

STATUS OF SMALL HYDRO POWER IN INDIA

ABSTRACT

Hydro energy is the most reliable and cost effective renewable energy source. Among all the renewable energies, hydropower occupies the first place in the world and it will keep this place for many years to come. Amongst the renewable energy sources, small hydropower is one of the most attractive and probably the oldest environmentally benign energy technology. The small hydropower project can be developed economically by simple design of turbines, generators and civil work. Small hydropower systems use the energy in flowing water to produce electricity. Although there are several ways to harness the moving water to produce energy, run of the river systems, which do not require large storage reservoirs, are often used for micro hydro and sometimes for small- scale hydro projects.

The position of hydro plants becomes more and more important in today's global renewable technologies. The cost effective way to bring electricity to remote villages that are far from transmission lines. It is expected to increase more rapidly than demand for other forms of energy. Hydro electric energy is worldwide responsible for some 2600 TWh of electricity output per year.

INTRODUCTION

Small and mini hydel potential can provide a solution for the energy problems in remote and hilly areas where extension of grid system is comparatively uneconomical and also along the canal systems having sufficient drops. The small hydro potential could be developed economically by simple design of turbines, generators and the civil works. Small and mini hydel capacity aggregating to about 1975 MW is in operation, and Government is determined to provide thrust for developing the assessed small hydel potential at a faster pace henceforth.

POTENTIAL SHP SITES IN INDIAN SCENARIO

An estimated potential of about 15,000 MW of small hydro power exists in India. Ministry of Non-conventional energy sources has created a database of potential sites of small hydro based on information from various states and on studies conducted by Central Electricity.

Authority 4,554 potential sites with an aggregate capacity of 11,356 MW for projects up to 25 MW capacity have been identified. Installed capacity is 602 sites with capacity of 1975 MW. The database is being continuously updated.

STATE WISE IDENTIFIED POTENTIAL SMALL HYDRO SITES UP TO 25 MW CAPACITY

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
Maharashtra	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	---

While in early 90s, most of the SHP projects were set up in the public sector, from last 10 years or so, most of the capacity addition is now coming through private sector projects. Beginning of the 21st century saw near commercialization in the small hydro sector. Private sector entrepreneurs found attractive business opportunities in small hydro and state governments also felt that the private participation may be necessary in tapping the full potential of rivers and canals for power generation. The private sector has been attracted by these projects due to their small adoptable capacity matching with their captive requirements or even as affordable investment opportunities. In line with Government of India policy, 18 states have announced their policy for inviting private sector to set up SHP projects. 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. Small hydropower projects are now governed by these policies and the tariff is decided by the State Electricity Regulatory Commissions (SERCs) as per the Tariff Policy.

SHP VIS A VIS OTHER RENEWABLE ENERGY SOURCE AS A COMPARATIVE VIEW

SHP is considered renewable source. In comparison with other renewable methods of Generation of Power, SHP is more advantageous.

Cost of generation

Generation cost comparison of various renewable energy sources

S. No.	Type of Plant	Cost (Rs)
1	Cost of Generation/unit in SHP	1-1.50
2	Cost of Generation/ unit in Biomass	1.75-2
3	Cost of Generation/ unit in Wind	2-2.75
4	Cost of Generation/unit in Solar Photo-voltaic	10-12

TABLE 1: Comparison: Per Unit Cost of Generation by Renewable Methods

Efficiency

Efficiency is very high in case of small hydro power plants. Table shows efficiency comparison of various Renewable energy sources

S.No.	Type of plant	Efficiency
1.	SHP	85-90%
2.	Biomass	35%
3.	Wind	40%
4.	Solar Photo-voltaic	15%

TABLE 2: Efficiency Comparison of Renewable Generation Methods

Life

Life of SHP plant is very high. It is of the order of 60-70 years. Table shows useful life span of various renewable energy sources

S.No.	Type of plant	Life span (in Yrs.)
1	Biomass plant	30
2	Wind plant	20
3	Solar plant	20
4	Solar Photo Voltaic	15

TABLE 3: Life Span Comparison of Renewable Methods

Yield Factor

It is the ratio of the quantity of energy produced by an installation during its lifetime and the energy required during its operation and disposal including secondary energy.

