DIRECTORATE GENERAL OF SCIENCE AND TECHNOLOGY (DOST)
GOVERNMENT OF KHYBER PAKHTUNKHWA

KHYBER PAKHTUNKHWA
SCIENCE AGENDA

DEPARTMENT OF
SCIENCE & TECHNOLOGY
AND INFORMATION TECHNOLOGY
GOVERNMENT OF KHYBER PAKHTUNKHWA

MICRO HYDRO POWER

Micro Hydro Plants produce renewable and clean electricity of up to 100 KW for small communities

TASKFORCE REPORT

Micro Hydro Power Sector in Khyber Pakhtunkhwa: Sectoral Analysis, Local Challenges, Strategic Insights and Recommendations

2023

FOREWORD

In alignment with the Science Agenda for Khyber Pakhtunkhwa, the Directorate General of Science & Technology initiated a landmark effort to identify and advance priority areas where science, technology, and innovation can meaningfully contribute to the province's socio-economic development. We present to you the sectoral reports in key natural resource areas that are ideally unique to Khyber Pakhtunkhwa and have been identified for R&D investments. Each of these sectoral reports marks an important milestone in advancing scientific understanding and strategic development within Khyber Pakhtunkhwa's natural resource sectors, through focused inquiry and collaborative expertise. These reports, developed by thematic Task Forces constituted under the Directorate General of Science & Technology, are foundational efforts under the broader Science Agenda for Khyber Pakhtunkhwa , a transformative initiative that seeks to reposition the province as a regional leader in science, technology, and innovation as we explore the potential of Khyber Pakhtunkhwa's rich natural resource landscape.

Under the Science Agenda, we hold a bold and pragmatic approach: to build on the province's existing strengths while investing in the future. The identification of eight natural resource areas — from gemstones and herbs to fisheries, fruits and vegetables, bees and honey, micro-hydro power, archaeology, and the urban environment — presents a unique opportunity for science-led value addition and sustainable economic growth. Each thematic area represents not just a resource, but a vibrant ecosystem of challenges and opportunities, waiting to be enhanced through strategic interventions in research, development, and innovation.These reports are the outcome of months of rigorous consultation, deep research, and collaborative ideation by multidisciplinary experts drawn from academia, industry, public sector, and civil society. The Task Forces were entrusted with the mission to map the current landscape, articulate key challenges, and recommend high-impact R&D pathways that can guide smart investment in the sector. This body of work now forms a scientific and strategic blueprint for stakeholders across sectors to drive meaningful change.

This initiative is aligned with our core vision to move Khyber Pakhtunkhwa from being a consumer of technologies to a creator of solutions — driven by our local talent, informed by global best practices, and anchored in our unique natural endowments. Through this endeavor, we reaffirm our commitment to building a culture of science that is inclusive, collaborative, and forward-looking.

I extend my deepest appreciation to all members of the Task Forces, as well as the wider science and innovation ecosystem that supported this effort. We look forward to translating the insights from these reports into tangible programs, R&D investments, and partnerships that uplift livelihoods, enhance competitiveness, and leave a lasting impact on the province's development trajectory.

Sajid Hussain Shah
Director General
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Government of Khyber Pakhtunkhwa

ACKNOWLEDGMENT

This policy report has been developed by the Directorate General of Science & Technology, Government of Khyber Pakhtunkhwa, as part of the Annual Development Program initiative focused on strategic natural resource development.
The report is the outcome of a time-bound effort by a dedicated Task Force constituted for this thematic area, comprising local experts from diverse institutional backgrounds, including academia, government, industry, and the development sector. The Task Force worked collaboratively through multiple rounds of consultations to undertake a deep-dive analysis, identify context-specific challenges, and offer actionable insights to guide future scientific, technological, and policy interventions. The Directorate General of Science & Technology gratefully acknowledges the valuable contributions of the Task Force members representing diverse institutions engaged in the micro-hydropower and related engineering sectors. Their collective expertise and insights were instrumental in shaping this report.

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RATIONALE

ENERGY POVERTY AND ENERGY SECURITY: The rising energy crisis in Pakistan, fueled by high fossil fuel prices and inflation, is impacting the economy, health, education and quality of life.

A sustainable and affordable energy supply is necessary for the socio-economic development of Pakistan, which in the recent past has been facing severe energy shortages. Electricity generated through various sources in Pakistan has not been able to meet the ever-growing demand of the urban and especially the rural population. In practice, electricity generation is much lower due to multiple reasons, resulting in several hours of load shedding per day (Pakistan Energy Crisis; Recommended Solution, 2012). The society, overall, is in the grip of multiple crises, including energy crises, poor economic growth with no or low employment opportunities, growing inflation, shortage of food commodities, and amongst others, poor law and order situation. This has created deterrence for genuine investors including energy sector, which has affected Pakistan's capacity to mobilize its energy resources, thus widening the gap between energy demand and supply.

It is also worth mentioning that cost of generating electricity has gone up over the last few years as attention has not been given to developing or expanding hydro power in Pakistan, which has resulted in shifting focus to more expensive thermal power generation or

- **22 % (51 million out of 229 million) Pakistanis lack access to even basic electricity.**
- **30% without national grid /electricity in KP.**
- **Pakistan Social & living measures (PSLM) report, 2014-2015, found that 55% of households are in multidimensional energy poverty.**
- **The energy demand is growing at a rate of 11–13% every year.**
- **Due to the gap between the supply and demand of electrical power, 90 million Pakistanis facing a daily 10–12 hours of load shedding in urban areas and 14– 20 hours in rural areas leads to increased use of diesel for generation and deforestation for wood-powered stoves**
- **The exports of Pakistan are severely affected due to under production in industries because of this shortfall in electricity generation.**
- **The energy demand in Pakistan is expected to be three times higher by 2050. According to the International Energy Agency (IEA), the electrical energy demand of Pakistan will**

Rental Power Plants. Interestingly, the cost per unit through hydro and thermal power generation through public or private institutions is nearly PKR 4 and PKR 15, respectively. The difference in cost of production has serious implications in terms of spending on energy by a common citizen. With nearly 45% poverty in rural areas of Pakistan, this means that availing or utilizing electricity, especially in extreme summers or winters, for the poor population is nearly impossible. One of the possible solutions could be shifting focus to low-cost renewable, sustainable energy sources, including solar, wind, bio-gas and hydroelectricity (Including mini/micro and or small hydro projects).

Utilization of electrical power is invariably recognized indicator of progress in the industrial, educational, agricultural, domestic and commercial sectors of an economy and is also considered a benchmark of the living standards of the people of any country. No major economic activity can be sustained without an adequate, cost-effective and reliable supply of power. It plays a vital role in employment generation, regional development and poverty eradication

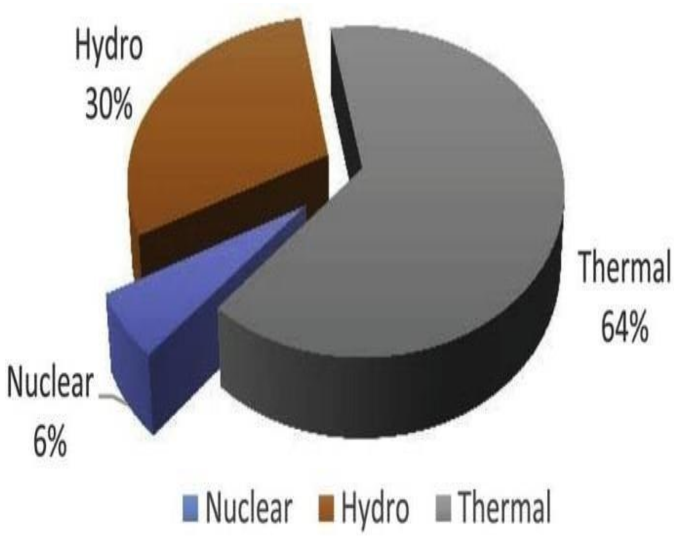
THE SOLUTION

Water: the world's most untapped natural energy source One-third of electricity/energy needs could come from low-cost, sustainable hydro sources (International Energy Agency (IEA) 2021 hydro power special Market Report).

