

Micro Hydropower for Sustainable Development in Pakistan

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Abstract:

This paper describes energy mix of Pakistan and how micro hydropower projects are suitable short term solution for current electricity crisis and sustainable development in Pakistan. Pakistan is having a large micro hydropower potential in tribal and remote areas of Khyber Pakhtunkhwa, Azad Kashmir and Punjab. This paper also describes how we can provide source of employment for these rural and tribal areas and make them self dependent in electricity production and maintenance.

Keywords: Micro Hydropower, Renewable Energy, Sustainable Development, Pakistan Energy Crisis

Introduction:

Experts from all over the world are saying that world is heading towards global energy crisis due to huge dependency on fossil fuels to fulfill energy demand and decrease in availability of fossil fuels resources. Now a day major source of energy is oil and during last decades oil prices have been increased at a very high rate. At the same time consumption of oil is increasing day by day but there is downshift in the supply of oil. Although efficient methods have been developed for oil extraction and use, but at the same time world population is increasing at high rate increasing energy consumption.

Pakistan energy scenario is same like above. Energy is most important for economic growth of a country. In order to achieve and sustain a targeted economic growth rate, there is a need to fulfill country energy requirements. But unfortunately Pakistan is facing energy shortfall in oil, natural gas and electric power; this is negatively affecting country economy development. During last 15 years energy need of Pakistan has been increased by 86% from 34 MTOEs in 1994/95 (PIP, 2010) to 63.09 MTOEs in 2009/10 (Pakistan Energy Year Book, 2010). However, since 2006/07 energy supply is unable to meet the energy demand of country (PIP, 2010).

Natural gas is largest source of energy supply in Pakistan and contributing about 30.8 MTOEs (48.8% of total energy demand), secondly oil, contributing 19.8 MTOEs (31.4% of total energy demand), hydel power contributing 6.7 MTOEs (10.6% of total energy demand), 4.6 MTOEs from coal (7.3% of total energy demand) which is mostly imported, 0.7 MTOEs from nuclear and 0.06% from imported electricity (Pakistan Energy Year Book, 2010).

Natural gas is widely used in all sectors (residential, power, industrial, transport) of Pakistan. This was due to low gas prices and widely available source of natural gas in Pakistan. Due to this, a vast network was developed for transmission of gas throughout country and setups were developed for its consumptions. But due to economic crisis in world and low gas prices in Pakistan, new gas suppliers were not attracted either through new gas pipeline from other countries or exploring domestic reserves and country gas reserves are declining. If same scenario persists then Pakistan's gas supply will decline from 4 billion cubic feet per day in 2010/11 to 1 BCFD in 2025/26 (PIP, 2010).

Other major energy supply source of Pakistan is oil, mostly imported. Due to high oil prices in international market and by keeping in mind economic condition of country it is very difficult to fulfill energy need through oil.

Above of all major and most disturbing energy crisis in Pakistan, now a day, is electricity crisis. Electricity crisis is badly affecting Pakistan's economic growth and industrial sector. Electricity consumption of Pakistan is increasing day by day but electricity supply is not increasing at rate with which demand is increasing. This is due to the fact that our most of electricity production rely on oil and gas which are becoming expensive to buy and decreasing day by day. Pakistan has a huge hydropower potential. This is cheaper source of electricity. One method of exploiting hydropower of country on emergency basis is micro-hydropower technology. Which can be easily installed and is immediate source of electricity for rural community and a contribution towards national grid. Most of countries are focusing on micro/small hydro power to provide electrification to off grid area and to fulfill their energy needs as it is cheap, readily available and locally produced technology.

In Thailand, province Nakhon Ratchasima, many sites are considered for assessment of micro hydropower potential to provide electricity of its rural community. The output showed that there are 6 suitable projects on reservoir schemes and 11 projects on run-of-the-river schemes, both having potential of generating 6000KW and 320 KW respectively (Kosa *et al*, 2011).

A religious NGO in Ubangi and Mongala Subregions of northwest Zaire developed a micro hydropower system in Zairian Village. A hydro-electric power system of 370 KW was constructed. Water wheels were also built for pumping water to community and for grinding floor and hull coffee. Local technology was used to manufacture/fabricate different components of micro hydropower system and experienced was transferred to local people (Thornbloom *et al*, 1997).

