UNIT III

Hydro and Ocean Energy Electric Technologies

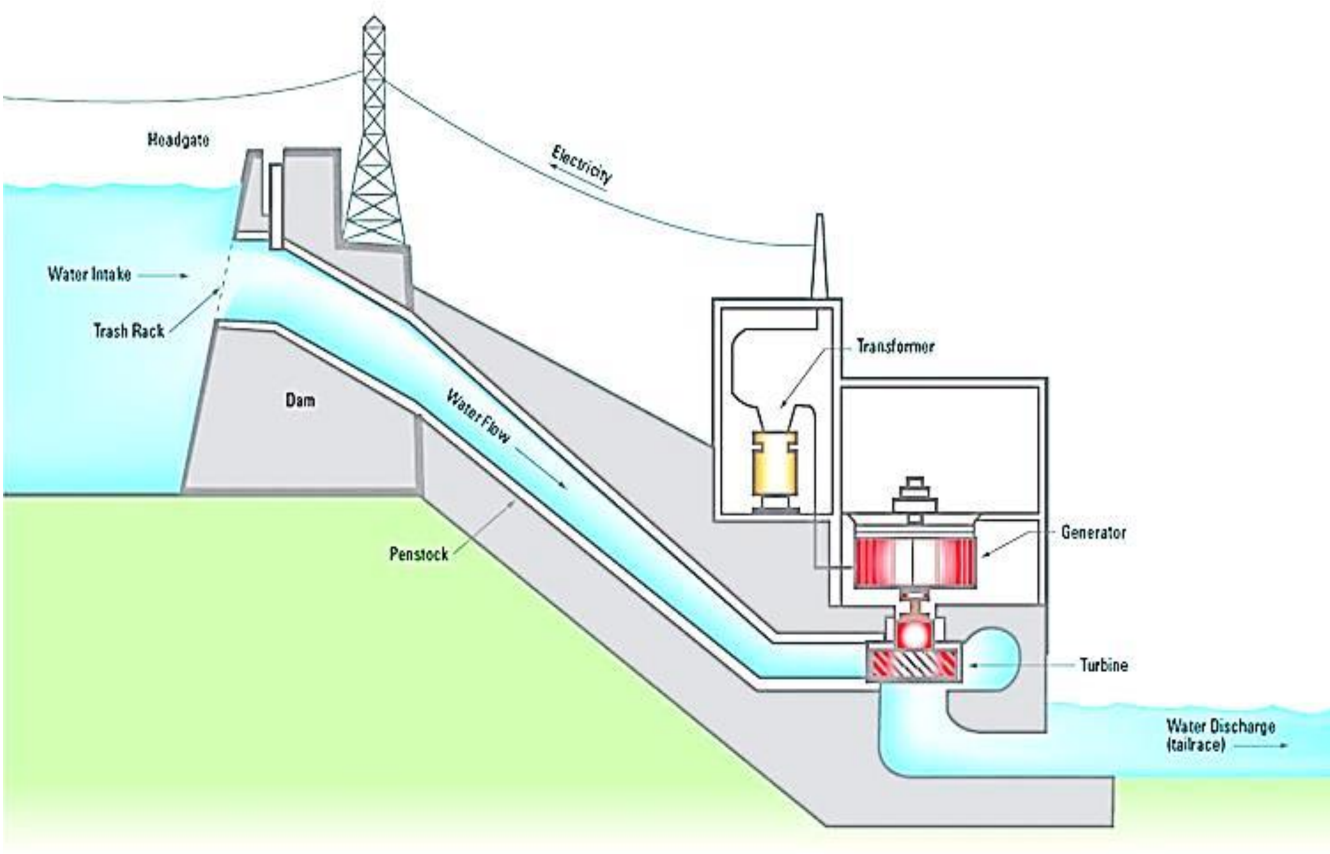
Hydroelectric power plant: **(April/May 2012)(November 2013)(April 2013)**

SITE SELECTION FACTORS OF A HYDRO-ELECTRO POWER PLANT

1. Quantity of water is available.
2. Quantity of water that could be stored and the method of storage.
3. Available water head before and after construction of the storages facility.
4. Narrow outlet (of the water stream) from the water basin which may require a dam of less volume.
5. Free from earthquake damage.
6. Free from mineral deposits of harmful nature less possibility of sediment
7. Distance from load centre.

LAYOUT OF A HYDRO-ELECTRIC POWER PLANT

The general arrangement is to create a water reservoir by building a dam across river and use this water to drive a hydraulic turbine. The figure below shows the-schematic representation of a hydro-electric power plant.



1. Water reservoir

The main purpose of the reservoir is to store the water during rainy season, supply the same during dry season, which ensures continuous availability of water.

2. 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 of the power plant.

3. Trash rack

The water from the dam or from the forebay is made to pass through this trash rack to prevent the entry of debris, which might damage the wicket gates and turbine runners or up the nozzles of the impulse turbine. When winter is severe, trash racks are heated t to prevent ice from clinging to the trash racks.

4. Surge Tank

A surge tank is a storage reservoir attached to the penstock at a junction near the turbine. The reservoir helps to supply water to the turbine when the load on the turbine increases and stores water when there is a decrease in load. In this manner, the pressure variations because of the rapid changes in water flow in penstock are controlled by surge tank. This also prevents water hammering.

5. Penstock

This is a duct line mainly used to carry water from the storage reservoir to the turbine house. Penstocks are built up of tubes made of steel, reinforced concrete and sometimes wood. The intake of the penstock at the dam or forebay must be at a level low enough to provide an adequate water supply under all conditions. It is desirable to have penstock always sloping towards the powerhouse, but its grade may be varied as desired to fit the topography. As far as possible sharp bends in the penstock line should be avoided as they cause loss of head and need special fittings for anchoring. Normally penstocks are left exposed to the atmosphere, but in certain locations, where there may be some danger because of snow, rock earth etc., and covering of penstock is essential.

6. Power House

A Power house consists of two main parts, a sub-structure to support the hydraulic and electric equipment and a super structure to house and protect this equipment. The super structure of most power houses is a building, housing all operating equipment. The generating units and exciters are usually located on the ground floor. The turbines which rotate on vertical axis are placed just below the floor level while those rotating on the horizontal axis are placed on the ground floor along the side of the generator.

7. Prime Movers

The main purpose of the prime mover is to convert the kinetic energy of water into mechanical energy to produce electrical energy. The Prime movers which are in common use are Pelton turbine, Francis turbine and Kaplan turbine.

8. Draft tube

The draft tube is a diverging discharge passage connecting the water with tail race. It is shaped to decelerate the flow with a minimum loss, so that, the remaining kinetic energy of water coming out of the runner is efficiently regained by converting into suction head thereby, increasing the total pressure difference on the runner. This regain of kinetic energy of water coming out from reaction turbine is the primary function of the draft tube.

WORKING PRINCIPLE

In hydroelectric power plants, the potential energy of water is converted into kinetic energy by passing through the tunnel and the nozzle. The kinetic energy of the water formed is converted into mechanical energy in the hydraulic turbines. The mechanical energy obtained from the water turbine is further utilized to run the electric generator.

Advantages:

1. Water is used as fuel for the generation of electrical energy.
2. It is quite neat and clean as no smoke or ash is produced.
3. It requires very small running charges because water is the source of energy which is available free of cost.
4. It is comparatively simple in construction and requires less maintenance.
5. It does not require a long starting time like a steam power station. In fact, such plants can be put into service instantly.
6. It is robust and has a longer life.
7. Such plants serve many purposes. In addition to the generation of electrical energy, theyalso help in irrigation and controlling floods.
8. Although such plants require the attention of highly skilled persons at the time of construction, yet for operation, a few experienced persons may do the job well.
9. It does not pose radiation hazard problems as in the case of nuclear plant.
10. No fuel transportation problems.
11. Life of hydro plant is very long (1 or 2 centuries) compared with thermal plant (3 to 4 decades), this is because the hydro plants operate at atmospheric temperature, whereas thermal plants operate at very high temperature (about 500 to 800ºc

Disadvantages:

1. It involves high capital cost due to construction of dam.
2. There is uncertainty about the availability of huge amount of water due to dependence on weather conditions.
3. Skilled and experienced hands are required to build the plant.
4. It requires high cost of transmission lines as the plant is located in hilly areas which are quite away from the consumers. This also increases the transmission losses.
5. Erection of hydro-plant (construction of dam) usually takes a long period of time.

Various types of hydroelectric power plants
(November 2012) (November 2013)(April 2015) (April/May 2014)

(a)Classification based on the availability of head:

1) Low head hydroelectric power plants

The low head hydroelectric power plants are the ones in which the available water head is less than 30 meters. The dam in this type of power plants is of very small head may be even of few meters only. In certain cases weir is used and in other cases there is no dam at all and merely flowing water in the river is used for generation of electricity. The low head types of hydroelectric power plants cannot store water and electricity is produced only when sufficient flow of water is available in the river. Thus they produce electricity only during particular seasons when abundant flow of water is available. Since the head of water is very small in these hydroelectric power plants, they have lesser power producing capacity.

2) Medium head hydroelectric power plants

The hydroelectric power plants in which the working head of water is more than 30 meters but less than 300 meters are called medium head hydroelectric power plants. These hydroelectric power plant are usually located in the mountainous regions where the rivers flows at high heights, thus obtaining the high head of the water in dam becomes possible. In medium head hydroelectric plants dams are constructed behind which there can be large reservoir of water. Water from the reservoir can be taken to the power generation system where electricity is generated.

3) High head hydroelectric power plants

In the high head hydroelectric power plants the head of water available for producing electricity is more than 300 meters and it can extend even up to 1000 meters. These are the most commonly constructed hydroelectric power plants. In the high head hydroelectric power plants huge dams are constructed across the rivers. There is large reservoir of water in the dams that can store water at very high heads. Water is mainly stored during the rainy seasons and it can be used throughout the year. Thus the high head hydroelectric power plants can generate electricity throughout the year. The high head hydroelectric power plants are very important in the national grid because they can be adjusted easily to produce the power as per the required loads.

(b) Classification according to the nature of load:

1) Base load hydroelectric power plants

The base load type of hydroelectric power plants produce power constantly irrespective of the total load in the national grid. They keep on producing power throughout the day and during all the times of the year. They will stop producing power only during breakdown maintenance. Usually these types of hydroelectric power plants have standby power generation unit to ensure continuous production of power even in case of failure of one of the power generation unit. The generation of power from base load power plants is cheaper so they can be run continuously.

The total power generated within the national grid includes the power generated by the base load type of hydroelectric power plant. The power output from the base load plants is constant and it does not usually vary in the normal working conditions. The total capacity of the national grid includes the power produced by the base power plant. The majority of the power in the national grid it supplied by the base power plants.

All the base plants within the national grid are allotted specific amount of base-load to handle constantly depending upon their power generation capacity. If there are fluctuations or peak demands like during the nighttime, these are handled by the other smaller plants that can be started and stopped easily. The thermal and nuclear power plants are the base plants, but there are many hydroelectric plants that can are being used as the base load power plants.

