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# The Worldwide Historical Facts Behind the Development of Hydroelectric Projects: A Review

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**ABSTRACT: The harness of water by human being to perform their work has thousands of year's history. The credit of water harness for human need is belong from the Greek those used water wheels for grinding wheat into flour more than 2,000 years ago. At present hydroelectric has played a prominent part in the electrification. In many regions of the world, hydroelectric has played major role in increasing and transforming development by industrial revolution. But still the mystery of hydroelectric history is undercover. This research helps to highlight the historical development facts of the hydroelectric projects.**

**Keywords:** Hydroelectric Power Projects; Historical Development and Types Hydropower.

**INTRODUCTION:** The word 'hydro' comes from the Greek which mean "water". The energy especially generated by burning of fossil fuels results the environmental pollutions (Oud, 2002; Safai et. al., 2002; Prasad, 2004 & Gajananda et al., 2005). There is always a need of some alternate eco-friendly energy sources that would help in conserving scarce fossil fuels (Kwant, KW, 2013). In this regard, the best alternate of fossil fuel is non-conventional energy sources like solar energy, wind energy and water energy (Demirbas, 2000). Among these energy sources, water energy is considered to be the most convenient in terms of renewal source. The water energy which is also called hydroelectric (renewable energy) energy that generated through the great intensity of gravitational force falling water into the turbine (Chauhan et. al. 2014). These electric current disseminated to user by transmission lines. Chandrasekharan (1995), Pinho et al. (2007) and Kumar, K., (2013) said that it is renewable source of energy, that which is easy to operate, economical, clean and pollution free.

The development of any nation is depending upon water or hydroelectric projects (HEPs) because it has been fulfilling our primary as well as secondary needs since decades. Not only the efforts are being made to replace fossil fuels, but also these are playing a major role in shaping our cultures and improving the quality of life and economy in remote and backward areas. The growth of industrial sector is also rapidly increasing by influence of hydroelectric projects development (Bartle 2002; Koch, 2002; Diduck et. al., 2007, Natesan et. al. 2005 & Raadal et. al. 2011).

There are three types of hydroelectric stations such as 'run of river', where the electricity is generated through the running river and second is 'reservoir', where power is generated through the release of stored water; and the third one is 'pumped storage', where stored water is recycled by pumping it back up to a higher reservoir in order to be released again (World Energy Council, 2014).

**HYDROELECTRIC TERMINOLOGY:** There is the specific terminology that is used in the hydroelectric projects. Hydroelectricity is generated through water, so that there is need of water accumulation that is called a reservoir or dam. There are different types of dams such as arch dams, gravity dams and buttress dams. The height of water in the dam is called head race.

The first man-made dam was built more than 5,000 years ago in arid parts of the Middle East to divert river water to irrigation purpose and world's largest dam is considered to be the "Three Gorges Dam" on the third world's longest River Yangtze. But now the scenario is entirely changed. The dams have been constructed to prevent from the flash floods to fulfil the demand of energy.

The water flows through a closed conduit or pipe to the powerhouse called penstocks. These penstocks are pipes which carry water from the reservoir to the tur-

bines inside the power station with high pressure. A turbine is a rotary engine that converts the potential energy of water into mechanical energy. This mechanical energy is converted into electric energy through powerhouse. It is a station for generation of electricity that is controlled by the transformer. A transformer is an electromagnetic device for changing alternate current (AC) electricity to higher or lower voltages. Finally, the dissemination of electric energy is possible with the help of transmission lines and it is usually measured in kilowatts (kW) (i.e., 1000 watts and kilowatt-hour (kWh) or megawatts (MW) of 1,000 kilowatts or 1 million watts).