Plant	Yield factor
Small hydro	80-100
Large hydro	100-200
Photovoltaic	3-5
Solar (thermal)	20-50
Wind power	10-30

CLASSIFICATIONS OF HYDRO PROJECTS

Classifications of Micro, Mini & SHP in India

- ❖ Up to 100KW – Micro Hydro Power
- ❖ 101Kw to 2000Kw – Mini Hydro Power
- ❖ 2001Kw to 25000Kw – Small Hydro Power

Classifications Based on Head

- ❖ Ultra Low Head – Below 3 meters
- ❖ Low Head – Less than 40 meters
- ❖ Medium/High Head – Above 40 meter

ADVANTAGES OF SMALL HYDRO POWER

- ✓ Environmental protection through CO₂ emission reduction, No Greenhouse Gas Emissions
- ✓ Proven and reliable technology
- ✓ Inflation free energy due to absence of fuel cost
- ✓ Reduces the dependency on imported fuels
- ✓ Improves the diversity of energy supply
- ✓ Grid Stability
- ✓ Reduced land requirements
- ✓ Local and regional development
- ✓ Good opportunities for technology export
- ✓ Assists in the maintenance of river basins
- ✓ High Energy payback ratio
- ✓ Cost effective energy solution
- ✓ Power for developing countries

COMPONENTS OF SHP

For generations water has been used as a source of energy by industry and by a limited number of utility companies. Harnessing a stream for hydroelectric power is a major undertaking. Careful planning is necessary if a successful and economic power plant is to result.

State water laws and environmental concerns must be determined. Precise field data must be gathered to compare the amount of power that can be expected from a hydroelectric installation to the electrical requirements of the home or farm. Then detailed plans that consider both construction and maintenance can be drawn up.

Perhaps the greatest mistake made when considering small hydroelectric installations is the overestimation of a proposed plant's capability. This bulletin will help you start the planning of a small power plant on a given stream of water. One of the first steps in planning is to measure the power potential of the stream. The amount of power that can be obtained from a stream depends on:

- ✓ The amount of water flow
- ✓ The height which the water falls (head)
- ✓ The efficiency of the plant to convert mechanical energy to electrical energy.
- ✓ State water laws and environmental concerns

Factors for the selection of site for Small Hydro Power Plant

- Climate
- Condition of main road to the area, weight and width limitations on bridges.
- Access to site and space for structures and site roads.
- Foundation conditions and slope stability
- Developable head
- Penstock/head length ratio
- Availability of construction materials (sand, aggregates, lumber and Impermeable fill, as required)
- Local services and skills availability
- High water levels and tail water and head pond flow rating curves
- Others

Components of Small Hydro Power Plant

Reservoir

Storage during times of plenty for subsequent use in times of scarcity is fundamental to the efficient use of water resources. The management of reservoirs and the lands which supply them is, therefore, a matter of great importance. Water stored is not only used for power generation, but also for irrigation, flood control, water supply and navigation. A reservoir may be natural like a lake on mountain or artificially built by erecting a dam across a river. The main purpose of reservoir is to store the water during rainy season and supply the same during dry season. Water held in upstream reservoir is called storage, whereas water behind the dam at the plant is called pondage.

Dam

The function of the dam is to increase the height of the water level behind it which ultimately increases the reservoir capacity. The dam also helps to increase the working head of the power plant. Many times high dams are built only to provide the necessary head to the power plant. (The head is the vertical distance from the surface of the water at the dam down to the water in the stream below where the turbine is located.) The higher the dam or head, the greater the power a given amount of water will produce. A dam also provides a storage basin to regulate stream flow and thereby increases power potential.

