Pakistan's Hydro Potential and Energy Crisis

Tahir Mahmood [1], Hasham Khan [2], Mohammad Ahmad Choudhry [1]

[1.] Department of Electrical Engineering, University of Engineering & Technology, Taxila 47050, Pakistan
[2.] Department of Electrical Engineering, GCT, Abbottabad, Pakistan
tahir010@yahoo.com

Abstract: Pakistan has abundant water resources. Hydro-potential resources can play effective role in contributing towards energy security as well as energy independence of Pakistan. This research paper delineates hydro potential in Pakistan. At present, Pakistan is facing severe short fall of electric energy. A brief history and the present situation of the hydro-electricity production, its consumption in the country and importance of utilization of water resources for the production of electric power have been discussed. Predictions to solve energy crises are made on the basis of empirical data and preliminary observations. The root causes of the shortfall in energy generation, an estimated forecast of demand and generation of electricity for the next twenty years has also been predicted. Energy projections have been discussed in detail.
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1. Introduction

Pakistan, at present facing serious short fall of electric energy and this has evolved as crises. All kinds of industries as well as common man had been facing difficulties to alive. The reason is that no worthwhile steps have been initiated to install new hydel capacity to meet the demand. As a result, the frequent power shutdowns; "load-shedding" is a common phenomenon throughout the country. Pakistan needs a total of 14000-15000 MW of electricity per day, and the demand is likely to raise approximately 20,000 MW per day by 2020. Presently, the power producing capacity is 11500 MW per day and thus there is a shortfall of about 2500-3500MW per day. The shortage of electricity is badly affecting not only the industry but also the commerce and daily life of the people. The investment of foreign investors in the industrial sector is also poor. Therefore, drastic steps are required in-order to explore all available energy resources particularly, Hydro. To resolve the energy deficient, Government of Pakistan (GoP) considering two options; 1.) to import electric energy from neighboring countries (Iran and Central Asian Republics) and, 2.) using indigenous sources, such as, Hydel, coal, waste, wind, solar power, nuclear power, and biomass for production of energy [1]. Although, Pakistan poses greater wind potential than India, yet India has become the fourth largest installed capacity of wind power in the world [2-8]. Needless to say that if the country desires to accelerate its economic growth and need to improve the living standard of people, it has to make serious efforts towards framing a coherent energy policy for utilizing rich Hydel potential in the country. Energy crisis is the most burning issue that is facing by the whole world now a day. At present, the duration of forced load shedding in peak season is between 8 hrs to 10 hrs in urban areas while 16 hrs to 18 hours in rural areas. Lack of management and planning are the main causes of the above mentioned circumstances. Main technical causes of the shortfall of energy in Pakistan are the followings;

- Insufficient installed generation capacity,
- Transmission system unable to transmit the load imposed,
- Substantial distribution system of power supply, and
- Neglecting the Hydel potential in the country.

Apart from technical causes, the management related problems are also playing key role in the present energy crisis. Some of these causes are:

- Faulty management information system,
- Inaccurate forecast and failure of future planning,
- No expansion in the existing transmission / distribution networks and grid stations,
- Unavailability of sufficient financial resources, and
- Rapid and uncontrolled increase in the population.

In the June 2012, the country is facing about 5000 MW power supply shortage - the most severe energy crisis to ever hit in the country's history [9]. The occurrence of prolonged and frequent power outages have negative impact on industry operation, the economy and the livelihood of common citizens, in general. While the energy shortage continues to grow, abundant indigenous sustainable energy resources such as Hydel, wind, solar, biomass are yet to be utilized [10]. The government is striving to promote sustainable energy in Pakistan. Currently, approximately 60% of power generation in Pakistan is derived from fossil fuels (primarily oil and gas) followed by hydroelectricity (35%) and nuclear energy (2.84%). Table 1 shows the electric power production by different sectors in Pakistan by the year 2009. The country's maximum generation between 2001to 2008 is given in Table 2. Table 2 also shows the share of main power producer companies in the country i.e. WAPDA (water and power development authority) and KESC (Karachi electric supply company). The forecast for demand and also for the generation for year 2009 to 2030 is given in Table 3. Table 2 and Table 3 shows that Pakistan's installed generating capacity have been increased but the shortfall is still there [11].The peak demand projection of the country is shown in Figure 1.

2. Brief History

Hydro power is the most significant, cost effective and environmental friendly renewable source of electrical power. It is robust and has minimum maintenance as well as operational cost. In 20th century, the massive obstacle of rock, concrete and earth were developed across the river and stream valleys to establish huge artificial lacks for obtaining electrical energy, for irrigation and to control floods. On the other hand, the dams flooded large area of fertile land and displaced thousand of local inhabitants. The useful life of dams is reduced due to silting [12].