In Nigeria there is a 360% growth in hydropower from 1971 to 2005 and only 5% of small hydropower potential has been trapped yet through a few number of systems built from 1923 to 1964. Government has taken steps to increase usage of renewable resource to fulfill energy needs

by encouraging private sector to invest in energy sector and suggestions have been given to government to provide subsidies and price reduction for small hydropower systems for its growth (Ohunakin *et al*, 2011).

Moldova has started efforts to exploits its renewable resources more and more. Share of renewable energy sources in energy consumption in Moldova was 3.6% of total energy consumption in 2005 and 3.2% in 2006. A goal of exploiting renewable energy sources 6% of total energy consumption was set by National Programme of RES in Moldova. Hydraulic resources were given second priority after biomass among renewable energy sources. Among hydro power potential, greater potential is for small hydropower development. In Moldova there are six small hydro plants installed with total capacity of 141 KW. Dinester River basin and Prut River basin are found best for hydropower projects (Karakosta *et al*, 2011).

In Spain in 2009, 23% of total hydropower electricity was produced by small hydropower plants. Small hydropower installed capacity is 10.6% of total hydropower installed capacity (Alonso-Tristán *et al*, 2011).

In Iran people felt that providing electricity to remote and inaccessible areas is not cost effective. So it was decided to use water resources of remote areas to fulfill their electricity demand. A study was performed to check the micro hydropower potential in province Lorestan's remote areas in Iran. Total 75 locations were found having micro-hydro potential. Out of 75 spots, 10 spots were selected as top priority hydropower potential for further case study due to urgency, availability of material and optimum head and flow rate. Designing of micro hydropower system has been started for 5 locations (Ghadimi *et al*, 2011).

Estimated small hydropower potential, an average of 25MW for each station, in India is 15000 MW and only 1509 MW of which is used upto May 2003. Now construction work has been started on 187 projects (Dudhani *et al*, 2006). In India a scheme has been started to provide small

hydropower systems of 15KW capacity for resident of hilly areas (Garg and Adhikari, 1998). Nepal and Sri Lanka have also started many micro/mini hydropower projects to provide electrification to off-grid rural areas (Palit and Chaurey, 2011).

In china, 19,000 micro hydropower plants of total capacity 687MW and 19606 mini hydropower plants of total capacity 7171MW were installed in a period from 1994 to 2004 (Jiandong and Damodaran, 2004). Moreover in china there is 128MW of small hydropower in rural areas that can be exploited and out of this 34.5MW has been installed (Peidong *et al*, 2009).

Taiwan has currently installed capacity of small hydropower plant 166 MW which is planned to increase to 300 MW by 2020 (Chen *et al*, 2010).

In turkey, from 1990 to 2002, the number of small hydropower electric projects has been increase from 55 to 71 (Dursun and Gokcol, 2010). At beginning of 2005, capacity of small hydropower plants increased to 190MW (Yuksel, 2010). During year 2006, 38 small hydropower plants of total capacity 79MW and 31 micro hydropower projects of total capacity 51MW come into operation (Kucukali, 2010). By 2010, national development plan aimed to exploit all hydropower potential of turkey. Estimated contribution of small hydropower to overall electricity generation, by 2010, was 5-10% (Yüksek *et al*, 2006)(Kaygusuz and Kaygusuz, 2002).

In Afghanistan, Provincial Reconstruction Team (PRT) installed a 7KW micro-hydropower plant in Padisaw village of province Nuristan. As a result of this project, there are 1 to 4 flourescent light in almost every house while situation was completely different before; no electricity in Padisaw village. (Hallett, 2009). On April 6, 2009 a micro hydropower plant of 60 KW capacity was installed on a stream in Dodarek, a village in Afghanistan, to provide electricity to 150 households in Dodarek, Dodailak and Gorkhal villages which were affected by war (DAI, 2012).

A learning base micro-hydro project was completed in Bolivia to motivate people to use this technology (Drinkwaard *et al*, 2010). In Lesotho, 22 sites were found feasible for installation of

mini and micro hydropower projects with a total capacity of more than 20MW (Taele *et al*, 2012). In US there are almost 500,000 sites have been identified having suitable small hydropower potential with capable capacity of 100,000 MW (Kosnik, 2010).

Materials and Methods:

Pakistan electricity crisis:

Pakistan is facing electricity crisis since last 5 to 6 years. Now it has become severe and during peak load period we face load shedding of 10-12 hours in urban areas and 14-16 hours in rural areas.

