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Small, Mini, Micro and Pico Hydro Power Plant: Scope, Challenges &Deployment in Indian Context

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Abstract — *As per present power crisis small hydro, non-conventional plants may be planned to work during peak demand. Small hydro is one of the best options for rural electrification which can offer considerable financial benefits to the individual as well as communities served. It is an attractive alternative to diesel technologies in rural and remote areas of developing countries as a means of achieving rural electrification. With the advancement of technology it is possible to harness hydroelectric power efficiently with heads as low as 2 meters. An approach by which multiple micro scale hydro generating units can be planned over a catchment area consisting of several potential installation sites so as to extract the maximum possible energy per unit investment cost. As a cheap, renewable source of energy with negligible environmental impacts, small, mini, micro & Pico hydro power technologies have an important role to play in future energy supply, particularly in developing countries.*

Integrated generation and distribution for rural area on fuel availability, small hydro capacity on run-off the river shall improve the availability and reduce energy cost. The maximum water level below the falls, during the record flood is used as a reference to find standard project flood protection equipment. The purpose of the paper is to develop an understanding about the various technologies used in the field to study performance of small, mini, micro, pico Hydel schemes. This study facilitates to take effective measures for reducing the cost which are also given. Usually small hydro units up to 5 MW are expected to require minimum amount of field assembly and installation work. While machine having capacity from 5 MW to 25 MW may have slow speed, large diameter and with split generator stator that require final winding assembly in the field.

Keywords- *Non- Conventional energy, Mini-Hydro Generation System, Small-scale hydropower, turbine, run-of-river, Renewable Energy, Economic Assessment of Small Hydro Power*

I. INTRODUCTION

The bulk of our energy comes from coal, oil, and natural gas exhaustible resources that create pollution when burned and contribute to global warming. Renewable energy (RE) is non-polluting energy that comes from inexhaustible resources, such as wind, sunshine, and falling water. Due to increasing global interest on conservation of environment, distributed generation of power is gaining attention. They do not encounter the problems of population displacement and can improve overall energy picture of the world. These are the clean, pollution free, eco-friendly energy sources. The hydroelectric power is the principal source of electric power in some 30 countries, and provides about one fifth of the world's annual electrical supply. Its power stations include some of the largest artificial structures in the world.

Figure below shows classification of hydro power plant on the basis of different aspect is done. Here we also introduce comparison of hydro power technology with other renewable and potential of different types of hydro power plant is introduced.

a.) Classification according to the availability of head:
1) Low head power plants (<10m) 2) Medium head power plants (10-50m)
3) High head power plants (>50m)

b.) Classification according to the nature of load:
1) Base load power plants 2) Peak load power plants

c.) Classification according to the quantity of water available:
1) Run-off river plant without poundage. 2) Run-off river plant with pond age.
3) Storage type plants. 4) Pump storage plants. 5) Mini and micro-hydel plants.

d.) Classification based on the power development by the plant:
1) Large hydro plant. (>100MW) 2) Medium hydro plant. (15-100MW)
3) Small hydro plant. (1-15MW) 4) Mini hydro plant. (>100KW)
5) Micro hydro plant. (5-100KW) 6) Pico hydro plant. (>5KW)

