M. H. Masud Butt

FUTUROLOGY OF HYDRO-ELECTRIC POTENTIAL IN PAKISTAN

Pakistan is deficient in fossil fuels like oil, gas and coal. There are no significant resources on which long range power generation could be planned. Today oil resources of Pakistan are extremely limited. Natural gas fields so far discovered and later exploited as an alternate use in Industry may not last longer provided further exploitation continues at a fast pace. The total recoverable reserves at Sui, Mari, Khand Kot, Mazarani Sari, Hundi, Uch, Khairpur, Zin, Dhulian, Mayal, Dhodak and Pirkoh are 502.34 Billion Cubic Meters. The recent oil crisis has led to a policy decision to restrict the use of gas for electric power generation but it may not provide the final answer to long term Electric Power Developments in Pakistan as natural gas has multifarious uses of its consumption.

2. Coal found in Pakistan is of very inferior quality as its calorific value is low and contains high percentage of volatile matter such as ash and sulphur. It is found in these seams at deep inclines with the result that cost of mining operations is high. The current indicated reserves of coal in the Country are located in Sor Range, Deghari, Mach, Shariagh, Makerwal, Salt Range, Jim Pir and Lakhra. Similar use of coal can be put to small scale power generation with the exception of Lakhra coal situated about 30 miles from Hyderabad, The current indicated reserves of coal in the Country are placed at 422 million tonnes, of which 50 per cent is concentrated in an area of 155 Square Kilometers at Lakhra in Dadu District of Sind.

Existing Hydel Generation

3. Practically the entire hydro-electric potential of Pakistan is dependent upon to River Indus and its tributaries. Today Hydel power generation is the backbone of WAPDA's power system. All the Hydro-Electric Power Stations are situated in the North and fall in the sphere of WAPDA's Grid System. In 1947 the total installed capacity of hydel power stations was 10.7 MW which was 6.67 MW

in 1959 and increased to 1567.2 MW in June, 1978 and to 2,724 MW at the end of March 1979 while the share of Hydel and Thermal units is 1,567.2 MW and 1,156.8 MW respectively. The Hydel power stations serving the National Grid are:

	Name of Power Station	Year of commissioning	No. of units	Generating Capacity
1.	Renala	1925	5×0.22 MW	1.1 MW
2.	Malakand	1938	3×3.2+2×5 MW	19.6 MW
3.	Rasul	1952	2×11 MW	22 MW
4.	Dargai	1954	4×5 MW	20 MW
5.	Kurram Garhi	1957-58	4×1 MW	4 MW
6.	Chichoki Mallian	1959-60	3×4.6 MW	13.2 MW
7.	Warsak	1960	4×40 MW	160 MW
8.	Shadiwal	1961	2×6.75 MW	13.5 MW
9.	Nandipur	1963	3×4.6 MW	13.8 MW
10.	Mangla	1966-74	6×100 MW	600 MW
11.	Tarbela	1977	4×175 MW	700 MW
			Total	1,567.2 MW

4. The Power Generation Statistics for each of the existing Hydro-Electric Power Stations is as follows:

	Power Station	Generation in Million KWH	
		1976-77	1977-78
1.	Renala	6.038	6.774
2.	Malakand	103.611	92.634
3.	Rasul	41.039	49.634
4.	Dargai	97.071	111.068
5.	Kurram Garhi	17.578	21.904
6.	Chichoki Mallian	44.119	53.383
7.	Warsak	405.596	434.890
8.	Shadiwal	57.104	58.396
9.	Nandipur	55.620	65 610
10.	Mangla	4,216.200	3,204.690
11.	Tarbela	138.020	3,367.400
	Total	5,182.397	7,466.383

Hydro-Electric Power Development Schemes

5. The growing demand of electricity for industrial, agricultural, domestic and other socio-economic uplift programmes, WAPDA has planned additional generating plants during the coming years. Some of the Hydro-Electric Power Projects are in hand and others are under different stages of implementation. The work on the installation of Warsak Units 5 on 6 of MW, Mangla units 7 and 8 of 100 MW and Tarbela Units 5 to 8 of 175 MW each is in progress and are planned to be commissioned as follows:

1. Mangla Unit —7....100 MW.....1980.
2. Mangla Unit —8....100 MW.....1980.
3. Warsak Unit —5.... 40 MW.....1980.
4. Warsak Unit —6.... 40 MW.....1980.
5. Tarbela Unit —5....175 MW Dec., 1981.
6. Tarbela Unit —6....175 MW March, 1982.
7. Tarbela Unit —7....175 MW June, 1982.
8. Tarbela Unit —8....175 MW Sep., 1982.

