



ENERGY CRISIS IN PAKISTAN, ADAPTATION AND MITIGATION MEASURES

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Abstract

Energy is part and parcel of every aspect of life as well as backbone of a country's economy. Pakistan is lagging behind in this area despite of rich reserves of raw energy, but there is dire need for the investment and proper use of these reserves for driving the wheel of economy. Present energy scenario of the country, its available resources and their potential towards the solution are addressed in this paper. Statistical data in this work provides ease to policy makers in deciding major investment area to take the country towards prosperous future. A lot of partial projects like Independent Power Producers (IPPs) and Rental Power Plants (RPPs) have been made and invested but all in vain rather burden on economy. The sequence of investment field is also proposed which will pay back more in the long run.

Keywords: Energy Crisis; Load Shedding; Electricity Generation; Energy Mix etc.

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1. Introduction

Some of the people interpret energy crisis as political/administrative/business conspiracy, while others think it a natural phenomenon [1]. On Pakistan's birth in 1947, its inherent power generation capacity was 60MW with 31.50 million people, thus per capita consumption of 4.50 units. Water & Power Development Authority (WAPDA) shaped in 1959 increasing the generation capacity to 119 MW (and generated power to 781 MKWH), which further increased to 636 MW (and generated power to 2,500 MKWH) in 1964-65. No. of villages having electricity was 609 in 1959 and 1882 (No. of consumers up to 688 thousand) in 1965. Time passed and the generation capacity crossed 7000 MW limit in 1990-91. No one dreamt today's horrible load shedding by then which ended up in reduction of electricity generation to 50% a few years back. The available power crossed breakeven in 2007 to reach a deficit of 15% in 2008 due to growing power demand, lack of system efficiency, governmental instability etc. If the current situation prevails, oil will be depleted within 42 years, natural gas within 61 years and coal will last for 133 years [2]. Thus, Coal is the best choice of today's world for solution to energy crisis for cheap electricity in near future to 2030 scenario [3].

2. Existing Status

Pakistan has three sources of energy, namely hydel, thermal (gas/ steam/ furnace oil) and nuclear. And there are four major power producers in the country: WAPDA, Pakistan Atomic Energy Commission (PAEC), Karachi Electric Supply Company (KESC) and Independent Power Producers (IPPs) at present. The installed capacities of these major power producers are detailed in Fig. 1 below.

Thus, Pakistan's Net Power Generation Capability (through all the sources) turns out to be 20, 190 MW and the electricity demand (as of April 2010) was 14,500 MW whereas Pakistan Electric Power Company (PEPCO) is just generating 10,000 MW. All the Power generation companies are suffering to buy furnace oil from PSO but the end users are all repaying for that. That's why the top refineries like PRL are running at 40% of their capacities. The average annual electricity consumption of the last decade has amplified by approx. 5%, 73 Million MWh of electricity being consumed in FY2010 (-1.7% growth from FY2009).

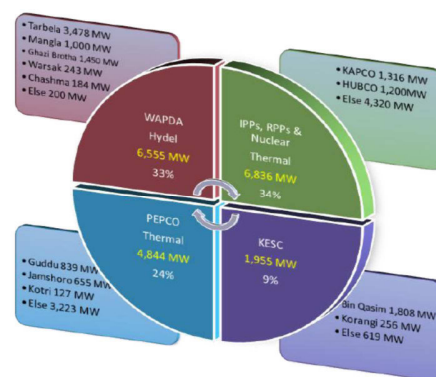


Fig. 1: Pakistan's Total installed capacity [4]

Thus the annual energy consumption and output for Pakistan is depicted in Fig. 2 below.

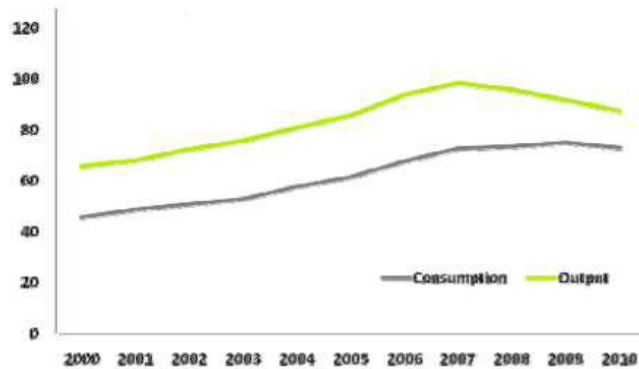


Fig. 2: Pakistan's annual energy consumption and output for 2000-10 [4]

The difficulty arises due to the gap between demand and supply which is growing terrifyingly as shown in the following plot (of Fig. 3).

