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Hydropower an Efficient Renewable Source of Energy: An Analysis

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***Abstract*: Hydropower, the power generated by the flow of flowing water. It is one of the most suitable as well as efficient sources of energy. Hydro-power is an efficient source of renewable energy and it has various potential application for future power generation needs cannot be underestimated. It is one of the most efficient, secure and reliable way generating power. The overall efficiency of the station (water to wire operation) is almost 90% efficiency. On the other hand, the startup cost of hydropower plants is high, but it has low operation and maintenance cost, thus it is more efficient in long terms. The main components of a hydropower plant are Reservoir, Turbine, Generator. Now a day's Domestic or In-Pipe hydro systems. are also getting attention of researchers because of their low-cost installation, low maintenance and ease of access.**

***Keywords*: Hydropower, Turbine, Generator, Hydro System.**

1. Introduction

In hydro power generation system we use potential or kinetic or both the form of energy and convert it into form of electrical energy. The flowing water of river or the water stored in reservoir passes through a tunnel through which a surge tank is also connected. Surge tank works as a pressure neutralizer in hydropower water flow systems in order to dampen excess pressure variance. After that it passes though a penstock. Penstocks provide a means of isolation of flows and regulate the flow of water while delivering it to waste management facilities or power plants. Then it passes through the turbine gate.

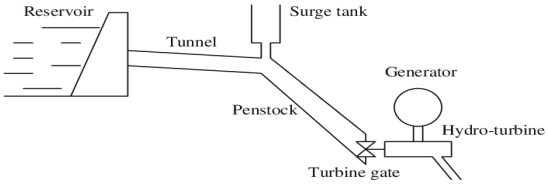

Fig. 1. Arrangement of Hydropower system [1]

The turbine has multiple no. of blades connected to it which rotates with velocity because of potential or kinetic energy of the water. Then the generator connected to the turbine converts that mechanical energy into the form of electrical energy. The whole layout of plant is shown if fig. 1. The energy which we get is clean source of energy and is one of the most efficient forms of renewable energy.

2. Hydropower

The One of the oldest and largest sources of renewable energy which uses the natural flow of moving water to generate electricity. The hydropower generation is a function of the flow discharge, head, and density of water [2]. The hydropower plants are classified on the scale of their power generation. The power plants are "large hydro" (over 10 MW) or "small hydro" (up to 10 MW). Small systems are in turn divided in "mini-hydro" (up to 1 MW), "micro-hydro" (up to 100 kW) and "pico-hydro" (up to 5 kW). HPP with capacity lower than 10 MW are estimated to represent about 10% of the global HPP capacity.[3]. These values can also vary into countries according to their scale shown in table below.

Table 1. Small-scale hydropower by installed capacity (MW) as defined by various countries [7]

Country	Small-scale hydro as defined by capacity (MW)	Reference
Brazil	≤30	Brazil Government Law No. 9648, of May 27, 1998
Canada	<50	Natural Resources Canada, 2009
China	≤50	Jinghe (2005), Wang (2010)
European Union	≤20	Directive 2004/101/EC ("Linking Directive")
India	≤25	Ministry of New and Renewable Energy, 2010
Norway	≤10	Norwegian Ministry of Petroleum and Energy 2008
Sweden	≤1.5	European Small Hydro Association
United States	5-100	US National Hydropower Association

Fig. 2. Small Scale Hydropower by installed capacity (MW) as defined by various countries [4].

1) Advantages of Hydropower Systems

The hydropower system possesses these:

- Higher reliability
- Energy Production
- More consistent
- Emission Free
- Less maintenance
- Create lakes

2) Limitations of Hydropower Systems

- There are limited no. locations for installation of plant on larger scale
- The hydropower plants are susceptible to draughts.

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- The leakage has a higher risk of disastrous floods.

3. Reservoir

Reservoir also known as dams which are large concrete wall like structure which holds a large amount of water beside it. The fluctuation of the water flow can be reduced by the reservoir [5]. It stores water and due to large storage capacity of water they provide the constant flow of water for a longer duration of time. When required the gates of dams are open and the water flows through the tunnel. It prevents excess water from flowing away and uses whole amount of water to rotate the turbine.

