UMP OPEN COURSEWARE

Universiti Malaysia PAHANG
Engineering • Technology • Creativity

CHAPTER 4
HYDRO POWER

Expected Outcomes

Able to learn Hydroelectricity production technique & Social and environmental effects

HYDROELECTRIC POWER

Hydroelectric power is a **renewable source of energy.** A renewable energy source is one that is not depleted in the energy production. Hydropower, the energy in falling water is converted into electricity without using the water.

Hydropower in Malaysia

➢Major hydropower plants in Malaysia are those belonging to TNB, namely the **Kenyir Sultan Mahmud Power Station with 400MW** installed capacity, the **Pergau Hydroelectric Power Station with 600MW** installed capacity and the Temenggor Hydroelectric Power Plant with 348MW installed capacity.

➢A total of 149 sites with an estimated micro hydropower potential of 28.9 MW have been identified (figure 2). It is also predicted that by the year 2020, most rivers and waterways will be fully utilized especially for the generation of electricity.

How Hydropower Works!

Hydrologic cycle

Hydropower energy derived from the sun, which starts the **water cycle**. In the water cycle, rivers are a source for continuous cycle. Reason of the force gravity, water flows from high points to low points. There is **kinetic energy** embodied in the flow of water.

Source: www.srh.noaa.gov 12/19/2015

Electricity generated by a hydroelectric power plant

The amount of electricity can be depend on two factors:

- **Flow rate -** the quantity of water flowing in a given time
- **Head** - the height from which the water falls.

Flow Rate

More quality of water flows through a turbine, more electricity produced. Flow rate depends on the size of the river and the amount of water flowing in it. Power production is considered to be **directly proportional** to river flow.

Head

Power production is also **directly proportional** to head. That is, water falling twice as far will produce twice as much electricity.

A standard equation :

$$\text{Power} = \frac{(\text{Head}) \times (\text{Flow}) \times (\text{Efficiency})}{11.8}$$

Power = the electric power in kilowatts or W

Head = the distance the water falls (measured in feet)

Flow = the amount of water flowing (measured in cubic feet per second or **cfs**)

Efficiency = How well the turbine and generator convert the power of falling water into electric power. This can range from 60% (0.60) for older, poorly maintained hydroplants to 90% (0.90) for newer, well maintained plants.

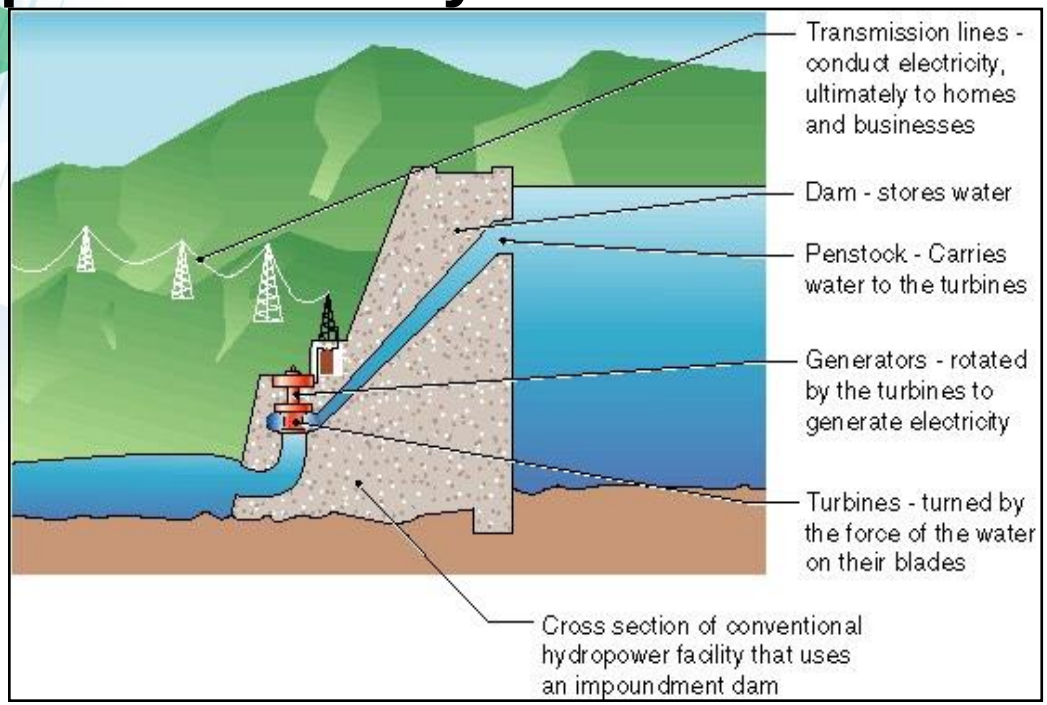
11.8 = Index that converts units of feet and seconds into kilowatts

Types of Hydropower Facilities

The two primary types of hydropower facilities are

1) **Impoundment system** (or dam)
2) **Run-of-the-river system**.