Waterwheel is being utilized in many parts of the world since the time of immemorial, mainly for milling grains. Continued development in the technology during the19th century combined with the need to develop smaller and higher speed devices to generate electricity result in the development of modern turbine. Most probably the first hydro turbine was designed in France in the 1820's by Benoit Fourneyron. The most prestigious period of hydel power was the early first half of 20th century. At present the concerns about the global warming has let the attention of engineers towards the renewable energy resources, Hydel is one of those [12]. A report published in the international journal of hydro power and dams indicates that the world's hydro potential is estimated to be a 14370 TWH/year out of which the economical most feasible proportion is 8080TWH/year [13].

At the time of independence in 1947, Pakistan inherited 60MW of electric power generation capability for a population of 31.5 million, yielding 4.50 kWh per capita consumption. Karachi Electricity Supply Company (KESC) was the main share holder for electric power generation, transmission and distribution to the industrial, commercial, agricultural and residential consumers of the metropolitan city of Karachi and its suburbs. Control of KESC was taken by Government of Pakistan in 1952. In 1958, Water and Power Development Authority (WAPDA) was created as semi-autonomous body for the purpose of coordinating and giving unified direction to the development of schemes for water and power sectors. In 1959, the generation capacity had increased to 119 MW and by that time the country had entered the phase of development. All of the main projects of power development were undertaken by WAPDA for executing number of Hydel and thermal generation projects. After the completion of first five years of its operation by 1964-65, the electricity generation capability rose to 636 MW from 119 MW in 1959, and power generation to about 2,500 MWh from 781 MWh. Under the supervision of WAPDA, the numbers of electrified villages in the country were 609 which were increased to 1882 villages (688,000 consumers) by the year 1965. With the increase of electric generation and the rapid progress witnessed a new life to the socio-economic structure of the country. Mechanized agriculture started, industrialization setup and general living standards improved. In the year 1970, the generating capability rose from 636 MW to 1331 MW with installation of a number of Hydel and thermal power units. By the end of the year 1980, the country generation capacity touched 3,000 MW which rapidly rose to 7,000 MW in 1990-91. Meanwhile, the electricity consumption in Pakistan has been growing at a higher rate compared to economic growth due to the increasing urbanization, industrialization and rural electrification. From 1970 to the early 1990s, the supply of electricity was unable to keep pace with demand that was growing consistently at 9-10% per annum. In the early 1990s, the peak demand exceeded supply capability by about 15-25%, necessitating load shedding (force load interruption) of about 1500-2000 MW. The main reason was the inability of the public budget to acquire the high investment of the power sector. During the 1990s, the economic growth rate of Pakistan declined to a level of 4-5% per annum from a level of 6% per annum in the 1980s. In order to overcome the power shortage in the minimum possible time, the Government established an Energy Task Force in 1993 to make consolidated and comprehensive policy for revamping the energy sector. As a result, "Policy Framework and Package of Incentives for Private Sector Power Generation Projects" was established in 1994. The main objective of this was to attract large scale private sector induction in power development. According to this policy, a number of other incentives to attract foreign investment in the power sector were given. The restructuring power policy during the fiscal year 1994 helped in overcoming load shedding in the country. However, the Policy attracted only thermal projects and no incentives were provided for the mega projects of Hydel generation. Meanwhile, in the year 2000, according to the country's new electricity market restructuring and liberalization program, the deregulation and vertical disintegration of WAPDA started. WAPDA has been divided into fourteen units: four thermal power generating companies, nine distribution companies and a transmission and distribution company. By the end of the year 2005, the Government of Pakistan privatized KESC (74.35%). Since then, KESC and WAPDA operate their own networks and are interconnected through 220 KV double circuit transmission lines. In 2008, the total electric power generation of the country, including WAPDA, KESC and Independent Power Procedures (IPPs) was 19420 MW.

3. Electric Power Generation; Present Scenario

At present, Pakistan's main resources of power generation are hydro, thermal and nuclear. Country's energy demands are met by gas around 41%, by oil 19%, and by hydro 37%. Coal and nuclear contribution to energy supply is only 0.16% and 2.84% respectively with a vast potential for growth.

