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Hydro Power Potential in Pakistan: Prospects and Challenges

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Introduction

Hydropower or hydroelectricity refers to the conservation of energy from the flowing water into electricity[1]. It is one of the main sources of renewable energy which has multiple advantages for instance, it is less costly, environment friendly, and found in abundance. This source of renewable energy accounts for 6.7% of worldwide electricity[2]. As the conventional methods to produce energy is depleting, the world is now shifting towards renewable energy resources to meet their energy requirements. For the socio-economic progress of the country, electric power is one of the essential pillars to get maximum advantages.

Water and energy are the prime needs of human beings living on earth. The burning of fossil fuels for the production of electricity releases a vast amount of greenhouse gas emissions into the atmosphere due to which global warming and sea level are on the rise and has eventually caused the human civilization to suffer. Water resources can be used for irrigation purposes and also be utilized to produce electricity in the form of hydropower.

[1] Studentenergy.org, https://studentenergy.org/source/hydropower/?gclid=EAIaIQobChMIqYXy17Lc7AIVzuvtCh0sJA_CEAAYASAAEgLoQfD_BwE

[2] Ibid

In this context, if we analyze Pakistan's hydropower potential there are a lot of problems in this field. Taking a glance at history, the production of hydropower in the subcontinent was started in 1925 and the Renala 1MW hydropower station was installed[3]. After a decade, Malakand-1 hydropower station was built, which was later upgraded to 20MW in capacity[4]. After independence, Pakistan faced multiple problems including the shortfall of electric power. The inherited small power base was of 60 MW capacity for its 31.5 million people. later on, Pakistan's total hydel power capacity was enhanced to 119MW, when WAPDA came into being[5]. With time the electric power capacity galvanized. In 1960, by the Indus Water Treaty, Pakistan was entitled to 142MAF (Indus 93, Chenab 26, and Jhelum 23) of water utilization. Subsequently, 240MW Warsak, 1000MW Mangla, and 3478MW Tarbela hydropower projects were constructed[6].

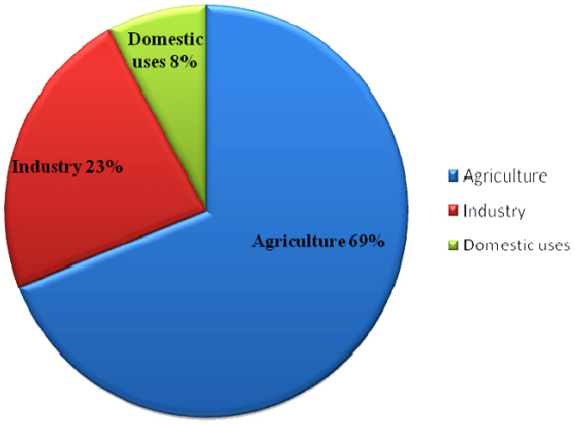
Now, the geographical terrain of Pakistan provides ample opportunities for hydropower production. There is huge potential in the northern sites of Pakistan for the development of hydropower. However, the scope of this study is restricted to the analysis of the major dams in the provinces. It also outlines the prospects and challenges that have slowed down the pace of development in hydel power. Finally, this study concludes the panacea to curtail the challenges and to enable Pakistan to

[3] Official Report: *Hydel power potential in Pakistan,* NEPRA. https://nepra.org.pk/Policies/Hydel%20Potential%20in%20Pakistan.pdf
[4] Official Report: *Hydel power potential in Pakistan,* NEPRA. https://nepra.org.pk/Policies/Hydel%20Potential%20in%20Pakistan.pdf
[5] Ibid
[6] Ibid

optimize benefits by the small hydropower plants (SHPP) projections and renewable energy resources.

