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(General article)

Small Hydro Power- A review

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Abstract

Energy generated by the force of water in hydropower can provide a more sustainable, nonpolluting alternative to fossil fuels, along with other renewable sources of energy, such as wind, solar and tidal power and geothermal energy. Among all the renewable energy sources, small hydropower is considered to be one of the most promising. Much of small hydro potential is in the hilly and remote, inaccessible areas of India, where generation from other sources or transmission of power over long distance would not be feasible. In the present paper, a brief description of small hydro potential and the methodology for developing small hydropower project has been discussed Based on the literature survey various environmental problems has been discussed.

Keywords: *Hydro-Power, Fossil fuels, energy*

1. Introduction

Water has always been one of mankind's most vital resources. While human body can go weeks without food, it can only survive for a couple of days without water consumption [1]. Crops in the field will shrivel and die without a readily available supply. We use it for cleaning, we use it for cooking. And since almost the start of recorded history, we have used it as energy source. People have been benefiting from the power of water for more than two thousand years [2]. Water wheels were used to grind wheat into flour as early as 100 B.C. During the 19th century the water wheel was used to produce electricity. At the end of century, the water turbine gradually replaced the water wheel, and soil and rock dams were built to control the flow of water. Since then, the hydroelectric potential of rivers continued to be developed [2]. The history of hydropower generation in India is more than 100 years old. The first hydropower station in India was a small hydro power station of 130 KW commissioned in 1897 at Sidrapong near Darjeeling in West Bengal. Hydro power plants convert potential energy which contained in falling water into electricity. The basic principle of hydro power is that if water can be channelized from a higher level to lower level, then the resulting potential energy of water can be used to do work. Hydro turbines converts water pressure into mechanical shaft power, which can be used to derive generator. Hydro power is very clean source of energy and only uses the water, the water after generating electrical power, is available for other purposes [3]. Presently, the following forms of hydro power projects exist in India.

- Storage schemes
- Run-of-River (ROR) schemes without poundage
- Run-of-River (ROR) schemes with poundage
- Pumped storage schemes

1.1 Strategy for small hydro power development SHP development envisaged through;

- Private sector participation
- State Government/SEB
- Central PSUs
- Local bodies and NGO

1.2 Small-scale hydro

Amongst the renewable sources of energy, small hydro power is one of the most attractive and probably the oldest environmentally began energy technology [4]. Small hydro is the development of hydroelectric power on a scale serving a small community or industrial plant.

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Today small hydropower projects offer emissions-free power solutions for many remote communities throughout the world such as those in Nepal, India, China, Iran, Peru as well as for highly industrialized countries like the United States [5].Small hydro is in most cases 'run-of-river'; in other words any dam or barrage is quite small, usually just a weir, and generally little or no water is stored [6]. The generating capacity of small hydro is up to 10 megawatts (MW) is generally accepted as upper limit but this may be stretched to 25 MW and 30 MW in Canada and USA [7]. Small hydro can be further subdivided into mini hydro, usually defined as less than 1000kW, and micro hydro which is usually less than 100kW[8]. The small hydro power project can be developed economically by simple design of turbines, generators and civil works. For run-of-river hydro projects, a portion of river's water is diverted to channel, pipeline or pressurized pipeline (penstock) that it delivers it to a waterwheel or turbine. The moving water rotates the wheel or turbine, which spins a shaft. The motion of shaft can be used to power a generator to generate electricity [4].

2. Small hydro potential

2.1. Global perspective

The world's installed capacity of small hydro power is 888.8GW [9] against an estimated potential of 180,000 the development of small hydro power appears strong in many parts of the world, especially in Asia, where it account for more than 19,000 MW to the grid. Within Asia, china alone contributes more than 15,000 MW to the grid. It is predicted that by 2005, an additional 8000 MW of small hydro capacity could be in service throughout the world; by 2010 it could total more than 42,000 MW and by 2020 that number could reach 65,000 MW [10].

2.2. Indian perspective

Hydropower is recognized as a renewable source of energy, which is economical, non-polluting and environmentally benign. Small and mini hydel projects have the potential to provide energy in remote and hilly areas where extension of grid system is un-economical. These projects are economically viable, environmentally benign and need a relatively short time for implementation and are not generally affected by the constraints associated with large hydro projects. Realizing this fact, Government of India is encouraging development of small and mini hydro projects in the country [11]. India's estimated potential of small hydro is 15,000 MW. There are over 5,415 small hydro projects aggregating 14305.47 MW in India [12]. These projects are spread throughout the country in hilly regions as well as on canal drops. Ministry of Non-Conventional energy sources is encouraging development of small hydro projects in the state sector as well as through private sector participation in various states. A target of adding about 550 MW during the 10th plan (2002-2007) and 1400 MW during 11th plan (2007-2012) was fixed by MNRE. Following are the year-wise capacity addition for SHP projects during the 10th and 12th plan [13] and state wise distribution of small hydro power development.