e.) Classification based on the purpose:
1) Single Purpose 2) Multi-Purpose

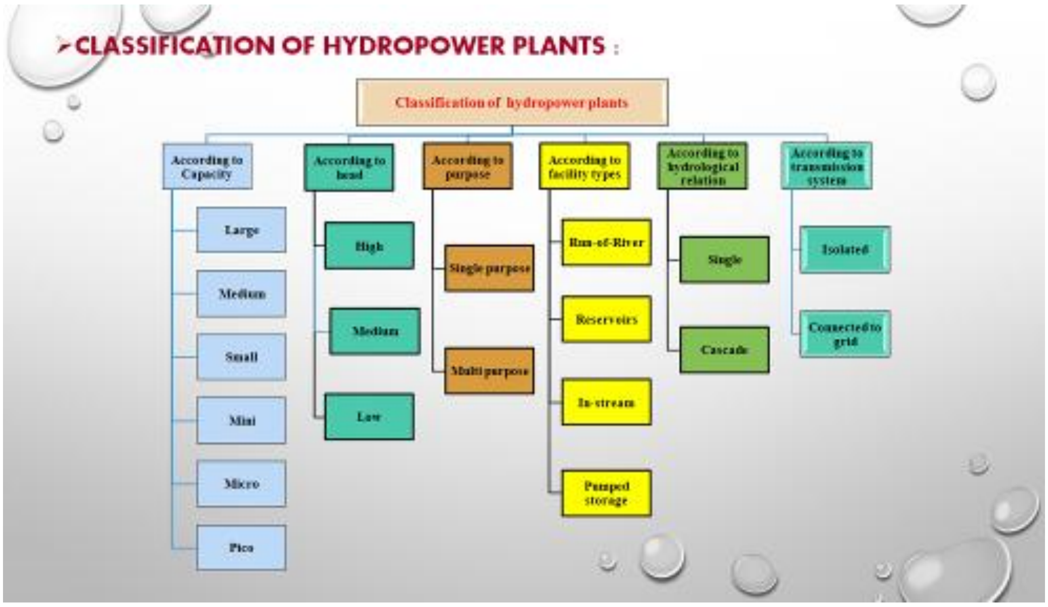


Fig.1 Classification of hydro power technology (Courtesy: http://www.slideshare.net/search/)

1.1 Comparison of hydro power with other renewables:
Hydropower is a renewable energy source where power is derived from the energy of moving water from higher to lower elevations. It is a proven, mature, predictable and price competitive technology.

Table 1: Renewable Energy Comparison (Courtesy: www.orfonline.org)

SOURCES/ PARAMETERS	BIOMASS	SOLAR PV	WIND	SMALL HYDRO
Potential capacity (MW)	61000	50000	45000	15000
Grid Interactive Installed Capacity (MW)	1083	46	14989	3153
Off-Grid Capacity Factor (MW)	122 MWeq	2 MWp		
Estimated Capacity Factor	70%	20%	14%	50%
Electricity Generation Cost (Rs./KWh)	4-5	12-20	3.5-4.5	3-4

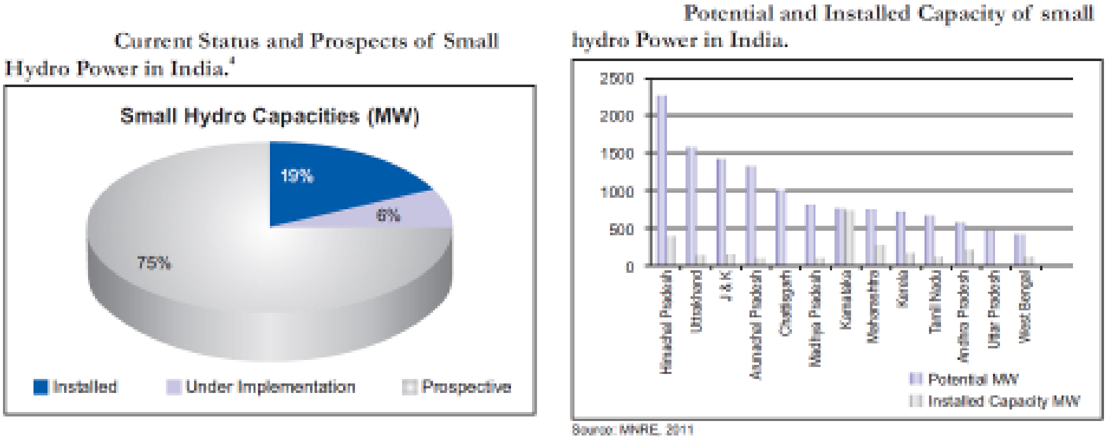


Fig.2 Comparison of hydro power technology with renewable (Courtesy: www.orfonline.org)

II. SMALL,MINI,MICRO,PICO HYDRO POWER TECHNOLOGY:

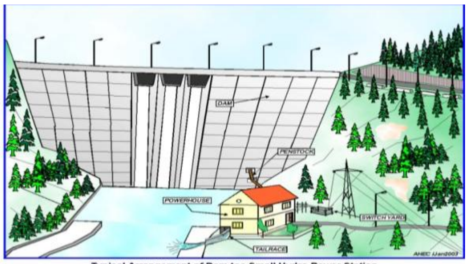
Small hydro is the development of hydroelectric power on a scale serving a small community or industrial plant. The definition of a small hydro project varies but a generating capacity of up to 10 megawatts (MW) is generally accepted as the upper limit of what can be termed small hydro. This may be stretched up to 30 MW in the United States, and 50 MW in Canada.
Small hydro works on the same principle as large hydro for electricity generation. The turbine converts the energy from falling water into rotating shaft power, which in turn gets converted into mechanical and electrical energy. In most of the cases, Small hydro is 'run of the river'; in other words, any dam or barrage is quite small, usually just a weir and generally

little or no water is stored. Power, P, is the energy converted over time or the rate of work being done. The Power, P, which can be extracted from a water flow; is: **P = η Q H ρ g**
Where; **η** is the efficiency of the system, **Q** is the total volumetric flow, **H** is the head, ρ is the water density, and **g** is the gravitational constant

