1963, Chemical Engineers' Handbook, 4th Edition.

A 15 (2 units of 7.5 each) MW Sor Range coal fired power plant near Quetta was operational till early nineties and was scrapped because of environmental threats or supply of adulterated coal of poor quality. The plant was designed on Sor Range coal, which is, comparatively, a better Pakistani coal.

In early nineties, a 150 (3 units of 50 each) MW lakhra coal fired power plant was installed using AFBC technique for minimising environmental pollution by fixing sulphur of Lakhra coal in $CaCO_3$ during combustion, producing $CaSO_4$ which is a fertiliser or a soil conditioner for better crops. It is applicable to soil after careful analysis of soil to examine the deficiency of nutrients of the soil. The coal fired plant has never produced desired results since installation; no more than 30 MW of energy has ever been produced. It is suggested that some other fuels – furnace oil, imported coal, etc., could be tried out.

Solution to Energy Crises

Following are the solutions for minimising energy crises and load shedding:

a) Construction of Hydel Dams for power generation.
b) Energy Conservation.
c) Alternate/Non-conventional and renewable sources of energy.
d) Coal Briquetting.
e) Switching over to coal.

The brief detail is as follows:

Hydel Dams: The only one and the most economical option for the generation of energy available is the "Construction of Dams". Hydroelectro potentials of Pakistan are presented in Table 8. Pakistan is one the most fortunate countries of the world with tremendous resources of water. Billions of acre feet of water are being wasted throughout the country. A number of reservoirs of one hundred square miles is required and to be constructed for the storage of water throughout the country. It will not only meet the requirements of water for industry or agriculture but also for potable water. The reservoirs should be constructed deep enough to minimise evaporation losses as about of 70% water is lost due to evaporation and 10-15% due to seepage, if proper care is not taken during construction of reservoirs.

Table 8. Hydroelectric Potential of Pakistan

Daso	**5500 MW**
Basha	**4500 MW**
Kalabagh	**3600 MW**
Thakot	**2400 MW**
Ghazi Barotha	**1450 MW**
Ghazi Gariala	**1000 MW**

Source: Government of Pakistan, 1988-89

Advantages of Hydel Energy: Most economical mode of power generation is hydel. Hydroelectric Potential of Pakistan sites of dams are projected in Table 8.

Construction of dams is inevitable for minimising load shedding and energy crises. The only solution of our energy crises and load shedding is the "Construction of Dams" in general, and Kalabagh Dam, in particular. More than Rs. 100 million has been spent on the feasibility studies of Kalabagh Dam. Only construction of the dam is to be initiated. Hydel energy is the cheapest source of energy with large number of other value-added benefits. Among others, few of them are:

- Storage of water for its supply throughout the year as and when required,
- Aquatic animals,
- Inexpensive electric power,
- Environment friendly energy,
- Energy and water conservation,
- Expertise on the subjects,
- Better agricultural growth,
- Better industrial growth,
- Export boost up,
- Tourists' attraction/spots,
- Self-reliance,
- Load shedding is minimised,
- Employment opportunities,
- Sustainable source of water and power, etc.,
- Prosperity of the country,
- Better control on floods.

It is also mentioned here that construction activities, in favour of the country, are always opposed (Le-Chatlier's Principle and Lenz's Law). When the proposal of construction of Lloyd Barrage at Sukkur was launched in twenties of twentieth century, it was feared that Sind would become desert. Now the barrage has paid billions of times of its cost in the shape best agriculture crops, aquatic food and potable water in 80 years. Entire Sind is benefited with this barrage.

Dams for the generation of hydel energy are the only solutions for energy crises to minimise load shedding and maximise agriculture and industrial growth.

Energy Conservation: Energy conservation is also one solution to minimise energy crises and load shedding. Most people do not pay attention to energy conservation and keep their houses fully loaded with lights, ACs, microwave ovens and indiscriminately use household appliances. To minimise energy consumption is to minimise the use of these appliances. Energy audits/surveys of industries and power plants are recommended in practical and true sense to minimise energy wastages/losses. Steps for energy conservation to minimise energy crises and load shedding should be widely propagated through print and electronic media.