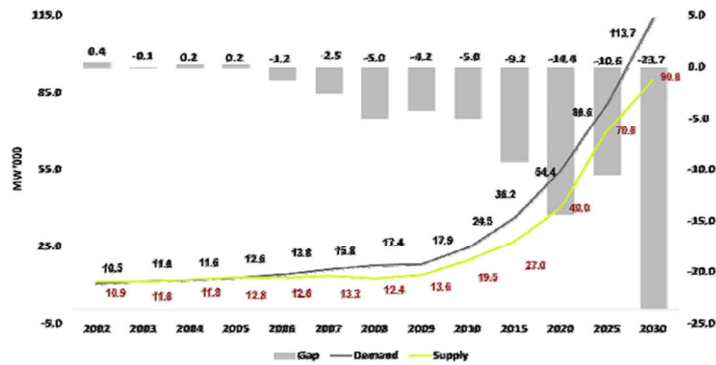


Fig. 3: Pakistan's energy demand and supply gap for 2002-30 [5]

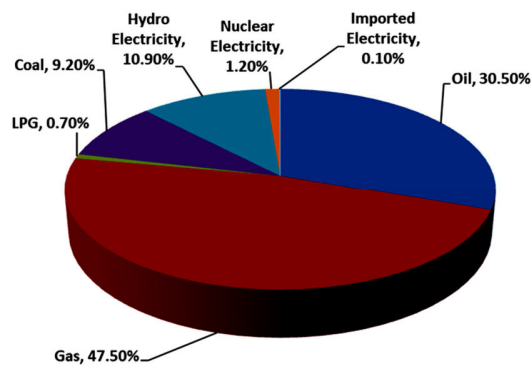


Fig. 4: Primary energy supply by source 2007-08 [18]

Due to surge in crude oil prices from \$ 60 to \$ 147 in the duration of 2005-2008, country's oil dependent thermal generation (32%) could not sustain resulting in a huge Energy Sector debt (\$ 3.6 billion).

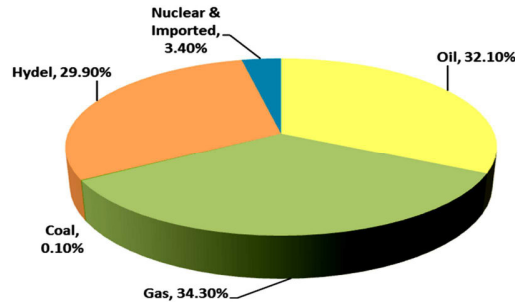


Fig. 5: Electricity generation by source 2007-2008 [18]

Power generation capability has not been improved for last decade or so, whereas the country's fuel consumption has the pattern shown in Fig. 6.

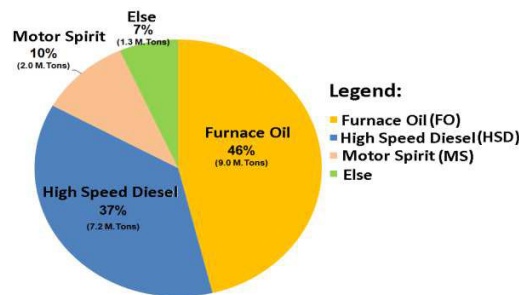


Fig. 6: Country's Fuel Consumption Pattern [6]

Electrical Energy is vital part of energy as a whole, whose generation for 2009-10 in the country depended upon the sources as given in Fig. 7 below.

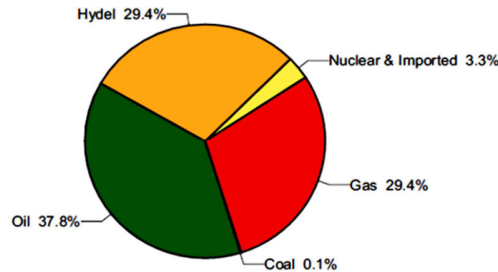


Fig. 7: Pakistan's electricity generation for 2009-10 [7]

Likewise, the subsequent dissemination of the electricity consumption for various sectors had the pattern of Fig. 8 below.