3. 1 Hydro Generation

At the time of partition of the Indo-Pak Sub-Continent in 1947, Pakistan's Hydro generation capacity was only 10.7 MW (9.6 MW Malakand Power Station and 1.1 MW Renala Power Station). With the passage of time, new Hydel power projects of small and medium capacities were commissioned including the first water storage dam and power house at Warsak and country's Hydel capacity increased to about 267 MW till 1963. In the year 1967 & 1977, Mangla Dam on Jhelum River and Tarbela Dam on Indus River having the provision of power generation were commissioned respectively. However, their capacities were subsequently extended in different phases. Tarbela with maximum head of 450 feet experiences variation of 230 feet while Mangla has 162 feet variation against the maximum head of 360 feet. The lean flow period of Tarbela reservoir is from November to June when the Capability reduced to as low as about 1350 W against the maximum of 3692 MW during high head period i.e. August to September (15% permissible overloading of Units 1~10). Lean flow period of Mangla reservoir was observed from October to March when the minimum generating capability was 500 MW. The capability rises to as high as 1150 MW during high head period (15% permissible overloading).

WAPDA's Hydel generating capacity varies between the two extremities of 2414 MW and 6746 MW over the cycle of a year. WAPDA is carrying out feasibility studies and engineering designs for different hydropower projects with accumulative generation capacity of more than 25000 MW. Most of these studies are at an advance stage of completion. After the completion of these projects the installed capacity would rise to around 42000 MW by the end of the year 2020. Pakistan has been blessed with ample water resources but could store only 13% of the annual flow of its rivers. The statistics warrant construction of number of reservoirs to enhance availability of water which stands at,070 cubic meters per capita. The hydropower potential in Pakistan is over 100,000 MW with identified sites of 55,000 MW. At the moment, feasibility studies under way include Diamer Basha (4500 MW), Bunji (5400 MW) and Kohala (1100 MW) amongst many others. As mentioned earlier, hydro is the only sustainable energy resource which Pakistan can effectively employed for large-scale power generation. Currently, Pakistan has an installed hydropower capacity of approximately 6.6 GW. This is only 16% of the total hydropower potential of Pakistan, estimated to be about 41.5 GW [10].

4. Electric Power Generation; Present Scenario

Pakistan is a mountainous country having Karakorum series (world 2nd highest mountain K-2) and is situated between Afghanistan, China, Iran and India. Pakistan has a number of water resources, having 25 rivers namely Sutlej, Ravi, Chenab, Jhelum, Indus(largest river), Kunhar, Swat, Kabul, Kohat, Kurram, Tochi, Chitral, Panjkoora, Gabral, Poonch, Gilgit, Naltar, Hunza, Ishkuman and Ghizar, Khunjarab, Kilik, Yasin and River Neelum. All these rivers pass through hilly areas, providing continuous flow of water and have proper head. There is wonderful hydropower potential in these rural areas.

Table 1 Total capacity of electric power generation of Pakistan by the year2009

Public Sector			Private Sector		
Institutions	Generation (MW)	Percent (%)	Institutions	Generation(MW)	Percent (%)
WAPDA	6444	32.742	IPP,S	6185	31.426
GENCO,S	4834	24.562	KESC	1756	08.923
NPP	462	02.347	_	_	_
Sub Total (MW)	11740	59.651	Sub Total (MW)	7941	40.349
Grant Total (MW)			19681		

Table 2 Country's Maximum Generation from 2001-2008

Year	WAPDA (MW)	KESC (MW)	Country(MW)
2001-2002	10109	1885	11875
2002-2003	10481	1973	12330
2003-2004	11078	2073	13012
2004-2005	12035	2197	14091
2005-2006	13212	2223	15282
2006-2007	15138	2349	17314
2007-2008	16484	2673	18983

Table 3 Forecast of Electric Power Demand and Generation during 2009-2030

Years		2009	2010	2015	2016	2020	2025	2030
Dependable capability	MW	17008	19477	33028	36560	52909	76200	106565
	Growth rate	9%	15%	9%	11%	10%	8%	8%
Peak demand	MW	20594	24474	36217	40555	54359	80566	113695
	Growth rate	7%	9%	8%	8%	9%	8%	7%
Surplus/Deficit		-3586	-2876	324	1147	4066	4031	5087

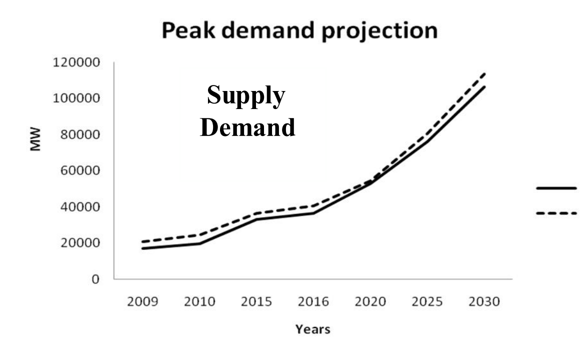

Fig. 1 Peak Demand Projection (2009-2030)

Pakistan is blessed with wonderful Hydel potential of higher than 40,000 MW. But, only 15% of this huge potential has been utilized. If the remaining potential is properly exploited it can meet our country growing demand for electricity in a cost-effective way. Table 4 shows the total installed capacity of hydro power along with the names of different projects. Pakistan has a Hydel potential of approximately 41722 MW, lies in the regions of Khyber Pakhtunkhwa, Gilget Baltistan, Azad Jammu and Kashmir and Punjab.