Hydroelectricity is one of the most mature forms of renewable energy, providing more than 19% of the world's electricity consumption from both large and small power plants. Many regions of the world have a large number of small hydro power plants in operation, e.g. China produces 19,000 MW of electricity from 43,000 small hydro facilities.

HYDRO POWER Sector in Pakistan

Pakistan and Khyber Pakhtunkhwa, endowed with plenty of water resources, have rich potential for hydropower generation, estimated at 60,000 megawatts, which could be economically harnessed.



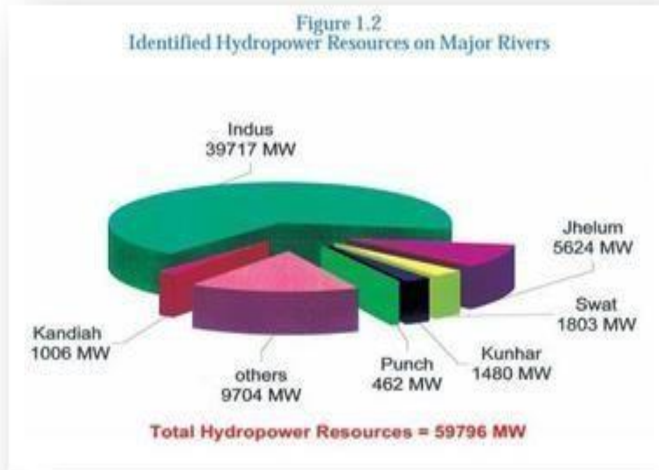
Over 60,000 MW of Hydro Power Potential exists.

Out of this vast hydropower potential only Only 7,320 MW (11%) has been developed to date.
(Pakistan's Water and Power Development Authority (WAPDA)

hydropower set to increase to 40% > by 2030, delivering on Government of Pakistan's Net Zero Targets

A reliable hydro energy source will reduce dependence on fossil fuels.

In view of multiple challenges, for Pakistan, Hydropower is one of the best available options in the current scenario to meet challenges of projected future energy demands of Pakistan, as it is sustainable, reliable, renewable, clean, low-cost and indigenous, thus can be a principal source of energy. Efforts, invariably, need to be directed towards the development of untapped hydropower potential in Pakistan and especially Khyber Pakhtunkhwa, as hydropower resources are mainly located in mountainous areas in the northern region of Pakistan. The hydropower resources in the South being scarce, mainly comprising small to medium schemes on barrages and canal falls (Hydro Power Resources of Pakistan, 2011).



Pakistan and specifically Khyber Pakhtunkhwa (KP) province is bestowed with enormous hydro power potential which, if exploited in a systematic, planned and transparent manner, can ensure our energy security on long-term basis in a sustainable manner. The need for harnessing the immense hydropower potential in the province and the rest of Pakistan cannot be over-emphasized. The topography of the area, coupled with the water flows, offers opportunities for the development of high-head, medium-head and low-head run-of-river and storage dam power stations across the rivers and their tributaries across the length and breadth of the province.

Most of the hydro power projects of Pakistan, contributing reliable and cost-effective electricity into the national grid, including the historical Tarbela and Warsak Dams are located in Khyber Pakhtunkhwa. The Khyber Pakhtunkhwa has an estimated power potential of generating nearly 30,000 MW. While most of the hydro power projects under development are in the public sector, the provincial government has embarked on a multi-pronged strategy for encouraging investment through NGO, Public, Private & Public-Private Partnership sectors.

MINI-MICRO AND SMALL HYDRO PROJECTS

Run-of-river Micro Hydro Power Plants

A. MINI/MICRO HYDRO POWER PROJECTS-NEED?

- In remote areas of Khyber Pakhtunkhwa province of Pakistan, 30% of the Population is still without the national grid/electricity.
- The Generation Cost per unit of hydro is ¼ (one fourth) of that of thermal power through

public or private institutions.

- In Solar, imported technology/spare parts are 3 to 5 times more costly. It is mostly used during the daytime. Costly backup, complex maintenance systems & suitable for individual households only.
- Big Hydro Power Projects: Long time, huge scope of work & cost, huge transmission networks for grid connectivity.
- National grid unlikely to reach remote areas because of high costs and maintenance.
- Government policy to promote tourism can only be boosted by the provision of electricity in remote areas.

Minim/Micro Hydro Power Projects are the most Practical & viable way to provide electricity to the remote off-grid & isolated areas because of:

Low cost, continuous, suitable for whole settlements, easy O & M, small installation time, small transmission systems, community involvement & contribution

Owing to the geographical location, Pakistan has an abundance of renewable energy resources, such as Small, Mini and Micro Hydro, To mitigate the energy crisis, the exploration of new renewable energy resources is essential. Small, Mini and Micro hydro is an alternative source of electrical energy to overcome energy shortages. Many countries around the world have a large potential for small hydro. In China, 19,000 MW of electricity is generated from 43,000 SHPPs and MHPs

There is no universally accepted definition of the term "small hydro" which, depending on local definitions can range in size from a few kilowatts to 50 megawatts or more of rated power output. Internationally, "small" hydro power plant capacities typically range in size from 1 MW to 50 MW, with projects in the 100 kW to 1 MW range sometimes referred to as "mini" hydro and projects under 100 kW referred to as "micro" hydro (Hydro Project, MNR, 2004). Apart from the discourse on mini-micro or small hydro projects, it is indeed an acceptable fact that hydroelectricity is one of the most mature forms of renewable energy, providing more than 19% of the world's electricity consumption from both large and small power plants.

Rasul Hydro power Station: The second MHP of 9.6 MW (3X3.2 MW) was put, into operation in Malakand (NWFP) in July 1938

In December 1952, MHP Rasul (Punjab) having 22 MW (2X11 MW) was made operational.

Same Year, Dargai (erstwhile N-W.F.P) and 20 MW (4X5 Mw) generation was installed..

In February 1958, 4 MW Kurram Garhi hydel 256 Kw. power stations, located in the erstwhile N-W.F.P, had started producing electricity.

In May-June 1959, MHP Chichoki Malian 13 MW, near Sheikhupura, had been commissioned.

in June 1961, a 14 MW (2x6.75 MW) Shadiwal small hydel power plant near Gujrat was commissioned.

Another 14 MW (3x4.6 MW) Nandipur MHP near Gujranwala had started producing electricity in March 1963.

The current energy crisis in Pakistan can be solved by the installation of MMHPs. Pakistan has extensive potential for hydropower generation due to the abundant water resources in Khyber Pakhtunkhwa (KP) province.

The development of small hydel power units in Pakistan was initiated in the early 1950s. The Pakistan Water and Power Development Authority (WAPDA) took over the responsibilities of the Power Sector in April 1959. The existing power generation, transmission and distribution facilities in different parts of the country were transferred to it.

The energy crisis can be easily overcome by installing SHPPs/MMHPs. The use of SHPPs/MMHPs has been estimated to save 120 million tons of coal or 83.3 billion liters of oil in a year. Thus, these plants are environmentally friendly and make a low contribution to global warming. Worldwide, SHPPs and MMHPs provide employment to 0.2 million people.

Currently, different government and non-governmental organizations are working on the installation of MMHPs in the country

MHPs in Khyber Pakhtunkhwa Province:

In 1986 – the Government of erstwhile N-W.F. P established a company with the name of “Small Hydel Development Organization” (SHYDO) with sole purpose of:

- To identify and develop the Hydel power potential up to 5 MW
- To construct small Hydel Power stations for isolated load centres
- To operate and maintain small hydel stations

Later in 1993, SHYDO had evolved into an autonomous body, incorporating an additional objective of involving the private sector in the exploration and development of the province's held potential.