2.1 COMPONENTS & WORKING OF SMALL HYDRO: "Mini-hydro" means which can apply to sites ranging from a tiny scheme to electrify a single home, to a few hundred kilowatts for selling into the National Grid. Small-scale hydropower is one of the most cost-effective and reliable energy technologies to be considered for providing clean electricity generation. The key advantages of small hydro are:

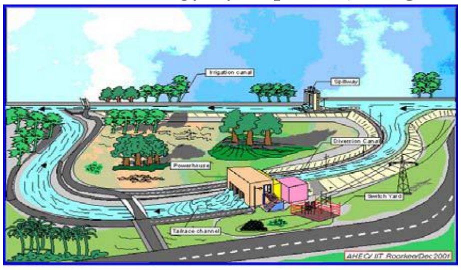
- High efficiency (70 - 90%), by far the best of all energy technologies.
- High capacity factor (typically >50%)
- High level of predictability, varying with annual rainfall patterns
- Slow rate of change; the output power varies only gradually from day to day (not from minute to minute).
- A good correlation with demand i.e. output is maximum in winter
- It is a long-lasting and robust technology; systems can readily be engineered to last for 50 years or more.

 Storage schemes Hydropower plants with reservoir: (1,528 MW)Manic-5, Québec, Canada



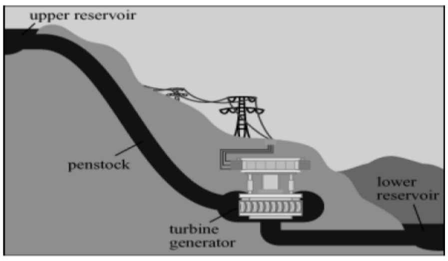
Typical Arrangement of Dam toe Small Hydro Power Station

 Instream technology hydropower(Narngawal,, India)

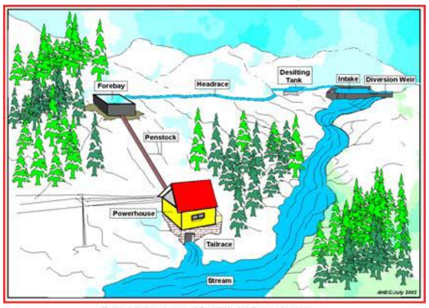


Typical Arrangement of Canal Fall Small Hydro Power Station

 Pumped storage schemes (Goldisthal, Thüringen Germany)



Run-of-River (ROR) schemes with poundage (Shivasamudram, heritage, India) (sources: http://www.slideshare.net/search/)



Typical Arrangement of Small Hydro Power Station

Fig.3 Typical arrangements of small Hydro power Scheme (Courtesy: http://www.slideshare.net/search/)

Small hydro is in most cases "run-of-river"; in other words any dam or barrage is quite small, usually just a weir, and little or no water is stored. Therefore run-of-river installations do not have the same kinds of adverse effect on the local environment as large-scale hydro. Fig.3 presents the forms of hydro power project exist in India.In practice, sites that are suitable for small-scale hydro schemes vary greatly. They include mountainous locations where there are fast-flowing mountain streams and lowland areas with wide rivers. In some cases development would involve the refurbishment of a historic water power site. In others it would require an entirely new construction. This section illustrates the four most common layouts for a mini hydro scheme.

To develop a small hydropower plant, there are a lot of considerations to be taken which are:
1) Hydrology and site survey 2) Measurement of head 3) Measurement of flow
4) Civil work components
- Weirand intake
- Channels
- Settling Basin
- Spillways
- Forebay tank
- Penstock

5) Selection of turbine
- Impulse turbines
- Reaction turbines

6) Drive systems 7) Electrical power

Various heads of turbines

Turbine type	Head range in meter
Pelton	50 to 1770
Francis	10 to 350
Turgo	50 to 250
Kaplan and Propeller	2 to 40
Cross flow(Michell- Banki)	3 to 250

Specific speed

Turbine	Specific speed
Pelton	8.5 to 47
Turgo	30 to 85
Cross flow	20 to 200
Francis	85 to 188

Fig.4: Selection turbine for small Hydro power Scheme (Courtesy: International Journal of Thermal Technologies Vol.1, No.1 (Dec. 2011))