4. Turbine

A water turbine is a mechanical rotary machine that converts the kinetic, potential or both forms of energy into mechanical form of energy. Turbines were firstly used in 19th century. They are rotated due to kinetic energy or potential energy which are generated due to head. Head is the difference between the upper and down streams of water level [5]. There are 3 types of head, high head, medium head and low head. The use of turbine depends on the head. Impulse turbines are most efficient for high head and low flow sites [6] ranging from 6 to 600 feet [7]. One of the example of it is Turgo turbine. Pelton Wheel Turbines are suited for high head, low flow applications [6]. The cross flow turbines like Osseberger turbine can be used where higher water flow and lower head is present. Reaction turbines have a better performance in low head and high flow sites [5].

5. Generator

Generators are the devices used to convert the mechanical form of energy into electrical energy. It is connected to the turbine which generates mechanical energy in the form of rotation that rotation of turbine is then converted by generator into electricity. Apart from hydropower plants generators are also used to generate electricity from steam turbine, gas turbine and wind turbine.

6. Domestic or In-Pipe Hydro System

Domestic or In-Pipe Hydrosystem are very small-scale hydropower generation systems with very low installation cost and also generate comparative less amount of energy that the large hydro power plants then too these systems are also one of the most efficient ways of domestic energy generation sources. These systems are mostly fitted in the piping system of houses and when the water flows through those pipes the turbine existing in it rotates and generates the electrical energy. These systems are compact in size and needs less maintenance and emission free source of energy. These systems do not have any chances prone to flood or something accidental like this. Generators are the devices used to convert the mechanical form of energy into electrical energy. These systems acts as money saver in by recovering the energy losses during the flow of fluid in the form of electrical energy.

7. Literature Review

Following is the review of related literature and studies.

Mohammad Mehedi Hasan et al. (2018) have studied the impact of climate change on hydropower generation in Rio Jubones Basin, Ecuador. It was stated Hydropower plants with low storage capacities are more susceptible to climate change, as a high storage capacity requires more workability to operate [2].

In this study, wind speed, relative humidity, and solar radiation data were derived from the monthly statistics of weather information for which seven rain gauge stations and three temperature stations were utilized. It was found hydropower generation will be increased in wet season and plant will face a significant power shortage during dry season [2].

Marco Casini (2015) has studied about harvesting energy from in-pipe hydrosystem at urban and building scale. It was found that in-pipe hydro systems can be operated on various head and flow conditions. He further classified them in 2 designs. Internal systems, where the runner is wholly inside the pipe section and only the generator protrudes from the conduit and External systems, where the runner is contained in a secondary conduit that bypasses the main one.[3]. These systems are not affected by climatic conditions.

Vergila Dadu et al. (2016) have studied concepts related to small hydro powerplants. He found the vortex in flow cause loss of energy to avoid that water access level should be lower than the diversion pipe level. He concluded that better economic results could be obtained by decreasing the diameter of the pipe from the intake to the power plant [8].

Renata Archetti (2011) has researched about feasibility of a domestic hydroelectric powerplant. The aim of this paper is to evaluate the feasibility and affordability of a micro-hydroelectric power station (installed capacity less than 100 kW) for domestic use [9]. It was concluded that to save energy, exploit the available flow flowing through a water system, using a pelton turbine generator coupled with a permanent magnet direct current that powers an inverter connected in parallel directly to a house [9].

A.H. Elbatran et al. (2015) have studied about Hydro Power and Turbine Systems. The power capacity and facility are two criteria required for the classification of hydropower plant. The first one consists of five technologies: dammed reservoir, run of river, pumped storage, in stream technology and new technology gravitational vortex. The other one is classified according to power scale is Large, Small, Mini, Micro and Pico Hydropower [5]. The overall efficiency of the station (water to wire operation) is almost 90% efficiency. On the other hand, the startup cost of hydropower schemes is high, but it has low operation and maintenance cost, thus it is more efficient in long terms [10]. This paper showed various types of hydropower turbines; it presented a general description of hydropower turbines systems and their various components and performance on the other hand this paper also indicated that hydro is a corner stone of the electric generation power plant which is achieved great significance for the global commercial, economic and environmental concerns [5].

8. Conclusion

In overall it was concluded that the hydro energy is one of the most efficient ways of renewable source of energy. Through this system electricity can be generated very easily with the help of domestic or in-pipe hydropower plants. Though hydropower plant require huge installation cost on larger scale but in comparison to that it gives us a large amount of energy in long term. The hydropower plants can have about 90% efficiency which can neither be achieved by any of the renewable sources of energy generation. As per future aspects the domestic or in-pipe hydro systems can be used in multi storey building.

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