Pakistan Current Hydro Power Situation

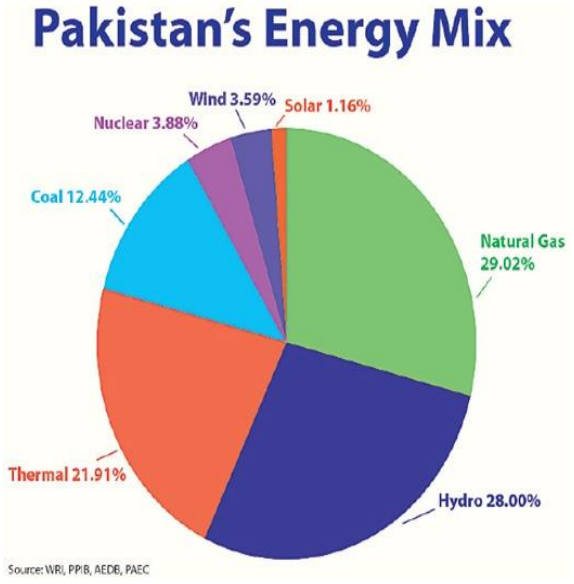
The energy crisis in Pakistan is a pertinent issue to highlight. Pakistan holds the capacity to generate hydropower but certain challenges hinder the way of developing hydropower.



The water consumption pattern in Pakistan is divided into three sectors; Agriculture, Industry, and Domestic use. Maximum water consumption can be attributed to the agriculture sector. However, there is a stark need to revamp the industrial policies to meet the hydro energy demand and to run industries. Under this perspective, an overview of Pakistan's hydropower capacity is given. Pakistan's need for hydropower potential is about 60,000 MW to 70,000MW but only 11% utilized for the production of electricity and the remaining potential is still untapped[7].

[7] Source: International Hydropower Association
https://www.hydropower.org/country-profiles/pakistan

Hydropower once accounts for 45 percent of power generation but this share has dropped to around 28% [8]. For more than a decade, the energy market investment in hydel power generation has been caught up in ambivalent paradoxes. Presently, Pakistan is amid an energy crisis and the situation is abysmal. Since it is a renewable energy source, there should be proper energy production apparatus in which Pakistan can work mitigate the menaces and progress further. In this domain, big MNCs are raising their concerns over the availability of electricity to meet their requirements. However, now the government of Pakistan is contemplating in this area and investing in the private big and small companies to meet their energy demands by switching to renewables energy resources, mainly to promote hydropower generation.



Current Storage Capacity of Water in Pakistan

The country's current water storage capacity where the hydro plants can work more effectively can be ascertained from the following factual representation[9].

[8] Ibid
[9] Source: "Pakistan Today", 29 july,2019.

Province Wise Analysis of Hydro Power Potential

This provisional analysis gives an overview of the hydropower capabilities. The South region of Pakistan has to scare hydel resources. However, hydel power potential in the North region of Pakistan is immense.

List of Dams	Active Storage Capacity
Warsack	31,207,090 m^3 (25,300 acre·ft)
Rawal	751.9 feet
Mangla	1186.40 feet
Terbella	525.75 feet
Khan Pur	1982 feet
Tanda	99,000 acre-feet
Hub	656,000 acre·ft[10]

The hydel power potential can be divided into six regions. A comprehensive analysis is mentioned below:

- Punjab
- KPK
- Northern Areas

[10] Source: WAPDA, http://www.wapda.gov.pk/index.php/projects/water-sector/o-m/hub-dam.

- Sindh
- Balochistan
- Azad Jammu and Kashmir

Punjab

In 1995 the Punjab Power Development Board was created in the Irrigation Department. The major aim of establishing the board was to promote hydel power generation on canal sites. At different canals, about 324 potential sites of medium and low head, with a total estimated capacity of 5895 MW were identified[11].

Khyber Pakhtunkhwa

The Government of KPK has established a corporate body known as the Sarhad Hydel Development Organization (SHYDO) for carrying out hydro-power prospects, hydropower development and to act as a utility company for isolated rural communities. With a total capacity of 18698 MW, about 150 potential sites were identified based on a high, medium, and a small head[12]. Out of these, 17 projects are in operation, 6 sites are under implementation in the public sector and 1 site has been offered to the private sector. Mainly, these are run-of-river sites, with some as daily storage projects.