Alternate Sources of Energy

After the oil embargo in 1973, western and advanced countries introduced the idea of alternate, non-conventional, renewable and non-fossil fuel sources of energy but these cannot compete with natural resources. There is no substitute for petrol. Similarly, there is no substitute of hydel dams. Energy extraction from renewable sources of energy is no more than 10%. The alternate sources of energy are dependent on weather. These include;

a) Biomass (Bio-gas, etc.),
b) Wind energy (Windmills),
c) Solar Energy (Thermal and photovoltaic, etc.)
d) Hydel etc.

Bio-gas: Bio-gas, a mixture of methane (CH_4) and carbon dioxide (CO_2) alongwith traces of other gases, like, hydrogen sulphi (H_2S), having energy potential of 600 btu/ft^3 (22.35 MJ/m^3), is generated from the anaerobic fermentation/ digestion of animals and agricultural wastes, but animal dung, abundantly available in the villages, is found ideal for bio-gas generation (Ali, 1987).

A large number of bio-gas plants, about more than four thousand, were installed in 1980s in various parts of the country. Still some of the bio-gas plants are propagated on television for cooking purposes. One of the plants has still been operational in Gulshan-e-Iqbal, Karachi, for the last 36 years.

Over one million in India and 10 million bio-gas plants in China have been installed for the production of bio-gas and more effective/ efficient/economical natural fertiliser for better agricultural production. The plants are ideal in remote areas for meeting energy requirements, etc. (Ali, 1987).

Sewerage treatment plants produce bio-gas in bulk. Sewerage plant at a site of Karachi Metroplitan Corporation was installed in 1958 for treatment of sewerage of the city of Karachi. The treated waste water is used/recycled for the agricultural purposes at Gutter Baghicha of 500 acres. The plant also generated 0.1 million ft^3 of bio-gas per day which was meant for generating 4MW through five generators of 800 kW each.

Recently, Karachi Electric Supply Company is planning to generate 25-30 MW electricity from 5000 tonnes of cattle dung at the Karachi Cattle Colony, using bio-gasification technology.

It is observed that:

1. Rate of bio-gas generation is very low; 0.25m^3 bio-gas per day is generated from 1m^3 of slurry (50 % animal excreta plus 50% water to produce slurry of 10% solid content).
2. Bio-gas generation is temperature dependent (favourable temperature range is 30 to 42^{o}C; below 15^{o}C, no gas generation).
3. Warming of slurry from external sources of energy is, thermally, not favourable.
4. Energy potential of bio-gas is 50% of natural gas.
5. Bio-gas contains moisture which disturbs its smooth combustion.
6. Cost of bio-gas plants needs to be reduced further, so as to be within the reach of a common villager.
7. R&D work is emphasised to enhance rate of gas generation and development of more convenient plant design.

Windmills: Windmill is a centuries old technology for pumping ground water in its early development. Netherland (Holland) has played pioneering role in the introduction of this technology. Now, it is an advanced technology.

Electric power is generated through this technology. For windmills, critical and constant wind-speed is required. Storage of produced-energy is problematic. Power generated by windmills is stored in batteries, using uninterrupted power supply device (commonly known as UPS) for desired voltage for electric appliances. A dozen windmills were installed in Karachi by a private party, twenty years ago for demonstration/commercialisation purposes. Four of them were installed on Rashid Minhas Road, Karachi, for pumping ground water for trees and plants for greenery of island. These were operational for more than five years.

Solar Energy: Energy obtained from the sun or sunlight is known as solar energy. It is classified as photovoltaic and/or solar thermal. Energy obtained from sunlight through photovoltaic cells is stored in storage batteries and upgraded to the desired voltage through UPS for consumption in electric appliances. These are used for street lights. Photovoltaic cells are expensive. Natural gas companies have installed such cells at various places for cathodic protection of gas transmitting pipelines. For photovoltaic sources of energy, a large number of storage batteries are required for constant supply of energy at a desired voltage. Storage batteries have a life of less than two years. Maintenance of the panels and storage batteries is required. Commercial plants based on photovoltaic cells are not very common because of economics.

Solar thermal technology is used for warming water. This technology is, comparatively, less expensive and technical.

Solar thermal energy is used for water desalination, taking the advantages of evaporation properties of water.

1. The evaporation occurs at all temperatures, and
2. The evaporation is faster on larger areas and higher temperatures.

Solar thermal desalination plant is a simple glass prism to allow sun rays to warm saline water enclosed in it in trays for evaporation and water vapours so formed are condensed after striking on the inner glass surface and collected in the salt-free water drain. Salt left is removed from time to time. First water desalination plant yielding 6000 gallons per day was installed in 1960s at Gwader on the recommendations of Dr. I.H. Osmani, world renowned nuclear scientist of Pakistan and founder and chairman of Pakistan Atomic Energy Commission.