Pakistan hydro potential can be divided into six regions as follows;

- Khyber Pakhtunkhwa
- Punjab
- Azad Jammu & Kashmir
- Gilget Baltistan
- Sindh
- Baluchistan

Table 5 illustrates a review of the hydro projects in different regions of Pakistan, in different stages and also right most columns tells the total Hydro Potential in Pakistan.

4. 1 Hydro Potential in Punjab

Punjab is one of the four Pakistan's province having five rivers namely, Sutluj, Ravi, Chenab, Jhelum and Indus. The first four join the mighty Indus at Mithan Kot which finally ends into the Arabian Sea. Punjab has the distinction of having the slope of gravity flow not only in Pakistan, but also in the world. Its irrigation system contributes 25 % of Pakistan's GDP and also engages 54 % of its labour force. After the Indus Water Treaty in 1960, large inter-basin link canals and storages were constructed. In this province the total in operation projects are listed in Table 6. there are only seven projects are runing, out wich four are small hydro projects. Only 1698MW is produced in this province, where 4100MW is untouch, which can also be produced by installing power stations at identified locations as listed in Table 7.

4. 2 Hydro Potential in Khyber Pakhtunkhwa

Khyber Pakhtunkhwa (KPK) is the heighest Hydel Potential province of Pakistan, which is surrounded by Afghnistan in the west, Gilget Baltistan in the north, the Azad State of Jammu & Kashmir in the northeast, Pakistan's Punjab province in the east and Balochistan in the South. KPK has five (5) Divisions, thirteen (13) Districts and six (6) Tribal Agencies. The River Indus separates it from the Punjab. The major rivers of KPK are the Kabul, Indus, Kunhar, Swat, Kohat, Kurram, Tochi, Chitral, Gabral and Panjkoora.

The Swat River is one of the oldest rivers mentioned in the chronicles of the Indo-Pakistan subcontinent is a very precious asset of KPK. It is a snow-fed stream, with a catchment area of 13,491 square kilometers. The Upper Swat Canal System was completed in 1918. It emanates from River Swat at Amandara Head Works and irrigates 121,400 hectares of land of the Peshawar valley. A 6 km long canal carries water from Amandara to the foot of Malakand hills where the 3.5 km long Benton Tunnel pierces the Malakand hills and passes water into the Dargai Nullah. Two cascade type power plants, Jabban and Dargai, each of 20 MW capacity, were set up in 1937 and 1953 respectively, and are located between the outlet portal of Benton Tunnel and the trifurcator at Dargai.

4. 3 Hydro Potential in Azad State of Jammu & Kashmir

Azad State of Jammu & Kashmir (AJK), due to its topography has been gifted with rich Hydel potential. AJK's major three river are named as Neelum River, Jhelum River and Poonch River. This province has a huge potential of raw sites of large and small Hydel power are identified in this region are listed in Table 10 and Table11 respectively.

4. 4 Hydro Potential in Sindh

Sindh is bounded in the north by the Punjab, in the east by the Indian Province of Rajsthan, in the south by the Runn of Kutch and the Arabian Sea, and in the West by Lasbela and Kalat districts of the province of Balochistan. In terms of population, it is the second largest province of the country. The lower Indus basin forms the province of Sindh and lies between 23 to 35 Degree and 28-30, north latitude and 66-42 and 71-1-degree east longitude. It is about 579 km in length from north to south and nearly 442 km in its extreme breadth (281 km average). It covers approximately 140,915 square km. It is basically an agrarian province. The Indus is by far the most important river of the Sindh. Within the last 45 years, three irrigation barrages have been constructed across the Indus. The command areas of the three barrages are: Sukkur Barrage 3.12 million hectares, Kotri Barrage 1.12 million hectares, and Guddu Barrage 1.172 million hectares. The Irrigation & Power Department, Government of Sindh is responsible for conducting hydropower activities in the Province, and for facilitating and liasing with the respective agencies.