A variation on the canal-and-penstock layout for medium and high-head schemes is to use only a penstock, and omit the use of a canal. This would be applicable where the terrain would make canal construction difficult, or in an environmentally-sensitive location where the scheme needs to be hidden and a buried penstock is the only acceptable solution.
For low head schemes, there are two typical layouts. Where the project is a redevelopment of an old scheme, there will often be a canal still in existence drawing water to an old power house or watermill. It may make sense to re-use this canal, although in some cases this may have been sized for a lower flow than would be cost-effective for a new scheme. In this case, a barrage development may be possible on the same site. With a barrage development, the turbine(s) are constructed as part of the weir or immediately adjacent to it, so that almost no approach canal or pipe-work is required.

2.2 SPECIFICATION & STANDARD: [21]

The Ministry of New and Renewable Energy is giving financial subsidy, both in public and private sector to set up SHP projects. In order to improve quality and reliability of projects, it has been made mandatory to get the project tested for its performance by an independent agency and achieving 80% of the envisaged energy generation before the subsidy is released. In order to ensure project quality/performance, the ministry has been insisting to adhere to IEC/International standards for equipment and civil works. The subsidy available from the Ministry is linked to use of equipment manufactured to IEC or other prescribed international standards. The equipment in the project is required to confirm to the following IEC standards.

Equipment	Standard
Turbines and generator (rotating electrical machines)	IEC 60034 – 1: 1983 IEC 61366-1: 1998 IEC 61116-1992 IS: 4722-2001 IS 12800 (part 3) 1991
Field Acceptance Test for Hydraulic performance of turbine	IEC 60041: 1991
Governing system for hydraulic turbines	IEC 60308
Transformers	IS 3156 – 1992 IS 2705 – 1992 IS 2026 - 1983
Inlet valves for hydro power stations & systems	IS 7326 - 1902

Fig. 5: IEC/International standards for equipment and civil works
(Courtesy: http://www.ahec.org.in/pdf/New_Standards/GL_for_spcn_of_control_monitoring_and_protection.pdf)

REFERENCES AND CODES:[27] Recently the Ministry has given an assignment to AHEC, IIT Roorkee to revisit the existing standards and come out with standards/manuals/guidelines for improving reliability and quality of small hydro power projects in the country.

- IEEE Std 1020 - IEEE guide for control of small hydro electric power plants
- IEEE Std 1010 - IEEE guide for control of hydroelectric power plants
- IEEE Std 60545:1976 - Guide for commissioning operation and maintenance of Hydraulic Turbines
- IEC 61116:1992 - Electro mechanical guide for small hydroelectric installations
- IEEE std 1046 - IEEE application guide for distributed digital control and monitoring for power plants
- IEEE std. 1249 - IEEE guide for computer–based control for power plant automation
- IEEE std. C 37101 - IEEE guide for generator ground protection
- IEEE std. C 5012 - IEEE standard for salient pole 50 Hz and 60 Hz synchronous generator and generator / motors for hydraulic turbine application rated 5 MVA and above
- IEEE std 4214 - IEEE guide for preparation of excitation system specification
- ANSI/ IEEE std 242:1996 - IEEE recommended practice for protection and coordination of industrial and commercial power systems
- ANSI/ IEEE std C 372-1987 - IEEE standard electrical power systems device function numbers
- ANSI/ IEEE std C 37.95 : 1974 - (R1980) IEEE guide for protective relaying of utility
- ANSI/ IEEE std C 37.102:1987 - IEEE guide for generator protection
- MASON, CR - Art & science of protective relaying 1956
- AHEC/PFC/FINAL REPORT 2002

III. SMALL HYDRO POWER IN INDIA: CHALLENGES & POTENTIAL[8],[9]

3.1 Barriers / Challenges:

Most of the challenges facing small hydropower exploitation are not specific to hydropower but generic for all types of renewable energy and rural electrification projects. General barriers for renewable energy projects are the absence of clear policies on renewable energy, limited available budget to create an enabling environment for mobilizing resources and encouraging private sector investment, and the absence of long-term implementation models that ensure delivery of renewable energy to customers at affordable prices while ensuring that the industry remains sustainable.

Table 2: State wise identified sites and installed projects with capacity in MW.