[11] Official Report: *Hydel power potential in Pakistan,* NEPRA. https://nepra.org.pk/Policies/Hydel%20Potential%20in%20Pakistan.pdf
[12] Ibid

In 2016, Several hydropower plants were completed including Ranolia (17 MW), Daral Khwar (37 MW), and Machai (2.6 MW), all located in the Khyber Pakhtunkhwa province[13]. Presently, With the support of the Asian Development Bank several micro hydropower plants are installed as a part of the KPK government initiative. These 1,000 micro plants are expected to have a capacity of 100 MW[14]. These micro-projects are designed to support rural, off-grid communities by providing affordable and reliable electricity.

Regarding the tax situation, the hydroelectric power tariff was Rs1 per unit. Now, it is Rs3.50 per unit, partly as a result of an increase in royalty payments to K-P. It is still an attractive price compared to Rs5-10 per unit of fossil-based power tariff. However, all recent projects are to produce expensive hydroelectric power. K-P government is developing expensive projects costing more than $2.5 million per megawatt, resulting in a tariff of around Rs10 per unit, approaching oil-based electricity.

Northern Areas

Multiple potential hydel sites have been identified in the Northern Areas but due to the absence of high-power transmission lines, these sites have not been developed so far. With the paucity of resources, absence of high-power transmission line system, and hurdles on the account of mountainous terrain, Northern Areas are not connected

[13] Source: International Hydropower Association https://www.hydropower.org/country-profiles/pakistan
[14] Ibid 10

to the National Grid and no projects have been undertaken by private investors. Currently, approximately 40 % of the local population of the Northern Area has been provided with electrical power. However, The Northern Areas Public Works Department (NAPWD) was established, which is responsible for the generation and distribution of electrical power. It has installed different mini hydel power stations in the region and has built 11 KV lines for the transmission of power to consumers. An 18 MW Naltar-III Hydropower Project is under implementation in the public sector.

Sindh

The Irrigation & Power Department is responsible for conducting hydropower activities in this Province. Six potential sites of an estimated total capacity of 178 MW have been identified with medium 4 Private Power & Infrastructure Board Private Power & Infrastructure Board 5 and low head at different canals. The hydropower projects identified in the Province are Nai Gaj Fall, Sukkur, Rohri canal, and Guddu Barrage Projects. These projects have an estimated 178 MW capacity. The project's study of the Rohri and Guddu Barrage has been completed, and it is expected that implementation work will be started soon. But still, Sindh stands vulnerable.

Balochistan

The National Water Resources Development for Balochistan included 8 irrigation projects, but none of them succeed to generate electricity. Presently, no hydel projects are in operation. To facilitate investors to participate in the development and

implementation of hydel projects data about the hydel projects in operation is essential.

Azad Jammu and Kashmir

Several hydel projects with a total capacity of 829 MW are being processed/undertaken by the private sector. Recently, the CPEC chairman stated that a total of 2000MW of hydel power will be produced under the project of Kohala, Azad Pattan, and would create 8,000 jobs. It is anticipated that under the CPEC hydel power project, AJK is likely to get a net profit of Rs.12bn annually. Two new projects will be set up in the power sector in AJK, with the capacity of 2,000MW of electricity. The karot hydro project will be generating 700MW of electricity.

Pakistan's Priority

To answer the most acute problem of water, some of the most prominent projects are listed below in the table. Which highlights the priority and capacity building for Pakistan and the possible benefits of power generation in the future. These dams would initiate a prosperity paradox for the national grid of the state. It will create an ideal case for highly efficient irrigation system i.e. topography, use of landfills, water supply through hydro turbines to generate electricity, beneficial for drip and sprinkle irrigation. It will

also maximize the benefits for the local farmers and produce job opportunities. It will create a lucrative amount of profit that will help in subsidies for the country's needs.

