Chapter 2
Hydropower Plants

Abstract The hydropower plants can be broadly subdivided into different classes based on quantity of water available, available head, and nature of load. Based on quantity of water available hydro power plant can be classified into Reservoir plants, Run-off river plants with pondage, and Run-off River plants without pondage. In case of available head, hydropower plants can be further subdivided into Low head, Medium head, and High head. With respect to nature of Load any hydropower plant can be grouped into Base and Peak load plants.

2.1 Classification of Hydropower Plants

The classification of hydro-electric plants is based upon (Fig. 2.1):

(a) Quantity of water available
(b) Available head
(c) Nature of load

2.1.1 Classification with Respect to Quantity of Water Available

(i) Run-off river plants without poundage: These plants does not have storage or pondages to store water; Run-off river plants without pondages uses water as it comes. The plant can use water as and when available. Since, generation capacity of these type of plants these plants depend on the rate of flow of water, during rainy season high flow rate may mean some quantity of water to go as waste while during low run-off periods, due to low flow rates, the generating capacity will be low.

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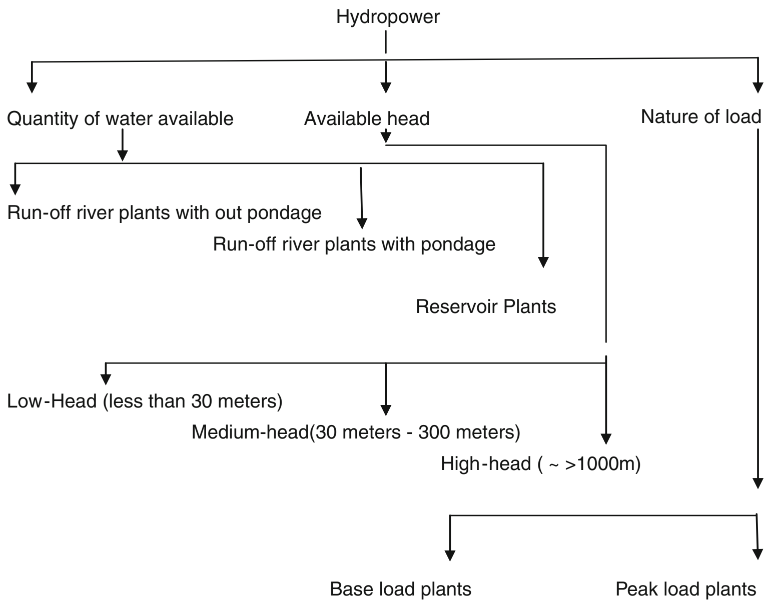

Fig. 2.1 Showing the classification overview of hydro-power plants

(ii) Run-off river plants with pondage: In these plants, pondage allows storage of water during lean periods and use of this water during peak periods. Based on the size of the storage structure provided it may be possible to cope with hour-to-hour fluctuations. This type of plant can be used on parts of the load curve as required, and is more useful than a plant without pondage. If pondage is provided, tail race conditions should be such that floods do not raise tail-race water level, thus reducing the head on the plant and impairing its effectiveness. This type of plant is comparatively more conscientious and its generating capacity is unabased on available rate of flow of water.

(iii) Reservoir plants: A reservoir plant is that which has a reservoir of such size as to accede carrying over storage from wet season to the next dry season. Water is stored behind the dam and is available to the plant with control as required. This type of plant has better extent and can be used efficiently throughout the year. Its firm capacity can be expanded and can be utilized either as a base load plant or as a peak load plant as required. It can also be used on any portion of the load curve as required. Maximum hydro-electric plants are of this type.

2.1.2 Classification According to Availability of Water Head

(i) Low-head (less than 30 m) hydro-electric plants: "Low head" hydro-electric plants are power plants which generally utilize heads of only a few meters or less. Power plants of this type may utilize a low dam or weir to channel water, or no dam and simply use the "run of the river". Run of the river generating stations cannot store water, thus their electric output varies with seasonal flows of water in a river. A large volume of water must pass through a low head hydro plant's turbines in order to produce a useful amount of power. Hydro-electric facilities with a capacity of less than about 25 MW (1 MW = 1,000,000 W) are generally referred to as "small hydro", although hydro-electric technology is basically the same regardless of generating capacity.