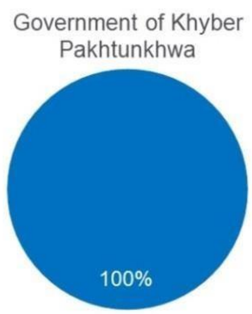
In 2013, The Organization was re-named as PHYDO “Pakhtunkhwa Hydel Development Organization”

In 2014, The Organization was re-named as PEDO “Pakhtunkhwa Energy Development Organization”

PEDO – Key Business Areas

Pakhtunkhwa Energy Development Organization (PEDO) is a body established under section 3 of the Khyber Pakhtunkhwa Energy Development Organization Act 2014 for the purpose of generation, transmission and distribution of power.

Ownership



Industry	Power
Key Businesses	Current: Hydropower , Solar, Other Renewables, Transmission & Distribution
Social Uplift Projects	Micro Hydro Units & Solar solutions
Installed Capacity	161 MW
Under Construction –Public Sector	233 MW
Offered to Private Sector	LOI Issued: Hydro(1160MW) Solar (249.5MW) Tariff approved: 201MW

PEDO HPPs UP TO 5 MW (OFF-GRID)

Sr. No.	Project Name	District	Capacity (KW)	Beneficiaries/ House Holds	Completion Year
1	Ashuran	Swat	400	808	1994
2	Thal Kohistan	Dir (Upper)	400	815	1993
3	Jhal Kot	Dasu Kohistan	150	352	1988
4	Kiyaal	Patan Kohistan	200	418	1988
5	Dubair	Dasu Kohistan	50	122	1987
6	Karora	Shangla	100	243	1989
7	Kund Bisham	Kohistan	100	234	1990
8	Gara Chashma	Chitral (Lower)	100	223	1989
9	Reshun	Chitral (Upper)	4200	17350	1999
10	Shishi	Chitral (Lower)	100	227	1990
11	Damorai	Shangla	50	107	1988
12	Kalam	Swat	100	235	1992
13	Kaghan	Mansehra	200	460	1989
Total			**6150**	**21594**	

PCRET installed 678 SHPP, ranging from 5 to 100 kW, across the country. These plants were installed from 1978 to 2016 and produce 9.507 MW of electric power.

Among non-governmental organizations, SRSP and AKRSP have played an important role in providing electricity to remote areas that are not connected to the national grid. During the two decades, SRSP constructed/installed 353 MMHPs ranging from 15 kw up to 2000 Kw, with an overall capacity of 29 Mw, benefiting 123,000 households and around one million population

PEDO is also working on SHPPs and MMHPs in partnership with other organization which include SRSP. AKRSP, Hydro Link, Mukhtiar Engineering, Zaif Foundation, DADO etc. So far, they have completed 316 MMHPs ranging from 15 Kw up to 500 Kw, with an overall capacity of 29 Mw benefiting 55,000 HHs and 415,000 population in the northern Districts of Khyber Pakhtunkhwa in the First Phase. Recently, PEDO has initiated the second Phase of More than 600 MMHPs in Khyber Pakhtunkhwa with funding from ADB.

Based on the completion time of the project, PEDO has developed an action plan consisting of short-term, medium-term, and long-term categories.

Completed Projects in Public Sector-PEDO

S #	Name of Project / Location	Date of Completion	Installed Capacity (MW)
1	**Malakand-III , Dargai**	Nov-08	81
2	**Pehur, Swabi**	Mar-10	18
3	**Reshun, Chitral**	Sep-19	4.2
4	**Shishi, Chitral**	Jun-10	1.8
5	**Machai**	Oct-17	2.6
6	**Ranolia**	Oct-17	17
7	**Daral Khawar**	Sep-18	36.6
Total			**161.2**

Under Construction Projects in Public Sector-PEDO

S. No.	Name of Project	District	Capacity (Mw)	Project Cost (USD Million)
1	**Jabori**	Mansehra	10.2	38
2	**Karora**	Shangla	11.8	46
3	**Koto**	Dir Lower	40.8	142
4	**Matiltan**	Swat	84	208
5	**Lawi**	Chitral	69	201
6	**Chapri Charkhel**	Kurram	10.56	26.53
7	**Barandu**	Torghar	6.95	25.42
Total			**233.31**	**686.95**

Keeping in view the long-term economic and environmental benefits, the private sector also constructed/installed some MMHPs for private commercial purposes. The details are given below.

Micro Hydro Projects constructed over Canals in KPK

S.#	Project name	Location	Capacity (Kw)	Load connected	Construction year
1	MHP Perano	Dargai, Malakand	800	Furnace	2018
2	MHP Brigadier	Katlang, Mardan	1000	Furnace	2019
3	MHP Katlang	Katlang, Mardan	2000	Furnace	2018
4	MHP Hatyan	Shergharh, Mardan	100	Ice Factory	2015
5	MHP Takkar	Tahtbhai, Mardan	200	Ball Mill	2019
6	MHP Qazi Surf	Tahtbhai, Mardan	40	Surf Factory	2020
7	MHP Markaz	Tahtbhai, Mardan	30	Tablighy Markaz	2010
8	MHP Chargali	Rustam, Mardan	50	Ice Factory	2020
9	MHP Warsak	Warsak Road, Peshawar	100	Ice Factory	2021
10	MHP Khanpur	Khanpur	250	Ice Factory	2014
11	MHP Ayun	Ayun, Chitral	700	Ice Factory	2001
TOTAL			**5270**		

Over the last few decades, there has been a growing realization in developing countries that micro-hydro schemes have an important role to play in the economic development of remote rural areas, especially mountainous ones. Micro-hydro schemes can provide power for industrial, agricultural and domestic uses.

The comparative strengths of micro hydro power

a. Affordable and reliable electricity

The public institutions have set up two types of tariffs; 12/unit for normal hours and 18/unit for peak hours. Notwithstanding, high rates, power outage for a minimum of 8 hours in urban and 12-16 hours/day in rural areas has added miseries to the lives of urban and rural population connected to the main grid. This unreliability and/or limited availability of electricity dramatically reduced its value and potential uses to both households and businesses. On the contrary, Mini/Micro Hydro Power Projects are providing 24/7 uninterrupted electricity to domestic and commercial users at much lower cost. In general, 4-5/unit is charged for domestic and 7-10/unit for commercial use, which has resulted in relieving economic stress at, especially, community level.

SRSP Mini/Micro hydro Power Stations
October, 2022

District	MHP	Capacity (Kw)	Units Consumed (Kwh)	No. of Months	Total Bills Amount (SRSP) (Rs.in M)	Total Bills Amount (as per Wapda) (Rs.in M)	Saving (Rs.in M)
Swat	Ashuran	1200	6,724,051	69	75.774	216.245	140.471
	Jungle Inn	400	3,964,815	100	46.125	127.508	81.384
Shangla	Damorai	560	2,905,707	55	26.510	93.448	66.937
Chitral	Birmogh Golain	2000	5,059,967	67	27.583	162.729	135.145
	Ayun	700	7,166,624	55	44.448	230.479	186.030
	Sarujalik	200	1,415,456	116	13.967	45.521	31.554
	Mastuj	700	2,146,509	55	15.832	69.032	53.200
	Booni	500	1,716,266	25	5.980	55.195	49.215
Total			**31,099,395**	**542**	**256.220**	**1,000.157**	**743.937**

b. Benefiting the local environment

The environmental benefits of hydroelectricity are well known. It has made a remarkable contribution in providing renewable, clean and sustainable energy to local population

It has reduced the usage of fossil fuels, besides reducing pressure on precious forests. Increasing reliability of electricity in these areas has encouraged households/businesses to stop use of other makeshift measures, such as costly diesel/gasoline generators, e.g. a local hotelier in UC Kalam, district Swat reported savings of PKR. 100,000/month by getting connected to recently completed Mini/micro hydro power projects by Sarhad Rural Support Programme (SRSP). In addition to useful savings for businesses and local community members, the transition to clean energy has already resulted in reducing air pollution (SO_2 and CO_2 emissions) that would otherwise result from the burning of diesel or other fossil fuels.