S.No	Name of State	Identified number of sites	Total Capacity in MW	Projects Installed	
				Nos.	Capacity (MW)
1	Andhra Pradesh	377	250.50	57	178.850
2	Arunachal Pradesh	452	1243.47	68	45.240
3	Assam	40	119.54	3	2.110
4	Bihar	74	149.35	7	50.400
5	Chhatisgarh	132	482.82	5	18.050
6	Goa	4	4.60	1	0.050
7	Gujarat	287	186.37	2	7.000
8	Haryana	23	36.55	5	62.700
9	Himachal Pradesh	457	2019.03	61	141.615
10	Jammu & Kashmir	208	1294.43	32	111.830
11	Jharkhand	89	170.05	6	4.050
12	Karnataka	468	1940.31	70	441.250
13	Kerala	207	455.53	16	98.120
14	Madhya Pradesh	85	336.33	9	51.160
15	Maharashtra	221	484.50	29	209.330
16	Manipur	99	91.75	8	5.450
17	Meghalaya	90	197.32	3	30.710
18	Mizoram	53	135.93	16	17.470
19	Nagaland	84	149.31	9	20.670
20	Orissa	206	217.99	6	7.300
21	Punjab	204	270.18	29	123.900
22	Rajasthan	55	27.82	10	23.850
23	Sikkim	70	214.33	14	39.110
24	Tamil Nadu	155	373.46	14	89.700
25	Tripura	10	30.85	3	16.010
26	Uttar Pradesh	211	267.06	9	25.100
27	Uttaranchal	354	1478.24	88	80.670
28	West Bengal	141	213.50	23	98.400
29	A&N Island	5	1.15	1	5.250
	TOTAL	**4861**	**12,841.81**	**604**	**2005.345**

Looking specifically at small hydropower development, the following barriers can be identified:

- <u>Policy and regulatory framework:</u> unclear or nonexistence of policies and regulations that govern the development of (small) hydropower. In some countries hydropower developments under a certain threshold arenot regulated at all, while in other countries it might be part of a broader regulatory framework for rural electrification in general. Generic frameworks often lack clarity on a number of hydropower specific issues like access to water and water infra-structure and the associated payments.

- Financing: hydropower developments are faced, even more than other sources of renewable energy, with high up-front costs and low O&M costs, something most available financing models do not favour. Nearly all of the new developments on the continent are relying in one form or the other on donor financing. Development of alternative financing models, including tapping into alternative funding sources, is needed to facilitate small hydro developments.
- Capacity to plan, build and operate hydropower plants: national and regional knowledge and awareness on the potential of small hydro in rural electrification is missing or very mini-mal. This includes knowledge at political, government and regulatory entities, as well as knowledge on local production of parts and components.
- Data on hydro resources: linked to the limited knowledge about the technology is the lack of proper resource data on water availability and flow on which hydro developments can be based.

3.2 Scopes / Potential:
The total hydroelectric power potential in the country is assessed at about 150,000 MW, equivalent to 84,000 MW at 60% load factor. The potential of small hydro power projects is estimated at about 15,000 MW.

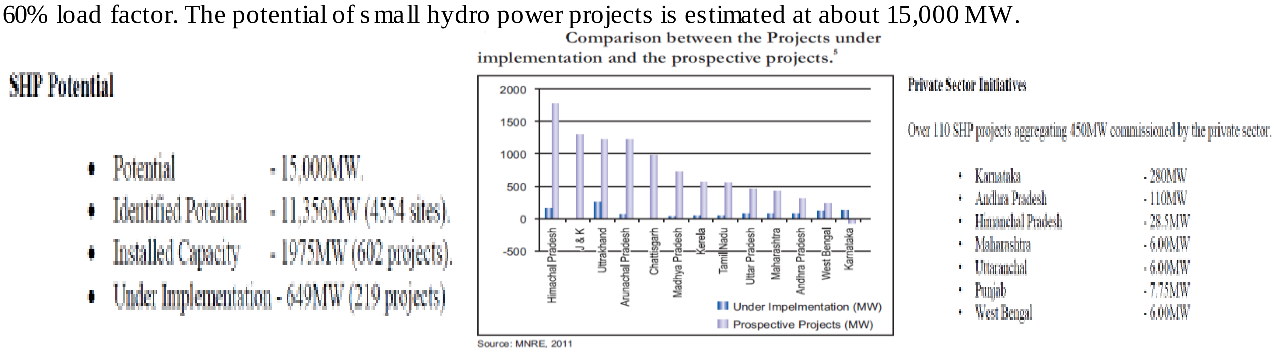


Fig. 6: SHP Potential and implementation
(Courtesy:http://ijesat.org/Volumes/2014_Vol_04_Iss_02/IJESAT_2014_04_02_20.pdf ,http://www.youtube.com/watch?v=1EU1FhtHbbs)

Of this, 4,861 potential sites with an aggregate capacity of 12,841 MW have been identified. The Indian small hydropower development programme received a new dimension and tempo after the liberalization of the economy and invitation private sector for investment in power. The private sector was attracted by these projects due to their small adoptable capacity matching with their captive requirements or even as affordable investment opportunities [8], [9]. In line with Government of India policy, some states announced their policy for inviting private sector to set up SHP projects and announced buy back rate for purchase of power from renewable energy projects.