Name of Dams	Estimated cost	Power potential	Water storage capacity
Katzara	12-15b $	15000 MW	35 MAF
Dassu Dam	9b $	4320 MW	11.4 MAF
Diamer-Basha	14b $	4500 MW	8.5MAF
Kalabagh	7b $	15000 MW	6.1 MAF
Munda	1.4b $	700 MW	1.29 MAF
Akhori	1.6b $	600 MW	7.6 MAF[15]

Challenges in Pakistan's Hydroelectric Power Generation

The demographic time bomb is tickling in Pakistan. To cater to the increasing demand for energy by a growing population is a crucial factor. The industrial revolution and massive population growth require a proper energy supply mechanism. Pakistan's energy demand has increased due to the high growth rate. Which is according to a projection, 3% per year. The conventional methods like coal, fossil fuels, oil are depleting and cannot accommodate the surging demands of the increasing

[15] Source: WAPDA, http://www.wapda.gov.pk/index.php/projects/water-sector/o-m/akhori-dam.

population. This implies a huge threat to meet the prospect of energy demand and supply of Pakistan.

Pakistan is among the most water-scarce countries. It is anticipated that by 2025, Pakistan would be an absolute water scare[16]. If serious steps are not being taken like conservation of water methods, shifting towards renewable energy to meet the energy demands would create huge repercussions for the country. The scarcity of water menaces the risks of political struggle in the country. When there is a shortage of water in the state, each stakeholder gets to involve in the talk of the town. Therefore, it becomes more of a matter of national security.

Quickly depleting freshwater and groundwater resources in any country, initiates political instability internally and it can be more obvious in Pakistan which is composed of many ethnically diverse groups. To achieve policy-oriented consensus among the provinces is crucial. The manipulation in the unequal distribution of resources and political disagreement is witnessed in the country since the start. The ongoing controversy of Daimer-Basha and Kalabagh dam is also one of the examples of conflicts among the provinces.

Particularly, such protests may rise from KPK, Balochistan, and Sindh. As they already hold grievances of discrimination and unequal distribution of resources or wealth by Federal and Punjab. Already politically divided weak states make more sense to

[16]https://www.dw.com/en/water-crisis-why-is-pakistan-running-dry/a-44110280

divided and exploited by external forces. The inter-state chaos makes any state fragile and exposed to outside aggression.

The climatic factor is another challenge to the conservation of water that due to climate change there are irregular monsoon rainfall patterns. Which is leading to the problem of excessive flooding as there is a paucity of dams and reservoir to store the water. Pakistan is facing an acute issue of water scarcity. The Indus River System Authority (IRSA) said the water level in Mangla and Tarbela Dam reached a dead level in 2019[17]. The level of water in Mangla is 1,166.50 acre-feet against its maximum conservation level of 1,242 feet and a dead level of 1,050-acre feet[18]. In Tarbela, the latest water level is 1,497-acre feet against its maximum conservation level of 1,550 feet and a dead level of 1,386 feet[19]. Dams are losing water storage capacity from 30-40% due to reservoir sedimentation and irregular rainfall patterns.

Due to the dearth of electricity, the inhabitants of Pakistan are facing blackouts of 10-12h in urban and 14-20h in rural areas, respectively. According to a projection of the International Energy Agency (IEA) current demand for electricity in the country is 15000 MW and it is anticipated that it will increase further to 49,078MW by 2050.[20] Hence, it is indispensable to work on hydel power projects and renewable energy technologies by the use of innovative and effective development apparatus.

[17] Khalid Hasnain, "*Water in Terbela to reach Dead level next week"* 17 march,2019.
[18] Sehrish Wasif, "*low rainfall causes water shortage*", The Express Tribune, October 2, 2018.
[19] Ibid 15
[20] Uddin, W., Zeb, K., Haider, A., Khan, B., ul Islam, S., Ishfaq, M., ... & Kim, H. J. (2019). Current and future prospects of small hydropower in Pakistan: A survey. *Energy Strategy Reviews*, *24*, 166-177.

i.e. use of small hydropower plants (SHPPs) can play a major role to achieve energy self-sufficiency in even the remote areas of Pakistan. The power generation system of Pakistan is based on the conventional methods that require a dire need to match the pace with the new technological advancement to generate electricity by hydropower.