An analysis based on standard procedures and calculations revealed that SRSP's current portfolio of 165 units producing 21.3 Mw has been a major contributor to the reduction of CO_2 emissions by 69,000 tons per year. Similarly, it reduced the use of kerosene oil from 9 liters to 1 liter per day per household (Hunzai, 2012), along with a reduction in its cost from 6.8 million € to 763,000 €, which is a huge economic benefit to the local population. The substantial decrease in usage of kerosene oil for lighting, cooking or heating has also contributed to improving the health of women and children. Similarly, these MHPs have also contributed to the regeneration and preservation of local forests. On average, 427 Kg firewood is saved from each household in these areas.

Powering flourishing eco-system in previously barren regions

- Irrigation for agriculture
- Bee-keeping
- Reforestation
- Bio-diversity

c. Impacts on gender through Productive Use of Renewable Energy (PURE)

Stereo-typing led to 'limiting' use of electricity produced by MHPs established in early years for lighting or lighting/heating (in case of bigger units) in Malakand Division and or Northern Districts. A recent study conducted internally by SRSP highlighted major problems faced by fresh fruit producers, comprising market price fluctuations, uncertain supply and demand, lack of access to market information, pre/post-harvest losses in fresh fruits, lack of storage facilities and ignorance about value addition in fruits. This resulted in huge post-harvest losses and low income from marketing fresh fruits in local/national markets. To make the best use of renewable energy and diversify utilization of electricity produced by MHPs, the concept of Productive Utilization of Renewable Energy (PURE) has been introduced to benefit poor/marginalized groups with special focus on women. On a trial basis, red persimmon has been processed (dried) by men and women members in Swat and marketed in local markets. This processed/dry fruit fetched a net income of PKR. 440 per Kg or more than 156% increase in income. Based on these figures, one can assume that the effects on production are significant.

d. Increasing incomes of local Communities

Electricity produced through these Mini/Micro Hydro Power Projects (MHPs) has immensely contributed to benefitting 110 local hotels accommodating (on average) a minimum of 5000 guests per day. The influx of tourists has risen due to the availability of uninterrupted electricity. These hotels are also a source of offering economic opportunities benefiting the local Poor population. In addition, these hotels, in a pre-MHP scenario, were compelled to use diesel or gasoline-based generators, which on one hand had a negative impact on the environment while on the other it was heavy on the pockets, thus cutting down profits of local hotels. The connection of these hotels has promoted eco-tourism besides saving useful resources for the local population. As per figures gathered, at least 12,943 local enterprises (saw machines, flour mills, welding machines, gasoline stations, grocery shops, hotels, restaurants, tailoring shops, etc.) have also been connected to these MHPs to generate local employment and benefit the local economy. Another interesting aspect is encouragement through identifying, developing and engaging 720 local community members as professional/technical operators operationalized MHPs, contributing to improving and strengthening the livelihoods of an equal number of families or approx. 5,400 populations.

e. Improving H & H and social sector services benefiting women and children

At this early stage, at least 35 boys and girls' schools benefiting over 2,700 children have been connected to MHPs with an improvement in the learning environment. The computer labs are again functional, and electricity is available to make classrooms comfortable in either weather. In addition to the education facilities, at least 17 hospitals/basic Health Units are also providing services in these areas, catering to the needs of 925 patients per day, mostly women and children. Availability of electricity at BHUs has ensured availability of vaccines and operationalizing the pathology lab at the local level, saving travelling time/cost. With improved conditions via connectivity to MHPs, these social sector service facilities have become more attractive for teachers and health workers, thus improving health and education in rural areas.

f. Improved living conditions and access to information

Access to electricity has considerably contributed to improving the living conditions of MHPs beneficiaries. New gadgets, including washing machines, butter churners, satellite televisions, computers, cell phones, fans, etc. have been acquired by community members, which has resulted in adding to their comfort and access to international media for information and entertainment. These gadgets have also decreased the workload on either gender through the replacement of labor-intensive activities. Community members have started using available time in productive activities and socialization. In Kalam, District Swat, electricity has encouraged extending the mobile phone services by connecting their towers to the MHPs electricity, which has considerably improved information sharing benefiting 6,000 population (individuals, businesses and public institutions).

In past 2 decades, SRSP installed 353 MMHPS with following ESG benefits:

Reduction of Co2 of 71,000 tons per annum

120 schools, benefitting over 22,000 students

17 basic health units and hospitals now connected, catering to 325 patients per day (majority women and children)

585 businesses supported through stable supply of low-cost electricity

Environmental, Social & Governance (ESG) Impacts:

To address energy poverty, improve energy security and decrease the rate of climate change by harnessing and distributing affordable hydroelectric power.
MHPs are planned and constructed aiming to provide low-cost, reliable and green energy to over 1M people in the poorest, off-grid communities, connecting small businesses, schools and primary health care facilities. These MHPs provide an opportunity to promote employability skills for locals with a focus on women, targeting Net Zero by 2030.

Hydel Impact – THE UN Sustainable Development Goal (SDGs)

MHPs are directly contributing to some of the Sustainable Development Goals of the United Nations. The practical illustration for one of the MHPs in Kalam is given below.

SDGs Impact of Kalam MHP Units

SDGs	Sustainable Development Goals Targeted	MHPs Contribution to SDG Impact
SDG-1	**No Poverty**	Approx **44,368 population** powering the local economy through a low-cost, reliable, energy supply and digital wellbeing access
SDG-3	**Good Health and Well-being**	A total of **5,546 households** were powered, including medical clinics, Hospital & digital health
SDG-4	**Quality Education**	**9 Nos** of education facilities powering and digital literacy

SDG-5	**Gender Equality**	More than **38** women-led jobs created. Releasing women from water fetching, focusing on gender-related impact targets.
SDG-7	**Affordable and Clean Energy**	**19.02 MWh** of renewable energy generated daily and supplied to **8606 Domestic** & **1257** Commercial consumers @ 50% discount to the national grid tariff.
SDG-8	**Decent Work and Economic Growth**	Approx **680** Direct jobs by reliable energy supply which is boosting local businesses, **235** No of small & medium enterprises including the tourism sector
SDG-9	**Climate Action (mandatory)**	Emission Reductions, on a daily basis, these plants replace diesel generation. This replaces a substantial greenhouse gas saving around **15.20 tonnes of CO2 per day**.

However, there has been direct and indirect contribution to all 17 SDGs.

Delivering on the 17 Global Goals for Sustainable Development.

- SDG #1 NO POVERTY (powering local economy, eco-tourism, hotels, remote jobs, etc., through low-cost, reliable energy supply and WiFi access)

- SDG #2 NO HUNGER (irrigation for agriculture)

- SDG #3 GOOD HEALTH AND WELLBEING (powering medical clinics and digital health)

- SDG #4 QUALITY EDUCATION (powering schools and digital literacy)

- SDG #5 GENDER EQAULITY (Hydel Impact is female-co-founded and female co-lead. Also, releasing women water-carriers; strong focus on gender related impact targets
- SDG #6 CLEAN WATER AND SANITATION (providing a source of potable water, communities will manage water resources for long-run sustainability of power source, indirectly ensuring access to safe water and sanitation for unlocking economic growth and productivity, and provide significant leverage for existing investments in health and education.)