IV. DEPLOYMENT OF SMALL,MINI,MICRO & PICO AT A GLANCE IN INDIA

4.1 PICO HYDRO POWER IN INDIA[8],[9],[10]**:** A 1 kW Pico hydro provides 24 kWh of 220 V, 50 Hz AC power per day in Karnataka for last 4year and all available equipment can be used by farmers who have access to quality power. The hydro systems have impacted the lives of the villagers as it provides an uninterrupted power supply and fulfils their electricity requirements positively. A number of installations have been made in remote locations which have no grid connectivity. Equipment includes lights, TV, grinder-mixer and household items. Some of the villagers run small businesses on the power generated from the power plant as an income generating activity.(http://mnre.gov.in/file-manager/akshay-urja/january-february-2012/EN/39.pdf)The Union ministry of new and renewable energy (MNRE) declared a financial aid to the tune of Rs 110,000 to establish 'Pico hydroelectric power projects' to promote hydroelectric power projects of 5 kW and below in Kerala.(http://www.sustainabilityoutlook.in/news/india-financial-aid-pico-hydro-projects-kerala-tendersinfo-india#sthash.UyQ908Xe.dpuf)

THIRUVANANTHAPURAM: To promote hydroelectric power projects of 5 kW and below in Kerala, the Union ministry of new and renewable energy (MNRE) has announced a financial assistance to the tune of Rs 110,000 for setting up 'Pico hydroelectric power projects' in the state.
The Energy Management Centre, Kerala, is the nodal agency for identifying potential investors for setting up the Pico hydroelectric projects in the state. According to centre director Dharesan Unnithan, Idukki and Wayanad districts have been identified as highly potential areas for setting up the projects. The scheme can be implemented in other districts as well, except Alappuzha. Financial assistance would be given to 50 projects on a first-come-first-served basis.
(http://timesofindia.indiatimes.com/city/thiruvananthapuram/Rs-1-10-lakh-central-aid-for-50-pico-hydro-projects/articleshow/17748207.cms)

4.2MICRO HYDRO POWER IN INDIA [8],[9],[10]**:** In the State of Uttarakhand, Uttarakhand Renewable Energy Development Agency (UREDA) is constructing MHPs for remote village electrification as well as for grid feeding. So far 44 MHPs of composite capacity 4.29 MW have been commissioned and more than 300 Villages & Hamlets have been electrified through these projects. Earlier the projects were constructing on turn-key basis but from year 2005, Govt. of **Uttarakhand** has decided to construct MHPs for village electrification on community participation. For construction of MHPs, tripartite Agreements have been signed between UREDA, Alternate Hydro Energy Center (AHEC), IIT, Roorkee and Concern User Energy Committee (UEC). As per tripartite Agreement AHEC, IIT, Roorkee is providing technical specialized services for construction of MHPs, preparation of DPR etc. and UREDA is providing its services for monitoring, funding and guidance to UECs.
The **Ghatta** is a traditional waterwheel with a vertical axis used extensively in the Himalayan region. The water generally hits the waterwheel from above while the axis of the waterwheel is vertical. The turbine (waterwheel) is made out of wood to enable simple building and repair techniques to be used. As a consequence of this design the traditional waterwheel have very low efficiency and power output (maximum 12 kW).