**HYDROELECTRIC CLASSES:** According to Saxena (2010) the hydroelectric project's classification is totally based on installed capacity. The Saxena categorized HEPs into three broad category in reference of power generation such as micro (below 100 kW) and mini (101 – 2000 kW) that belongs to the HIMURJA and small (2001-25000 kW) belongs to the under Ministry of New and Renewable Energy, the two HEPs medium (25,001-1000,000 kW) and large (1000,000 kW and above) considered as a part of Ministry of Power. A general classification in term of generation capacity the hydroelectric power projects is explained in figure 1.

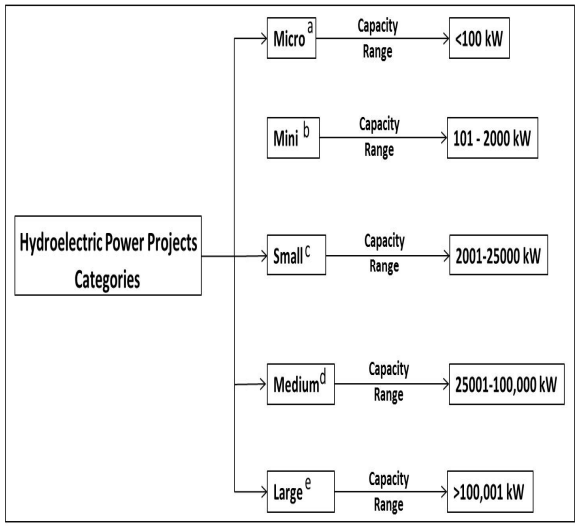


**Figure 1: Types of hydroelectric power projects (Source a,b&c Saxena and Kumar (2010 ), d&e Ministry of New and Renewable Energy, India (2015).**

**WORLDWIDE HISTORY OF HYDROELECTRIC POWER GENERATION:** The most important year was 1831 in the history of hydroelectric projects when the first electric generator was invented by Michael Faraday, whereas the first hydroelectric power project was installed during 1870 at Cragside, Rothbury, England to supply electric light. The world's first full-fledged electric power generation was started in 1877 in Switzerland when a hydroelectric power project was installed to supply electricity to hotel in St. Moritz (Mathur, 2003). In England, the first hydroelectric power project was used to power a single lamp in the Cragside country house in Northumberland, England by William George Armstrong in 1878 and in 1880 at Cragside, Northumberland, England the another hydroelectric power project was constructed.

This was the year which was considered to be a milestone for the first industrial use of hydroelectric to generate electricity in Grand Rapids, Michigan. Here 16 brush-arc lamps were powered at the wolverine chair factory in 1881. Table 1 shows an overview of the historical development of hydroelectric projects (HEPs).

**Table 1: History of HEPs in the World.**

| S. No. | Year | The historical milestones of HEPs in the World |
|---|---|---|
| 1 | 1831 | 1st Electric generator |
| 2 | 1870 | 1st HEP of England |
| 3 | 1877 | 1st Full-fledged HEP to supply electricity to hotel in Switzerland |
| 4 | 1880 | 2nd HEP of England |
| 5 | 1880's | 1st Time HEP served private and commercial customers in USA |
| 6 | 1881 | 1st Industrial use of HEP in New York |
| 7 | 1882 | 1st General distribution of DC electricity in New York |
| 8 | 1887 | Starting of History of HEP in the West United State |
| 9 | 1890 | 1st HEP at Scotland |
| 10 | 1891 | 1st Three phase HEP in Germany |
| 11 | 1895 | 1st Publicly owned plant of Australia |
| 12 | 1895 | World Largest HEP at Nigeria Fall |
| 13 | 1907 | 1st Nepal HEP |
| 14 | 1912 | 1st HEP of China |
| 15 | 1925 | 1st HEP of Pakistan |
| 16 | 1929 | 1st Pumped Storage HEP |
| 17 | 1936 | 2nd HEP in Nepal |
| 18 | 1936 | World largest HEP Hoover Dam |
| 19 | 1986 | 1st Mega HEP at Bhutan |
| 20 | 2008 | World largest Three Gorges Dam, China |

During the 1880s, the first hydroelectric plant was opened to serve the private and commercial customers in Wisconsin, U.S.A. In the North America, the numbers of hydroelectric plants were installed during 1880s such as Ottawa, Ontario (1881), Dolgeville, New York (1881), Niagara Falls and New York (1881) were installed in a series. They were used to supply light to some local buildings and mills.