2) Peak load hydroelectric power plants

Most of the normal power requirements are fulfilled by the base load hydroelectric power plants. However, during night times the requirement of power becomes very high; it is called peak load period. During peak load periods small power plants are started that add to the total power generated in the grid by base load plants. The peak load plants are not run continuously since the cost of production of power from them is high. The hydroelectric power plants can be used as the peak load plants since they can be started and stopped easily. The diesel power plants are also used as the peak load plants since they can be started and stopped easily, but their operation is very expensive

(c) Classification according to quantity of water available:

Hydroelectric plants are classified commonly by their hydraulic characteristics, that is, with respect to the water flowing through the turbines that run the generators. Broadly, the following classifications are made

a) Run-of-river without pondage (little or no storage)
b) Run-of-river with pondage (storage suitable to balance diurnal variation in power generation)
c) Storage schemes (reservoirs to store excess water of flood flows)
d) Pump-storage schemes

1. *Run-of-river schemes:*

These are hydropower plants that utilize the stream flow as it comes, without any storage being provided (Figure6a). Generally, these plants would be feasible only on such streams which have a minimum dry weather flow of such magnitude which makesit possible to generate electricity throughout the year. Since the flow would vary throughout the year, they would run during the monsoon flows and would otherwise remain shut during low flows. Of course, the economic feasibility of providing the extra units apart from the regular units have to be worked out. Further, the monsoon tailwater in rivers with flat slopes becomes higher, causing the plants to become inoperative. Run-of-river plants may also be provided with some storage (Figure6b) to take care of the variation of flow in the river as for snow-melt rivers, emerging from the glaciers of Himalayas. During off-peak hours of electricity demand, as in the night, some of the units may be closed and the water conserved in the storage space, which is again released during peak hours for power generation.

2. *Storage schemes:*

Hydropower plants with storage are supplied with water from large storage reservoir that have been developed by constructing dams across rivers. Generally, the excess flow of the river during monsoon would be stored in the reservoir to be released gradually during periods of lean flow. Naturally, the assured flow for hydropower generation is more certain for the storage schemes than the run-of-river schemes.

3. *Pumped-Storage schemes:*

Hydropower schemes of the pumped-storage type are those which utilize the flow of water from a reservoir at higher potential to one at lower potential. A typical schematic view of such a plant is shown in Fig.3.9. The upper reservoir (also called the head-water pond) and the lower reservoir (called the tail-water pond) may both be constructed by providing suitable structure across a river .

During times of peak load, water is drawn from the head-water pond to run the reversible turbine-pump units in the turbine mode. The water released gets collected in the tail-water pond. During off-peak hours, the reversible units are supplied with the excess electricity available in the power grid which then pumps part of the water of the tail-water pond back into the head-water reservoir. The excess electricity in the grid is usually the generation of the thermal power plants which are in continuous running mode. However, during night, since the demand of electricity becomes drastically low and the thermal power plants cannot switch off or start immediately, there a large amount of excess power is available at that time.

4. *Tidal power development schemes:*

These are hydropower plants which utilize the rise in water level of the sea due to a tide, as shown in Fig.3.11. During high tide, the water from the sea-side starts rising, and the turbines start generating power as the water flows into the bay. As the sea water starts falling during low tide the water from the basin flows back to the sea which can also be used to generate power provided another set of turbines in the opposite direction are installed. Turbines which generate electricity for either direction of flow may be installed to take advantage of the flows in both directions.

d) Classification based on the power developed by the plant:

Large hydro	More than 100MW and usually feeding into a large electricity grid
Medium hydro	15-100 MW usually feeding a grid
Small hydro	1-15 MW usually feeding a grid
Mini hydro	Above 100 kW, but below 1 MW either stand alone schemes or more often feeding into the grid
Micro grid	From 5 kW upto 100 kW usually provided power for a small community or rural industry in remote areas away from the grid
Pico grid	From a few hundred watts upto 5 kW

Power equation of hydroelectric power plant:

A central concept in relation to reservoir plant operation is the available power. We can derive this by considering that the potential energy of a mass m of water at height h is given by

$$E = mgh \qquad (1)$$

where g is the acceleration due to gravity.

Differentiating to get power results in

$$P = \frac{dE}{dt} = \frac{d}{dt}(mgh) \qquad (2)$$

Now the only thing in (2) that changes with time as water flows down the penstock is the mass of the water in the reservoir, and so (2) becomes:

$$P = \frac{dm}{dt} gh \qquad (3)$$

Where dm/dt is the mass flow rate, which is given as the product of density ρ (kg/m3) and volume flow rate r (m3 /sec), that is,

$$P = \rho r g h \qquad (4)$$

There are some friction losses in the penstock, and there are losses in the turbine, and so we are not able to convert all of the power of equation (4) to electric energy. This influence is considered via a multiplying factor η so that the electric power available from a turbine having head h is given by

$$P = \eta \rho r g h \qquad (5)$$

For water flowing at one cubic metre per second from a head of one metre, the power generated is equivalent to 10 kW assuming an energy conversion efficiency of 100% or just over 9 kW with a turbine efficiency of between 90% and 95%.

Environmental aspects for selecting site: **(Nov/Dec 2014)**

The following basic principles governing selection of the intake site can be suggested:

1. Intakes should be located, whenever possible, on the concave side of a curved stretch,

2. Efficiency of the intake in preventing sedimentation increases with the sharpness of the bend,

3. The amount of bed load transported into the canal decreases, as the ratio of the total discharge to the amount increases.

4. Intakes are most favorably located along the downstream reach of the curve, near the end.

5. The lower the head, the more effective the intake.

6. Conditions in a straight stretch are opposite to those described under No. 3; with diverted flow being constant, any increase in the river discharge will involve more extensive sedimentation in the canal.

7. The silt releasing sluice of the diversion weir, the canal sill and the desilting sluice can only be operated at good efficiency if more or less favorable bend conditions are created through proper design and arrangement in keeping with the above principles.

8. With intakes from straight stretches, but more so along the convex side, the aforementioned measures offer no significant contribution to the protection against sedimentation in the canal. In such cases both canal sill and desilting canal give satisfactory results if heads are considerable even during high-head periods.

9. Intakes from straight stretches can be made more favorable by forcing water to follow a curved route with the convex side of stream curve facing the intake structure. This can be achieved by an inlet section extending crosswise into river bed, and a weir shorter than the width of flow above the intake make the flow to follow a curved route.

WAVE ENERGY AND ITS TYPES:

INTRODUCTION TO WAVE ENERGY

The movement of large quantities of ocean water up and down can in principle be harnessed to convert into usable forms of energy such as electricity or mechanical power. Waves are formed on the surface of water by the frictional action of the winds resulting in the radial depression of energy from the blowing winds in all directions.

The ocean is a big collector of energy transferred by wind over a large surface area which is stored as wave energy. Wave energy is more concentrated compared to wind energy, which is thinly distributed. Wave energy is available in coastal areas, islands and its potential depends upon its geographic location. Energy available in ocean waves varies in different months and seasons. Wave energy, if harnessed with improved technology, can prove to be a large dependable source of renewable energy.

FACTORS AFFECTING WAVE ENERGY

There are three major factors which govern the quantum of wave energy. The first is the wind speed, i.e. the higher the wind speed, the higher is the wave energy .The amplitude of the waves depends on the wind speed.

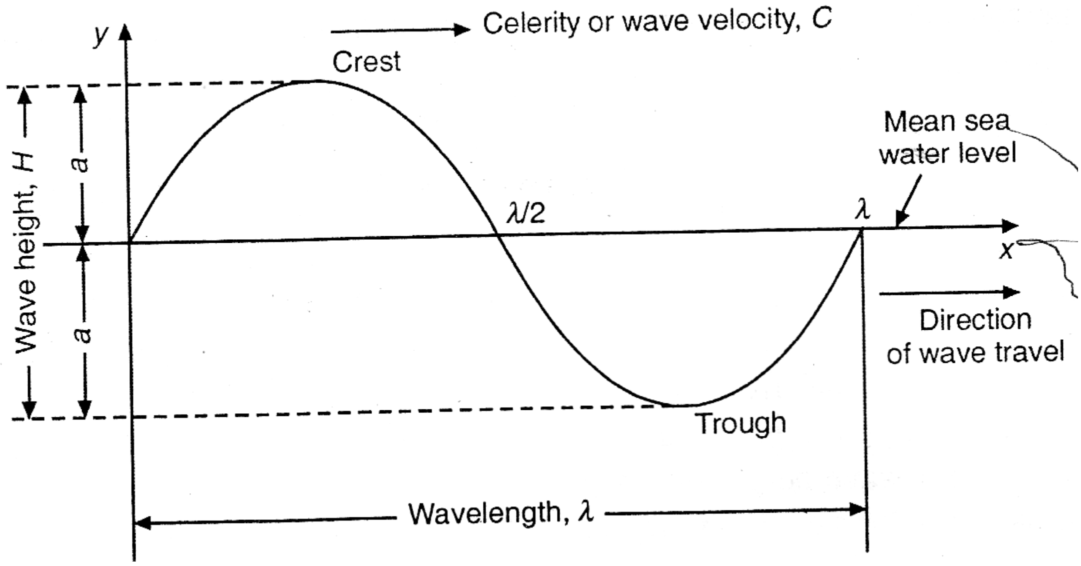
The second factor is the effective fetch value', i.e. the uninterrupted distance on the ocean over which the wind can blow before reaching the point of reference. The larger the distance, the higher is the wave energy. This distance may vary from 5 km to 45 km.

The third factor is the depth of the sea water. The greater the depth of ocean water, the higher the wave velocity. Very large energy fluxes are available in deep ocean waves.

Wave energy is abundantly available on the Indian sea coast touching Bay of Bengal and Arabian Sea in high wind belts. All the three factors described above are available along India's long coastline of 6000 km.

Ocean Wave Parameters

The periodic, up and down, to and fro motion of water in seas and oceans is known as 'ocean wave' as shown in Figure.



The important wave parameters with their notations are given below:

H = wave height. It is the distance from the trough to the crest (not to the height above sea level). It mainly depends on wind speed and the fetch. The value varies from 0.2 m to 3 m.

a = amplitude of the wave = H/2
λ = wavelength
T = wave period which usually ranges from 4 sec to 12 sec
f = frequency expressed as the number of periods per second.

As a progressive wave moves, the crest line travels in a horizontal plane with a wave velocity or celerity C (wave velocity) in the direction of the x-axis, which also represents the wean sea level.

The frequency (f) is defined as the number of troughs or crests passing per second through a given point in the direction of wave motion.

The wavelength (λ) is the horizontal distance between two successive troughs or crests.

The wave velocity or CelerityC $= \lambda/T$ m/s

The relation between wavelength λ and period T is given by the equation $\lambda = 1.56T^2$ metre

Energy from High Waves

High waves are generated in deep ocean areas. As the train of waves approaches the shore, the wave period necessarily remains constant, but the wavelength, the celerity and the wave height undergo changes. As the wave approaches shallow waters (breaker zone), the decreasing depth of water gives rise to bed friction, here a part of the wave energy is dissipated in overcoming the frictional force. In this process the wave gets distorted. The water particles which have closed orbits in deeper water now start moving forward with the wave. Consequently, when the depth of water decreases to a value nearly equal to 1.3 times the local wave height, the crest plunges forward and the wave breaks dissipating its energy on the shore.

Wave energy is defined as the rate at which it is transferred across one metre line at right angles to its direction.

The energy available in random sea is expressed as

$P = 0.96\ H^2T$ kW/m of wave crest

where H is the wave height measured in metres and T the wave period in seconds.

The wave energy potential varies from place to place depending upon its geographic location. Even at a given place, the energy availability varies during the different parts of the day, for different months and from season to season.

Waves in ocean are not regular sine waves but are random in nature. This indicates that a wave condition with a wave height of 1.5 m and a zero crossing period of 7 seconds possesses a power of about 15 kW/m of the wave crest. During a severe gale, the ocean fluxes could be as high as 1000 kW/m of wave crest. During the protracted calm or in sheltered inlets, the power could be as little as 0.001 kW/m.