4. 5 Hydro Potential in Gilget Baltistan

Gilget Baltistan is the 2nd heigest Hydro Potential provinces of Pakistan. There so many sites are identified in Gilget Baktistan, but not develop reason for it is absence of large transmission line. These areas are not connected to grid. In this region different hydel power stations are constructed and also built 11 kV transmission lines for consumers. Now electricity is provided to more than 50 % of the local population. Raw sites identified in GB are listed in Table 12.

4. 6 Hydro Potential in Baluchistan

Balochistan is handsomely gifted with natural(minral) resources and this province contain huge reservior of gas,oil,coal mining, gold and iron. Pakistan's biggest reservoir of gas is situated at Sui in this province. In 1952, it was largest reservior in Asia. This province have a number of irrigation control and water supply projects. But unluckley a proper head is not available,therefore electricity is not be to produced from its cannals. The total 0.50 MW potential is identified in the province. There are several proposed dams in Balochistan, such as Talli Tangi Dam, the Mirani Dam, Naulung Dam, Magi Dam, and Hingol Multipurpose Dam, none of them is feasible for making electricity as a by-product excluding Hingol Dam and the Mirani Dam Multipurpose Project. The purpose of Mirani Dam is to give water for irrigation but it can produce about 0.2 MW. The Hingol Dam site is situated close to Aghor on the Hingol River; it can also produce about 0.2 MW.

Table: 4 Total installed capacity of the hydropower

S. No.	Name of Project	Category	Capacity (MW)
1	Tarbela	Large Hydro Power	3478
2	Ghazi Barotha	Large Hydro Power	1450
3	Mangla	Large Hydro Power	1000
4	Warsak	Large Hydro Power	240
5	Chashma	Large Hydro Power	184
6	Malakand	Medium Hydro Power	19.6
7	Dargai	Medium Hydro Power	20
8	Rasul	Medium Hydro Power	22
9	Shadiwal	Medium Hydro Power	13.5
10	Chichoki Malian	Medium Hydro Power	13.2
11	Nandipur	Medium Hydro Power	13.8
12	Kurram Gari	Small Hydro Power	4
13	Reshun	Small Hydro Power	2.8
14	Renala	Small Hydro Power	1.1
15	Chitral	Small Hydro Power	1

16	Jagran-I	Medium Hydro Power	30.4
17	Kathai	Small Hydro Power	1.6
18	Kundel Shahi	Small Hydro Power	2
19	Leepa	Small Hydro Power	1.6
20	GB	Large Hydro Power	94
	Total		6595.032

Table 5 Total Hydel Potential in Pakistan:

S.No.	Province Name	Projects underway (MW)	Implementation stage Project(Public Sector) (MW)		Private Sector Projects (MW)	Untouched Hydel Potential (MW)	Total Hydel Potential (MW)
1	KPK	3767.2	81	554	84	14211.9	18698.1
2	Punjab	1698		96		4101.82	5895.82
3	AJK	1036.1	4.8	969	828.7	1797.2	4635.8
4	Gilget Baltistan	93.732	18			12295.5	12313.5
5	Sindh					178.05	178.05
6	Baluchistan					0.5	0.5
Total Cap. (MW)		6595.032	103.8	1619	912.7	32584.97	41721.77

Table 6 Projects in operation in Punjab

S. No	Name of Project	Category	Capacity (MW)
1	Ghazi Barotha	District Attock	1450
2	Chashma	Chashma	184
3	Rasul	District Mandi Bahuddin	22
4	Shadiwal	Gujrat	13.5
5	Chichoki Malian	Upper Chenab Canal	13.2
6	Nandipur	Gujranwala	13.8
7	Renala	District Okara	1
	TOTAL		1698

Table 7 Identified raw sites in Punjab

S.No	Name of Project	Capacity (MW)
1	Panjnad Barrage	19.5
2	Marala Barrage Hydropower Project	18.9
3	Trimmu Barrage Hydropower Project	18.4
4	Qadirabad Barrage Hydropower Project	17.7
5	Chashma Jhulem Link Canal RD	13.9565
6	Chashma Jhelum Link Canal RD	13.8565
7	Upper Chenab Canal Lower RD	10.5249
8	Khanki Barrage Hydropower Project	8.5
9	T.P.Link Canal RD	8.1579
10	Islam Barrage Hydropower Project	6.7
11	Panjnad Canal Hydropower Project	6.209
12	T.P. Link Canal Rd	6.1579
13	Upper Chenab Canal Lower RD	5.9574
14	Lower Caanab Canal RD	4.9538
15	Upper Chenab Canal RD	4.7899
16	Sidhnai Barrage Hydropower Project	4.7
17	Sulemanki Barrage Hydropower Project	4.7
18	Upper Chenab Canal Lower RD	4.6799
19	Abbasia Canal Road	4.6717
20	Upper Chenab Canal Lower RD	4.6714
21	Sidhnai Mailsi Bahawal Link RD	4.4793
22	Pakpattan Canal RD	4.3471