Intake or control gates

These are the gates built on the inside of the dam. The water from reservoir is released and controlled through these gates. These are called inlet gates because water enters the power generation unit through these gates. When the control gates are opened the water flows due to gravity through the penstock and towards the turbines. The water flowing through the gates possesses potential as well as kinetic energy.

Weir

Normally you would need to build a low weir (1 m to 2 m high) across the stream at the intake to the pipeline, to form a head pond. This head pond would:

- (a) Ensure a high enough water level to keep water always above the top of the pipe.
- (b) Allow some of the sediment in the stream to settle out before entering the sediment trap,
- (c) Allow an ice sheet to form, giving some protection against water freezing in the pipeline, and
- (d) Provide pondage (water storage) to compensate for one or two-day water shortages.

Forebay

The forebay serves as a regulating reservoir, temporarily storing water when the load on the plant is reduced and provides water for initial increment of an increasing load while water in the canal is being accelerated. In many cases, the canal itself may be large enough to absorb the flow variation, if the canal is long; its end is sometimes enlarged to provide the necessary temporary storage. In short, forebay is naturally provided storage which is able to absorb the flow variation. This can be considered as a naturally provided surge tank as it does the work of the surge tank. The forebay is also provided with some type of outlet structure to direct water to the penstock depending upon load conditions.

Trash Rack

The water intakes from the dam or from the forebay or provided with trash rack to prevent the entry of debris which might damage wicket gates and turbine runners or chock up the nozzles of impulse turbine.

If winters are severe the special provision is made to trouble from ice, sometimes air bubbling system is provided in the vicinity of trash racks which brings warmer water to the surface of trash rack.

Penstock

A pipe between the surge tank and prime mover is known as penstock. The penstock is a long shaft that carries the water towards the turbines where the kinetic energy becomes mechanical energy. The force of the water is used to turn the turbines that turn the generator shaft. The turning of this shaft is known as rotational kinetic energy because the energy of the moving water is used to rotate the generator shaft. The work that is done by the water to turn the turbines is mechanical energy. This energy powers the generators, which are very important parts of the hydroelectric power plant; they convert the energy of water into electricity. Most plants contain several generators to maximize electricity production.

The concrete volume of a typical penstock intake is approximately 15. QP m³ and net cost can be estimated as:

$$C1 = 15.Qp.fl$$

where:

QP = plant flow (m³/s)

fl = unit price of reinforced concrete (Rs/m³) C1 = cost of intake (Rupees).

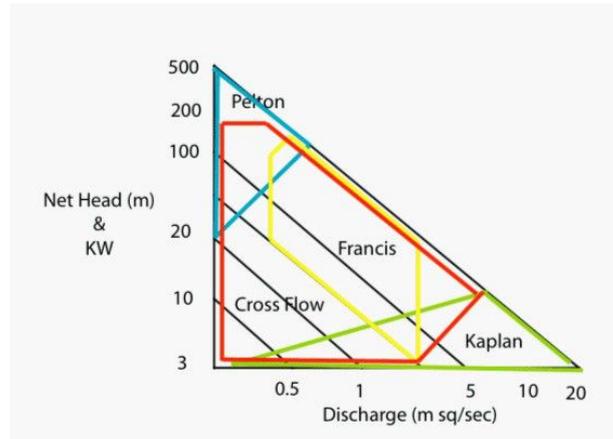
Turbine

A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

While there are only two basic types of turbines (impulse and reaction), there are many variations. The specific type of turbine to be used in a power plant is not selected until all operational studies and cost estimates are complete. The turbine selected depends largely on the site conditions.

A reaction turbine is a horizontal or vertical wheel that operates with the wheel completely submerged a feature which reduces turbulence. In theory, the reaction turbine works like a rotating lawn sprinkler where water at a central point is under pressure and escapes from the ends of the blades, causing rotation. Reaction turbines are the type most widely used.