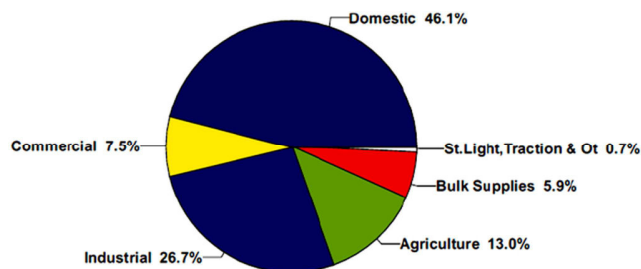


Fig. 8: Pakistan's electricity consumption for 2009-10 [7]

To sum up, the GDP has decreased on the average as plotted in Fig. 9 below for 1972-2008. It is apparent from Fig. 9 that growth ascends to 6-7 % but abruptly descends back to 3-4% and can't persist.,

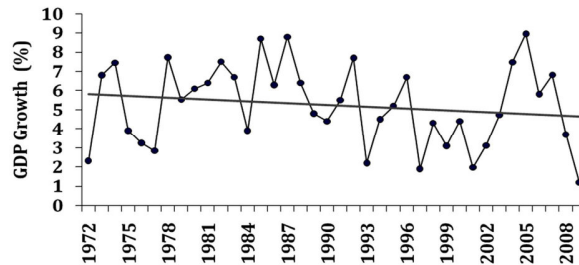


Fig. 9: Pakistan's GDP, rise and fall for 1972-2008 [8]

The average is declining indicating that there is not only something wrong but the same is accumulating.

Table 1: Per Capita Electricity Consumption (2008) [9]

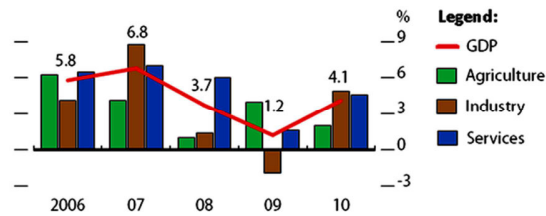
Sr. No.	Country	Per Capita Consumption (KWh)
01.	Afghanistan	35.032 kWh per capita (2006)
02.	Australia	10,864.152 kWh per capita (2007)
03.	China	2,584.876 kWh per capita (2008)
04.	India	502.714 kWh per capita (2007)
05.	Indonesia	508.321 kWh per capita (2007)
06.	Iran	2,160.441 kWh per capita (2006)
07.	Korea, South	7,515.579 kWh per capita (2007)
08.	Malaysia	3,724.977 kWh per capita (2006)
09.	Maldives	604.484 kWh per capita (2006)
10.	Nepal	77.608 kWh per capita (2007)
11.	Pakistan	438.261 kWh per capita (2007)
12.	Singapore	8,053.094 kWh per capita (2008)
13.	Sri Lanka	398.367 kWh per capita (2008)
14.	Thailand	2,052.118 kWh per capita 2008

Pakistan's per capita energy consumption is very low as compared to other countries given in Table 1. And the electricity demand is going further up as is clear from Table 2 below. It depicts figures of the year 2008. Later, it went upto somewhat 6700 MW.

Table 2: Electricity Supply and Demand in Pakistan for 2008-2020 (MW) [10]

Years	Standing Generation	Proposed Generation	Total Current / Committed Generation	Projected Available Generation	Demand (Summer Peak)	Additional / Deficit Generation
2008	15,903	530	16,484	13,146	16,484	-3,338
2009	15,903	4,235	20,138	16,110	17,868	-1,758
2010	15,903	7,226	23,129	18,503	19,352	-849
2011	15,903	10,115	26,018	20,814	20,874	-60
2012	15,903	10,556	26,459	21,167	22,460	-1,293
...
2018	15,903	18,448	34,351	27,481	34,918	-7,437
2019	15,903	18,448	34,351	27,481	37,907	-10,426
2020	15,903	18,448	34,351	27,481	41,132	-13,651

The GDP growth rate of 2.4% for 2010-11 than the target rise at 4.5% is due to: overwhelming floods, great inflation, vexing fiscal growths, increasing oil prices, decaying capital and financial inflows etc. disturbing the economy severely [11], [12]. The major economic setbacks faced in FY2008 by the country are still seen in FY2010 and even in FY2011. So, the decline to 4.1% was seen for FY2010 (Fig. 10) resulting in decelerating the growth for FY2008–FY2010 to the average value of only 3%, further down the 8% desired to generate employments for the increasing young inhabitants



13.Fig. 10: Country's sectoral GDP growth [13]

FY2010 was the 3rd successive year to face cut in investment in large-scale engineering sadly to 15.4% and electricity & gas to 11.0% poorer. Overall, the steady investment decay in GDP share reached from 20.5% in FY2006 to 15.0% in FY2010 as in Fig. 11.