The world's first central station for the distribution of Direct Current (DC) for the purpose of lighting was installed in New York Edison Company, which began operational in New York City in September 1882, whereas the first Alternative Current (AC) hydroelectric plant started in 1889 at Oregon City, Oregon, the Willamette Falls Station that was transmitting single phase power 13 miles to Portland at 4,000 volts. The first three phase of hydroelectric system developed 25,000 volt demonstration line of about 175 km from a plant at Lauffen, Frankfort Main, Germany in 1891. Australia launched its first public owned plant in 1895 in the Southern Hemisphere at Duck Reach, Tasmania and supplied power to the city of Launceston for street lighting. In 1895, the world's largest hydroelectric power project, the Edward Dean Adams Power Plant, was constructed at Niagara Falls. The history of hydroelectric development in the west United State started with High Grove hydroelectric Station during 1887 at San Bernadino, California. The first hydroelectric scheme in Scotland to provide power to the public was built by the monks at Fort Augustus Abbey in 1890.

In 1905, a hydroelectric station was built on the Xindian creek near Taipei, with an installed capacity of 500 kW. This was quickly followed by the first station in mainland China, the Shilongba plan in the Yunnan province, which was built in 1910 and put into operation in 1912. Shilongba had an installed capacity of 480 kW; today it is still in operation with an installed capacity of 6 MW. In 1907, Pharping hydroelectric plant was the first hydroelectric plant in Nepal and in 1936 the second hydroelectric plant (640 KW) was established at Sundarijal (Sharma and Ripendra, 2013). In 1929, the River Rocky Plant in New Milford, Connecticut, was the first major pumped storage hydroelectric plant.

It was hydroelectric power projects saw rapid changes in its design between the years 1895 to 1915; and the design became fairly well standardized after World War I. The modernization of hydroelectric projects considered during the 1920's and 1930's. The 1930's was also related to the development of thermal plant, transmission line and distribution.

In Pakistan, HEPs developmental activities started in 1925, with the construction of the 1 MW Renala hydroelectric stations. After a decade, the 1.7 MW Malakand-I hydroelectric station was built, that was later upgraded to 20 MW capacity and in 1953, the 20 MW Dargai hydroelectric stations were also commissioned. At the time of independence, Pakistan harnessed a very small hydro energy with only 60 MW for its 31.5 million people (Abdul et al. 2012).

The Hoover Dam on the River Colorado became the world's largest hydroelectric plant in 1936 with a capacity of 1,345 MW. At the time of commissioning at Washington in 1942, Grand Coulee Dam (1,974 MW) came into existence and was upgraded up to 6,809 MW today. The Itaipu Dam, including Brazil and Paraguay, opened in 1984 with 12,600 MW that was upgraded to 14,000 MW. Today Itaipu Dam is only eclipsed in size from China's Three Gorges Dam (22,500 MW) that was opened in 2008, and it is considered as the world's largest dam (Zhao and Liu, 2015).

In case of Bhutan, the Chhukka hydroelectric project was Bhutan's first mega power project that was commissioned in 1986. This project is the nation's major growth driver and constitutes around 20% of the Bhutan's economy.