23	T.P. Link Canal RD	4.2353
24	Q.B. Link Canal RD	4.1075
25	Balloki Barrage Hydropower Project	4.1
26	T.P. Link Canal RD	4.0402
27	T.P.Link Canal RD	4.0402
28	T.P.Link Canal RD	3.7894
29	T.P. Link Canal RD	3.7894
30	Q.B. Link Canal RD	3.6025
31	Lower Bari Doab Canal RD	3.5112
32	Upper Chenab Canal Lower RD	3.4651
33	Trimmu-Sidhnai Link Canal RD	3.2221
34	B.S. Link Main Line RD	3.1788
35	Lower Bari Doab Canal RD	3.1493
36	Mailsi Canal RD 0+000 Hydropower Project	3.1433
37	B.R.B.D. Link Canal RD	3.1414
38	Lower Bari Doab Canal RD	2.784
39	Lower Bari Doab Canal RD	2.63
41	Rasul Qadirabad Link	2.602
42	Upper Jhelum Canal RD	2.5
43	Upper Jhelum Canal RD	2.43
44	Lower Chenab Canal Feeder RD	2.1432
45	Q.B. Link Canal RD	2.1432
46	Upper Jhelum Canal RD	2.1259
47	Rasul Qadirabad Link RD t	2.1176
48	Q.B. Link Canal RD	2.1162
49	Lower Bari Doab Canal RD	2.0823
50	Panjnad Canal RD	1.9821
51	B.R.B.D. Link Canal RD	1.9812
52	Lower Chenab Canal RD	1.9399
53	Upper Jhelum Canal RD	1.845
54	Upper Chenab Canal Lower RD	1.7612

Table 8 In operation Projects in KPK

S.No.	Project	Site Location	Capacity(MW)
1	Tarbela	Tarbela (Reservoir)	3478
2	Warsak	Warsak (Reservoir)	240
3	Dargai Power Station	Swat River	20
4	Kurram Garhi	Kurram Garhi (canal)	4
5	Malakand Power Station	Swat River	20
6	Reshun	Chitral	2.8
7	Shishi	Lower Chitral	0.3
8	Garam Chashma	Chitral	0.1
9	Kalam	Swat	0.2
10	Ashuran	Swat	0.4
11	Karora	Shangla	0.2
12	Damori	Shangla	0.1
13	Thall	Dir	0.4
14	Kaghan	Mansehra	0.2
15	Duber	Kohistan	0.15
16	Keyal	Kohistan	0.2
17	Jalko	Kohistan	0.15
18		Total	3767.2

Table 9 Identified raw sites in KPK

S. No	Project Name	Location	Capacity (MW)
1	DongaiGah	Spat-Indus River	32.00
2	Tirich Gol, Alt 3A	Upper Chitral	29.70
3	Machi Branch	Mardan	28.00
4	Arkari Gol (Alt 2)	Lower Chitral	26.40
5	Tirich Gol, Alt 1 A	Upper Chitral	25.70
6	Arkari Gol (Alt 1)	Lower Chitral	24.00
7	Tirich Gol, Alt 2 A	Upper Chitral	22.60
8	Damtour	Dor/hazara	15.00
9	Bimbal	Mansehra	14.00
10	Serai, Karora	Indus Swat / Mansehra West	13.50
11	Y.I.A Golen	Lower Chitral	11.30
12	Chokel Khwar	Swat River near Bahrain	10.50
13	Barum Gol	Upper Chitral	10.00
14	Turkho River, Alt 2	Upper Chitral	9.90
15	Turkho River, Alt 1	Upper Chitral	9.40
16	Baral Darra	Swat Valley (Garni)	9.00
17	Mastuj River 2	Upper Chitral	8.90
18	Bhimbal	Dist. Mansehra	8.10
19	Jabori	Dist. Mansehra	8.00
20	Karora	Basham	8.00
21	Rish Gol, Alt 2	Upper Chitral	7.70
22	Karora New	Indus Swat / Mansehra West	7.50
23	Kedam Khwar	Kedam Khwar-Swat	7.00
24	Lutkho River	Lower Chitral	6.40
25	Rish Gol, Alt 1	Upper Chitral	6.20
26	Ushiri	Ushiri River Dir	6.00
27	Balkanai	Indus Swat / Mansehra West	5.30
28	Gande Gar	Dir Distt. (Ushri Khwar)	5.20
29	Ayun	Lower Chitral	5.06
30	Garbral River	Swat Valley (Kalam)	4.75
31	Khghan (Alt 1)	Kaghan Valley	4.10
32	Dadar	Siran/ Hazara	4.00
38	Jashil Gah, G1	Indus Kohistan	2.77
39	Ritch Gol	Upper Chitral	2.75
40	Khelian Khwar	Indus Kohistan	2.60
41	Chaudwan	Chaudwan/DI Khan	2.50
42	Swat River	Swat Valley (Asrit)	2.40
43	Kaghozi Gol (Alt 2)	Lower Chitral	2.27
44	Bhimbal	Kaghan Valley	2.25
45	Kaghozi Gol (Alt 1)	Lower Chitral	1.98
46	Kao Gol, Alt 1	Upper Chitral	1.90
47	Bumburet	Lower Chitral	1.80
48	Biar	Dir Distt (Panjkora River)	1.72
49	Ushiri (Alt 1)	Dir Distt (Ushiri Khwar)	1.65
50	Murdan	Lower Chitral	1.60
51	Bangroan Khwar, Barigo Alt 2	Indus Kohistan	1.48
52	Jashil Gah, Badakk	Indus Kohistan	1.39
53	Thal	Dir Distt (Kumnrat Sin)	1.35
54	Kaghan (Alt 2)	Kaghan Valley	1.28
55	Soyal Khwar (Alt 2)	Indus Kohistan	1.14
56	Patrak	Dir Distt (Ghaldai sin)	1.09
57	Chitral	Chitral	1.00
58	Chakosh Gol, Alt 1	Upper Chitral	0.93