WAVE ENERGY CONVERSION

Waves with amplitude of 2 m and period of 10 s are of considerable interest for power generation with energy fluxes averaging between 50 and 70 kW per metre width of the oncoming wave. Wave energy can be better concentrated than the solar energy. Devices that convert energy from waves can therefore produce much higher power densities than those produced by solar devices.

Ocean wave energy is primary energy. Our approach is to convert it into usable secondary energy. Based on the design data developed in the laboratories, a demonstration plant of 150 kW capacity for conversion of wave energy into electrical energy has been built at Trivandrum. This site was selected considering its good wave power potential, easy access to d water, away from cyclonic zone and nearness to the available infrastructural facilities. The plant was commissioned in October 1991.

PRINCIPLE OF WAVE ENERGY PLANT

The wave energy plant utilizes an 'oscillating water column' chamber and a self-rectifying air turbine p the device works similar to the operation of a bellow. Ocean waves enter the chamber inside the caisson and cause the water mass to move up and down producing a bidirectional air flow through an opening at the top of the caisson. The special design of the turbine makes it rotate unidirectional even though the actuating air flow is bidirectional. The turbine drives an induction generator connected to the grid.

Wave Energy Conversion Machines with neat diagram. **(April/May 2012)(April 2013)**

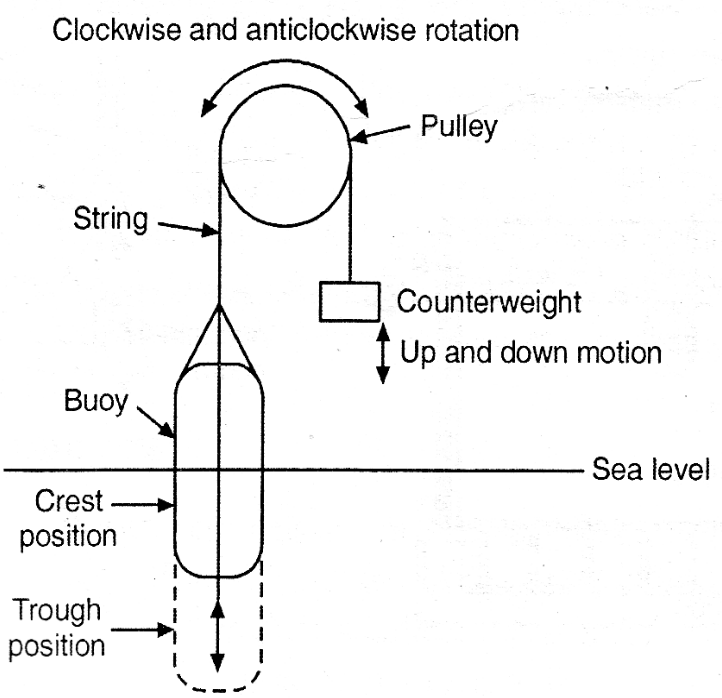
WAVE ENERGY CONVERSION MACHINES

Wave energy is a combination of kinetic and potential energies available in sea waves. The forward motion of sea water can easily be seen on sea beaches, lashing up to 100 metres. In deep sea this forward motion of the wave strikes the ships, depicting the presence of kinetic energy. The potential energy is due to rise of sea water at the wave crest. The difference of head between the crest and the trough of sea wave is the potential energy. It can easily be experienced when a large ship in the ocean is lifted up by swell and oscillates up and down due to huge ocean waves.

Thus, if the wave advances in a horizontal plane it is due to kinetic energy; when the water moves in the vertical plane, it is the action of potential energy. Some of the devices or machines are as follows:

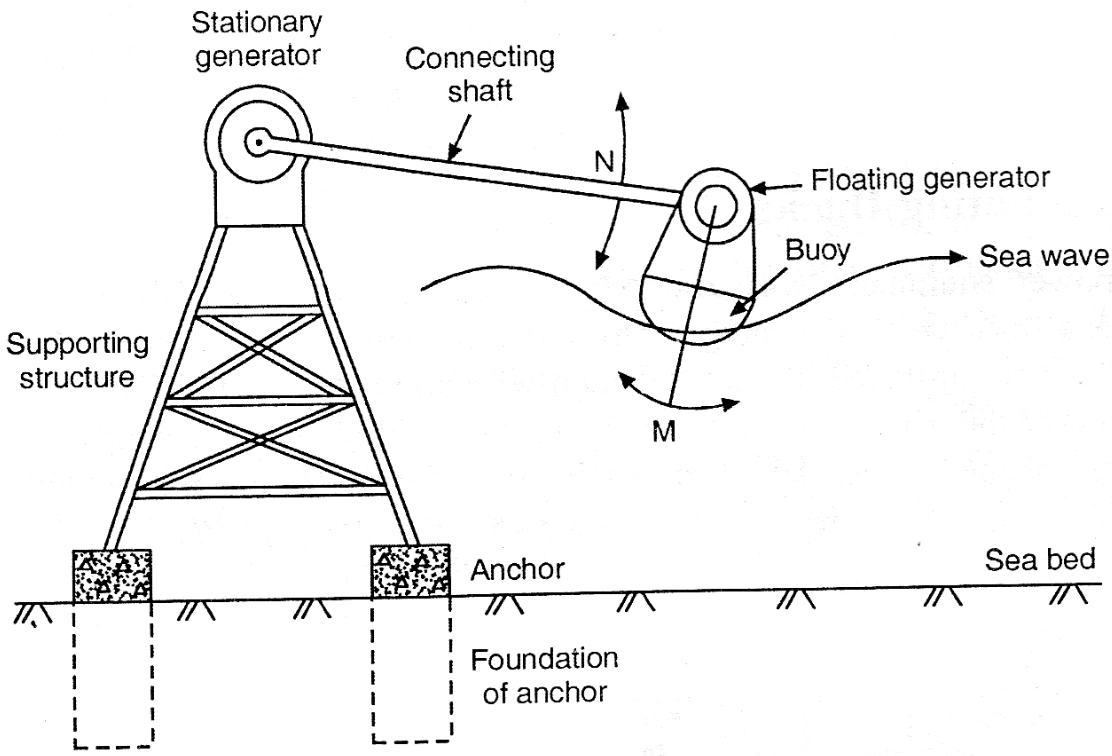
1. Buoy Type Machine

The buoy is a floating part of a system which rises and falls with rise and fall of sea waves. However, the device is moored and anchored as per design methodology to avoid drifting. The buoy oscillates up and down with the wave, the energy can be exhibited on a pulley with a string and counterweight arrangement as shown in Figure below. The up and down motion of the counterweight can be converted into to and fro motion of a piston which can operate a machine or a generator.



2. Dolphin Type Wave Energy Generator

Dolphin type wave energy generator was designed by a research laboratory in Japan. It essentially consists of the following components as detailed in Figure below.



A supporting structure is built in the sea bed to provide a firm position for the equipment. The structure is erected on pile foundations. One generator is installed on the top of the structure which collects wave energy from the connecting shaft with rolling motion. The gear arrangement with the stationary generator rotates the rotor to generate electric power. The buoy is at the other end of the connecting rod floats and has two motions, namely rolling motion and oscillator motions represented by N and M respectively. The floating generator collects wave energy from the buoy through a gear arrangement and continuously generates power.

$$\text{Power density, } (P/B) = 1740a^2T \text{ in W/m}$$

Where,

B = width of the wave, in metres
a = amplitude of the wave, in metres
T = wave period, in seconds

Normally one dolphin type wave energy generator is of 100 kW capacity. Several such energy generating systems are installed; say 50 numbers, along a width of 500 metres to an installed capacity of 5 MW.

3. Oscillating Ducks

It is a float type wave energy conversion plant in which several duck-shaped devices (each 25 m long) are installed in a linear width-wise array along a line which is perpendicular to the direction of the wave. The system consists of a long cylindrical spine of 15 m diameter on which cam shaped ducks are installed in an array to form an assembly as shown in Figure. It responds to the incoming wave with a nodding action.

When the forward moving wave front strikes the head on the face of the ducks, wave energy is passed on and the ducks start to oscillate. The face of the duck is designed for maximum wave energy absorption. Power is generated by the relative motion of the ducks where the wave energy is converted into mechanical energy. The cylindrical spine transfers motion through linkages and gears to the generator rotor. The overall length of the cylindrical spine -varies between 100 and 500 metres.

To achieve a highly efficient absorption it is necessary to mount a series of ducks on a non-movable spine. If the spine is sufficiently long (more than wavelength), the angular distribution of the waves incident on this structure will produce phase cancellations of translation force components along the spine and the spine will remain stationary.

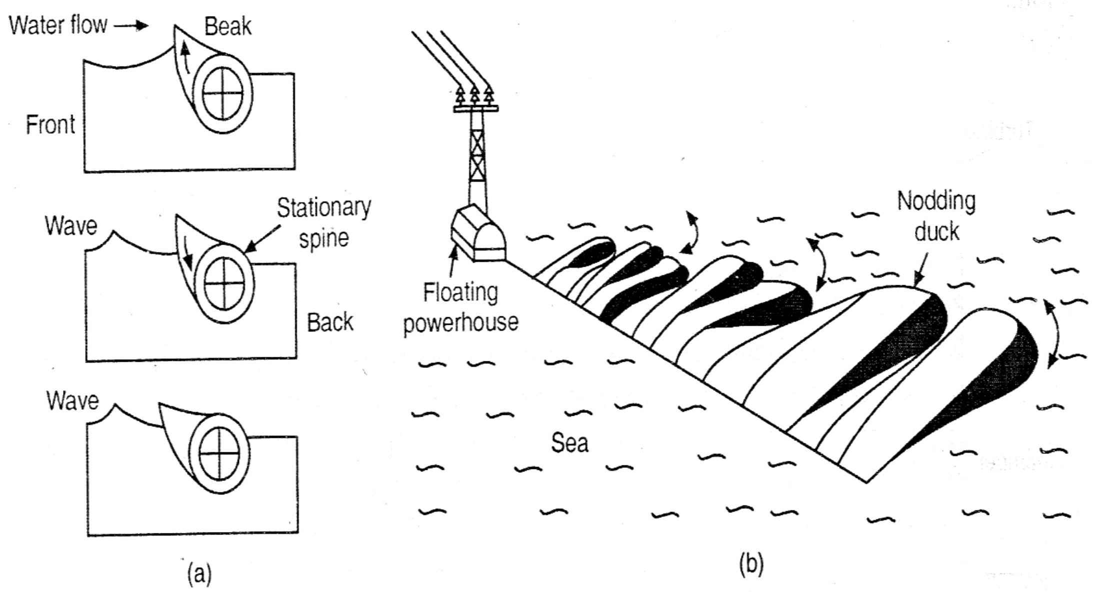


Figure: (a) Phases of duck motion, and (b) oscillating ducks with a floating powerhouse.