An impulse turbine is a horizontal or vertical wheel that uses the kinetic energy of water striking its buckets or blades to cause rotation. The wheel is covered by a housing and the buckets or blades are shaped so they turn the flow of water about 170 degrees inside the housing. After turning the blades or buckets, the water falls to the bottom of the wheel housing and flows out.



Classification of turbines w.r.t Discharge(Q) & Net Head

Generator

The generators are comprised of four basic components: the shaft, the exciter, the rotor, and the stator. The turning of the turbines powers the exciter to send an electrical current to the rotor. The rotor is a series of large electromagnets that spins inside a tightly wound coil of copper wire, called the stator. “A voltage is induced in the moving conductors by an effect called electromagnetic induction.” The electromagnetic induction caused by the spinning electromagnets inside the wires causes electrons to move, creating electricity. The kinetic/mechanical energy in the spinning turbines turns into electrical energy as the generators function.

IMPORTANT PARAMETERS DETERMINING POTENTIAL ASSESSMENT OF A SITE

The two important parameters that are essential for determining the potential assessment of site are the **head** (which would generate the required rated power by appropriately locating the powerhouse, forebay, the power canal and the intake) and the **discharge**.

The discharge data for the site has to be collected over a number of years because installed capacity of a hydro plant cannot be based on discharge data of one year. We might have very high rainfall in a particular year but next year could be dry. So installed capacity has to be based on discharge available over a period of 10- 15 years so as to have more realistic estimates.

The following aspects need to be taken care of while taking flow measurements:

1. Depth of stream should be adequate at the place of flow measurement and location should be so chosen that measurements can be done easily.
2. Flow should be steady (not changing significantly) during the period of measurement.
3. Flow should be measured by at least two different methods so that results are authentic.

Measuring Flow

MEASURING FLOW with a FLOAT

STEP 1: MEASURING CROSS-SECTION AREA

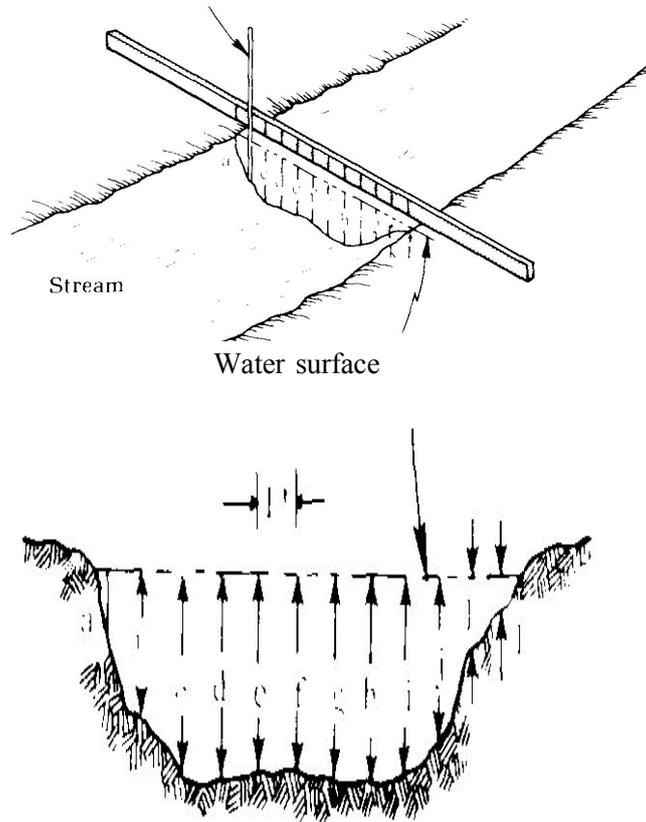


Fig. : Cross-section Area on Stream Average

$$\text{Depth} = \frac{\text{Sum of measured depths}}{\text{Number of Intervals measured}}$$