Pakistan has electricity capacity of 20,922MW upto 30th June 2010 (Pakistan Energy Year Book, 2010). During winters total estimated load is 10,000-12,000MW and during summers estimated load is 14,000-16,000MW. This means Pakistan has electricity capacity more than demand. Then why we have to face load shedding hours? To understand this, see electricity generation by source as illustrated in Fig.1.

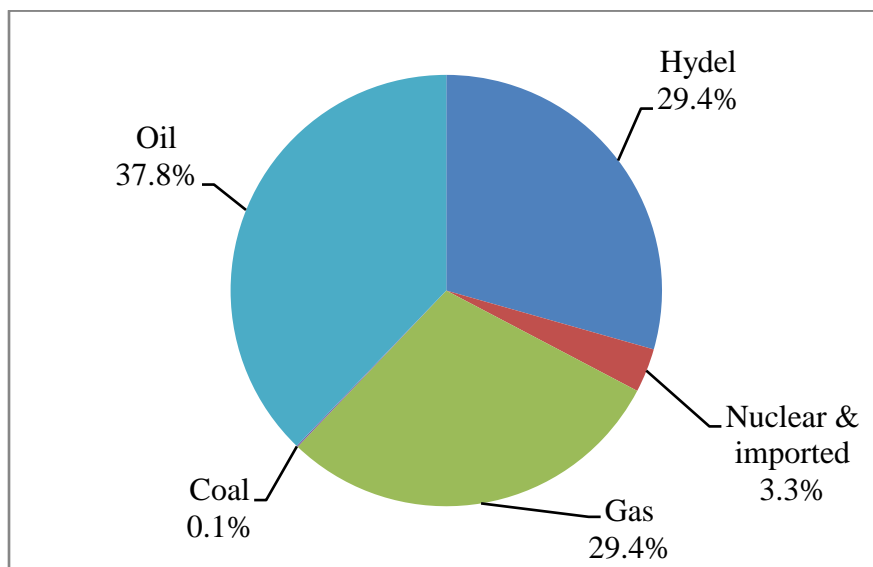


Fig. 1. Electricity Generation (By Source) in Pakistan 2009-10 (Pakistan Energy Year Book, 2010)

More than 68% electricity is generated by thermal power plants which run on oil and natural gas. But hydel part is 29.4% which is cheaper source. But price of oil is increasing day by day and their

resources are decreasing. On the other side attention have not been paid to discover more natural gas reserves and relied on previously discovered sources. As a result there is a gas shortfall which is certainly affecting country electricity generation. Due to less gas supply large amount of oil is imported to fulfill our electricity demand. Table 1 shows fuel consumption for thermal power generation.

Table 1. Fuel Consumption for Thermal Power Generation (Pakistan Energy Year Book, 2010)

Fuel	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	AGGR
Coal	80,481	66,812	73,551	72,568	50,341	56,141	-7.00%
Furnace Oil	3,308,574	4,076,897	6,521,503	6,741,614	7,210,211	8,339,330	20.30%
Diesel oil	55,899	32,176	45,125	168,449	173,947	262,499	36.30%-
Gas	10,305,897	8,694,561	8,640,101	8,492,919	7,830,065	7,106,962	7.20%
Total:	13,750,851	12,870,446	15,280,281	15,475,550	15,264,564	15,764,932	2.80%
Annual growth rate	12.54%	-6.40%	18.72%	1.28%	-1.36%	3.28%	

Unit: TOE

But import oil is not according to country need and it is costly, which results in less electricity production than demand and high electricity prices. Instead of going towards cheaper source of electricity, which is hydel, thermal power plants were installed as illustrated in Fig. 2.