Despite all the challenges like lack in policymaking in the use of renewable energy, to build a coherent consensus of provinces, to match the pace with the technological advancement, to raise awareness in water conservation methods, there is still a lot of potential for hydropower in Pakistan which can meet the electricity requirement. For example, to produce electricity by planting a small hydropower station in an area which tackles its demands

Way Forward

To meet the energy demands of Pakistan a broader policy-oriented perspective is needed. In this context, a detailed sectoral framework for environment-related sustainable development goals is developed containing clear indicators and a framework of implementation. The targets should be categorized in short, medium, and long term goals so that implementation may properly be evaluated and altered, if necessary. Environment-related sustainable development goals should be aligned with the development strategy of Pakistan.

To shift more towards renewable energy and increase the capability of the energy sector is essential. These resources are the sustainable energy development model. There is a dire need for all the small and big institutions to work in the progressive development of hydel power in Pakistan. The current energy crises of Pakistan can be resolved by installing the small hydropower projects (SHPP) which are monitored under the Alternative Energy Development Board (AEDB).

The Definition of SHPP may vary from state to state. It can be categorized into small, hydro, mini, micro, and Pico. Usually, the upper limit of SHPP varies from 10 to 30MW. SHPP does not require reservoirs. They are established at the run of the river. The water is diverted to the mainstream through pipes with high energy to create heads. Including SHPP into the national grid system provides surplus profit in hydel energy generation.

Recently, already AEDB has launched the “net metering” system. Which is to create own energy via solar panels at a cheaper cost. Apart from these plants, Pakistan has taken the initiative to installed a 16,170 MW capacity electric plant with the collaboration of China under CPEC. Many of these projects were about to be

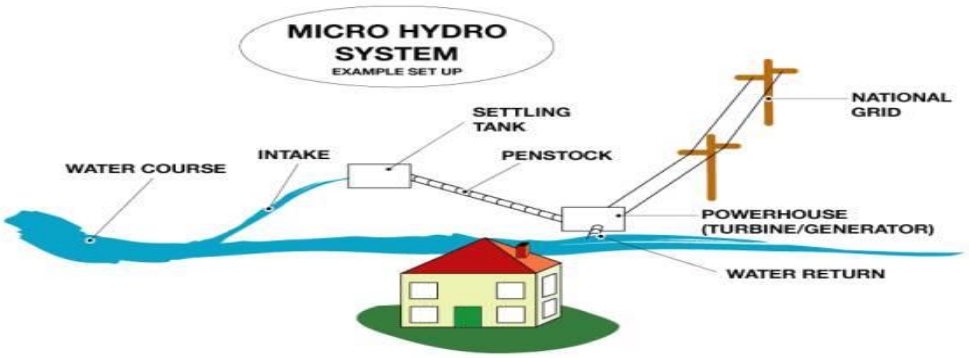
completed by 2020-2021. The recent September 2020 progress report of net metering in Pakistan is mentioned below[21]:

Progress of Net Metering in Pakistan up to September 30, 2020

S.No	Name of DISCO	Application recevied in DISCOs		Applied to NEPRA	Generation License issued by NEPRA		Commissioned Systems	
		Nos.	Capacity (KW)	Nos.	Nos.	Capacity (MW)	Nos.	Capacity (MW)
1	IESCO	2050	24110	1910	1832	24	1691	19
2	LESCO	1906	35845	1793	1753	31,00	1289	22,67
3	MEPCO	527	14328	450	413	8,76	298	6,61
4	FESCO	337	6863,7	320	304	5,01	153	2,70
5	HESCO	9	504,61	8	5	0,13	1	0,01
6	SEPCO	9	1472,56	6	6	1,43	5	1,42
7	QESCO	4	331,07	3	1	6,00	2	0,01
8	TESCO	0	0	0	0	0,00	0	0,00
9	GEPCO	336	8076,49	336	312	8,35	253	7,13
10	BTPL	488	4478,07	488	448	4,24	448	4,24
11	K-Electric	1555	26987	1326	1245	21,83	1179	20,08
12	PESCO	263	4558,74	237	254	4,39	160	2,44
13	EME (DHA Phase XII)	163	1805	149	136	1,51	136	1,51
Total:		7647	129360	7026	6709	116,18	5615	87,93

Another issue of water wastage can be tackled by the construction of safety valves canals. It provides a solution to the floodwater in monsoons when we have water in surplus, beyond the capacity of our barrages/rivers. It would be useful for the Southern Punjab and some parts of Sindh and Baluchistan Furthermore, investment in the private sector should be enhanced to get maximum advantages in SHPP. These goals must be communicated to the local government and community level so that reservation of each province may be catered at the grass-root level.

[21] Official Report of AEDB Sep 2019: http://www.aedb.org/articles-list/344-net-metering-progress-in-pakistan

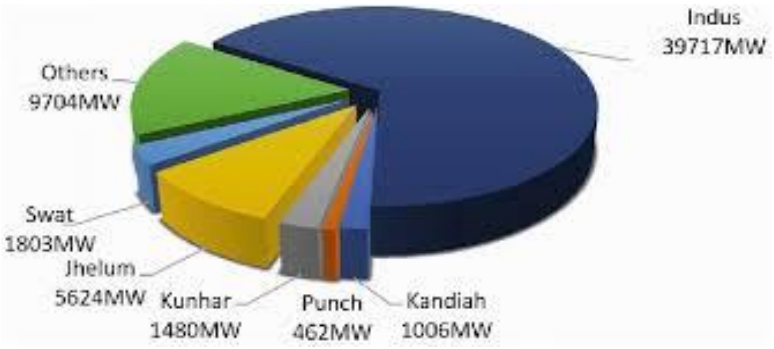


River bed transit storage capacity can be enhanced by selecting suitable sites at appropriate distances in the country's existing rivers, where less effort is required to raise the banks and create storage capacity. Construction of auto-over flowing spillways at the river bed according to the capacity of its bank can be an effective step. It would have two prime benefits: one, a certain quantity of water shall always be available in the river for grazing animals as well as for plantation. Secondly, during the dry spells, the water might be realized to meet our downstream requirements. That will ensure that in flood-like situations there will have all rivers holding water as per designed capacities of spillways and banks. Structural reforms should be made in state institutions which are working in this domain of hydropower so that effective implementation of policies and accountability in case of negligence be properly carried out.

Big hydropower projects are monitored by WAPDA. WAPDA has identified numerous sides of hydropower stations that can generate electricity up to 60,000MW[22]. These potentials are mainly identified in Northern areas. The acknowledged hydropower

[22] Source: The Tribune news, 06 November 2020.

resources can be constructed on several riversides of Pakistan. the major portion can be obtained by the Indus River which is about 66% of identified resources.



Conclusion

In a nutshell, the government should develop renewably sustainable policies to build positive apparatus energy mix apparatus to counter energy crises. Apart from the policy, to match the pace with new advanced technology to optimize more power efficiency from water is required. The construction of new mega-dams has been a contentious issue over the last many years. Which required large scale rehabilitation and also to address the reservations of provinces to create new dams. The hydropower plants could play an intrinsic role in these areas**.** Moving towards renewable energy mainly, adding hydropower in the national grid not just helps to lower the carbon footprints, preserve the ecological system but also provide lucrative surplus in the future. Having immense potential in the hydel sector, the government yet needs to take serious and pragmatic steps on building more capability in hydropower to ensure a prosperous and peaceful future for the nation to come and to meet the existing electricity demands.

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