- SDG #7 AFFORDABLE AND CLEAN ENERGY (providing energy source from nature at a 50% discount to national grid)

- SDG #8 DECENT WORK AND ECONOMIC GROWTH (reliable energy supply will boost local businesses)

- SDG #9 INDUSTRY, INNOVATION AND INFRASTRUCTURE (reliable energy supply on an economical tariff basis will facilitate the establishment and boost of cottage and hotel industries and fruit processing units)

- SDG #11 SUSTAINABLE CITIES AND COMMUNITIES (providing a source of renewable power for local villages)

- SDG #12 RESPONSIBLE CONSUMPTION AND PRODUCTION (promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for local communities)

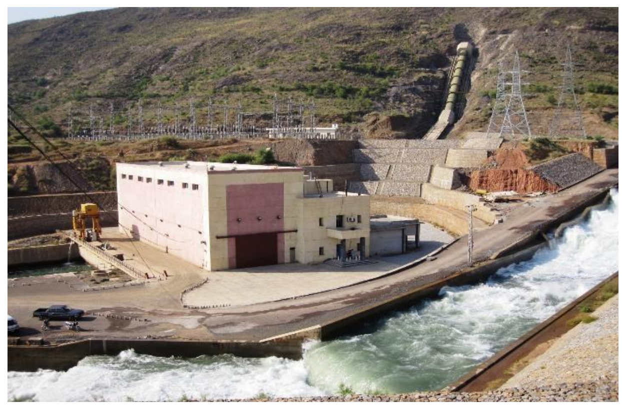
- SDG #13 CLIMATE ACTION (accelerating net zero through renewable energy sources

- SDG #14 LIFE BELOW WATER (management of water resources for long-term sustainability of energy sources will ensure prevention and reduction of marine pollution and promote fish farming)

- SDG #15 LIFE ON LAND (de-desertification, reforestation, irrigation for agriculture and bio-diversity)

- SDG #16 PEACE, JUSTICE AND STRONG INSTITUTIONS (targeting some of the causes of radicalization through opportunity, education, health and poverty eradication)

- SDG #17 PARTNERSHIPS FOR THE GOALS (public-private partnerships with NGO's and securing local government grants to co-fund capital costs)



Role of MHPs in Provincial Economy

Despite the huge potential for hydro power generation within the KP province, there was no appropriate realization of any potential positive role of hydro generation within the provincial economy till the construction and commissioning of Malakand-3 Hydro Power project in 2008.

S #	Name of Project / Location	Date of Completion	Installed Capacity (MW)
1	Malakand-III , Dargai	Nov-08	81
2	Pehur, Swabi	Mar-10	18
3	Reshun, Chitral	Sep-19	4.2
4	Shishi, Chitral	Jun-10	1.8
5	Machai	Oct-17	2.6
6	Ranolia	Oct-17	17
7	Daral Khawar	Sep-18	36.6
Total			**161.2**

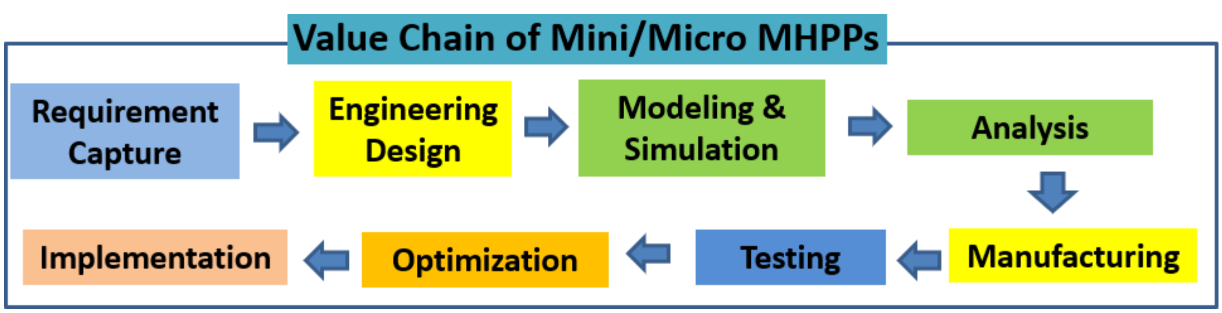
As per the PEDO record, during the past 14 years (since 2008-09 up to 2020-21), total revenue generated by the above-mentioned seven hydro power projects is worth PKR.30,491.46 million.

Besides the huge financial gain mentioned, there are many other added advantages in terms of employment
within these hydro power projects directly and through industry linked with these hydro power projects, with the province in another positive aspect of its contribution to the provincial economy.

S.No	Financial Year	Receipt (Rs Million)
1	2008-09	716.96
2	2009-10	1,891.64
3	2010-11	2,986.23
4	2011-12	1,835.29
5	2012-13	3,273.21
6	2013-14	2,643.30
7	2014-15	2,404.08
8	2015-16	2,708.88
9	2016-17	2,091.02
10	2017-18	2,287.21
11	2018-19	1,571.14
12	2019-20	3,302.40
13	2020-21	2780.1
Total		30491.46

Value Chain of Mini/Micro Hydro Power Projects

A standard value chain of mini/micro hydro power projects is shown below. Following such a value chain is advantageous in all respects since it ensures a quality product, full use of the energy potential and the resources, capacity building of the students, engineers as well as practitioners from participating industry & rural communities. Moreover, the activities may lead to the establishment of a center of excellence (COE) in the field of MHPs.



Gaps in the existing value chain of MMHPs

Although there has been a spurt of activity in MHPP in recent times, unfortunately, there has been no systematic technical development of mini/micro hydro technology to harness the true potential of numerous micro hydro sites in KP. Local design, manufacturing, and installation of MHPs fail to grasp the full potential of the site conditions because of the adoption of a non-engineering approach. As a result, the installed systems tend to stop/break down because of the poor design, mainly after a very short service period. Moreover, without periodic condition monitoring, such a value chain is missing from the

The process of harnessing the full potential is limited because of:

- Lack of technical expertise in the MHPP industry
- Compromise on the sustainability of locally manufactured turbines
- The installation of expensive/imported ELCs
- Untrained local manpower
- Unavailability of monitoring systems
- Old and rudimentary technology.
- Capacity issues in design & Fabrication.
- Non-availability of required Spares & services for O & M at Local Level (within the Districts)
- Limited number of Manufacturers/fabricators
- Limited number of required skilled persons both at the factory & community level.
- Non-availability of all services under one roof
- Limited attention in public and private sectors to fulfil the technological requirement of EME at the local/national level.
- Underutilization resulting in substantial surplus energy
- Non-compatibility & legal/technological hurdles of MMHPPs with the national Grid
- Huge Gap/vacuum in availability of authentic/certified O/M & management Models.

Therefore, it is imperative that a systematic and scientific approach is adopted in developing MHP-related technologies and providing crucial support in harnessing the potential of micro hydro sites across KP. Moreover, it should be well-augmented by providing post-installation condition monitoring and failure analysis technical support services.

The gaps in the above-mentioned value chain are basically the main hurdles in achieving the desirable results within the sector. Some of these are listed and explained below.

Unavailability of appropriate forums for sector development.

- Provincial entity/forum
- Sector-friendly policy
- Regulation
- Standardization
- Certification

Site identification:

So far, the typical and conventional potential site identification in MMHP sector is being followed, which results in various issues affecting the end product, wastage of resources and long-term sustainability of the constructed MHPs.

Serious Capacity Issues:

In the existing value chain of the MMHPPs, there are some very basic and serious gaps in the capacities and available facilities, which is constantly affecting the positive growth and development in the sector. Some of these are:

- Civil Structure designs
- Modeling, simulation & Analysis:
- Design &Fabrication/Manufacturing of Electro-mechanical equipment/assembly.
- Design & fabrication Alternators, drive, control & protection systems:
- Installation, testing & commissioning of electro-mechanical equipment at the site:
- Operation, maintenance & management of MMHPPs:
- No certification entity within the country/province
- Technology transfer
- Unavailability of a commercial business model
- Research. Innovation & development.(missing Link between Academia, industry & implementers)

Problem Statements

In KP, Micro hydropower is the alternative, being inexpensive and independent of all issues relevant to large systems because:

- Practical & viable way to provide electricity to the remote off-grid areas.
- low cost , affordable & reliable energy source
- Improvement in standards & quality of life of rural communities
- Opportunities for the use of appliances and communications
- Very Low T & D network cost
- Easily manageable
- Less time-consuming
- Low maintenance cost
- Basic technical and manufacturing, installation, testing, commissioning and O & M expertise locally available.