4. Wave-Energy Conversion by Floats

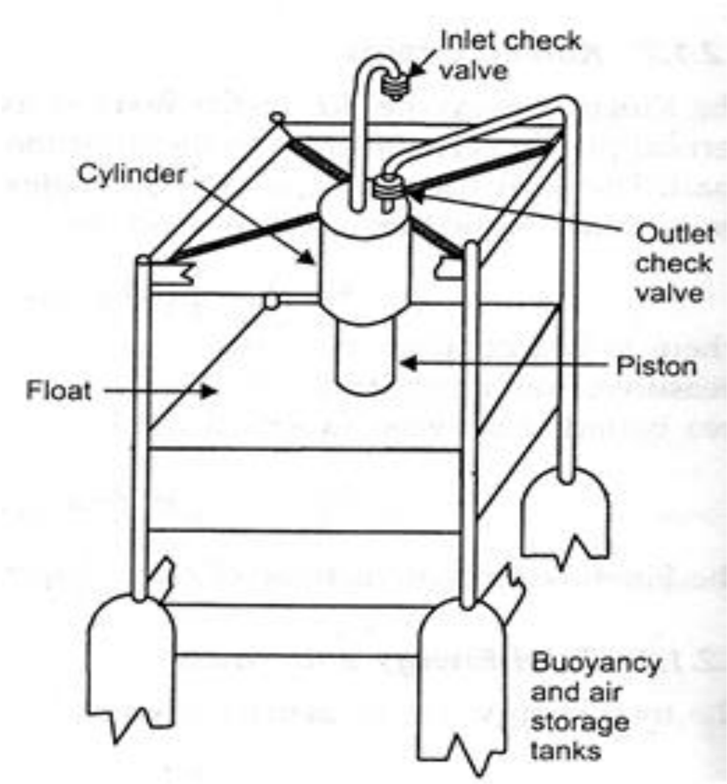
Wave motion is primarily horizontal, but the motion of water is primarily vertical. The vertical motion of water is exploited in obtaining mechanical power with the help of floats. The concept gives a large float that is driven up and down by the water within relatively stationary guides. This reciprocating motion is converted to mechanical and then electric power.

The system is shown in Fig. A square float moves up and down with the water. It is guided by four vertical manifolds that are part of a platform. Four large under water floatation tanks stabilizes the platform. The platform is supported by buoyancy forces. No significant vertical of horizontal displacement of the platform due to wave action occurs. Thus, even in heavy seas, the platform is expected to be relatively stationary in space. A piston, attached to the float, moves up and down inside a cylinder which is attached to platform and is therefore relatively stationary.

The piston cylinder arrangement acts as a reciprocating air compressor in which the down-ward motion of the piston helps to draw the air into the cylinder through an inlet check valve and the upward motion of the piston helps to compress and send it through an outlet check valve to the four under water floatation tanks via the four manifolds.

The four floatation tanks thus serve the dual purpose of buoyancy and air storage and the four vertical manifolds serve the dual purpose of manifolds and float guides. The compressed air is utilized to run an air turbine which in turn drives an electrical generator. The generated electricity is transmitted to the shore via an underwater cable.

A linear array of such modules perpendicular to wave motion is recommended as the modules attenuate the wave amplitude in the direction of wave motion and would affect other modules in that direction. To produce 100MW or more, miles of linear arrays are required. This scheme is having some problems some of which are shared by other schemes.



The problemsare:

(1) Waves not perfectly sinusoidal;

(2) Aspiration of water into intake and even submersion by large waves;

(3) Water entering turbine;

(4) Materials problems, such as cost and corrosion (which may be partly overcome by the use of molded plastic);

(5) Design to withstand storms;

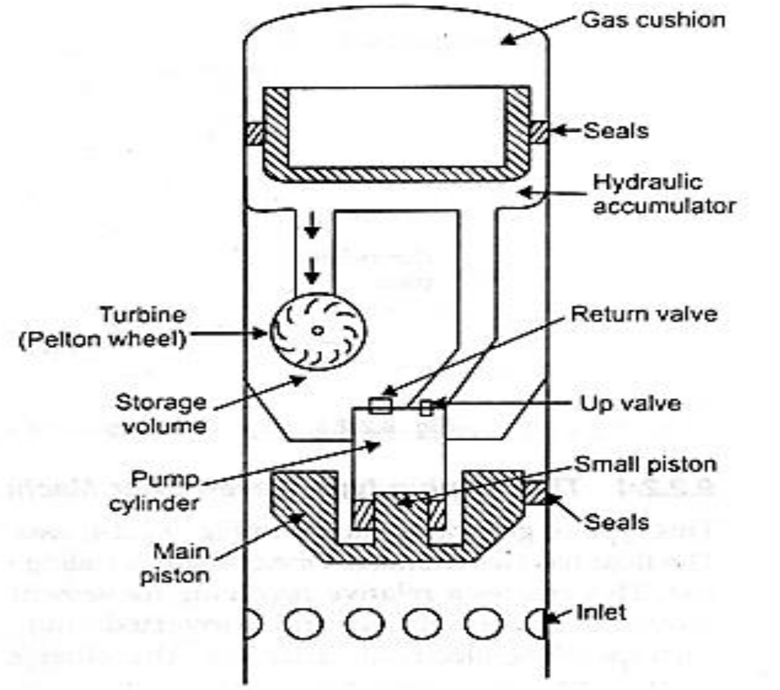
(6) Marine growth;

(7) Power transmission to shore.

5. High-pressure Accumulator Wave Machines

A typical hydraulic accumulator wave machine is shown in Figure below. In this machine, the water itself is pressurized and stored in a high pressure accumulator or pumped to a high- level reservoir. Then it flows through a water turbine to produce work output. A composite piston is used to transform large volumes of low-pressure water at wave crest into small volumes of high-pressure water. The composite piston is composed of a large Turbine diameter main piston and a small diameter piston at its center. The main piston is allowed to move up and down with the entering of the wave water through the opening. Above the small piston, there exists a closed water loop.

During upstroke, the pressure on the main piston is magnified on the small piston. Then high pressure water passes through a one-way piston valve to a hydraulic accumulator at the top of the generator. Two air (or other gas) volumes counter balance and act as cushions in a chamber above the main piston and in a sealed compartment in the hydraulic accumulator. The later also maintains the high pressure.



Part of pressurised water is allowed to flow through a Pelton wheel or Francis hydraulic turbine that drives an electrical generator and is then discharged to a storage chamber below the turbine.

6. The Dam-Atoll Concept

The dam-atoll wave power conversion device, shown in Fig below .was designed by Wirt and Morrow of the Lockheed Corporation, Burbank, California. The device is a massive and robust one. It overcomes complexity and fragility in heavy sea. It is also strong enough to counter any ocean storm. It incorporates some of the characteristics of both dams and atolls.

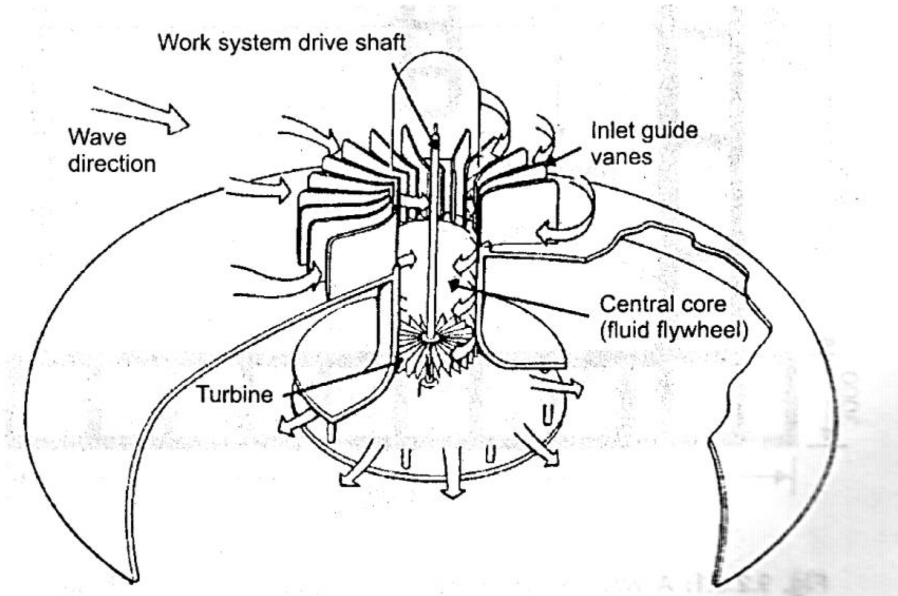


Fig. Cross Section of a Dam-atoll Wave Machine

On the basis of the observed action of waves as they approach atolls (small volcanic islands) in an ocean the principle of its operation is decided. Around the atolls from all sides, the waves wrap themselves. It creates a spiral motion in the center and drives a turbine before discharging laterally outward. A module, 80 m in maximum diameter and 20m high, is capable of generating 1 to 1.5 MW in 7 to l0 sec period waves.

7. Oscillating Hydraulic Piston Wave Energy /Pumped Storage Plant

Such a plant has three major parts:

(A) Wave Machine submerged in the ocean and inst on the ocean bed,

(B) Water Reservoir at higher level on the shore.

(C) Hydro-Electric Power Plant at lower level than (B) higher level than ocean.

The wave machine (A) pumps-up ocean water to rise using wave energy. The reservoir (B) stores potential hydro energy. The Hydro-Electric Power Plant delivers electrical energy. The water discharged through the tail-race of Hydro Electric Power plant is discharged Back to ocean

The wave machine (A) has a oscillating piston (5) sliding within a fixed chamber (1). The hydraulic pump (2) is located above the fixed chamber. The entire wave machine (A) is installed firmly under water. The piston (5) slides within cylindrical fixed chamber(1) and oscillates up-and down with wave crest and wave trough respectively.

The area of water pressure is large at bottom of piston(1) and small at the top. Remaining area on top side of piston acts on air chamber (3).

Let, P1 be the pressure of ocean water on the bottom of piston(5) on area A1. The P1 varies periodically due to crests and troughs of the waves.

P2 on the water on upper side of piston is P2 = P1 (A1/A2)

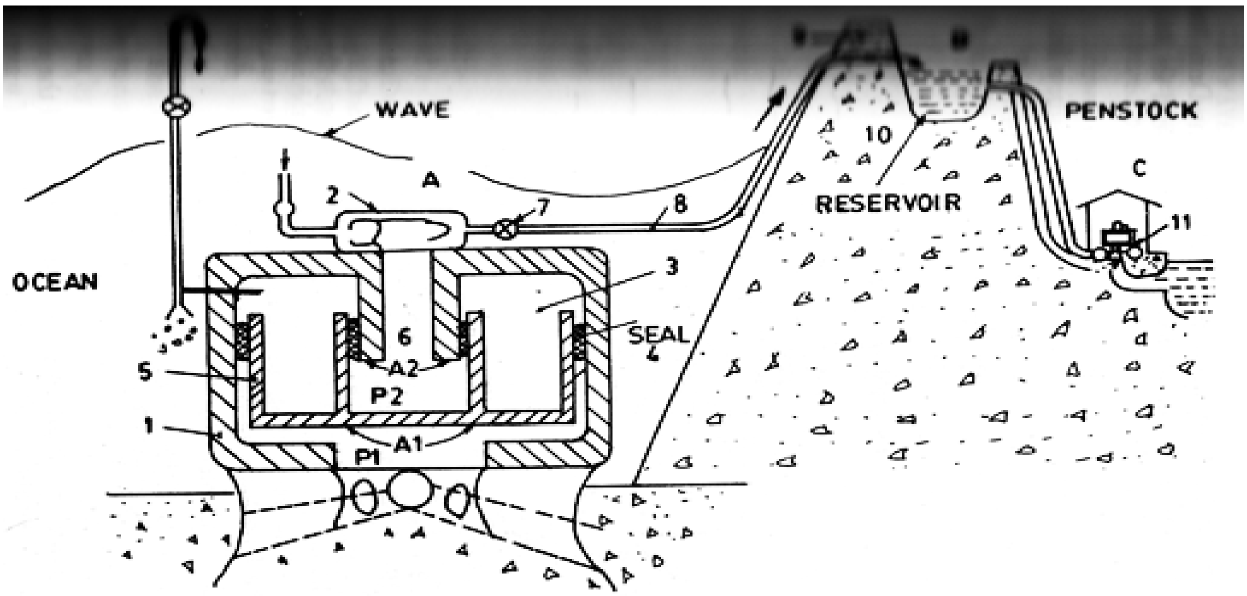


Fig. Oscillating hydraulic piston, pump wave machine and pumped storage hydro-electric power plant.