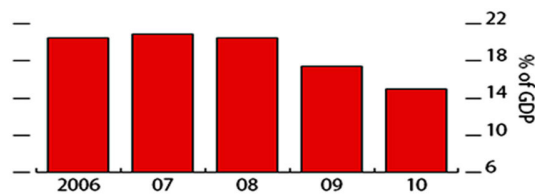
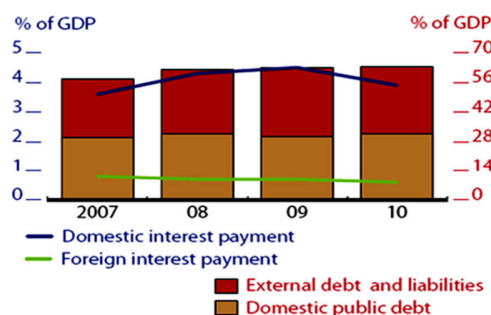


Fig. 11: Country's fixed investment as a % of GDP [13]

The public debt of the country apart from guarantees in % of GDP persisted to ascend in



FY2010 (Fig. 12). The domestic debt of Government aggregated to 37.00% of GDP, also with commodity debt and liabilities of state-owned enterprises (SOEs). The rise of external debt was to 31.90% of GDP, plus 0.60% of GDP in external liabilities of SOEs [14].

Fig. 12: Public debt and interest payments [14]

Table 3 shows the selected economic indicators in % share of GDP from ADB estimates. The present scenario of primary energy mix for the country is really unjustified relying on gas at 47.50% and costly oil at 30.50% (72 % imported).

Table 3: Selected Economic Indicators (% of GDP) [15]

Year	2011	2012
GDP Growth	2.5	3.7
Inflation	16.0	13.0
Current Account Balance	-1.7	-2.3

If LNG of 1.0 bcfd is imported by 2015 the natural gas supply-demand gap will rise to 1.7 bcfd, and is not likely to be hid as IPI project can't be over in this interim. So we must review Primary Energy Mix especially on electricity generation basis by source for 2010–2030 scenario.

3. What is Going On in The World

Reshuffling Pakistan’s energy policy to match today’s needs is exhibited by the ensuing evidences. The world total primary energy supply (WTPES) in Million Tonnes of Oil Equivalent (Mtoe) is presented in Fig. 13 below.

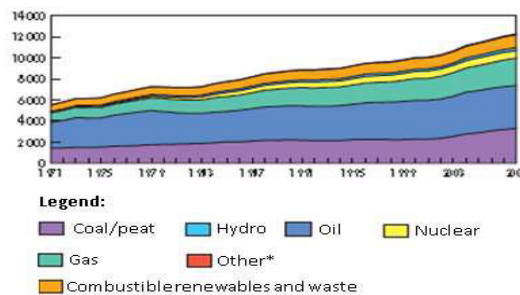
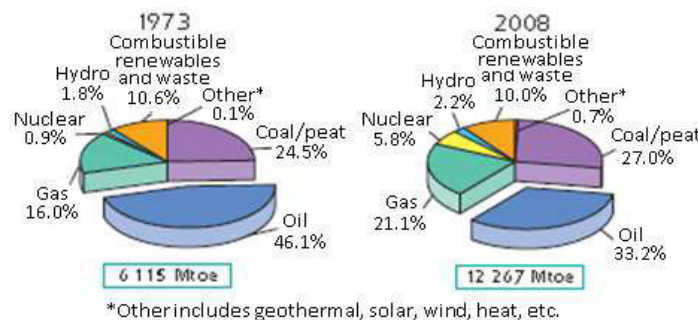


Fig. 13: WTPES by fuel (Mtoe) from 1971-2008 [16]

Whereas the 1973 & 2008 fuel shares of total primary energy supply are obvious in Fig. 14 below. Oil is depleting due to top consumption (Fig. 14), so world energy crisis demands the use of other resources now.



*Other includes geothermal, solar, wind, heat, etc.

Fig. 14: Fuel Shares of WTPES for 1973 and 2008 [16]

Also, world electricity generation (WEG) by fuel is presented in Fig. 15 below.

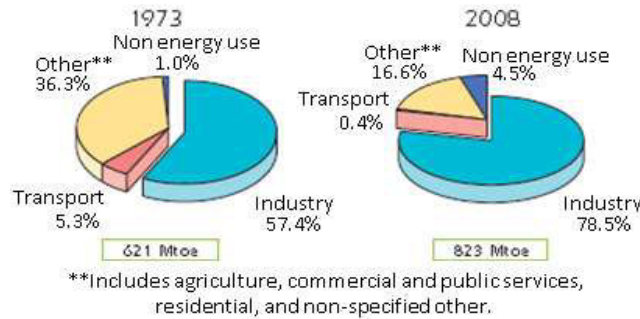


Fig. 15: WEG* by fuel (TWh) from 1971-2008 [16]