STEP 2: MEASURING WATER VELOCITY STEP

STEP 3: CALCULATING FLOW RATE

The flow rate is calculated by the formula:

$$Q = 0.83 \left(\frac{bd}{144} \right) \left(\frac{100}{t} \right)$$

Q = flow rate, cubic feet per second

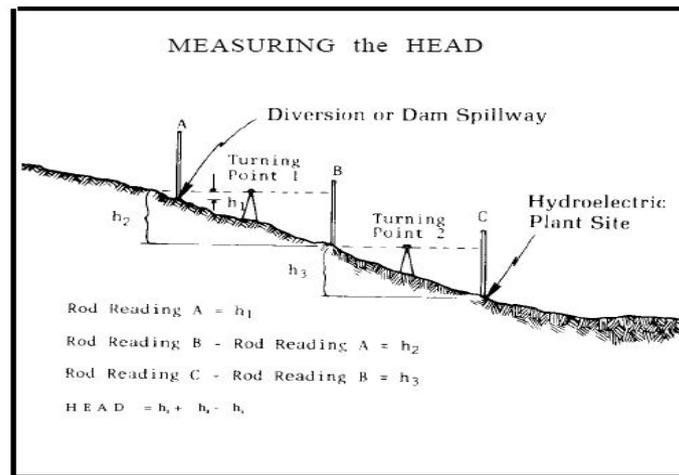
b = stream width, inches

d = average stream depth, inches

t = time for float to drift 100 feet, seconds

Measuring Head

After the height of the water behind the proposed dam or diversion has been decided, it is necessary to measure the head of water that will result. To determine the difference in level between two points, set a surveyor's level about midway between the points. Have an assistant hold a surveyor's rod at one point, sight through the level and record the height reading on the rod. Move the rod to the second point and read. The difference of the readings is the difference in elevation of the two points. Often it is impossible to see the two points from a single setting of the level so rods must be read at intermediate or turning points. The differences in readings between each pair of points can be added together to calculate the total elevation drop from the dam or diversion.



Method for Measuring the Head

Case Study & Discussion

Stream: "Kandheri"- Near Assar Block Headquarters

Location: NH-1B 12 kms from Batote on Doda J&k - Batote Highway

Beneficiary: Zaffarullah & 20 other families

Point	Reading	Height	Distance
A	1.50	1.50	0
B	3.00	1.50	10
C	4.50	3.00	20
D	6.00	4.50	30
E	7.50	6.00	40
F	9.00	7.50	50
G	10.50	9.00	60
H	12.00	10.50	70
I	13.50	12.00	80
J	15.00	13.50	90
K	16.50	15.00	100
L	18.00	16.50	110
M	19.50	18.00	120
N	21.00	19.50	130
O	22.50	21.00	140
P	24.00	22.50	150
Q	25.50	24.00	160
R	27.00	25.50	170
S	28.50	27.00	180
T	30.00	28.50	190
U	31.50	30.00	200
V	33.00	31.50	210
W	34.50	33.00	220
X	36.00	34.50	230
Y	37.50	36.00	240
Z	39.00	37.50	250
AA	40.50	39.00	260
AB	42.00	40.50	270
AC	43.50	42.00	280
AD	45.00	43.50	290
AE	46.50	45.00	300
AF	48.00	46.50	310
AG	49.50	48.00	320
AH	51.00	49.50	330
AI	52.50	51.00	340
AJ	54.00	52.50	350
AK	55.50	54.00	360
AL	57.00	55.50	370
AM	58.50	57.00	380
AN	60.00	58.50	390
AO	61.50	60.00	400
AP	63.00	61.50	410
AQ	64.50	63.00	420
AR	66.00	64.50	430
AS	67.50	66.00	440
AT	69.00	67.50	450
AU	70.50	69.00	460
AV	72.00	70.50	470
AW	73.50	72.00	480
AX	75.00	73.50	490
AY	76.50	75.00	500
AZ	78.00	76.50	510
BA	79.50	78.00	520
BB	81.00	79.50	530
BC	82.50	81.00	540
BD	84.00	82.50	550
BE	85.50	84.00	560
BF	87.00	85.50	570
BG	88.50	87.00	580
BH	90.00	88.50	590
BI	91.50	90.00	600
BJ	93.00	91.50	610
BK	94.50	93.00	620
BL	96.00	94.50	630
BM	97.50	96.00	640
BN	99.00	97.50	650
BO	100.50	99.00	660
BP	102.00	100.50	670
BQ	103.50	102.00	680
BR	105.00	103.50	690
BS	106.50	105.00	700
BT	108.00	106.50	710
BU	109.50	108.00	720
BV	111.00	109.50	730
BW	112.50	111.00	740
BX	114.00	112.50	750
BY	115.50	114.00	760
BZ	117.00	115.50	770
CA	118.50	117.00	780
CB	120.00	118.50	790
CC	121.50	120.00	800
CD	123.00	121.50	810
CE	124.50	123.00	820
CF	126.00	124.50	830
CG	127.50	126.00	840
CH	129.00	127.50	850
CI	130.50	129.00	860
CJ	132.00	130.50	870
CK	133.50	132.00	880
CL	135.00	133.50	890
CM	136.50	135.00	900
CN	138.00	136.50	910
CO	139.50	138.00	920
CP	141.00	139.50	930
CQ	142.50	141.00	940
CR	144.00	142.50	950
CS	145.50	144.00	960
CT	147.00	145.50	970
CU	148.50	147.00	980
CV	150.00	148.50	990
CV	151.50	150.00	1000