A. Wave machine with pump B. Reservoir C. Hydro-Electric Plant
1. Fixed chamber 2. Hydraulic pump 3. Air chamber
4. Seal 5. Piston 6. Piston 7. Non return valve
8. Pipe 9. Dam 10. Pumped storage 11. Generator

Due to large ratio A1/A2 the pressure gets amplified. The high pressure water is discharged periodically by water pump (2) non-return valve (7).

The check valve (7) discharges water in pipe (8) and does not allow reverse flow.

The ocean water is thus pumped periodically to high level reservoir (B). The water from reservoir (B) is used by conventional Hydroelectric Power Plant and then discharged back to ocean.

The air cushion trapped in (3) pushes the piston (5) downwards during wave-through due to reduced P1 on bottom side.

The water at higher level has potential hydro energy. This is to convert to rotary mechanical energy by hydro-turbines installed at lower level. The turbine drives generator rotor and electrical energy is obtained .The scheme is similar to the pumped storage hydroelectric schemes.

MERITS OF OCEAN WAVE ENERGY

- Ocean wave energy source is renewable and free of cost.
- Waves are continuous. So continuous supply is obtained.
- The energy storage requirement of wave energy plant is less.
- Wave plants reduce erosion of coastal land.
- The coastal regions which lack other energy sources may develop economically by investments in wave energy plants and availability of electrical energy from wave plants.

LIMITATIONS OF OCEAN WAVE ENERGY

- Difficulties associated with construction on shore or in ocean
- Corrosion of materials used in plant.
- Obstruction to ships
- Obstruction by floating objects
- Storms can damage the plants completely
- Power transmission to shore is costly and complex.

Power equation of hydroelectric power plant

Hydraulic energy is available wherever water can be collected at a higher level and made to flow through the turbine to lower level.

Hydraulic energy is proportional to $Q_t \times H$

where, Q_t is the total quantity of water, m^3

H is the gross head of water, m

The energy liberated in mechanical form from water is :

— For mass of water falling through 101.9 m... 1 kJ/kg

— For volume of water falling through 367 m... 1 kWh/m^3

— Potential Energy in Hydro-Reservoir with Head .. 1 MJ/m^3 hm (Exact value 0.981 MJ/m^3 hm)

— Potential Energy in Hydro-Reservoir with Head

$$9.81\ \text{kJ}/\text{m}^3 \ldots \text{m} = 2.72\ \text{Wh}/\text{m}^3 \ldots \text{m}$$

Power Equations for a Hydro-turbine Unit

$$P_g = \frac{1000\ Q \cdot H}{102} = \eta_g \cdot \eta_t \quad \text{kW}$$

where, P_g = Power generated, kW

Annual Energy Supply

The energy delivered by a hydroelectric scheme depends on annual rainfall over catchment area and the amount of water stored in the reservoir. Some rivers deliver water during summer by melting of snow and the reservoir gets filled during summer.

$$E_a = \text{Annual Electrical Energy Delivered}$$

$$E_a = \frac{1000\ Wr \cdot H}{3600 \times 102} \eta_g \cdot \eta_t \quad \text{kWh/year}$$

where Wr = Annual *useful* water in reservoir, m^3

H = Head, m

3600 second = 1 hour. Q is replaced by Wr/3600.

The useful water may be only in the upper 15 to 20% of the reservoir. Lower water is usually not taken into turbines due to silt.

Let, $\frac{1000\ \eta_g\ \eta_t}{102} = 8$, as explained above

$$E_a = 0.0022 \quad Wr \cdot H \quad \text{kWh in a year}$$

where, E_a = Electrical energy from a hydro electric station/year

W_r = Useful water in reservoir in a year, m^3

H = Effective head

(Useful water in reservoir is only about upper 15% to 20%).

Environmental aspects of hydro electric power plant

Hydro Power Plants are environment friendly and compatible with the environment (unlike fossil fuel plants which emit CO_2, SOx, NOx, Particulate Matter and Nuclear Power Plants associated with adioactive Wastes).

The major environmental issues to be analysed before planning and sanctioning a Hydro Scheme are however related with the reservoir volume and tailrace water flow and their impact on the population, agriculture, geography, geology, forests, aquatic life, etc. The impact is related with the catchment area. The permits from environmental authorities for large hydro projects should be taken in advance.

Hydro Schemes are *multipurpose*. The water is used *before* and after power generation and there is no wastage of water. Only the *head* is lost during power generation. Hence environmental aspects are viewed from multi-purpose influence. There is a trade off between the environmental disadvantages and multi purpose advantages (Drinking water, agriculture, fishery, navigation, flood control, power).

Comparison of Environmental Influence of Hydro Power Plants, Fossil Fuel Power Plants and Nuclear Power Plants

Type of Plant	*Multipurpose*	*Emissions*	*Radioactive Radiation*	*Social Impact*	*Earthquake Prone*
Hydro*	Yes	No	No	Yes	Yes
Fossil Fuel	—	Yes	No	Less	No
Nuclear	—	No	Yes	No	No
Wind*	—	No	No	No	No
Solar *	—	No	No	No	No

* Require vast areas away from large cities in scarcely populated regions.

Hydro thermal coordination: **(Dec 2015)**

The hydro generation is planned on the basis of available generating capacities of thermal, nuclear and hydro power plants. Nuclear power plants are operated with highest load factors for economic generations and as transportation of fuel is simpler.
Hydro generation is maximized during availability of reservoir level. Thermal generation is maximized during remaining months.

Coal fired stream thermal power plants lack the flexibility of starting quickly, loading quickly and stopping quickly due to the thermal nature of the boiler, stream turbine.

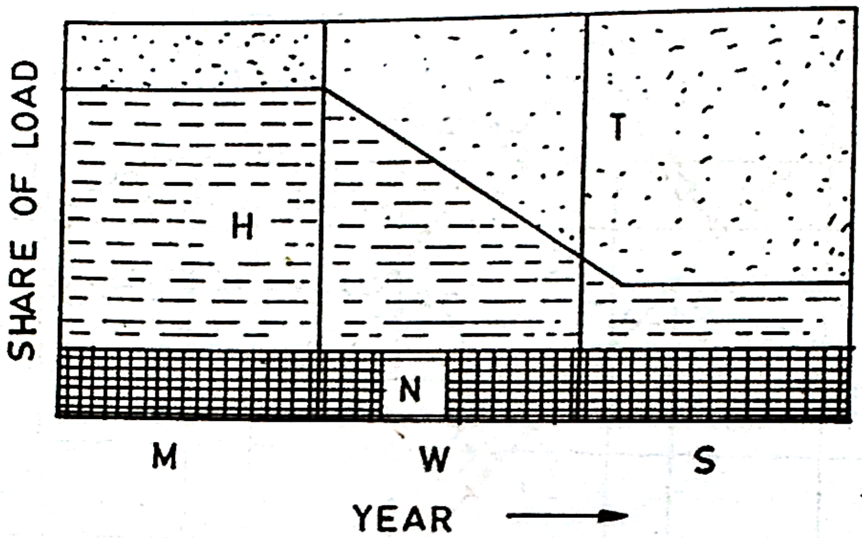
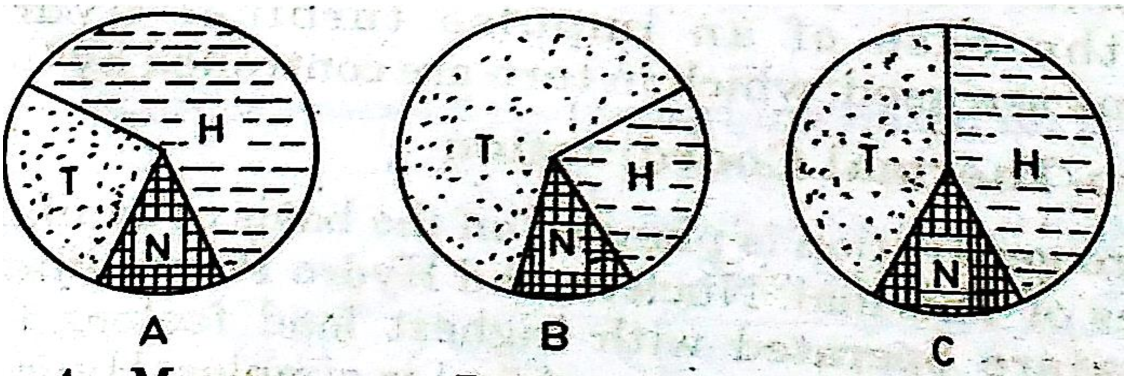


Fig. 34.12. Example of Sharing Base Load.

H = Hydro *T* = Thermal *N* = Nuclear
M = Monsoon months : Hydro = Maximised
S = Summer months : Hydro = Minimised
W = Winter : Hydro Tapered off, Thermal increased.

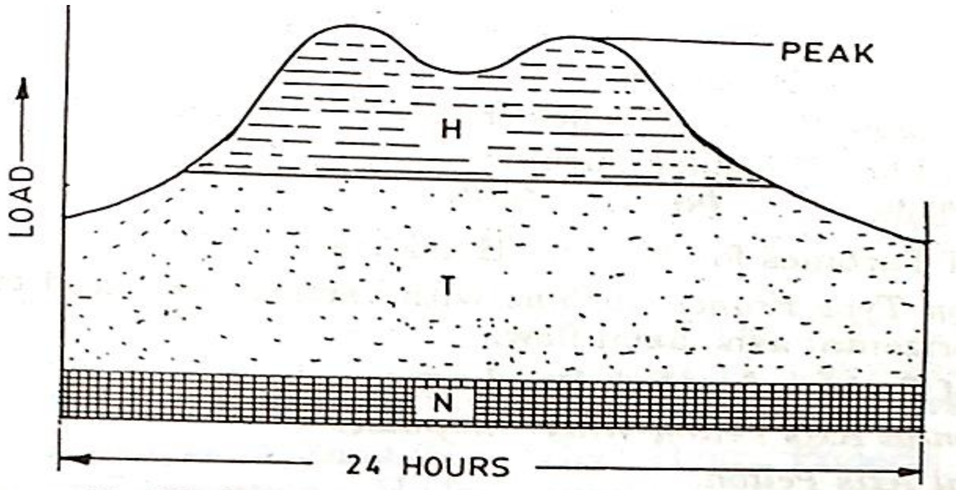
Hence the coal fired thermal power plants are used as base load power plants.
Hydro turbine power plants can be started quickly loaded quickly and load can be changed over wide range without sacrificing efficiency.

Hydro power plants are designed to operate as base load power plants during monsoon, so as to utilize water in the reservoir usefully for power generation, instead of letting out of gates directly.



A – Monsoon B – Summer C – Winter

Some divers originating in snow capped mountains have more flow during monsoon as well as summer. Hydro schemes on such rivers are suitable for base load operation during summer and monsoon. Thermal generation may be reduced accordingly.
With rivers drying during summers, the choice is to conserve reservoir water for summers and use the hydro electric energy to peaking power and coal thermal energy or nuclear energy for base power.