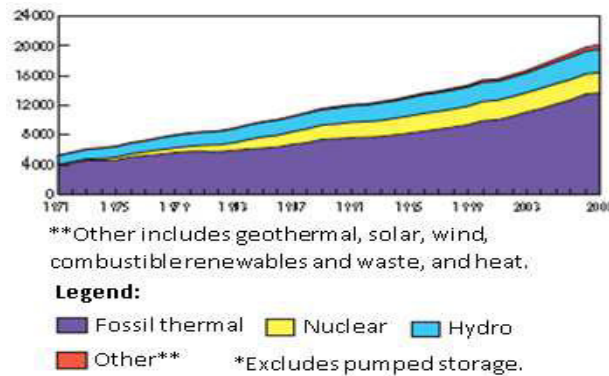


Fig. 16: Fuel shares of WEG for 1973 and 2008 [16]

Whereas the 1973 & 2008 world electricity generation (WEG) fuel shares are exposed in Fig. 16. Coal is broadly used as a major fuel in the world's industry to meet the present energy needs which is clear in Fig. 17 below. Similarly, the 1973 & 2008 fuel shares of world coal consumption (WCC) are set in Fig. 18 below.

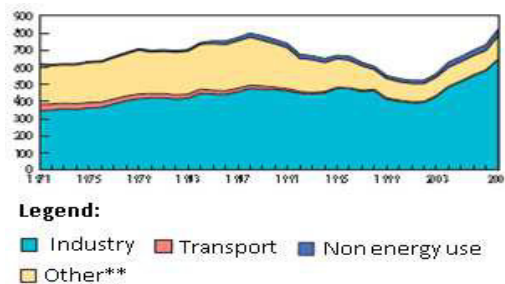


Fig. 17: Total Sectorial Coal Consumption (Mtoe) for 1971-2008 [16]

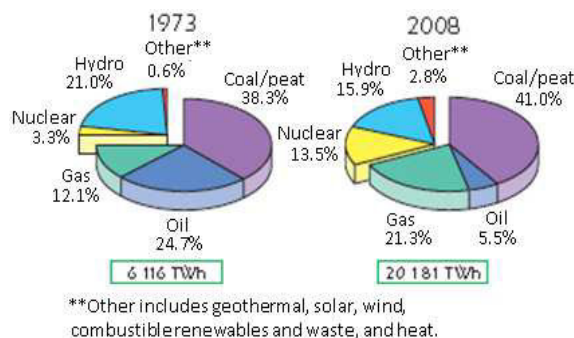


Fig. 18: Fuel Shares of WCC for 1973 & 2008 [16]

After Oil & Coal, next choice with the world is gas as an energy source shown in Fig. 19. IEA gives 1973 & 2008 world Gas consumption shares as percentage in Fig. 20 below. The Asian Development Bank gives the energy indicators of various Asian countries.

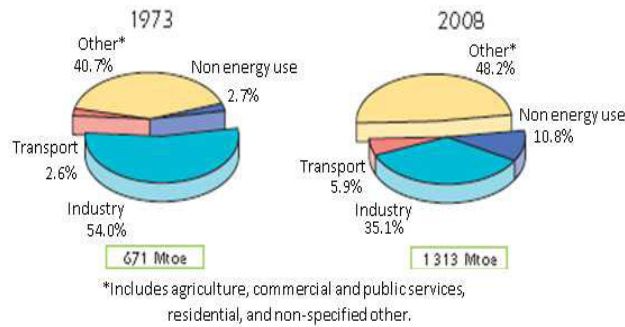


Fig. 19: World Energy Sources in % [17]

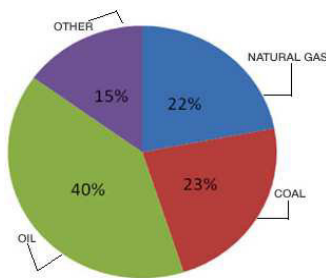


Fig. 20: World Gas Consumption shares for 1973 & 2008 [16]

These energy indicators are used for energy comparison of the countries as is given in Table 4:

Region /Country /Economy	Population (million)	GDP (billion 2000 USD)	GDP PPP (billion 2000 USD)	Energy Prod. (Mtoe)	Net Imports (Mtoe)	TPES (Mtoe)	Elec. Cons. ^(b) (TWh)	CO ₂ Emissions ^(b) (Mt of CO ₂)
Malaysia	26.99	139.16	303.78	93.12	-17.61	72.75	94.28	180.87
Nepal	28.58	7.31	43.09	8.73	1.14	9.80	2.57	3.33
Netherlands	16.44	449.28	546.32	66.54	34.14	79.68	118.84	177.86
Oman	2.79	30.82	47.76	63.49	-42.72	16.44	13.63	34.92
Pakistan	166.04	112.53	398.63	63.33	20.21	82.84	72.44	133.79
Panama	3.40	18.97	29.12	0.70	2.25	2.90	5.60	6.53
Poland	38.12	237.47	560.54	71.39	30.29	97.88	142.27	298.69
Qatar	1.28	37.71	33.78	124.83	-99.80	24.12	20.09	53.91
Saudi Arabia	24.65	252.08	375.69	579.02	-412.41	161.60	186.73	389.16

Table 4: Comparison of Pakistan with the world energy indicators [16]

Gross production + imports – exports – losses.