We recorded some observations as required for evaluation of discharge in the stream. A section 10m long of the stream was considered to evaluate the discharge using a float methodology.

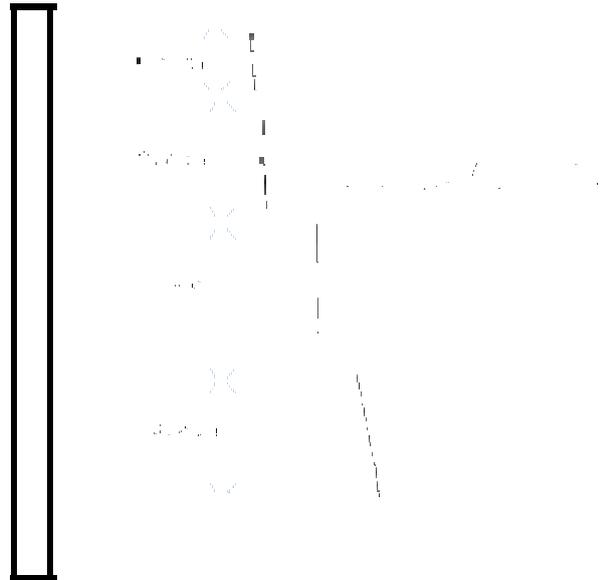


Fig: Head Measuring Method

Discharge Calculation

Method Used: Float Method

In Float method, float is used and made to travel the stream under consideration in this case length of 10 m. Time is noted from start to end of considerate length of stream. For better results multiple observations are made and averaged. Double Float could also be used.

DESIGN OF SHP

Most significant question to be answered is that of installed capacity of the site under consideration. Installed Capacity is design keeping in mind few things primarily a) should justify the potential of the stream, b) economically viable, c) having good load factor.

CONCLUSION

The development of small hydropower around the world is on increase, small hydro offers a wide range of benefits especially for rural areas and developing countries. Governments, financiers, and developers are finding new ways to fund and promote small hydropower development. Efforts are also being made to improve the exchange of ideas and technology related to small hydropower development. Small hydropower stations throughout the world contribute more than 45,000 MW, representing about 5% of the installed hydropower capacity worldwide.

In India, small hydropower up to 25 MW capacities also includes the mini- micro hydro power projects, which are usually confined strictly to local use. A potential of over 15,000 MW has been identified from small hydropower and Government of India has been according priority to SHP development as thrust area. SHP is considered non-conventional as against HP which is conventional. Focus has now shifted to SHP.