First ever nuclear, 137MW power plant, known as Karachi Nuclear Power Plant (KANUPP), with the help of Canada, was also installed near Karachi in late 1960s. It is still operational.

Any way sustainable energy is not guaranteed from renewable sources of energy. In spite of more than forty years R&D work on alternate/ renewable sources of energy, the technologies, so far developed, are, still, in infancy.

Comparison Between Fossil and non-Fossil fuels

Fossil Fuels	Non-Fossil Fuels
- These are conventional fuels, such as, coal, mineral oils and natural gas. - These are found underground and are exhaustible. - Create environmental problems - Produce ash and smoke - Responsible for global warming - Capital and operating/maintenance cost is high. - Require extensive processing. - Require high technical skill for installation and operation/ maintenance. - These are available in a limited number of countries, including, USA, UK, Russia, South Africa and the Middle East.	- These are non-conventional renewable, or alternative fuels – biomass, solar, wind and hydel energy. - These are found on the ground - These are inexhaustible - Environmentally benign - No or minimum ash and smoke - No or minimum global warming - Minimum operating and maintenance cost - Minimum processing required - Skill is not necessarily required - These are found everywhere all over the world

Coal Briquetting

Briquetting of Pakistani coals is also one of the easiest/convenient methods of the coal utilisation with some reservations regarding ignition/combustion of briquettes, storage and environmental issues. Briquetting is a centuries old method for using solid fuels. Coals are moulded by hand for spherical shape. In Pakistan, a commercial coal briquetting plant had been operational till 1992, by the Pakistan Mineral Development Corporation (PMDC), at Bijli Road, Quetta. The plant was shifted in 1942 from Assam, India, during World War II, to warm the sheds of soldiers stationed there in winter. The plant produced 100 tonnes of coal briquettes per day from Sharigh and Degari coals as there was, then, no convenient fuel available. The entire plant was operating on steam as there was no electricity. The steam was produced from coal using a boiler. Sui gas was supplied to Quetta in 1980s and hence briquettes lost the market. The plant was scrapped and disposed off in 1992 (Ali, 1993, 1994 and1996).

40 tonnes of coal briquettes were produced at PMDC Coal Briquetting Plant, Quetta, in 1986, for USAID for marketing studies. Based on the studies, Oakridge National Laboratories (ORNL), Tennessee, USA, has published a comprehensive report on the subject and widely distributed it in Pakistan. 270,000 tonnes of briquetting plant at Multan, Pakistan, has been suggested to meet only 10% of energy requirements of Pakistan. Multan has been pointed out as focal point as it is the nearest to coalmines and coal briquettes market in Pakistan.

Salient Features of Coal Briquettes

- Energy for a long time.
- Easy Transportation and Storage.
- Maximum extraction of energy.
- Minimum spontaneous combustion.
- Maximum retention of energy for a very long period of time.
- Regular shape for maximum storage in minimum space.
  - Ideal for space warming.
- Minimum environmental threats.
- Disposal of ash is easier as compared to ash of raw coal.
- Weathered coal can be better utilised.
- Coal wastage and fines are utilised.
- Can be produced in any desired shape.

It is observed that,

1. Coal briquettes are slow burning fuel. Ignition of briquettes is time consuming as these contain water (Ali, 1993).
2. Emissions produced during combustion of coal briquettes can be let out to atmosphere through chimney.
3. Coal briquettes are burnt in technically designed/fabricated stoves with chimney.

It is recommended that Pakistan Railway may use coal/coal briquettes in the steam locomotives, minimising expenses incurred on fuel oil and dependence on imported fuel. 2 to 3 tonnes of coal briquttes per hour would be required for 3000 HP steam engines. The cost of coal briquettes would be Rs.10,000/- per tonne at the maximum. Cost of fuel oil is double the cost of the coal briquettes on the basis of energy potential. Pakistan Railways would save 50% on fuel. Experimentally, one of the steam engines may be converted to coal briquettes.

Coal briquttes are ideal for space heating and recommended for poultry farms for warming chicken sheds, particularly in winter. Technically designed stoves have been reported (Ali, 2004).