CO₂ emissions only from combustion of fuel. Emissions are calculated using energy balances of IEA and the Revised 1996 IPCC Guidelines.

Now sectorial energy consumption of 34.7 Million TOE in 2009-10 for Pakistan distributed as in Fig. 21.

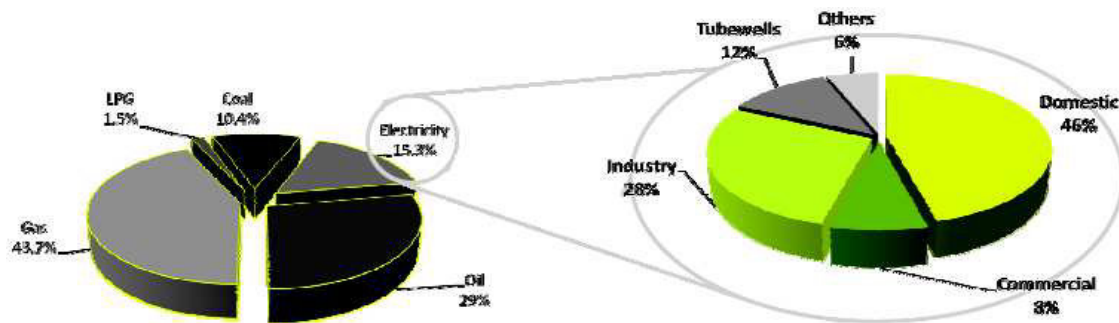


Fig. 21: Sectorial Energy Consumption for 2009-10 [4]

Pakistan’s Economic Survey 2009-10 exposed fuel consumption of Pakistan vs. world as in Fig. 22.

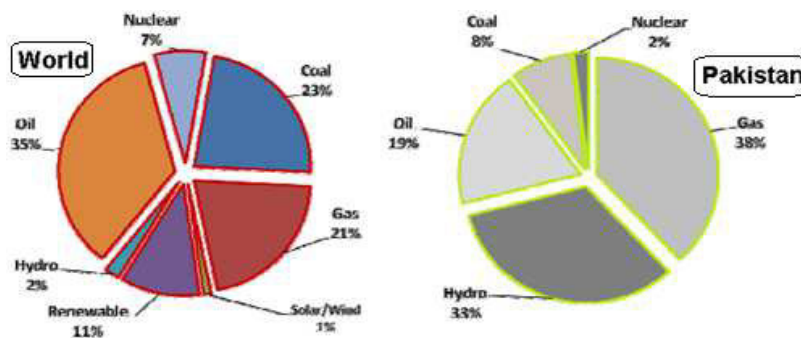


Fig. 22: Comparison of Pakistan’s fuel consumption with that of the world [4]

4. Rationales of Energy Crisis

At present the country is trapped in a grave Energy Shortfall owing mainly to mismanagement and some inevitable constraints adding to the status quo [18] briefed as follows:

Deficiency of Rational and National Approach for the energy projects & Future Demand Envisaging and nonexistence of responsible authority for Energy Sector. Unprovoked Energy Mix with substantial dependence on gas (47.5 percent) and Oil (30.5 percent) (72 percent imported), although world counts more on coal. Another imbalance produced because of over dependency on dams for the generation of electricity [19] which resulted in adverse effect on country's mangrove forests and augmented threat of devastating floods [20].

Making no use of huge inherent possessions of Coal (especially Thar reserves), Hydel capabilities and gas resources resulting in very low production advancement in the country lying amongst the lowermost in South Asia. Coal utilization is about 9% in the Energy Mix (Fig. 4) and only 0.1% for Power Generation vs. 72% in China, 56% in India and more than 50% in the USA. We have shifted to costly oil from indigenous gas depicted in Fig. 23 below. Limited energy projects, lack of proper forecast and execution of approved and worthy projects. Some of the energy projects suffered court trials due to irregularities irritating the industry and labour rather than facilitating. Huge inconsistencies on the part of RPPs were reported in June 2011 [22].

Dearth to the access of major energy sources locally and the cheaply available foreign projects. Some of these due to physical rigors and others due to managerial limitations such as unreliable law and order state, political unpredictability and incoherence of governmental strategies.