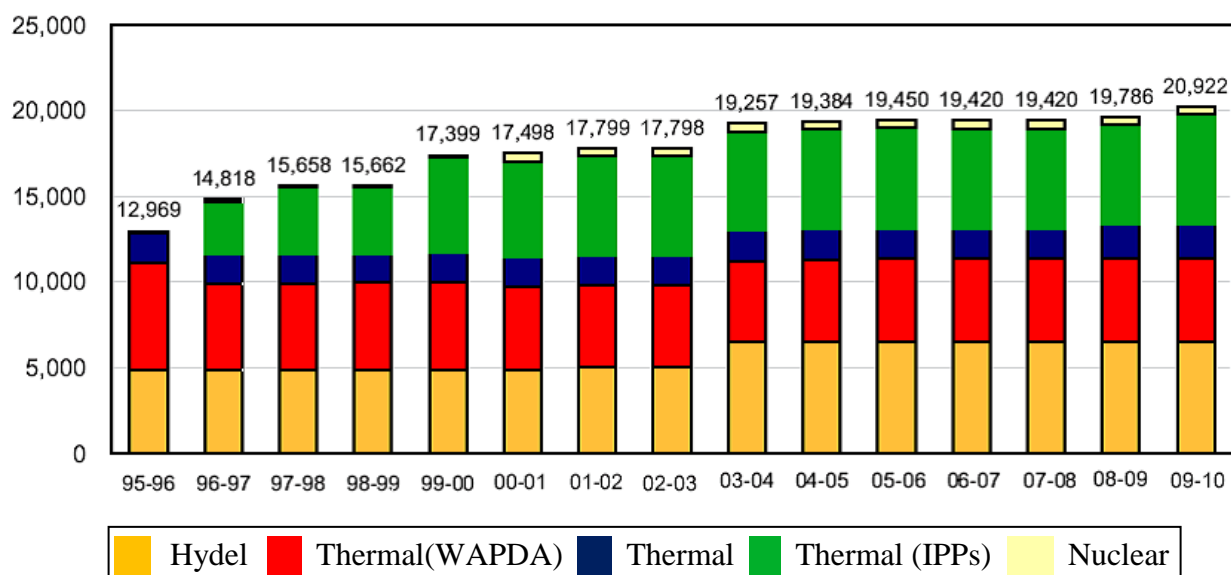


Fig. 2. Electricity Installed Capacity (By Type) in Pakistan (Pakistan Energy Year Book, 2010)

Pakistan is blessed with hydropower potential of 42,000MW but currently only 6500MW, 15% has been exploited (Asif, 2009). One method of exploiting hydropower is large-scale project. For large scale hydropower projects, large dams have to build which require large investment and displacement of people from their homeland. Building of dams has many geological impacts one of which is flooding of many cultivated land. If all above problems are covered then large- hydropower projects are long term projects which will serve in long run but may not overcome current shortfall.

So as short term plan, mini energy schemes should be considered which are readily available, requires less investment, readily installed and very low operating cost. Micro hydro power technology is a great solution to exploit hydro potential and to provide quick electricity supply to northern and remote areas as well as great contribution towards national grid. Pakistan has more than 1000MW micro hydropower potential mostly in northern areas of country but out of which only 10MW, 1% has been exploited (RE, 2005). Most of the areas of northern region of Pakistan are cut off from national grid (Asif, 2009). So through micro hydro technology power can be supplied to small communities of these areas to make them self dependent and additional power can be supplied to national grid.

Results and Discussion:

Micro hydro power technology:

Micro-hydro technology is a type of hydro technology in which large head is not required and there is no need to build large civil structure, dam for storage of water. Micro-hydro technology requires very small head which can be getting from rivers, lakes etc. of northern areas to run turbine and can provide electricity to rural communities and remote areas. Table 2 shows hydropower classification.

Micro hydro power technology is a very effective and best way to supply electricity to rural communities and remote areas of less developed countries. It will also be a future project in developed countries because of problems associated with the use of large scale hydro opportunities or their

Table 2. Classification of Hydropower Generation (Haider *et al*, 2011)

Hydro generator	Capacity	Feeding
Large	More than 100 MW	National power grid
Small	Up to 25 MW	National power grid
Mini	Below 1 MW	Micro power grid
Micro	Between 6 and 100 KW	Small community or remote industrial areas
Pico	Up to 5 KW	Domestic and small commercial loads

environmental effects. Micro-hydro power systems require a very low maintenance and lasts for more than 50 years. This technology is readily available and environment friendly. As compared with micro-hydropower projects, large-hydropower projects need a very solid and large concrete structure, a large land is flooded and many of people are displaced from their home land and have many environment issues.

Micro-hydro potential in Pakistan:

There are many sites in Pakistan where micro-hydel potential is available which can be utilized to fulfill need of local community and can be used to supply power to national grid. Let's take a look at installed capacity of micro-hydel systems in Pakistan, table 3.