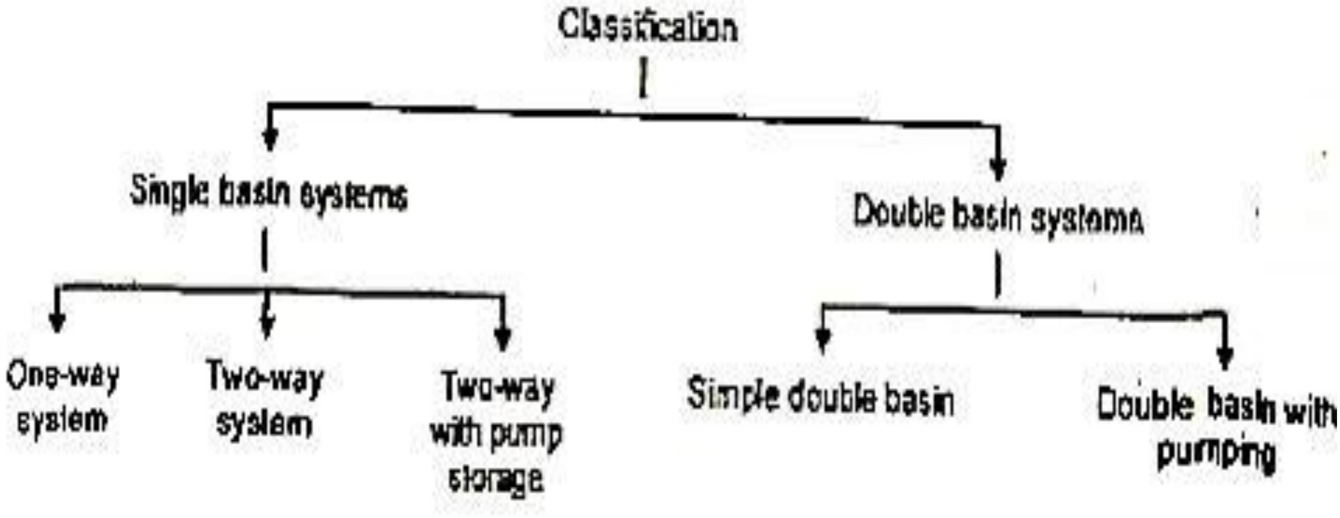
N – Nuclear T – Thermal H – Hydro

Operational flexibility is improved greatly by using a suitable coordination between thermal, nuclear and hydro power plants with higher percentage share of hydro during high reservoir level months and using hydro plants for peak sharing during medium hydro reserve months. The hydro generation may be discontinued during low water levels in reservoirs.

Operation of Single basin and Double basin tidal power plant. (May 2016)

The tidal power plants are generally classified on the basis of the number of basins used for the power generation. They are further subdivided as one-way or two-way system as per the cycle of operation for power generation.

The classification is represented with the help of a line diagram as given below.



Working of different tidal power plants

1. Single basin-one-way cycle

This is the simplest form of tidal power plant. In this system a basin is allowed to get filled during flood tide and during the ebb tide, the water flows from the basin to the sea passing through the turbine and generates power. The power is available for a short duration ebb tide.

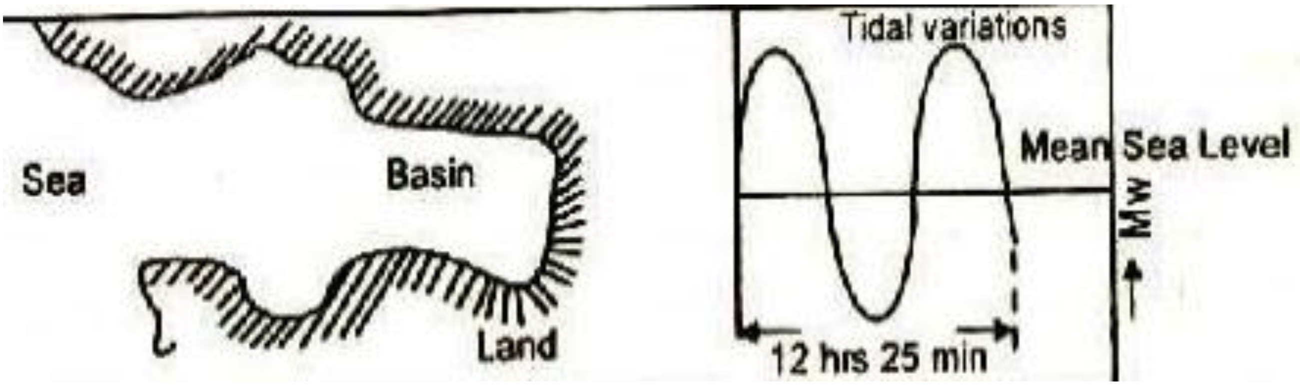


Figure: (a) Tidal region before construction of the power plant and tidal variation

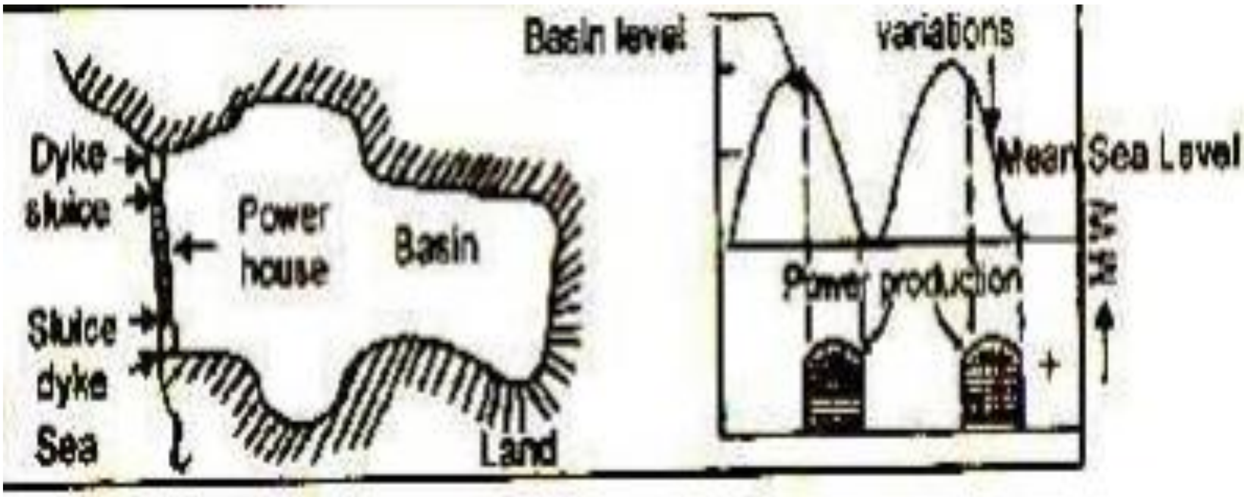


Figure: (b) Single basin, one way tidal power plant

Figure (a) shows a single tide basin before the construction, of dam and figure (b) shows the diagrammatic representation of a dam at the mouth of the basin and power generating during the falling tide.

2. Single-basin two-way cycle

In this arrangement, power is generated both during flood tide as well as ebb tide also. The power generation is also intermittent but generation period is increased compared with one-way cycle. However, the peak obtained is less than the one-way cycle. The arrangement of the basin and the power cycle is shown in figure.

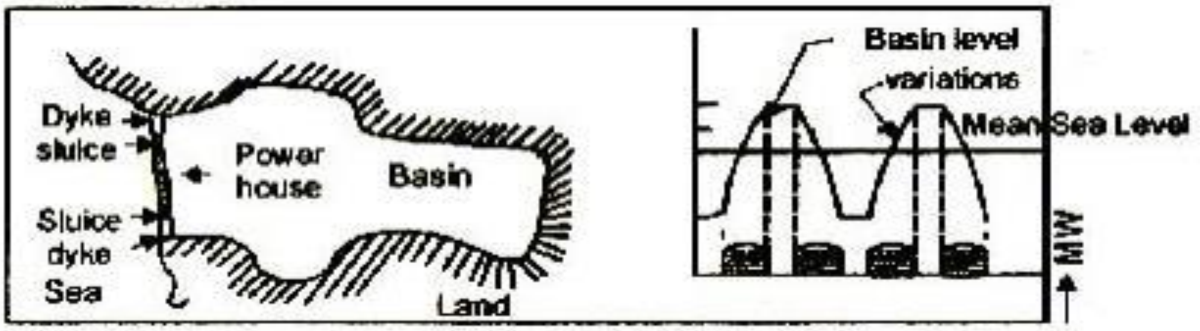


Figure: Single basin two-way tidal power plant

The main difficulty with this arrangement, the same turbine must be used as prime mover as ebb and tide flows pass through the turbine in opposite directions. Variable pitch turbine and dual rotation generator are used of such scheme.

3. **Single basin two-way cycle with pump storage**

In this system, power is generated both during flood and ebb tides. Complex machines capable of generating power and pumping the water in either directions are used. A part of the energy produced is used for introducing the difference in the water levels between the basin and sea at any time of the tide and this is done by pumping water into the basin up or down. The period of power production with this system is much longer than the other two described earlier. The cycle of operation is shown in figure.

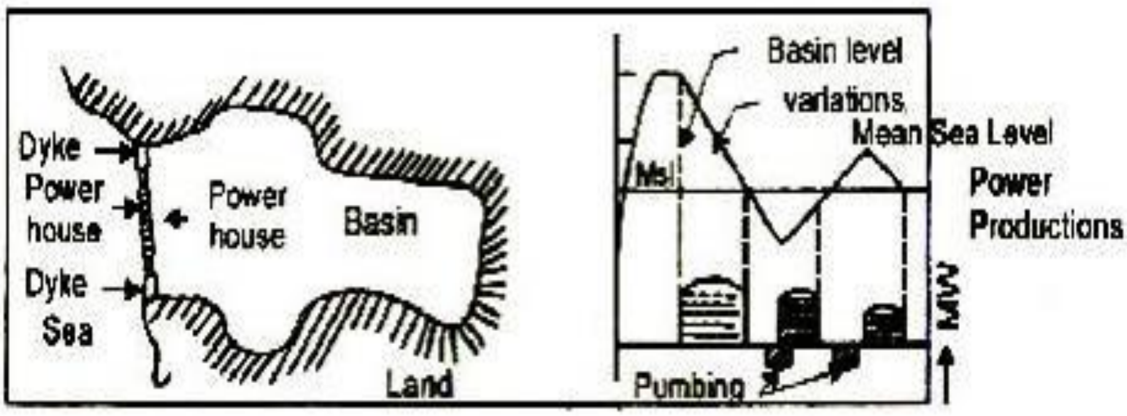
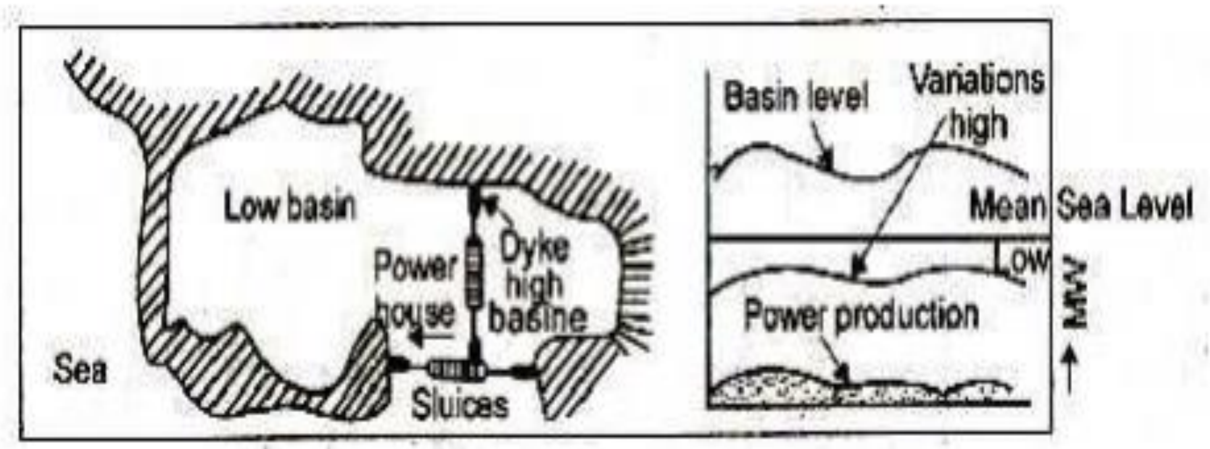


Figure: Single-basin, two-way tidal plant coupled with pump storage system.