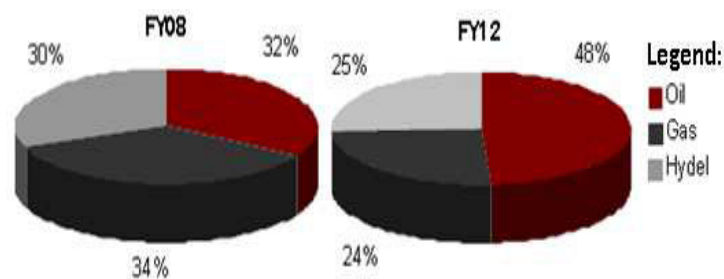


Fig. 23: Pakistan's Power Generation Mix for FY2008 & FY2012 [21]

Subsequently the energy deficiencies have magnified with major supply chain and substructure gaps, viz.;

The Energy Sector (Electrical Energy in particular) went in stagnant mode giving rise to demand-supply gap (Fig. 3) with the end result that GDP ratio for exports also remained stagnant. The Gas Sector also suffered with rise in supply-demand gap & delays in availing foreign opportunities (like IPI, TAPI, LNG etc.) with the indigenous fields not technologically ready for production.

Insufficient Energy Setup for energy providers as well as for the end consumers to facilitate both with the electricity and fuel oil for Power producing units. The net result is that amenities developed a bit but stay insufficient and overloaded. The infrastructure inefficiencies and theft reduce more than 30 percent of electricity from the system at the cost of Rs. 100 billion approx. (i.e. about 1.16 billion dollars) to the economy which is seven times more than that in an efficient system [7].

The Energy Producing Units with deficient unit running fuel either in the form of gas or oil because of payment irregularities to the oil providers. It was reported in June 2011 that 5000 MW energy shortfall caused due to non-payment of dues to IPPs [11].

Lacking Proper Education and Awareness on the part of Society gives rise to unfitting and deliberate misuse of energy in kitchens, water geezers, lighting, offices' ACs and PCs etc. Yet more are 2005 earthquake and 2010 flood contributing to the deterioration of existing infrastructure.

5. Sequential Mitigation Measures and Scope

Coal should be prime route in tackling the current energy crisis as world has also opted for the same now. Pakistan has largest contiguous coal reserves but not being attended well and timely. Pakistan's Coal Fields are shown in Fig. 24 [23]. Thar coal field is over 10,000 km² in Sindh containing 175–200 billion tons of coal reserves. It tops the oil equivalent reserves of Iran, Iraq, and Saudi Arabia worth several trillion USD. Its oil and gas equivalents are as given below [24]:

$$\begin{array}{ccccccc}
 175 \text{ Billion Ton} & = & 50 \text{ Billion TOE} & = & 2000 \text{ TCF} & , & 1\% & = & 25\% \\
 \text{Total Thar Coal Reserve} & & \text{More than Saudi Arabia} & & \text{68 times more than} & & \text{Thar Coal Reserve} & & \text{Pakistan's Power Generation} \\
 & & \text{and Iranian Oil Reserves} & & \text{Pakistan's total Gas Reserves} & & & & \text{Capacity in 2010}
 \end{array}$$

Opening progress on its own will bring in, an investment of US\$ 12 billion. Full Thar Coal Reserves are able to yield 100,000 MW of electricity for over 200 years with price and natural returns.



Fig. 24: Pakistan's Coal Fields [23]

China is interested to invest nearly 600 million \$ to deliver 180 million tonnes of coal per annum for a 405 MW power plant. ADB report May 2007 declared Thar lignite a useful fuel or carbon resource and coal to liquid a firm deployment choice [18]. GDP in

different fields of economy will clearly increase than the current. Anyhow the ecological fears are to be truly addressed coming from coal utilizing power stations. Hydel Power Generation is the cheapest way of electricity generation for an agricultural country like Pakistan, but its quota in producing electricity has dropped from about 70% in 1970s to 30% in 2008 (Fig. 5). On the other hand, it has a potential of increasing the generation to closely 60% amongst 2008 and 2018. China is working in this field e.g. construction of a 1,000 MW hydel plant on Neelum-Jhelum River, levitating Mangla Dam altitude by 30 feet to provide supplementary storage and power and building the Gomal Zam Dam (South Waziristan). The country's overall Hydel Potential is expected to be nearly 45,000 MW but the present installed value is just 6,500 MW i.e. 11 percent share in the Energy Mix (Fig. 4). It should further be increased nearly to 32,100 MW (20 percent) by 2030 (i.e. 30% contribution in total Power Generation). The plan to fulfill this target includes 8,000 MW small plants on rivers or canals, run of the river units and 17,600 MW huge hydro versatile reservoirs/dams till 2030. These versatile Dams include, (i) Bunji Dam– 5,400 MW, (ii) Bhasha Dam– 4,600 MW, (iii) Kalabagh Dam– 3,800 MW, (iv) Dasu Dam– 3,800 MW. Hydel units should be used with Hydel/Thermal Mix to outfit its low production periods.