Table 3. Micro-Hydropower Projects status in Pakistan (Pakistan Energy Year Book, 2010)

MICROHYDEL	
Feasibility/Designing completed	30
Civil Work completed	25
Construction of Power Houses completed	20
MHP plants installed	18
Generation capacity installed plant (18)	425 KW
Electricity generated per annum	2482000 Kwh
Market Prices electricity generated/annum	Rs. 24.82 million

A rough estimate of social and economic impact of these installed micro-hydropower projects on Pakistan is shown in table 4.

Table 4. Impact of Micro-Hydropower Projects in Pakistan (Pakistan Energy Year Book, 2010)

SOCIO-ECONOMIC IMPACT	
Houses electrified	2804
Employment generated	36 Nos.
Annual CO ₂ abatement	104244 kg

AEDB is developing feasibility study of 30 micro-hydel projects of 0.1 to 2MW capacity in northern areas (Sheikh, 2010). Different organizations have proposed many different micro-hydro projects at different sites in Pakistan. Names of these projects are listed below (Chaudhry, 2011):

Northern Areas:

In northern areas of Pakistan, there is 300MW potential of micro hydropower with installed capacity of 100 KW each (SARI, 2011). The appropriate technology development organization and northern areas works organization are undertaking the construction mini-hydel schemes at Narai, Seer, Thothi, Soor, Garhi, Harbankot, Sazine, Slove, Berh, Sogo Chillari, Songlo Kehlo, Kass, Kothay, Sakru, Khyber, Syamayar, Siggall, Stak, Mehdi, Hashupi, Kayu, Thalley, Manthokha, Niaslo Shigar, Ghandus, Thore, Chilas, Astore, Gorikote, Rattu, Brashing.

Azad Jammu and Kashmir:

The electricity department of Azad Jammu and Kashmir will be undertaking small/mini hydel projects at Kel, Neelum, Luat, Kundel shahi, Lipa and Kathai.

Khyber Pakhtoonkha:

The hydel development organization of Khyber pakhtoonkha will undertake several mini hydel projects at Shishi Gole, Garam Chashma, Ayun, Bouni, Thell, Ashouran and Dasu.

Attention should be paid on micro hydropower potential of Pakistan. Planned projects need to start soon. It will fulfill energy need of national grid and of rural and tribal areas but it will also provide a source of employment for people of rural and tribal areas. Micro-hydropower is very cost effective and cheap technology if local resources are used. Pakistan has many resources through which machinery

required for micro-hydel projects can be developed locally. Research has been done on use of pump as a turbine and centrifugal pumps are found suitable for use as hydraulic turbine (Dr. Williams, 1996). Instead of importing turbines, there are many local pump manufacturing companies and we can use our resources to use that locally manufactured pumps as a turbine. Steel pipe which is used as penstock can be easily manufactured locally and also electric generators can be manufactured locally. Micro-hydro power systems require very less maintenance, so maintenance training can be given to local resident. In this way we can make different communities self dependent.

Conclusion:

World is heading towards energy crisis. Today most of systems are depending on fossil fuel energy resources, which are declining day by day. Pakistan is facing similar energy crisis. Country most common energy sources are oil and natural gas. Most of electricity production depends upon fossil fuels. Oil price is increasing day by day and becoming a very expensive source of energy for less developed country like Pakistan. Today country is also facing natural gas shortfall, which was cheaper source of energy, because we have not paid attention on discovering new sources of gas and there is no immediate solution to cover our gas demand. Shortage and high cost of fossil fuels are affecting our electricity production and we face load shedding, severe condition in rural areas. Pakistan is blessed with very large hydropower potential but unfortunately these resources are not properly exploited. During our current electricity crisis, an immediate solution of electricity crisis and use of hydropower is micro-hydropower systems. Micro-hydropower systems require less investment, have less completion time and less available head. Pakistan is blessed with large hydropower potential in northern areas, Azad Kashmir, Khyber Pakhtunkhwa and Punjab. We can install micro-hydropower systems at different location and can supply electricity to local communities of rural areas and remote areas and excess production can be given to national grid. If micro-hydropower capacity of Pakistan is properly exploited then it can create better energy condition in village and remote areas simultaneously

creating jobs for young peoples in areas of fabrication and maintenance of different components of micro-hydropower systems such as turbine etc. Fabrication setups of micro-hydropower systems can be easily developed in Pakistan and local people can be easily trained for its maintenance. So we can train local people for its fabrication and maintenance. In this way we can make rural communities self dependent and it will be a source of employment for them.

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