4.3 MINI HYDRO POWER IN INDIA[8],[9],[10]**:** 5 small hydro power projects of Uttarakhand Viz Lacchiwala micro hydro project, Ramgaarh laghu jal vidyut pariyojna, Niti micro hydel project, Khairana (ramgarh) micro hydro project and Malari micro hydro power project.
Lacchiwala is a village situated on the foothills of Mussoorie. It is alongside NH 74 and is 20 km from Dehradun towards Haridwar. Song is the river that provides all irrigation facilities to the farmers. Apart from irrigation facility it also acts as a source of hydro-electric power. The village has a capacity of 200 villagers. The hydro power has a capacity of 7.5kW but runs at capacity of 5 kW.
Ramgaarh project is situated on the banks of the tributary of river Kosi Ramgaarh. Its location is 30 km down towards **Haldwani** on Almora- Haldwani National Highway. The total capacity of the project is 5kW (1kW x 5). It was established during the year 2006-07 under UREDA. The project has been benefiting 10 families of the village Dopakhi (Bargal). It is a multipurpose project with electricity generation capacity as well as facility of flour mill (Punchakki) and Dhan machine.
Niti Micro Hydel Scheme has been identified on the stream Ghat gadera in Chamoli district of the hilly region of Uttarakhand. The project is well connected by metalled road upto Gamashali and up to 200 metres foot track upto Niti. The diversion/intake site is about 0.75 km from Niti village. The powerpotential available with the project is 25kW (1 x 25).
Khairna is a village situated on the foothills of Almora. It is alongside of NH 87 and is 20 km from Bhimtal towards Almora. Ramgaarh is the river that provides irrigation facilities to the farmers. Apart from irrigation facility it also acts as a source of hydro-electric power. The village population is about 400 in numbers. The micro hydro power plant is setup by UREDA, as an initiative to provide electricity to the area. It was established in the year 1990. The micro hydro power has three turbines two of them in operation.
Malari is a village in hilly area, which do not have much of power requirement due to being undeveloped, since it is situated in a remote area. The village is cut of from the Ganges plain by the Garhwal range of greater Himalaya which comes under the great Himalayas. The 50kW plant (2 x 25kW) has now become the life line of village as it caters to the need of 90 families of the village and a border outpost establishment of Indo Tibetan Border Police (ITBP) force. The power plant taps water from a local rivulet called Malari gaarh, though most of the time and only 25kW electricity can be produced due to paucity of water. 50kW is being produced only in the month of June, July and August. The power plant has to be stopped in the month of January, February due to freezing of water. Due to electrification of village the living conditions in the village has improved and the Government have succeeded to check migrating population from the village.

4.4 SMALL HYDRO POWER IN INDIA [8], [9], [22]**:** The Indian Renewable Energy Development Agency (IREDA) started financing private sector SHP projects. Consequent to the ESMAP study, in 1993-94, the World Bank offered a line of credit worth US$ 70 million to IREDA to be utilized to support SHP projects on irrigation dams and canals for a target capacity of 100 MW.
The credit line moved successfully and IREDA could sanction 33 SHP projects with an aggregate capacity 113 MW by the year 2000. Following this World Bank offered a second line of credit worth US$ 110 million to IREDA, Today the SHP programme in India is essentially private investment driven. 133 private sector SHP projects of about 605 MW capacity have been setup. Private sector entrepreneurs are finding attractive business opportunities in small hydro and state governments also feels that the private participation may be necessary for tapping the full potential of rivers and canals for power generation. The Government of India announced the Electricity Act in 2003, Electricity Policy in 2005 and Tariff Policy in 2006 to create a conducive atmosphere for investments in the power sector.
Hydropower plants range in size from small systems for a home or village to large projects producing electricity for utilities. The sizes of hydropower plants with design & application aspects comparison are described below in table 2.

Top Ten SHP potential State

State	Sites (Nos)	Potential in MW	Achievement in MW
Himanchal Pradesh	323	1624	141.61
Uttaranchal	354	1478	75.67
J&K	201	1207	111.83
Karnataka	258	652	416.50
Maharastra	234	1160	209.33
Kerala	252	514	98.12
Tamil Nadu	147	338	89.70
MP	85	336	51.16
U.P	211	267	25.10
A.P	286	254	---

Fig. 7: Hydro power Scheme at a glance in India (sources: http://www.slideshare.net/search/)[21]

V. PERFOMANCE ANALYSIS[16]

As there is limited availability of coal and other fossil fuels, hence for total upliftment of country, growth of remote places is must With these analysis may results and suggestions of new technologies can be developed so that overall cost will reduce, efficiency will increase, and such schemes will be attractive especially for standalone & grid connected applications. Comparison with other Non-Conventional energy sources based on parameters of Site selection, Grid connection problems, operation, maintenance & control problem, economic consideration and impact on environment are also considered. Hydrological information is obtained from the meteorology or irrigation department usually run by the national government. This data gives a good overall picture of annual rain patterns and likely fluctuations in precipitation and, therefore, flow patterns. The site survey gives more detailed information of the site conditions to allow power calculation to be done and design work to begin. Flow data should be gathered over a period of at least one full year where possible, so as to ascertain the fluctuation in river flow over the various seasons. The constraints and problems arising in development of power hydel schemes are demonstrated.
Performance evaluation studies of the projects under taken are Environmental, Social and Technical aspects like Utilization factor, Plant outage factors are considered.