4. Double basin type

In this arrangement, the turbine is set up between the basins as shown in figure. One basin is intermittently filled tide and other is intermittently drained by the ebb tide. Therefore, a small capacity but continuous power is made available with this system as shown in figure. The main disadvantages of this system are that 50% of the potential energy is sacrificed in introducing the variation in the water levels of the two basins.



5. Double basin with pumping

In this case, off peak power from the base load plant in a interconnected transmission system is used either to pump the water up the high basin. Net energy gain is possible with such a system if the pumping head is lower than the basin-to-basin turbine generating head.

Oil pressure governor system for turbine in hydro power station;. (May 2016)

Introduction Governing system or governor is the main controller of the hydraulic turbine. The governor varies the water flow through the turbine to control its speed or power output. Generating units speed and system frequency may be adjusted by the governor.

Governing system as per IEEE std. -75 includes following.

a) Speed sensing elements

b) Governor control actuators

c) Hydraulic pressure supply system

d) Turbine control servomotors-these are normally supplied as part of turbine

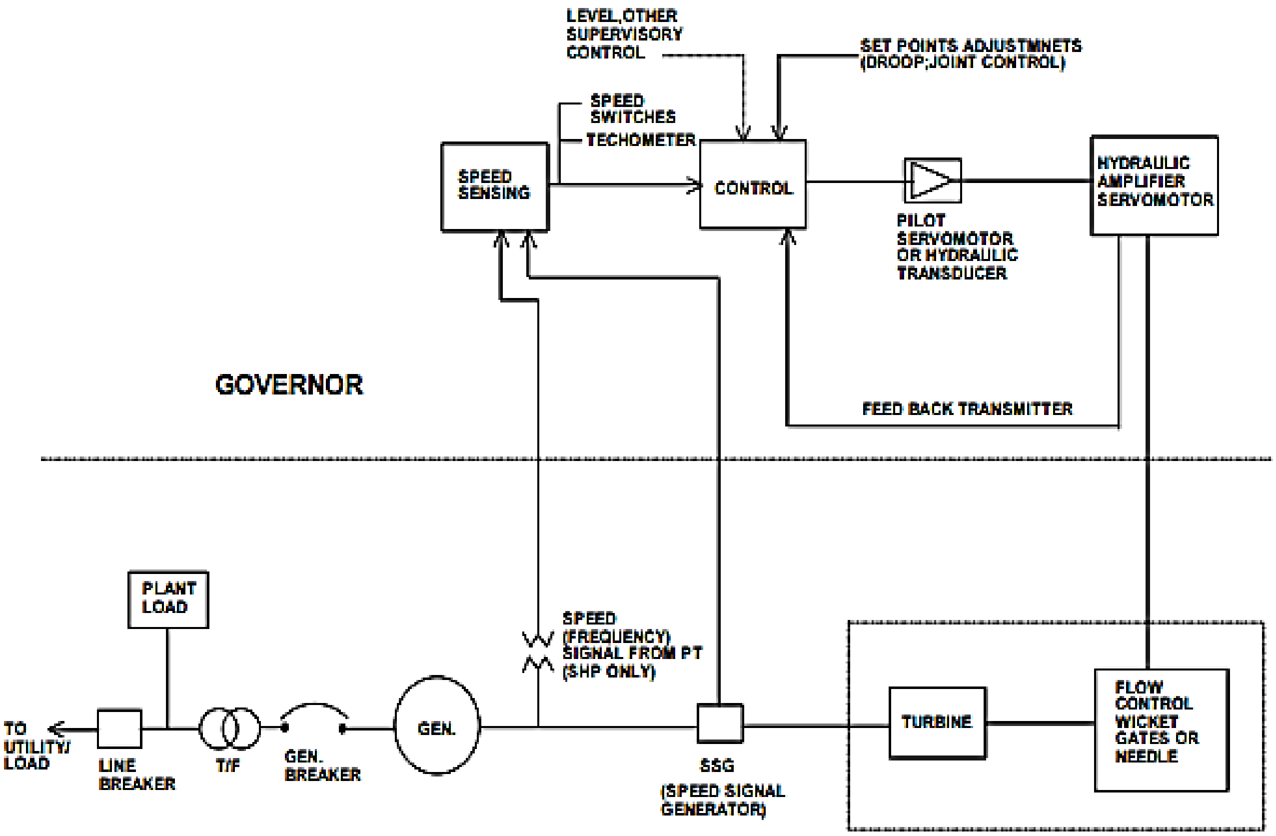


Figure Governing System – Block Diagram (Typical)

The primary functions of the hydraulic turbine governor are as follows:

i) To start, maintain and adjust unit speed for synchronizing with the running units/grid.

ii) ii) To maintain system frequency after synchronization by adjusting turbine output to load changes.

iii) iii) To share load changes with the other units in a planned manner in response to system frequency error.

iv) iv) To adjust output of the unit in response to operator or other supervisory commands.

v) v) To perform normal shut down or emergency over speed shut down for protection.

In isolated systems the governor controls frequency. In large system it may be needed for load operation control for the system. A block diagram is shown in figure. Digital electronic load governor are now employed. Mechanical analogue electronic governors used in earlier plants are also briefly discussed. In small hydro units digital governors are employed for plant control and protection also which is discussed in detail in Vol. II - Control and Protection.

Basic Control System

Governor control system for Hydro Turbines is basically a feedback control system which senses the speed and power of the generating unit or the water level of the forebay of the hydroelectric installation etc. and takes control action for operating the discharge/load controlling devices in accordance with the deviation of actual set point from the reference point. Governor control system of all units controls the speed and power output of the hydroelectric turbine. Water level controlled power output controllers can be used for grid connected units. Governing system comprises of following sections (figure).

a) Control section

b) Mechanical hydraulic Actuation section

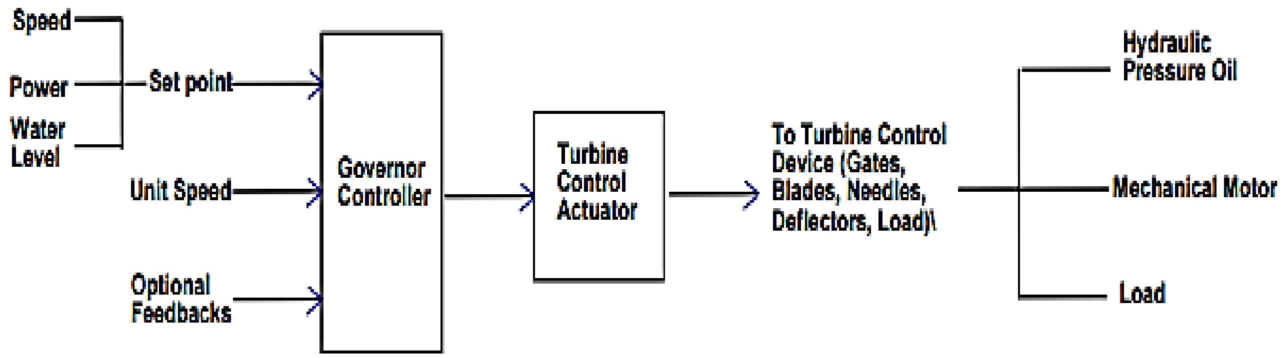


Figure – Basic Governor Control System (Typical)

The control section may be mechanical; analogue electronic or digital electronic. Actuator can be hydraulic controlled, mechanical (motor) or load actuator. Load actuator are used in micro hydro range; mechanical (motor operated) actuators may be used say up to about 1000 kW unit size. Hydraulic actuators are mostly used. Actuator system compares the desired turbine actuator position command with the actual actuator position. In most of the hydroelectric units reaction turbines are used. In these turbines it requires positioning of wicket gates, including turbine blades in Kaplan units. In Pelton units it requires positioning of spear and deflector. Pressure oil system with oil servomotor is most commonly used actuator. In micro hydros electronic loads controllers are used and shunt load bank is adjusted.

Governor Capacity (oil servomotor) Governor capacity rating in meter-kilogram is the capacity of the wicket gates/nozzles and blade servo motors (Kaplan units) as required for operation of the turbine at minimum rated oil pressure. USBR Engineering monograph no. 20 criteria is mostly followed. The size, type, and cost of governors vary with their capacity to perform work which is measured in (meter kilograms). Governor having a capacity of more than 8500 m kg are of cabinet actuator type. Those having a capacity less than 7000 m kg are gate shaft type. The capacity is the product of the following factors: turbine gates servomotor area, governor minimum rated oil pressure, and turbine gates servomotor stroke. For gate shaft governors, the turbine gates servomotor area is the net area obtained by subtracting the piston rod area from the gross piston area. For governors controlling two servomotors mounted directly on the turbine, the effective area is the sum of the net area of the two servomotors.

Servomotor capacity can be estimated by following empirical relations:

1. Wicket gates servomotor capacity.
2. FYM = 34 (hwhDg.M)1.14(metric)

Where, FYM = Servomotor capacity (m. kg.)

M = wicket gate height hwh = maximum head, including water hammer, and

Dg = wicket gate circle diameter

Blade servomotor capacity (adjustable blade Kaplan turbine). - The blade servomotor capacity also varies among manufacturers. This can be roughly estimated by the formula:

$$FY_b = \frac{6.17P_{max}(n_s)^{1/4}}{(Hmax)^{1/2}}$$

Where FYb = Servomotor capacity (m. kg.)

Hmax = maximum head,

ns = design specific speed, in metric HP units

Pmax = turbine full-gate capacity at Hma

Mechanical Controller

Early mechanical governors were directly driven by prime movers through belt for small machines. The speed of rotation was sensed by fly-ball type pendulum. In second-generation mechanical governors, permanent magnet generator and pendulum motor were utilized for sensing the speed of the machine. The isodrome settings were achieved through mechanical dashpot and droop setting by link mechanism. These mechanical governors were fully capable of controlling the speed and output of the generating unit in stable manner. In case of faulty pendulum, manual control of the units was possible with handles and knobs. This was PI type controller. Bhakra Left Bank commissioned in 1960-61 have mechanical cabinet governors supplied by M/s Hitachi Ltd. Cabinet type governors have remotely mounted servomotor and are referred as cabinet actuators. Following operating control are on the cabinet face. i) Gate –limit control ii) Speed level control iii) Speed droop control iv) Manual gate control v) Speed level indicator vi) Speed droop indicator vii) Speed indicators viii) Low speed switch ix) Oil pressure switch.