Switching Over to Coal

One of the options to minimise energy crises is switching over to coal, whether local or imported. Coal fired power plants could be installed in the remote areas of the country nearest to coal mines, which are normally deserted and barren areas where there will be no environmental issues. As shown in Table 2, Poland, South Africa, Russia, USA, China, India and Australia are producing power using their coal reserves for power generation ignoring environmental issues or observing some of environmental standards/precautions to minimise environmental threats. On the protests of public and environmentalists, India has shifted its coal-fired power plant from the vicinity of Agra to a far way locality to meet some of the environmental standards to protect the Taj Mahal from environmental hazards. It is also mentioned here that the Indian coals are not better than Pakistani coals. India imports more than two million tonnes of lignites for meeting its coal demand for power generation and cement factories.

Very recently, Karachi Electric Supply Company (KESC) has entered into an MoU to switch over two of its units of Bin Qasim power plant from furnace oil/natural gas to coal. As reported in the newspapers, the conversion will be completed in the month of March 2011. Two of units of Bin Qasim power plant will produce power from coal.

Imported coal from Indonesia and South Africa is recommended for power plants as local coals are not suitable for combustion from environmental point of view. This will, considerably, reduce dependence on fuel oil which is imported at the cost of expensive and hard earned foreign exchange. It could be partially saved.

The construction of dams should immediately be undertaken before the situation becomes more severe and serious. However, Thar coal could be tried out for power generation in Lakhra 150MW (3 units of 50 each) power plant at Khanot, Sindh, as it is a very small pilot plant for coal testing facility. This plant was installed by advanced and developed countries to study their technology developed for the utilisation of low grade (high in sulpher and ash) coal for combustion purposes for the production of electric power.

Underground Gasification of Thar Coal

Underground gasification of unmineable coal is suggested without knowing the products (Table 9), available from the gasification and the testing equipment required for testing of gases, liquids and solids formed as quality of coal differs from mine to mine and even seam to seam. Table 10 shows the Thar coal fields.

Table 9. Composition of Synthetic fuels gases.

Synthetic fuel gases	Composition %							
	CO	CO_2	H_2	N_2	O_2	CH_4	C_2H_4	C_6H_6
Anthracite Producer gas	24.0	7.5	16.5	50.2	0.6	1.2	–	–
Bituminous Producer gas	27.0	4.5	14.0	50.9	0.6	3.6	–	–
Blast Furnace gas	27.5	10.0	3.0	58.0	1.0	0.5	–	–
Blue Water gas	42.8	3.0	49.9	3.3	0.5	0.5	–	–
Carbureted Water gas	33.4	3.9	34.6	7.9	0.9	10.4	6.7	2.2
Coke Oven gas	6.3	1.8	53.0	3.4	0.2	31.6	2.7	1.0
Retort Coal gas	8.6	1.5	52.5	3.5	0.3	31.4	1.1	1.1
Water gas	50.0	–	50.0	–	–	–	–	–
Oil gas	6.8	1.0	59.2	2.7	0.1	25.4	3.8	1.0

Source: Perry, 1963, Chemical Engineers" Handbook, 4th Edition.

Mendelive, a Russian scientist, suggested this technology for unmineable coal more than 150 years ago but there is no live plant of this kind in any parts of the world so far on commercial scale. No research papers on the work of gasification of Pakistani lignites are available. R&D work carried out in advanced/developed countries on good quality coal is not applicable on Pakistani lignites.

Table 10. Thar Coal Fields

Area	9100 sq. Km
Identified	185.00 Billion Tonnes
Indicated	9.75 Billion Tonnes
Inferred	3.00 Billion Tonnes
Moisture Content	50 – 70%
	(On dry basis)
Fixed Carbon	30 – 40%
Volatile Matter	30 – 40%
Ash	30 – 40%
Sulpher	5 – 7%

Advanced and developed countries test their technologies in Pakistan at the expenses of economics of Pakistan. Investors recover their money with interest even at the level of penny.

Conclusion

Hydel, coal and nuclear sources are the only three economical options of energy for Pakistan to minimise energy crisis and load shedding.

Combustion of natural gas in industries and power plants is not advisable as it is used for the production of value added chemicals, like, artificial fertilisers. However, domestic use is recommended for its convenience as it is ashless, produces smokeless fuel and needs no storage.

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