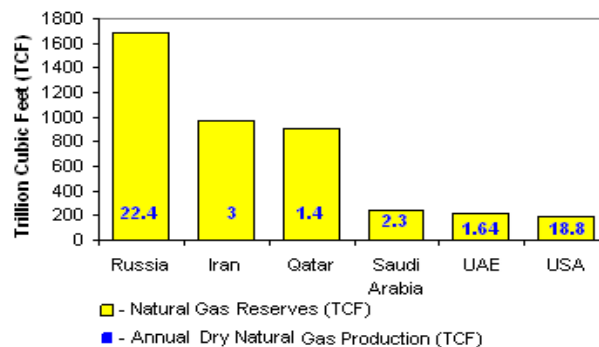
China is ready to help in constructing two 300 MW nuclear power plants at Chashma (Punjab Province) and has also decided for another three, regardless of American doubts. Nuclear Energy is also a good source for electricity generation; hence it should be promoted to rise to almost 5% in the scenario of 2030. Private sector should also be encouraged and facilitated for investment in power sector of Pakistan. The renewables are set to increase to 3% in the scenario of 2030. Policies should be clearly established to attract the investors. An area of 18,500 hectares is available in Landhi cattle colony capable of producing 15-20 MW of renewable energy for Karachi Electric Supply Company from 3,000 MT of animal dung (being disposed on daily basis to the sea). A coastline of 1000 Km in length is able to provide electricity through wave energy for at least coastal areas [11]. Sindh has an area of 9,749 KM² as a wind source of energy. This area of Sindh Coast has a potential of 43,000 MW. Whereas the available potential of electricity generation of this area is 11,000 MW [11].

Pakistan is 6th fortunate country worldwide with sun availability about 16 hours per day and 330 days a year comparing 100 days a year in Germany [11]. With these 100 days, Germany can generate 17,100 MW from sun [11]. The solar energy is ample, environment-friendly, and freely available and Pakistan has very good irradiation [11]. Fossil fuel potential of the country on June 30th, 2010 is in Table 5 below [11]:

Table 5: Matching Coal, Oil and Natural Gas [11]

	Oil (MTOE)	Natural Gas (MTOE)	Coal (MTOE)
Resource Potential	3,622	6,849	78,450
Proven recoverable reserves	130	1,067	845
Cumulative production, so far	88	568	~89
Remaining recoverable reserves	41	499	797
Annual production	3.3	29.3	1.6
Reserves to production ratio	12 years	17 years	~528 years

We have biomass potential for electricity generation as well. Cogeneration purpose has also been served by subcontinent's first biogas power plant of Shakarganj Sugar Mills [25]. A large sugar sector in the country can well be utilized to add to the solution of energy shortage. Short-term policy measures include two days off weekly, early closure of street markets and privatization of state-owned companies [11] and weekly shutdowns of CNG stations [11] etc. But privatization didn't work well for Brazil [26]. Now, medium-term policy measures include 62 MW Gulf Power Plant [27], 840 MW SK Hydro Power Project [11], and LNG import project by the Federal Government [11] etc. Also the long-term policy measures contain rely less on oil for power generation, assenting all the investors in the energy sector, setting up National Energy Authority and 800 KM Pak-Iran gas pipeline to get 4,500 MW cheap electricity.

**Fig. 25:** Top World proven Natural Gas reserves & Annual Production (2006) [28]

The Fig. 25 reveals that Iran is 2nd largest oil producer of OPEC (Organization of Petroleum Exporting Countries) with about 9% of the world's total oil reserves [11]. Country's debt has crossed the \$58 billion limit whereas experts say that Reko Diq has gold and copper reserves worth around \$260 billion dollar [11]. There is plan of upgradation of Tarbela to add 1,350 MW [11] and Mangla to add 1,000 MW [11] etc. One of the prominent issues being faced by the world currently is the optimum Energy Mix to be pre-planned technically and managerially [29].

6. Conclusions

Owing to rich reserves nature bestowed Pakistan, this country has flexibility in energy mix. Fortunately, coal the best world resource is abundant in the country and stands the first choice in solving the energy crisis. Agriculture is the backbone of Pakistan's economy, so the second best choice is Hydel resource. Thanks to nature again that Pakistan has rich gas reserves adding another very important energy resource. Yet small, medium and long-term measures include the upgradation of existing resources and incorporating solar, wind, wave and fossil fuels energies to resolve the threatening issue of energy crisis.

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