Table 1 Year wise hydro power

Year	Target (MW)	Capacity addition during the year (MW)	Cumulative SHP installed capacity (MW)
2002-03	80	80.39	1519.28
2003-04	80	84.04	1603.32
2004-05	100	102.31	1705.63
2005-06	130	120.80	1826.43
2006-07	160	149.16	1975.59
2007-08	200	205.25	2180.84
2008-09	250	248.93	2429.77

Table 2 (a) State wise perspective of hydro power

State	# Sites (Megawatts)	Total Capacity (Megawatts)
Haryana	22	30
Himachal Pradesh	323	1.625
Jammu & Kashmir	201	1.207
Punjab	78	65
Rajasthan	49	27
Uttar Pradesh	211	267
Uttaranchal	354	1.478
Gujarat	290	157
Madhya Pradesh	85	336
Chhattisgarh	47	58
Maharashtra	234	599
Andhra Pradesh	286	255
Karnataka	230	653
Kerala	198	467
Tamil Nadu	147	339
Bihar	92	194
Jharkhand	89	170

Table 2 (b) State wise perspective of hydro power

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State	# Sites (Megawatts)	Total Capacity (Megawatts)
Orissa	161	157
West Bengal	68	203
Sikkim	145	183
Arunachal Pradesh	492	1.059
Assam	46	118
Manipur	96	106
Meghalaya	98	182
Mizoram	88	190
Nagaland	86	181
Tripura	8	10
A&N Island	6	6
Goa	3	3
Total	4.233	10.324

3. Basics

Hydro-turbines convert water pressure into mechanical shaft power, which can be used to derive an electric generator. The power available is proportional to the product of pressure head and volume flow rate [14]. The general formula for any hydro system's power output is:

$$P = \eta \rho g Q H$$

Where P is the mechanical power produced at the turbine shaft (Watts), η is the hydraulic efficiency of turbine, ρ is the density of water (Kg/m^3), g acceleration due to gravity (m^2/s), Q is the volume flow rate passing through the turbine (m^3/s) and H is the effective pressure head of water across the turbine (m)

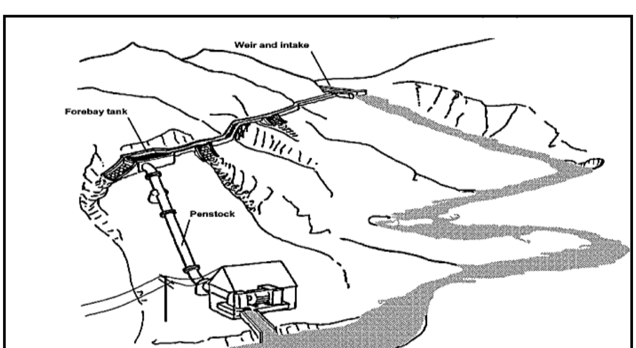

Figure1. Small hydro site layout

4. Methodology

To develop a small hydropower plant, there are a lot of considerations to be taken which are [15]:

1) Hydrology and site survey
2) Measurement of head
3) Measurement of flow
4) Civil work components
   - Weir and intake
   - Channels
   - Settling Basin
   - Spillways
   - Forebay tank
   - Penstock
5) Selection of turbine
   - Impulse turbines
   - Reaction turbines
6) Drive systems
7) Electrical power

5. Turbine selection

The type, geometry and dimensions of the turbine depend on the net head available, range of discharge through the turbine, rotational speed and cost. The head is the first criteria for the selection of type of turbine [16]. Table 3 specifies the range of head for different types of turbines.

Table 3 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

For small and micro hydro schemes choices are limited to either Francis, propeller or Cross flow types. The specific speed N_s is another criterion for selection of a turbine operating at its optimum efficiency. The specific speed is defined as

$$N_s = \frac{N\sqrt{p}}{H^{0.25}}$$

Where N is rotational speed of turbine in rpm, p is output power in KW and H is net head in meter. The range of the specific speeds for various turbines is [17] given in table 4.

Table 4 Specific speed

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

6. Environmental problems

From 1980 until today, there has been no appreciable increase in hydroelectric power production while other forms of electricity production have been increasing. In the last decade or so, we have begun the process of tearing done dams rather than building them [1]. There is no doubt that hydropower plant design, construction, and operation are complex tasks. Such an undertaking requires, among other things, competent environmental and hydrological assessments, careful planning and design, visionary financing, long sighted political planning, demanding construction and supervision and troubleshooting [19]. More importantly, conventional hydroelectric power is not as clean as we would like to believe. They convert a river ecosystem to Lake Ecosystem overnight. While both of these systems have water, the plant and animal life in each can be radically different. Organisms that might get by fine in a river system can be wiped out by a lake system [1]. There are environmental changes that are wrought by building dams. Dams are responsible for the release of greenhouse gases because as filling up the reservoir, fast areas of land are covered in water. Before they are covered, many regions contain a fair amount of land-based plant material. After these regions are covered with water, the plants die and begin to breakdown. If there is enough oxygen in the water, this breakdown will result in the production of carbon dioxide, which is a greenhouse gas. Thus hydroelectric dams are not totally free from greenhouse gas emissions.

7. Problems in operating small hydro power

The development and operation of small hydro power projects poses unique challenges:

- The power stations are located in remote hilly areas where even road linkages are not available.
- The small hydro power stations are prone to natural calamities such as flash floods due to cloud bursting, land sliding causing heavy damages and long shut downs.
- Road blockages and severe climatic conditions causing difficulty in construction, operation and maintained.
- Small hydro power stations are normally connected through service lines or weak grid connections, which causes disruptions and causes low generation.
- Every year plant has to be shut down for about 30 days during monsoon season due to water carrying high silt and debris in the flowing water.

8. Conclusion

As small hydro power continues to grow around the world, it is important to show the public how feasible small hydro systems actually are in a suitable site. The only requirements for small hydro power are a water source, the proper equipment-a turbine and a generator-and a proper installation, which not only helps each individual person but also helps the world and environment as a whole. Experience has shown that there is no more cost-effective, reliable and environmentally-sound means of providing power than a hydropower system, moreover it has almost no environment impact. Against these there are shortcomings also small hydro power is site specific technology, sites that are both well-suited to the harnessing of water power and close to a location where the power can be exploited are not that all common.

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