However, the mini/micro hydro sector is facing the following challenges.

i. **Standardization, Stakeholders mapping, and Regulation.**
There is no standardization within the MMHPs sector, neither at the country level nor at the provincial level. Lack of this standardization usually results in low-quality or less efficient MHP units with multiple other problems. Identification and formulation of minimum quality standards, design parameters, and fabrication standards would be very helpful for the sector. Also, there is still no stakeholder mapping or regulation entity from MMHPPs within the province/country. In the absence of appropriate stakeholder mapping, involvement of irrelevant actors is always there, which may just waste time and resources without any meaningful contribution to the sector.
Similarly, without any regulatory entity and bylaws within the MMHPs sector, there are always chances of wastage of potential sites, development of poor quality, low efficiency and low performing MHP units, duplication of efforts and resources.

ii. **Unavailability of authentic and accurate hydrological data**
Although the hydrological statistics of the main rivers are usually available with Irrigation,

water management and PEDO , however it is not available for every stream and source for hydro generation. The unviability of required hydrological parameters like flow, sediment accumulation, and boulder carrying capacity is assumed, which may go wrong and thus can reverse the whole project. The wrong assumption in flow rate may result in underutilization of the real, genuine potential site or otherwise.

iii. Site identification:

Currently, site identification in the MMHP (Micro/Mini Hydropower) sector follows conventional practices, which have resulted in several challenges:

a) There are no reliable prefeasibility assessments of potential MMHP sites available with the government, relevant organizations, or other stakeholders.

b) The target-oriented and project-based approach of a predefined number of sites with targeted output has always resulted in wastage of the full potential of the sites on one side and improper and inappropriate utilization of resources on the other side.

c) MHP sites with limited capacity (small units with less than 100 Kw) lead to insufficient power for economic opportunities.

d) Unavailability of required correct/authentic technical data for the potential sites

e) No regulation and coordination mechanism.

iv. Non-consideration of climate change factors in the design of civil structures.

Although sufficient and reasonable capabilities in design of civil structure (Intake, Power Channel, Gravel Trap, Silting Basin, head race, Forbey Tank, Tailrace) of MMHP project are available within the sector/province; however there is still need to incorporate the newly emerging challenge of climate change resulting from the global warming which are now causing frequent flash floods and unpredicted hydrological changes. For this purpose, some additional factors of safety in hydrological designs of civil structures may be considered at the design stage, like:

a. Inclusion of Proper protection of all the civil works components against the frequent and unexpected natural hazards.

b. Additional factor of safety against the high flood level.

c. Properly regulated control gates at the intake and escape points.

d. Increase in the free board in the power channel.

e. Required protection works.

v. Lack of designing capabilities in modern and most efficient turbines.

Similarly, there are huge gaps in the design of the electromechanical equipment in the sector within the province/country.

f. There is no existing or very limited design capability of modern and efficient EME equipment within the sector at the provincial or national level.

g. Due to the unavailability of the design capabilities for modern and more efficient electro-mechanical equipment, we are still stuck with old and outdated types of EME.

h. No standardization and regulation policy.

vi. Lack of fabrication/Manufacturing capabilities of modern/efficient turbines and other essential components, alternators, drive, control & protection systems of electro-mechanical equipment/assembly.

Despite the huge potential, requirement and priority for hydro Power generation, ironically, there are very few manufacturers or vendors for the fabrication of electromechanical equipment within Pakistan. Only five manufacturers within the country have the experience, required facilities and basic knowledge for the fabrication of EME equipment.

EME manufacturers within Pakistan

1. Mukhtiar Engineeering – Mardan (KP)
2. Green Hydro Engineering- Mardan (KP)
3. Hydrolink Engineering- Taxila (Punjab)
4. Chitral Engineering- Taxila (Punjab)
5. Lahore Engineering- Lahore (Punjab).

a. Limited manufacturing capabilities of all the existing manufacturers within the country.
b. No required machines and technology within their fabrication facilities/workshops under one roof.
c. No required skilled manpower
d. Lack of required scientific approach and capacity.
e. No facility or knowledge for selection of appropriate metallurgy for the turbine components.
f. Though the fabrication challenges may be countered through the machines and skills available within the national market of big cities like Lahore, Karachi, Gujranwala, Faisalabad, HMC Taxila, but that requires very effective and well-planned coordination, more precise efforts and effective management of dispersed resources.

g. No locally manufacturing facility for alternators within the country, and the entire dependence is on imports.
h. Conventional and very ordinary type of belt drive system is very common, which is far less efficient than the modern direct coupling drive system.
i. There is no capability or facility for the fabrication of an electronic load controller or hydraulic governor within the country.

vii. Installation, testing & commissioning of electro-mechanical equipment at site:

For local EME installation, testing and commissioning, reasonable capabilities and resources are available within the province/country, however, for imported EME, there are still some gaps in installation, testing and commissioning. e.g.

j. Unavailability of hi-tech preseason-based tools and equipment for installation with the vendors.
k. Appropriate required skills for installation, testing and commissioning.
l. Lack of required hi-tech gadgets for testing and commissioning.
m. Unavailability of standardized testing & commissioning protocols/SOPs.
n. Unavailability of an appropriate, certified and authentic testing entity within the province.

viii. Operation, maintenance and management:

For locally fabricated and small capacity MMHPs, adequate capabilities of operation, maintenance, and management are available within the sector, yet these still need some crucial measures for further strengthening. e.g.

- **a.** No Systematic approach and mechanism in terms of appropriate training of the concerned communities on O&M system is usually applied in the construction and installation of the MMHPs.
- **b.** No technical, backstopping or need-based Support provided to concerned communities in establishing a proper O & M system.
- **c.** No networking or linkages with existing service and spares providers within the province/country.
- **d.** No on-job technical & managerial support to the concerned communities.
- **e.** Non-Localized fabrication, installation, operations and maintenance parts & services.
- **f.** Lack of certified and authentic training facilities within the province/country.

However, for large capacity or MMHPs with imported EME, the operation, maintenance and management are usually beyond the capabilities of the community. In such a case, initially, involvement of an appropriate technical and managerial partner/organization is essential.

After shifting focus from operations, maintenance and management of MMHPS to the large capacity units, there is a huge vacuum in the field of operations, maintenance and management of MMHPs. Also, there are some other factors which need to be considered in applying any model for O & MM of the MMHPs. These may include:

- No existing appropriate authentic/certified & tested/successful model of O/M & management
- The issue of Scale, size, and inadequate capacities at the local level
- Demand for Quality Electricity.
- Management challenges at the Community level.
- Large beneficiary base
- Involvement of community & revenue
- Land & Water rights belonged to the community
- More complex and sophisticated EME, Civil works & T & D.
- Lack of technology and modern equipment, tools and gadgets for streamlining Operations, maintenance and management of MMHPPs.

ix. Limited or no involvement of academia, private investors & industry in the MMHPPs sector:

For Positive growth in any sector, a collaboration of academia and industry is pivotal.

All the innovation, research, and demonstration is sphere headed by the department of academia concerned, which is the main missing link in MMHPS sector due to the following reasons.

- Lack of sector-friendly policy.
- No attraction/incentives for private investors/industry
- Demand gaps (discontinuity).