First Maiden Survey of Hydel Potential

6. Since the inception of Pakistan, the *first Maiden Survey* of Hydel Potential was made by the Power Commission in 1963. The desk studies made at that time estimated the resources of hydel potential of the order of 25,274 MW or 25.274 million MW. No proper survey was ever made but the Planning Commission in the Second Five Year Plan estimated the total exploitable Hydel Potential as 10 million KW. The available known Hydel Potential on different rivers is as follows:

I. Indus River—On the main Indus River the desk studies ascertained the Hydro-Electric Potential as 21,850 MW and is detailed below:

Skardu	1,860 MW
Bunji	8,300 MW
Chilias	2,300 MW
Jalkot	1,850 MW
Rasham Qila	1,850 MW
Kot Kai	1,250 MW
Tarbela	2,600 MW
Kalabagh	1,850 MW
Total	21,850 MW

II. Swat river—The reconnaissance survey of the Upper Swat and Lower Swat resources revealed that 295 MW and 670 MW of Hydro-Electric Potential is available in this region thus totalling the estimate as 965 MW. Identification of these theoretical estimates are as follows:

(*i*) UPPER SWAT

Kalam	79 MW
Chodgram	72 MW
Madi Jan	72 MW
Chakdara	72 MW
Sub-total	295 MW

(*ii*) LOWER SWAT

Kalamgai	315 MW
Tauta, Kabar	109 MW
Dabr	126 MW
Mara Dab	109 MW
Munda Qila	11 MW
Sub-total	670 MW

(*iii*) PANJKHORA RIVER

Chutian-underground tunnel 162 MW.

(*iv*) CHITRAL RIVER

Singer	18 MW
Chitral	20 MW
Toren	37 MW
Kunbat	56 MW
Cahriat	45 MW
Kesu	33 MW
Drosh	37 MW
Mirhani	75 MW
Sub-total	324 MW

(*v*) KABUL RIVER

Work	240 MW
Sub-total	240 MW

(*vi*) KARRUM RIVER

Kurram Tangi	83 MW
Kurram Garhi	4 MW
Sub-total	87 MW

(*vii*) GOMAL RIVER

Khajuri Katch	73 MW
Nali Katch	16 MW
Mirtaza	21 MW
Sub-total	110 MW

(*x*) SOAN RIVER

Bora Hotar	4 MW
Sambli	3 MW
Charah	9 MW
Dhok Pathan	93 MW
Sub-total	100 MW

(*viii*) JHELUM RIVER

Mangla	900 MW
Sub-total	900 MW

(*ix*) KUNHAR RIVER

Suki Kinari	198 MW
Naran	207 MW
Naran (Other site)	95 MW
Sub-total	500 MW

(*xi*) CHANAB RIVER

Chichoki (U. C. Canal)	13.4 MW
Gujranwala (U. C. Canal)	13.5 MW
Sub-total	27.0 MW

7. There are three main factors which are important while considering the Hydro-Electric Potential of Pakistan. They are:

(*i*) High seasonal variations of the flow.

(*ii*) The use of Water from the reservoirs for irrigation has absolute priority over the use of power.

(*iii*) High siltation rate in the reservoirs.

8. The high seasonal variations of the flow and the use of water from the reservoirs for irrigation has absolute priority over the use of Power which reflects on the installed capacity and firm capacity of Hydro-Electric Power Stations but the siltation rate limits the life of the existing or planned reservoirs. For instance the mean year load of sediment on the Indus at Tarbela is about 440 million tons which is equivalent to about 0. $\times$ 109 Cubic meters compact value. It means that the large Tarbela reservoir will lose 90 per cent of its capacity in 50 years. Mangla reservoir will also lose 30 per cent of its capacity in about 50 years.

Estimates made by Different Agencies

9. The World Bank Study Group headed by Dr. Pieter Lieftnick carried out studies and published it in three volumes. In the Sector Planning Report of 1967, it has been indicated that Hydro-Electric Potential is 10 million KWH. Keeping in view the desk studies made by the Power Commission in 1963, this estimate is rather too conservative as there are number of sites which could not find their way in this Survey.

10. The World Bank Study Group assumed an average plant factor of 60% and an average heat rate of 12,000 BTU per KWHs. Thus the estimated 10 million KW or 10,000 MW of Hydro-Electric

Potential would be equivalent to about 52,000 million KWHrs, or 600 trillion BUTs. This Hydro-Electric Potential of 10 million KW or 10,000 MW if converted into equivaledt tons of coal, it would be 32 million tons, of coal per year or 13.5 million tons of oil. In spite of all this, the Hydro-Electric Potential so far exploited is 1567.2 MW. It means that only 15.6% of the Hydro-Electric Potential as estimated by the World Bank Group has been exploited and still there is ample room for exploitable hydel potential.

11. Sufficient desk studies had been made by WAPDA, Planning Commission, defunct Central Engineering Authority, Chief Engineering Adviser's Office, Pakistan Atomic Energy Commission, M/s Harza Engineering Co., META International, CIDA-EHV Consultants, World Bank Study Group and other agencies but no serious effort was ever made to identify the exploitable Hydro-Electric Potential. Today, most of the new promising sites are known but all these sites call for scientific, planned and detailed studies in order to estimate the rational hydel potential in the country. Further power generation banks upon the futurology of Hydel Potential.