**HISTORY OF HEP IN INDIA:** India has a history of about 118 years of hydroelectric projects that started from a small Sidrapong hydroelectric plant (130 kW) installed at Darjeeling on 10 November 1897 by Sir C. C. Stevens (then Acting Lieutenant Governor of Bengal) and operational in 1898 (Abdul et. al. 2012). The site for power house was selected in the fine orchard of Maharajah of Burdwan. This hydroelectric project is considered the first hydroelectric plant of the Asia. The second hydroelectric plant, Shimsha (Sivasamudram 7.92 MW) was installed on the River Cauvery in 1902 for the purpose to supply the electricity to the Kolar Gold Mine (NIH, 2015). The capacity of this powerhouse was increased to 47 MW by 1938. Initially power was supplied to Kolar Gold Fields for mining development and operations and later to Bangalore and Mysore cities too. The second HEP development in Mysore's was noticed in 1940, as a Shimsapura hydro power station (2 × 8.6 MW) on River Cauvery (NIH, 2015). In the table 2, the historical development of hydroelectric power projects in India is summarized.

**Table 2: Historical development of hydroelectric power projects in India.**

| S. No. | Year | Historical development of HEPs in India |
|---|---|---|
| 1 | 1897 | 1st HEP Sidrapong in Darjeeling |
| 2 | 1902 | 2nd HEP Shimsha on River Cauvery |
| 3 | 1907 | HEP in Mussorie |
| 4 | 1909 | HEP Mohra on River Jhelum |
| 5 | 1911 | HEP in Jubbal, Shimla , Himachal Pradesh |
| 6 | 1913 | HEP Chhaba, on River Satluj |
| 7 | 1915 | Tata Industrial Group installed their 1st 40 MW Khopoli HEP in Maharashtra, Western Ghats |

| | | |
|---|---|---|
| 8 | 1925 | 48 MW Bhivpuri HEP in Maharashtra, Western Ghats by Tata Industrial Group |
| 9 | 1927 | 90 MW Bhira HEP in Maharashtra, Western Ghats by Tata Industrial Group |
| 10 | 1932 | HEP Shanan on River Uhl in Joginderna-gar, Himachal Pradesh |
| 11 | 1937 | Mettur Dam, Madras |
| 12 | 1940 | Mysore HEP |
| 13 | 1944 | HEP Papanasam, Madras |

Gagoi hydroelectric project with 3,000 kW capacity close to Mussoorie installed by Mohara (4500 kW) on the River Jhelum in 1909. Some major contributions in the sector of hydroelectric power projects in 1990 and onward, took place mainly in Jubbal (50 kW) in 1911 and Chhaba (1,750 kW) in 1913 (Abdul et. al. 2012). Another hydroelectric project of 48 MW capacity was constructed in 1932 at Shanan near Jogindernagar on River Uhl in Himachal Pradesh (NIH, 2015). These hydroelectric stations are still in working conditions and the energy from these plants was primarily used for domestic needs in adjacent towns. It is noteworthy that the first power utility under public sector was run on a commercial basis for general use of the public in India.

A major contribution in the direction of hydroelectric development was made by the Tata Industrial Group that successfully established three major hydroelectric plants in the Western Ghats in Maharashtra. These are Khopoli (40 MW) in 1915, Bhivpuri (48 MW) from 1922 to 1925 and Bhira (90 MW) in 1927. Further, two hydropower projects such as, Mettur hydro station (40 MW) in 1937 and Papanasam (14 MW initial) in 1944 was established in Madras state.

The Gagoi power house near Mussoorie was built by Lt. Col. W.W. Bell. It provides electricity and pumps water upward to Mussoorie town. It was the first time that water was pumped up to a height of 516 m which was highest in Asia (NIH, 2015). At present, the second biggest plant is running on the River Satluj at Naptha-Jhakri hydroelectric power project (1500 MW) in Himachal Pradesh.

**CONCLUSION:** The dependency on hydropower energy is increasing as the development of hydropower sector. It is noticed that in Asia the development of hydropower projects is highest from other continents. In Asia the China is on the top of harness the hydropower project energy. From the history it comes out that, developing countries have no reliable electricity supply. In these countries for the foreseeable future, hydroelectric offers a renewable energy source on a realistic scale.

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