- Unavailability of required resources with Academia
- Limited knowledge and awareness about the sector within academia.
- Low priority on the list of policymakers
- Unavailability of a formal, appropriate bridging and coordination forum.
- Lack of formal R&D systems.

x. Lack of efforts and strategy for Technology Transfer

For the last 3 to 4 decades, despite huge potential and scope, both public and private sectors have paid less or no attention to meet and fulfil the technological requirements of electromechanical equipment (EME) of MHPs at the local level. This can be judged from the fact that there are only a few local manufacturers who have the required capacity to design and fabricate turbines for micro hydro power stations in their workshops or factories. Due to this specific reason, the capacity of fabrication of electro-mechanical equipment at the domestic level is limited to 200 kilowatts and beyond that, they are importing EME from abroad, mostly China.

Furthermore, this capacity is also restricted to one or two types of Turbines, namely crossflow and Pelton, whereas internationally, both turbines have been obsoleted for the last decade due to low efficiency and high costs. It is a serious dilemma that there is not a single manufacturer in Pakistan that can design and fabricate modern, efficient turbines like Francis, Kaplan, etc. On the other hand, there is a huge scope and potential for enhancing the existing capacities at the local level for designing and fabrication of larger turbines as well as smaller ones based on modern techniques and requirements, with much better efficiency and desired output. This will bring down the dependency on the import of these turbines, hence a huge amount of resources and time would be saved.

Despite the potential and availability of some basic facilities and infrastructure (though limited), the sector is entirely dependent on imported and international markets for most of the components, especially the EME power house assembly of the MHP. For smaller capacity units, we are still stuck to the old rudimentary technology (cross-flow turbines, belt drive system, and local control & protection systems) with almost no focus or serious efforts nor strategy for the development in the sector through reverse engineering and technology transfer. The implications are:

- Technology transfer issues (Licensing is too costly).
- Wastage of time and resources in the import of the required equipment/items
- Dependency on external markets/vendors for O & M (again, costly and time-consuming)
- Negative implications on national & provincial economy.
- Relatively low-grade final product.
- Loss of genuine potential sites.

xi. Lack of capacity-building opportunities

Although huge investments have been made in the last decade in MMHPP sector, there was no attention or focus at all on the capacity building and enhancement of the local departments concerned, organizations, manufacturers or industry.

This lack of interest, attention and focus on capacity building within the province and country is mainly due to:

- Absence of research innovation and demonstration culture within the sector/province
- Missing link between academia and industry
- Sector-friendly policy
- Lack of required resources
- Limited existing potential vendors/market
- Less involvement of the mainstream departments and players within the country/province
- Unavailability of short, medium and long-term sector development strategies.
- Missing link of Strategic objectives in the available investments.

xii. No or limited awareness about the Business model in the MMHPS sector:

Although there is huge potential and opportunities for investments and business in the MMHPS sector for the private and public sectors, there is still not much focus and attention from the private sector/investor on the MMHPs as a "Business opportunity". Coupling with social aspects, one can generate a reasonable revenue stream from the sector if it is planned, implemented, and operated commercially as a business model. This lack of attention on business model development may be due to:

- No formal policy or regulation for the sector
- No attraction for the private sector/industry
- No authentic data and information about the potential and profitable sites.
- Unavailability of an appropriate business model for the sector
- No policy for interconnection with the GRID.
- Limited skills and capacities within the sector/ local or national market.

Proposed Appropriate Solutions

To solve the problem, the following solutions are suggested.

a. Constitute a Provincial forum comprising all appropriate & relevant stakeholders to develop and implement **Standardization, Stakeholder mapping, and regulation**

For real development of the MHP sector in the province, it is important to house the sector within an appropriate and proper public sector entity with clear, focused and sector-friendly TORs.

The best way to go about it is to form /constitute a provincial body/forum that comprises all important stakeholders having some relevance in the field of the micro hydro power sector. The ideal combination with tentative/draft TORs may be.

S#	Name of Entity	Proposed TORs
1	MHP Coordination Unit (Housed in Appropriate Government entity e.g. PEDO, P & D , Energy & Power department, KP)	**1.** Stakeholders Mapping **2.** Standardization for the entire Project cycle of MHPs (feasibilities, specifications, standards, costing, implementation models, O & M models) **3.** Advocacy for investment in the sector
2	Organizations working in MHPs sector for a minimum 5 years. (e.g SRSP, AKRSP, Integration, WWF, Zaif Foundation, etc.)	

<table>
<tr><td>3</td><td>Potential existing fabricators/manufacturers (Mukhtiar Engineering, Green Hydro Engineering, Hydrolink, Chitral Engineering, SK hydro etc.)</td><td>4. Regulation Strategy Development
5. Inputs/advice to the Government in sector-friendly policy making.</td></tr>
</table>

<table>
<tr><td>4</td><td>Donor/funding organizations with relevant experience (e.g GIZ, EU, UNDP, SDC, ADB, PPAF, KFW) etc.</td><td rowspan="4">6. Lead, initiate, support and encourage Support for research & Innovation within the sector
7. Relevant data and information centre
8. Networking (Academia, industry and implementers' strong networking)
9. Monitoring & Oversight
10. Backstopping support</td></tr>
<tr><td>5</td><td>Academia (UET-CNSIR , GIK, NUST, COMSAT)</td></tr>
<tr><td>6</td><td>Representation of Industry/Private sector</td></tr>
<tr><td>7</td><td>PEDO, PCISR, P&D (energy wing) , Energy & Power Department</td></tr>
</table>

b. Capacity building

The gaps related to the design capabilities identified in the problem statement are the bottlenecks for the micro hydro sector development within the province. These lack of capacities are almost in each step/component of the project cycle/value chain.

<table>
<tr><th>S#</th><th>Capacity Gape</th><th>Proposed Solution</th></tr>
<tr><td>1</td><td colspan="2">Design</td></tr>
<tr><td></td><td>Climate change implications in civil works design</td><td>Development of climate resilience measures/scope by involving academia</td></tr>
<tr><td></td><td>Designing modern, efficient turbines</td><td rowspan="4">Training of the relevant stakeholders including relevant human resources from Govt Department , Organizations, manufacturers, academia, industry)</td></tr>
<tr><td></td><td>Designing the Drive System</td></tr>
<tr><td></td><td>Designing of Control & Protection system</td></tr>
<tr><td></td><td>Designing of operating system</td></tr>
<tr><td>2</td><td colspan="2">Fabrication</td></tr>
<tr><td></td><td>Fabrication of Moving Parts (runner, wicket gates, etc.)</td><td>On The Job training of the potential technicians & manufacturers</td></tr>
<tr><td></td><td>Fabrication of the Drive system</td><td>On The Job training of the potential technicians & manufacturer</td></tr>
<tr><td></td><td>Fabrication of Control & Protection System</td><td>Exploring, involving and utilizing the local/national expertise, experience and knowledge through strong coordination & networking along with R&D (Academia, Industry, Implementing partners, donors etc.)</td></tr>
<tr><td>3</td><td colspan="2">Certification</td></tr>
<tr><td></td><td>Certification of available/potential manufacturer</td><td>Networking & MOUs with International & national certification entities, equipment &</td></tr>
</table>

	Quality Control & Assurance	service providers
4	**Installation, Testing & Commissioning**	
	Modern & Efficient EME Systems	Training of potential technicians/ manufacturers with the required tool kits and assets transfer
	Tools & Gadgets Required	
5	**Operation, maintenance & Management**	
	Spares and services are rare locally	Private entrepreneurship/workshops development
	Lack of trained and skilled human resources	Training facilities provisions

c. Technology Transfer

It is, therefore, SRSP suggests a '*Programme for Technology Transfer and Capacity Building for Designing and Fabrication of Most Efficient Micro Hydro Units at the local level*'. The programme will focus on enhancing the design capacities of local experts, both at the organizational and manufacturer level, upgrading manufacturing and fabrication (efficient modern types of turbines). capacities of local existing manufacturers, developing and training existing installation capacities of local existing manufacturers and available technicians, both at organizational and manufacturer level and reducing dependency on imported machinery and foreign experts, leading to cost and time efficiency in establishing micro and mini power stations. Under the programme, a local organization with relevant experience in the energy sector would be selected as 'focal' for spearheading the training and technology transfer programme. It would develop linkages with service providers (within or outside Pakistan) in developing training modules, imparting training and a follow-up system. In one year, the programme would develop a cadre of trained and specialized personnel, who would play a vital role in meeting the demand of local markets and ultimately the long-term sustainability of MHPs.

d. Research, Innovation & Development:

There is hardly any concrete and solid effort for encouraging any research, innovation and development/demonstration activity within the micro hydro power sector within the province. The main reason for this may be the huge gap between academia, industry, implementers and planners. Another reason could be the lack of interest, proactive role and visionary leadership within the mandated department driving organization in the public and private sectors. The 3rd reason may be the limited engagement of private investors/industry within the MHP sector, due to which the demand was never non-rated for the research, innovation and demonstration. Also, there has been no visible financial resource allocation for R&D, neither in the private nor the public sector.