Table 2: Performance of Hydro power Scheme in Uttarkhand (Courtesy: *http://www.renewablesfirst.co.uk/hydro-learning-centre/what-is-the-difference-between-micro-mini-and-small-hydro/*, *http://www.engineering.lancs.ac.uk/lureg/nwhrm/project/Joule%20Centre%20conf%2008/krompholz.pdf)*

Hydel Scheme	Typical Power	Flow	Runner Diameter	Application	No. of Home Powered
Large	>100 MW	>100 m^3/s	>2m	Feeding in large Grid, Large urban population centres	100,000+
Medium	15- 100 MW	>50 m^3/s	1.5 to 2m	Feeding in a Grid, Medium urban population centres	10,000-100,000
Small	1 to 50 MW	> 12.8 m^3/s	> 0.8 m	Feeding in Grid Small communities with possibility to supply electricity to regional grid	10,00-10,000
Mini	100 to 1,000 kW	0.4 to 12.8 m^3/s	0.3 to 0.8 m	Stand alone or often Feeding in a Grid, Small factory or isolated communities	100-10,00
Micro	< 100 kW	< 0.4 m^3/s	< 0.3 m	Power for small community or rural industry in remote areas away from the grid. Small isolated communities.	5-100
Pico	Upto 5 kW	<0.1 m^3/s	<0.05m	Remote areas away from grid, 1 – 2 houses.	0-5

Say example of Uttarakhand have an immense scope of development of micro hydropower projects as large number of river ulets runs along its land but following data shows performance and evaluation.

Table 3: Performance of Hydro power Scheme in Uttarkhand (Courtesy: http://www.slideshare.net/search/)

Sr. No.	Name of the Project	Utilization Factor	Plant outage factor
1	Lacchiwala Micro Hydro Project	0.66	0.37
2	Ramgaarh Laghu Jal Vidut Pariyojna	0.80	0.33
3	Niti Micro Hydel Project	0.88	0.08
4	Khairana (Ramgrah) Micro Hydro Project	0.80	0.30
5	Malari Micro Hydro Power Project	0.54	0.65

Moreover most of the villages are situated along these rivulets only and at many places there is even more than one, these are the lifeline of the villages. The local people call them gaarh and these gaarhs can be proved as the energy boosters of the villages.

The major problems faced by these projects due to which the plant outage factor is elevating are-:

1. Paucity of water.
2. Breaching of conduits.
3. Very high flow during rainy seasons.
4. Silt and muddy water during periods of high discharges.
5. Freezing of water.
6. Problem of fragile ice.
7. Non availability or inaccessible grids to tap up surplus energy produced.
8. Wear and tear of conveyor belt.
9. Large time lapsed in repair and replacement of parts due to remoteness of power plants.

Following remedial measures are suggested to minimize the plant outage factor.-:

1. Connecting two or more gaarh where available.
2. Lining of conduits, as it will also reduce losses as well as breeching will be checked.
3. Making proper arrangement for disposing surplus water during high discharge.
4. Installation of filters.
5. The fragile ice can be avoided by building up turbulence where its deposition creates problem. For eg. put ribs inside the penstock.
6. Foam method may also be used as in other countries to deal with ice.
7. Extending grids to the micro hydropower plants where surplus energy is produced.

VI. CONCLUSION [21]

Small hydro power plants are usually up to capacity of 15MW whereas mini hydro plants are above 100KW but below 1MW either stand-alone scheme or more often feeding into the grid. Mini hydel schemes can be constructed on dam-toe, canal drops, and return canals of thermal power stations and also in the flowing small river as well as small revolute which are flowing usually nearby villages. Area required for the construction work is small as canal already exists. It requires very small gestation period and such power stations can be ready for generation within 3 years, in contrast to the large hydro schemes. Micro hydro plants ranging from a few hundred Watts for battery charging or food processing application up to 100KW usually provided power for small community or rural industry in remote area away from the grid. Micro Hydro Power Schemes are already been constructed at the deserted weir and contribution to approaching to Directive EU for renewable energy sources. But to transmit power to such remote places is very costly, which gives rise to Pico-hydro power plants that does not require construction of dams and hence considered as run-off-river. The designed discharge is constant for canal drop project. But for runoff river project there are considerable changes in the discharge available as the river flow is seasonal. During dry season, the flow rate is so slow, that existing stand-by (diesel generator) unit would have to be used to supplement the available generation.

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