Some Promising Hydel Potential Sites

12. Serious effort to identify some sites of Hydro-Electric Potential may provide a guide line to the future exploitations. The futurology of Hydel-Potential reserves around the following promising sites along the rivers are indicated below :—

(i) INDUS RIVER
1. Bunji
2. Chilas
3. Kalabagh

(ii) JHELUM RIVER
1. Raised Mangla
2. Kohala
3. Jhelum Neelam combination.

(iii) KANHAR RIVER
1. Kunhar

(iv) SWAT RIVER

(*A*) *Upper Swat*
1. Kalam

(*B*) *Lower Swat*
1. Munda
2. Kulangi
3. Khazana
4. Abbhar
5. Bazargai

(v) CANAL PLANTS
1. Chashma Jhelum link.
2. Warsak Re-regulation
3. Dhok Pathan
4. Dhok Abakai.

Hundreds of Small Hydro-Electric Sites

13. No doubt, Pakistan has abundant Hydel Potential for exploitation which can share its future needs. There are a large number of small Hydro-Electric potentials which can be identified. Ministry of Water and Power had already identified one hundred Small Hydro-Electric Potentials in the Northern Areas, NWFP and Azad Kashmir. Due to the bad management, lack of administrative powers and paucity of incentives, hardly ten sites are being exploited where Generating sets of 50 KW or 100 KW would be installed. Some such sites are detailed below :—

1. NORTHERN AREAS

Station	*No. and Size of Units*
(*i*) Minapin	1 × 100 KW
(*ii*) Singal	2 × 50 KW
(*iii*) Kachura	1 × 100 KW
(*iv*) Sirmik	1 × 100 KW

2. N.W.F.P.

(*i*) Karora	2 × 100 KW
(*ii*) Garam Chashma	1 × 100 KW
(*iii*) Darosh	3 × 100 KW

3. AZAD KASHMIR

(*i*) Chinari	2 × 50 KW
(*ii*) Pattika	1 × 100 KW

14. If a survey is carried out a number of new sites can be located in the Northern Region of Pakistan where Power units of even 500 KW could be installed. Along Panjkhora River, one can locate numerous sites where power units of more than 500 KW could be provided. A large number of water falls could be exploited in the Northern Areas, NWFP and Azad Kashmir. Topography of these orbits provide many promising new sites where natural water falls are available for exploitation. So far Ministry of Water and Power is unable to handle this natural gift. Hardly ten hydro-electric power stations are being constructed out of one hundred promising sites.

15. Today most expensive and uneconomical power stations are being constructed by M/s National Construction Limited. The cost per KW installed is on the increase day by day and when these ten power stations would be finally completed they may be most expensive units installed.

16. Some countries in Asia, Europe and Latin America have exploitad this natural gift at much cheaper capital cost per KW installed. Unless a separate agency is established or new authorities in these regions are created, it is not possible to construct cheap power units on the run off a brook or rivulet or stream. Water mills are being manned in the private sector in these areas. If incentive is given in the private sector the capital cost of per KW installed can be substantially reduced and also the overall annual maintenance cost will be reduced further.

17. Futurology of Hydel Potential

Futurology of Hydel Potential mainly depends upon Research and Development (R & D). More research made in this field under the local conditions might result in better developments, generators, turbines, switchgears, transformers, transmission and distribution lines and equipment can be locally manufactured at cheap rates provided the transfer of technology and technical know-how is imparted in the local conditions. In Europe, a large number of small and medium units have been installed in the private sector which are meeting the power demand of the needy areas. In short, the Science and Technology policy has rightly provided a great incentive to exploit the small and medium size Hydro-Electric Potentials. Futurology of Hydel Potential is still very bright as it can meet the ever rising need for more power generation in the areas where nature has been kind enough to provide the small and medium water falls and large hydel potentials.

BIBLIOGRAPHY

1. M. H. Masud Butt, "Strategy of Power Development in Pakistan," in the *Proceedings of the Ninth World Energy Conference* held at Detroit, USA, 1974.

2. Mohammad Waseem Khan, "A Survey of Hydro Electric Potential of Pakistan," *The Journal of the Institution of Electrical Engineers (Pakistan)*, April-May-June, 1978, Vol. VII, No. 2.

3. Muhammad Ikram-ul-Haq, "Hydro-Electric Resources of Pakistan", *The Journal of the Institution of Electrical Engineers (Pakistan)*, April-May-June, 1978. Vol. VII, No. 2.

4. Mr. James G. Boggis and Professor Fred-H-West Field, *Power Load Control Study*, Vol. I. and II., International Book for Reconstruction and Development, International Development Association.

5. WAPDA Annual Reports 1977-78 & 1978-79.

6. *WAPDA Then—Now—Tomorrow*, Water & Power Development Authority, Pakistan, Lahore.

7. Annual Plans 1977, 1978-78-79 & 1979-80, Planning Commission, Government of Pakistan Islamabad.

8. "Power Generation System," by the Editors of *Power*, McGraw Hill Book Company, New York.

9. *Pakistan Economic Survey* 1978-79, Finance Division, Economic Advisory Wing, Government of Pakistan, June 1979.