59	Harban Gah, Harban	Indus Kohistan	0.90
60	Ushiri (Alt 2)	Dir Distt (Uushri Khwar)	0.90
61	Chokel Khwawar	Swat Valley (Ghundoputai)	0.89
62	Rehmat Shah Sind	Swat Valley (Garral)	0.86
63	Lower Thal	Dir Distt (Ghaldai sin)	0.80
64	Anakar gol	Swat Valley (Anaker)	0.76
65	Dongai Gah, Jalkot Nallah	Indus Kohistan	0.76
66	Kapar Banda Gah	Indus Kohistan	0.74
67	Seo Khwar	Indus Kohistan	0.71
68	Sheringal	Dir Distt. (Dok Darra Khwar)	0.71
69	Soyal Khwar (Alt 1)	Indus Kohistan	0.66
70	Kumrat	Dir Distt. (Kumrat Sin)	0.59
71	Birzin	Lower Chitral	0.50
72	Dir Alt No.1	Dir Distt. (Dir Khwar)	0.45
73	Dardabahm Gol, Alt 3	Upper Chitral	0.40
74	Baraul Bandai	Dir Distt. (Shingara Khwar)	0.24
75	Kolandai	Dir Distt. (Dir Khwar)	0.24
76	Sundraul	Dir Distt. (Landai Khwar)	0.21
77	Dir Alt. No.2	Dir Distt. (Dir Khwar)	0.12
78	Booni	Chitral	0.02
	Total		426.41

Table 10 Identified raw sites in AJK

Sr.No	Identified Project	Category	Capacity (MW)
1	Mahl	Bagh	245.00
2	Karot	Kotli	240.00
3	Azad Patan	Poonch	222.00
4	Chakothi-Seri	Muzaffarabad	139.00
5	Kotli	Kotli	97.00
6	Jagran-III	Muzaffarabad	90.00
7	Serha	Kotli	65.00
8	Hari-Ghal	Bagh	54.00
	TOTAL		1152.00

Table 11 Small Hydel raw sites identified in AJK

Sr.No	Name of Project	Category	Capacity (MW)
1	Doarian	Muzaffarabad	14.1
2	Naghdar	Muzaffarabad	11.2
3	Taobat	Muzaffarabad	5
4	Jana Wai	Muzaffarabad	5
5	Jing	Muzaffarabad	3.7
6	Dakhari	Kotli	3.2
7	Chamm Fall	Muzaffarabad	3.2
8	Hotreri	Muzaffarabad	2.5
9	Hajira	Poonch	2.4
10	Sharda	Muzaffarabad	2
11	Samani	Mirpur	1.6
12	Riali-I	Muzaffarabad	1.6
13	Dghanwan	Kotli	1.5
14	Sarhota	Kotli	1
15	Rerah	Kotli	1
16	Patni	Bhimber	0.20