Sufficient knowledge, expertise and experience in the field of research, innovation and development related to the micro hydro sector is available within the province/country. The missing link between industry, academia and the implanters has always been a major hurdle for R&D in MHP sector.

The suggested model/strategy for Research, innovation and development can be:

i. Identification of real field-related issues in all the stages of the MHP value chain or project cycle.
ii. Sharing of these issues/challenges with concerned stakeholders, including academia.
iii. Analysis of the challenges/issues at the academic level.
iv. Planning for specific issue-based research, innovation and development.
v. Creation of the R&D fund by one or all of the stakeholders concerned (Public sector, private sector, donors, manufacturers, etc.).
vi. Application on any appropriate site (Old or new, depending on the scope and desired objectives).
vii. Piloting and then replication.

Based on the evolved experience of the recent two decades in MHP sector, there are many areas and equipment which are best suited for R&D at the local/national level. Some of these include:

- Designing & fabrication of a local hydraulic Governor
- Designing and fabrication of an electronic load controller
- Designing and fabrication of an electronic governor
- Automation of regulatory Gates
- Designing and development of a local operating system SCADA.
- Designing and fabrication of a Flat belt drive system
- Designing and fabrication of quality control panels locally. Control system
- Designing and fabrication of the unit protection system
- Design and fabrication of HMI unit
- Design and fabrication of the excitation control system

One of the few notable research and development initiatives in this field has recently been undertaken by the Center for Intelligent Systems and Network Research (CISNR) at the University of Engineering and Technology (UET), Peshawar. This initiative focused on developing a set of innovative products designed to improve and streamline the operation, maintenance, and management of electricity generated through micro-hydropower (MHP) or other renewable energy sources—spanning the powerhouse, transformer, and consumer ends.

These products were tested and successfully demonstrated on SRSP-built MHPs in Kalam a few years ago. The products are:

✓ Electro-cure, Transfo-cure, Feeder Management system, Smart HVDS system,

e. Scope expansion of MHP-generated electricity

- Connectivity to the national Grid
- Net-metering Policy for MHPs, like for solar
- Establishment of Micro/Mini Grids

Although the MHPs are providing electricity to rural off-grid communities yet they may not be able to obtain maximum benefits from these MHPs due to various operation and maintenance issues, limited capacities leading to insufficient supply of energy for economic opportunities and, sometimes, unstable and unreliable transmission of power. The concept of establishing micro/mini by combining some of these MHPS installed/constructed in contiguous locations in one mini grid, which is best suited to provide essential access to electricity in rural areas from a single controlling system. Due to the remoteness of locations, the concept of establishing mini grids, using appropriate business models, represents a cheaper option than extending the national grid. This aims to establish and implement replicable and sustainable off-grid electricity generation to promote development and well-being. Mini Grids are cost-effective and present a minimal technical risk solution to address energy poverty in many parts of the country.

k. **No or limited awareness about the Business model in MMHPS sector:**

- By commercializing and scaling the tested and successful model of hydropower projects in Khyber Pakhtunkhwa (KP), Pakistan
- ROI: Potential for delivering a targeted annual financial return of 16% >
- To provide low-cost, reliable and green energy to people in the poorest, off-grid communities,

To address energy poverty, improve energy security and decrease the rate of climate change by ***harnessing and distributing affordable hydroelectric power***

Blended finance for social enterprise: a public-private partnership of donors and ESG investors.

- Investment size: $20M (50% donor-funded, * 25% loan, 25% equity)
- Return on Investment: 16% > (32% with half the capital costs donor funded)
- Payback period/exit: 5 – 7 years
- Tariff pricing: Three quarters of revenue from commercial customers at an average of PKR 15 to PKR 18; 25% of revenue from householders at an average of PKR 10 (50%-75% discount to national grid).

MHP: Business Plan Model			
1	MHP Name		MHP-1
2	District		Chitral
3	Installed Capacity	KW.	**10,000**
4	No of MHP	Rs.	**3**
5	Standard Avg Cost per KW	Rs.	**340,000**
6	Useful Life	Yrs.	**15**

7	Land Required *(per MHP 10 Kanal)*	KN	**30**
8	Per Kanal Land Cost (If purchased)	Rs.	**3,000,000**
9	Units Generated *(Power House per Hrs.)*	No.	**24**
10	Units Generated *(Power House No of Months)*	No.	**12**
11	Units Loss *(against Units Generated)*	%	**16%**
12	Domestic Connection *(Plan 1)*	%	**80%**
13	Commercial Connection - Plan 1	%	**20%**
14	Domestic Connection - Plan 2	%	**25%**
15	Commercial Connection - Plan 2	%	**75%**
16	Per HHs Units Consumed	No.	**100**
17	Per Commercial Units Consumed	No.	**300**
18	Monthly Expense *(Per KW)*	Rs.	**800**
19	Monthly Depreciation(Per KW)[1]	%	**1,200**
20	*Depreciation Fund Investment Rate*	%	**10%**
21	Return to Investor (Per KW)[2]	%	**8,000**
22	Connection Charges- Domestic	Rs.	**3,000**
23	Connection Charges- Commercial	Rs.	**7,000**
24	Institutional Cost against total Investment	%	**10%**
25	Exchange Rate Dollar	Rs.	**200**

If you want to change Rate of Return please make changes in RED BOX If you want to change EME & TLE Upgradation please make changes in GREEN BOX If you want to change No of Connection Please make changes in BLUE BOX

If you want to change Per Unit Tariff Please make changes in YELLOW BOX

Summary Of Business Plan		
Heads	**Rs.**	**$**
System Cost	3,400,000,000	17,000,000
Land Cost	90,000,000	450,000
Implementation Cost	558,760,000	2,793,800
Total Investment	**4,048,760,000**	**20,243,800**
Total - Return	14,400,000,000	72,000,000
Direct Return %		**23.7%**
After Dep Amount		**30.5%**
Tariff - Plan 1(Domestic 80% & Commercial 20% Connection)		**27.56**
Tariff - Plan 2(Commercial 100% Connection)		**28.94**

Conclusions and Recommendations

- MMHPs are the only viable and sustainable solutions for off-grid isolated areas.
- Constitution of the required active forums on the provincial level.
- Developing sector-friendly policy and implementation.
- Sufficient time and focus should be given to find appropriate, feasible sites.
- Adequate time and resources should be allocated for proper social, technical surveys, designs & feasibility.
- Reasonable cost should be allocated with no compromise on quality.
- Public-Private Partnership Model should be encouraged and expanded.
- An alternative & localized solution should be developed for post-completion services.
- Capacity building on modern, efficient EME should be part of the project & ensured.
- Dependency on imported equipment should be minimized.
- Govt should step in for standardization, regulations and quality control.
- Research, innovations & value additions should be a regular and constant feature in the hydro sector.
- Utilization of surplus energy by connecting MMHP to grid/wheeling arrangement
- Regulation Policy & Authority
- Involvement of Academia
- Technology Transfer

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KHYBER PAKHTUNKHWA SCIENCE AGENDA

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