(ii) Medium-head (30–300 m) hydro-electric plants: These plants consist of a large dam in a mountainous area which creates a huge reservoir. The Grand Coulee Dam on the Columbia River in Washington (108 m high, 1,270 m wide, and 9,450 MW) and the Hoover Dam on the Colorado River in Arizona/Nevada (220 m high, 380 m wide, and 2000 MW) are good examples. These dams are true engineering marvels. In fact, the American Society of Civil Engineers as designated Hoover Dam as one of the seven civil engineering wonders of the modern world, but the massive lakes created by these dams are a graphic example of our ability to manipulate the environment—for better or worse. Dams are also used for flood control, irrigation, recreation, and often are the main source of potable water for many communities. Hydro-electric development is also possible in areas such as Niagra Falls where natural elevation changes can be used.

(iii) High-head hydro-electric plants: "High head" power plants are the most common and generally utilize a dam to store water at an increased elevation. The use of a dam to impound water also provides the capability of storing water during rainy periods and releasing it during dry periods. This results in the consistent and reliable production of electricity, able to meet demand. Heads for this type of power plant may be greater than 1,000 m. Most large hydro-electric facilities are of the high-head variety. High-head plants with storage are very valuable to electric utilities, because they can be quickly adjusted to meet the electrical demand on a distribution system.

2.1.3 Classification According to Nature of Load

(i) Peak Load Plants : The peak load plants are used to supply power at the peak demand phase. The pumped storage plants and Gas Turbine plants are this type of plants. Their efficiency varies between 60–70%.

(ii) Base load plants: A base load power plant is one that provides a steady flow of power regardless of total power demand by the grid. These plants run at all times through the year except in the case of repairs or scheduled maintenance.

2.2 Advantages of Hydroelectric Plants

The benefits of hydropower plants are manifold as described below:

- The running, operation and maintenance cost of this kind of plants are low.
- After the initial infrastructures are developed the energy is virtually free.
- The plants is totally free of pollution as no conventional fuels are required to be burned.
- The lifetime of generating plants are substantially long.
- Reliability is much more than wind, solar or wave power due to its easy availability and convertibility.
- Water can be stored above the dam ready to cope with peaks in demand.
- The uncertainties that arises due to unscheduled breakdowns are relatively infrequent and short in duration due to the simplicity and flexibility of the instruments.
- Hydro-electric turbine generators can be started and put "on-line" very rapidly.
- It is possible to produce electricity from hydro-electric power plant if flow is continuously available. Benkovic et al. (2013); Panic et al. (2013); Sharma and Awal (2013); Dursun and Cihan (2011) etc. has already discussed the benefits of the HPP in different aspect in their published literatures.

2.3 Disadvantages of Hydro-Electric Plants

But along with the advantages, the disadvantages (Bahadori et al. 2013; Chen et al. 2013; Jensen et al. 2002) of such renewable energy projects are also manifold but lesser than the other sources of infinite and also finite energy.

- The potential of hydro power depend on locations and if properly not selected may cause lots of hostility and absurdity during operational stage of the power plant.
- The dams are very expensive to build. However, many dams are also used for flood control or irrigation, so building costs can be shared.
- The capital cost of electrical instruments along with civil engineering works to be installed and cost of laying transmission lines is generally high.
- The impact on plant life due to the water quality and quantity downstream of hydro power plants are reported.
- The impact on residents and the environment may be unacceptable environmental and social activist if location is not optimally selected.
- Due to increase in water temperature and insertion of excess nitrogen into water at spillways health and migration of fish as well as other aquatic plants get effected.
- Due to the installation of reservoir in the flow paths the siltation rate get altered.

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