2- MARKS

1. **What are the factors considered while selecting the site for hydroelectric stations?** **(April 2014)**
    i. Availability of water and water head
    ii. Accessibility of site
    iii. Water storage capacity
    iv. Distance from the load centre
    v. Type of land
2. **List any four advantages of hydro power**? (Nov' 2015)
    i. Water source is perennially available
    ii. Running cost is very low
    iii. Non-polluting
    iv. Power generation can be switched on and off in a very short period.
3. **List any four disadvantages of hydropower?**
    1. High capital investment and low rate of return
    2. Development period is very large
    3. Power generation depends on availability of water
    4. Transmission cost and losses are high
4. **Mention the classification of hydroelectric plant according to regulation of water flow? (NOVEMBER 2013)**
    (a) Overflow type dam
    (b) Non-overflow type dam
5. **What are the social effects of implementing of hydroelectric plants? (April 2012)**
    a. Landslide
    b. Ramping effect will affect fish habitat.
    c. Submerge due to lose sand.
    d. Water flow is not continuous
6. **List the classification of dams?April 2015**
    1. Based on their functions:
        (a) Storage dams
        (b) Diversion dams
        (c) Detention dams
    2. Based on their shape:
        (a) Trapezoidal dams
        (b) Arch dams
    3. Based on the materials of construction:
        (a)Earth dams
        (b) Rock pieces dams
        (c) Stone masonry dams
        (d) concrete dams
        (e) RCC dams
        (f) Timber and Rubber dams
    4. Based on hydraulic design:
        (a) Overflow type dam
        (b) Non-overflow type dam
    5. Based on structural Design:
        (a) Gravity dam
        (b) Arch dam
        (c) Buttresses dam
7. **What is hydro graph?(November 2012)**

A hydrograph is a graph showing the rate of flow (discharge) versus time past a specific point in a river, or other channel or conduit carrying flow. The rate of flow is typically expressed in cubic meters or cubic feet per second (cms or cfs).

8. Give any two advantages of pumped storage plant.

1. Increases the peak load capacity at low cost
2. High operating efficiency
3. Better load factor
4. Independence of steam flow conditions

9. What is meant by magneto hydrodynamic generator? **(November 2011)**

A magneto hydrodynamic generator (MHD generator) is a magneto hydrodynamic device that transforms thermal energy and kinetic energy into electricity. MHD generators are different from traditional electric generators in that they operate at high temperatures without moving parts. MHD was developed because the hot exhaust gas of an MHD generator can heat the boilers of a steam power plant, increasing overall efficiency.

10. What is the principle of Hydel power generation?

Energy from flowing water is used to spin a generator.Mostly, the fast moving water (kinetic energy) strikes the turbines and they start moving (mechanical energy) and then this energy is used to run electric generators. The transference of energy takes place from one form to another.

11. What is the principle of pumped storage scheme?

The basic principle of pumped storage scheme is to convert the surplus electrical energy generated by a power plant or available in a system in off-peak periods, to hydraulic potential energy, in order to generate power in periods where the peak demand on the system exceeds the total available capacity of the generating stations.

12. What is the main purpose of reservoir?

The main purpose of reservoir is to store water received from catchments areas during the rainy seasons and supply the same during the dry season.

13. What is the main purpose of the dam?

The main purpose of the dam is to increase the height of water level and also to increase the working head of the hydraulic power plant.

14. Why trash rack is used?

The trash rack is used to prevent the entry of debris, which might damage the turbine runners and chock up the nozzle of impulse turbine.

15. What is the use of surge tank? **(April 2013)**

The surge tank is used to provide better regulation of water pressure in the system. The surge tank controls the water when the load on the turbine decreases and supplies water when the load on the turbine increases. Thus, surge tank controls the pressure variations resulting from the rapid changes in water flow in penstock and hence prevents water hammer.

16. What is the function of fore bay? **(November 2012)**

Fore bay is considered as naturally provided surge tank. It is temporary water storage when the load on the plant is reduced and provides water for initial increment on increasing load.

17. Explain about penstock?

The pipe between surge tank and prime mover is known as penstock. It is designed to withstand high pressure. It is made up of reinforced concrete. In very cold areas, the penstock is buried to prevent ice formation and to reduce the expansion joints.

18. What is spill way? **(November 2013)**

A spillway is a structure used to provide the controlled release of flows from a dam or levee into a downstream area, typically being the river that was dammed. Spillways release floods so that the water does not overtop and damage or even destroy the dam.

19. Write about prime movers?

Prime mover converts the kinetic energy of water into mechanical energy to produce electrical energy. Pelton wheel, turbine, Francis turbine, Kaplan turbine and Propeller turbine are prime movers used in hydraulic power plants.

20. What is the use of draft tube?

The draft tube is used to regain the kinetic energy of water coming out of reaction turbine. It enables the reaction turbine to be placed over tailrace level.

21. List the types of hydro power plants based on availability of head.

1. High head power plant (head>100m)
2. Medium head power plant (30m-100m)
3. Low head power plants (head<30m)

22. List the advantages of pumped storage power plants.

1. Increases the peak load capacity at low cost
2. High operating efficiency
3. Better load factor
4. Independence of steam flow conditions

23. What are the essential elements of hydro power plant?

1. Catchment area
2. Reservation
3. Dam
4. Surge tanks
5. Draft tubes
6. Power house
7. Switched for transmission of power

24. List hydro power plants in India.

Name	State	Capacity(MW)
Tehri Dam	Uttarakhand	2400 MW
Koyna	Maharashtra	1920 MW
Srisailam Dam	Andhra Pradesh	1670 MW
NathpaJhakri	Himachal Pradesh	1500 MW
SardarSarovar	Gujarat	1450 MW

25. Write the formula to calculate the hydraulic power produced by a hydro turbine?

The hydraulic power is given by the formula:

$$P = G\rho QH$$

Where,

P is the hydraulic energy in watts

G is acceleration due to gravity (9.81 M/s2)

ρ is water density

Q is the flow or discharge

H is the height of fall of water or head in meter.

26. What is meant by catchment area and explain its function:

The whole area behind the dam is called the catchment area. The rain water in the area will be drained into the dam through a dam or river.

27. What is mini Hydro plants?

The mini power plants operate with 5m-20m head and produce about 1 MW to 5MW of power.

28. What are micro hydro plants?

The micro power plants require a head less than 5m and produce 0.1 MW to 1MW.

29. Define turbines?

Turbine is used to convert energy in the form of falling water into rotating shaft power. The selection of best turbine for any particular site depends on the site characteristics.

30. What is the basic principle of Ocean Thermal Energy Conversion (OTEC)? (April 2014)

Sun radiation warming up water of ocean surface is creating a temperature difference this difference ΔT is fairly low About 10K. Whereas 25K at best in tropical seas (surf – 0.5km/1km). This temperature difference is used to vaporize the low boiling point liquid like ammonia (15K) with the help of heat exchanger, which is then used for power generation.

31. What is the cause of tides? And what its tidal range. (April 2012)

TIDE is a periodical rise and fall of the water level of sea which are carried by the action of the sun and moon on the water of the earth. The main feature of the tidal cycle is the difference in water surface elevations at the high tide end, the tidal energy can be converted into electrical energy by means of a generator. Tidal range is expressed as the difference in water levels between two consecutive high tides and low tides.

32. What are the limitations of tidal energy power plant? (April 2013)

1. Orientation problem
2. Requires storage devices
3. Available at a lower rating and time
4. High capital cost

33. What are the main types of OTEC power plants? April 2015

There are three kinds of OTEC systems: closed-cycle, open-cycle, and hybrid.

34. What are the energy conversion schemes in hydro electric power generation Nov'2015

Hydro energy is available in many forms, potential energy from high heads of water retained in dams, kinetic energy from current flow in rivers and tidal barrages, and kinetic energy also from the movement of waves on relatively static water masses. Many ingenious ways have been developed for harnessing this energy but most involve directing the water flow through a turbine to generate electricity.

35. Give a short note on role of surge tank in high and medium head hydro power plants April 2016

Surge tank is a small storage tank or reservoir required in the hydro power plants for regulating the water flow during load reduction and sudden increase in the load on the hydro generator (water flow transients in penstock) and thus reducing the pressure on the penstock. This is the advantage of surge tank.

Thus surge tank helps in stabilizing the velocity and pressure in the penstock and protects penstock from water hammering and negative pressure or vacuum.

36. Differentiate hydro power plants and ocean energy technology April 2016

Hydro

"Hydro" power conventionally refers to the use of a height difference between two bodies of water to generate electricity as water falls from one to the other. Typically this is achieved by damming a river, or running a pipe ("penstock") from a high lake to a lower lake, river or sea.

Tidal

Tidal power refers to generating electricity from the flow of the tides. There are two approaches:

Exploiting the vertical rise and fall of the water level over a tidal cycle. A barrage is constructed with gates that close at high water, to retain the water inside the barrage while the water level outside goes down. Once a height difference has developed, the water inside is allowed to run out through turbines, operating much like the traditional hydro systems described above, but with a relatively small height difference. There are variations on this approach, but all exploit the cyclic change in water level in a similar way.

Exploiting the speed of a fast tidal flow. Some places in the world have exceptionally fast flows for various reasons, and this approach puts turbines in the water to extract energy from them, analogous to underwater wind farms.

PONDICHERRY UNIVERSITY QUESTIONS

2 MARKS

1. What are the factors considered while selecting the site for hydroelectric stations? (April 2014)
2. Mention the classification of hydroelectric plant according to regulation of water flow? (NOV2013)
3. What are the social effects of implementing of hydroelectric plants? (April 2012)
4. What is hydro graph? (November 2012)
5. What is meant by magneto hydrodynamic generator? (November 2011)
6. What is the use of surge tank? (April 2013)
7. What is the function of fore bay? (November 2012)
8. What is spill way? (November 2013)
9. What is the basic principle of Ocean Thermal Energy Conversion (OTEC)? (April 2014)
10. What is the cause of tides? And what its tidal range. (April 2012)
11. What are the limitations of tidal energy power plant? (April 2013)
12. How the hydel plants are classified. April 2015
13. What are the main types of OTEC power plants? April 2015
14. Enumerate the advantages of using hydro electric power plant Nov’2015
15. What are the energy conversion schemes in hydro electric power generation Nov’2015
16. Give a short note on role of surge tank in high and medium head hydro power plants April 2016
17. Differentiate hydro power plants and ocean energy technology April 2016

11- MARKS

1. Explain the Hydroelectric power plant with neat diagram.
(April/May 2012) (November 2013) (April 2013)
2. Explain the classification of hydro-electric plants according to available head. (April 2015)
3. Describe about the various types of hydroelectric power plants?
(November 2012)(November 2013) (April 2015) (April/May 2014)
4. What are the environmental aspects for selecting site? (Nov/Dec 2014)
5. Explain the different types of Wave Energy Conversion Machines with neat diagram.(April/May 2012) (April 2013)
6. Explain the basic principle of Tidal power generation (April 2015)
7. Explain hydro-Thermal coordination in detail. (Nov 2016)
8. Explain working principle of ocean power plant and also discuss its limitations. (Nov’ 2015)
9. Explain the operation of single basin and double basin tidal power plant in detail. (May 2016)
10. Explain the operation of oil pressure governor system for turbine in hydro power station; also mention the importance of governing system of power plant. (May 2016)