Table 12. Small Hydel raw sites identified in GB

S.No.	Project Name	Location	Capacity (MW)
1	Darel Phase-IV	Chilas	1.8
2	Tangir Phase-III	Chilas	3.7
3	Darel Phase-III	Chilas	1.5
4	Chilas Phase-III	Chilas	0.7
5	Darel Phase-IV	Chilas	1.1
6	Chilas Phase-IV	Chilas	0.6
7	Tangir Phase-IV	Chilas	12.2
8	Doyian	Astore	362.3
9	Parishing Phase-III	Astore	5.5
10	Parishing Phase-IV	Astore	3.1
11	Dichil	Astore	4.1
12	Bulashbar	Astore	0.5
13	Chhichi	Astore	1.1
14	Bubind Phase-II	Astore	1.1
15	Dango Das	Astore	0.5
16	Harchu	Astore	0.4
17	Aspai Alt-II	Astore	0.6
18	Aspai Alt-I	Astore	0.33
19	Rama Phase-II	Astore	0.26
20	Gurikot	Astore	0.14
21	Rattu Phase-II	Astore	0.15
22	Gozer/ Gulo	Astore	0.12
23	Amni	Astore	0.14
24	Jaglot Alt-I	Gilgit	3.9
25	Naltar Phase-III	Gilgit	5.4
26	Sai Phase-I	Gilgit	10.5
27	Naltar Phase-V	Gilgit	17.3
28	Nomal	Gilgit	2.6
29	Kar Gah Phase-X	Gilgit	1.4
30	Naltar Phase-IV	Gilgit	2.2
31	Kar Gah Phase-VIII	Gilgit	1.4
32	Sher Qila Phase-II	Gilgit	1.02
33	Singal Phase-II	Gilgit	1.4
34	Damot	Gilgit	0.7
35	Kar Gah Phase-XI	Gilgit	3.9
36	Sai Phase-II	Gilgit	0.97
37	Hamuchal HPP	Gilgit	14
38	Kar Gah Phase-IX	Gilgit	1.7
39	Henzal HPP	Gilgit	15
40	Naltar Phase-II	Gilgit	0.75
41	Daintar	Hunza	4.2
42	Boldas Phase-II	Hunza	2.9
43	Hassanabad Phase-VI	Hunza	1.8
44	Hispar Phase-II	Hunza	2.6
45	Altit HPP	Hunza	36
46	Chalt Phase-III	Hunza	0.51
47	Nasirabad HPP	Hunza	15.3
48	Hassanabad Phase-VII	Hunza	0.4
49	Sumayar Phase-II	Hunza	0.38
50	Minapin Phase-III	Hunza	0.23
51	Baru	Ishkuman	7.6
52	Ishkuman	Ishkuman	1.8
53	Asambar	Ishkuman	1.3
54	Chhantir	Ishkuman	9.6
55	Gulmiti	Ishkuman	1.6

5. Discussion and Conclusion

Present acute shortage of electric energy affected badly not only the industry but also the commerce and daily life of the people. Hence, drastic steps are required to utilize all available sources, especially the Hydel potential, within the country. If the government of Pakistan desires to accelerate its economic growth and wants to improve the living standard of its people, then it has to make serious efforts towards framing a coherent energy policy for effective utilization of Hydel potential. Energy crisis is the most burning issue that is facing by the whole world now-a-days. Generation of sufficient electricity is the one of the basic requirement of industrial development and economic growth of any country. Currently, about 60% of power generation in Pakistan is derived from fossil fuels, primarily using oil and gas, followed by a small percentage of hydel that is 37%, coal and nuclear contribution limited to 0.16% and 2.84% respectively. Hydro is the only sustainable energy resource which Pakistan must employ for large-scale power generation.

As described in section 4, Pakistan has a huge hydel potential to produce electric power. Also this hydel potential in not concentrated in only in one part of the country but spread over all provinces and territories. If dams are constructed at feasible location then almost 6444 MW of hydel power can be generated which can easily meets the electrical energy demand of Pakistan for next 20-25 years. Already installed capacity of hydropower in Pakistan is only 6.6 GW which is 16% of the total hydropower potential in Pakistan estimated to be about 41.5 GW. Other reasons for this energy crises involved insufficient installed generating capacity, old and deteriorated transmission and distribution system are the technical causes of the shortfall of energy in Pakistan. Faulty management information system, inaccurate forecast and failure of future planning, rapid and uncontrolled increase in the population are the management related causes of the energy shortage in the country. The government must take serious steps to handle this situation, especially by exploring and exploiting the immense sources of rich Hydel potential, available throughout the country.

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Corresponding Author:
Dr. Tahir Mahmood
Department of Electrical Enginering
University of Engineering & Technology, Taxila 47050, Pakistan
E-mail: tahir010@yahoo.com

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