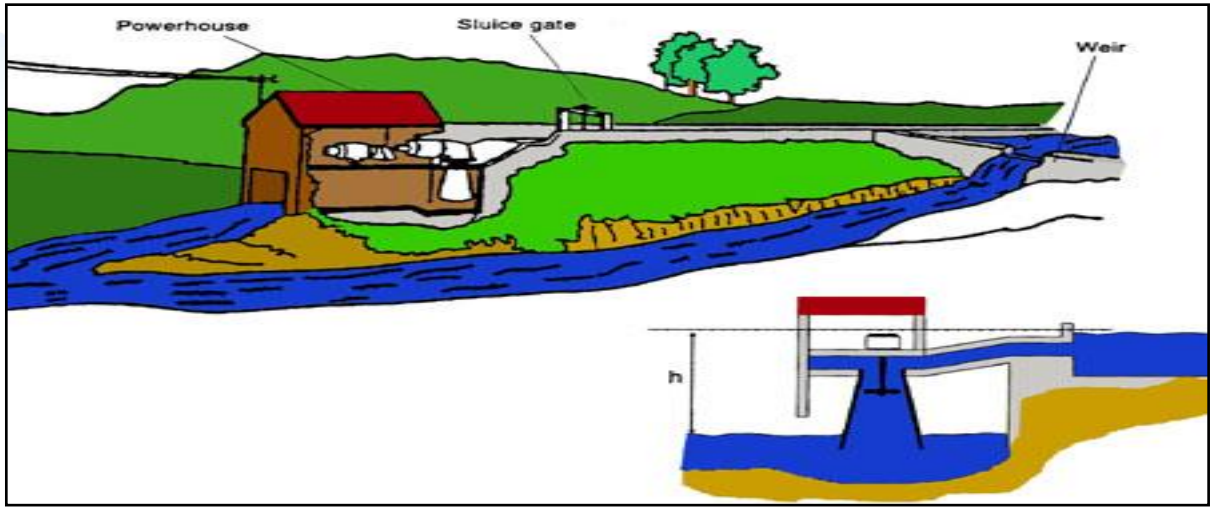
Impoundment System



Source: http://energy.gov/eere/water/types-hydropower-plants 12/19/2015

This illustration shows the parts of a standard hydroelectric dam. Most large, high-head hydropower facilities use impoundments.

A **run-of-the-river** system uses the river's natural flow and requires no impoundment. It may involve a diversion of a portion of the stream through a canal or penstock, or it may involve placement of a turbine right in the stream channel. Low head are often use in Run-of-the-river systems.

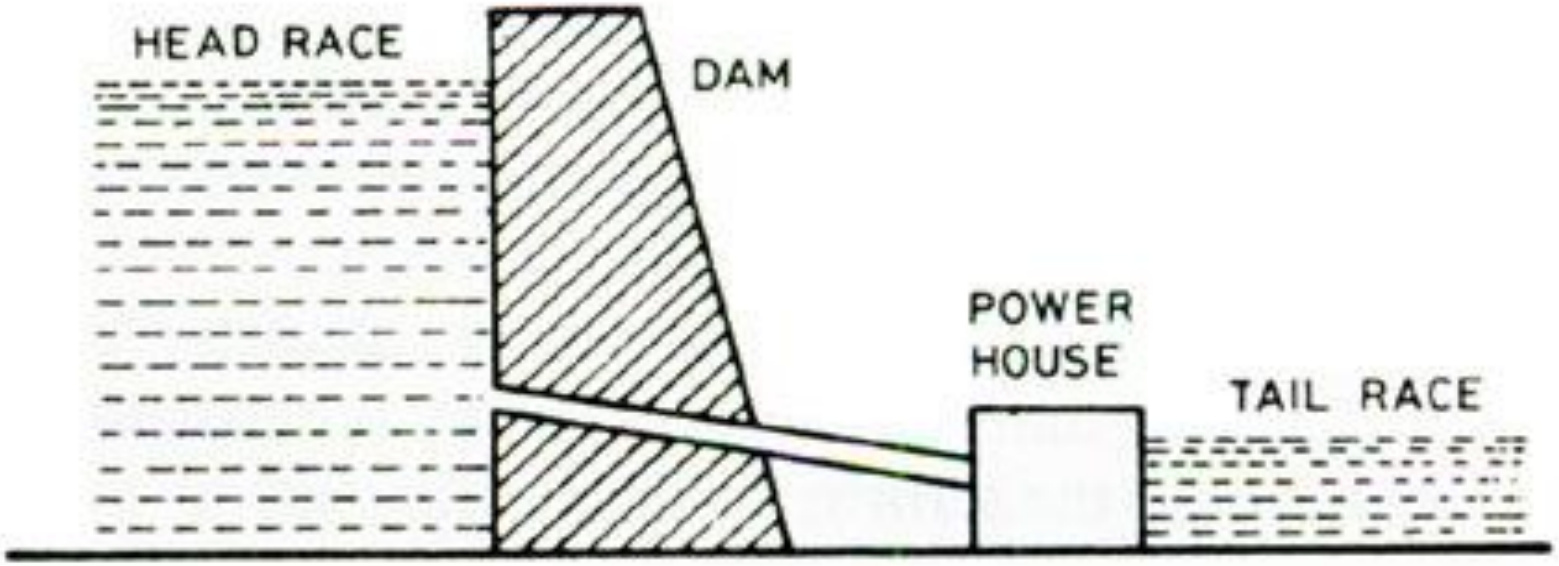


Source: largeandsmallhydroelectric.weebly.com 12/19/2015

Low head plants

- Small dam is built across the river to provide the necessary head.
- The excess water is allowed to flow over the dam itself.
- In such plants Francis, Propeller or Kaplan types of turbines are used.
- The production of electricity will be less due to low head.

Low Head Plant

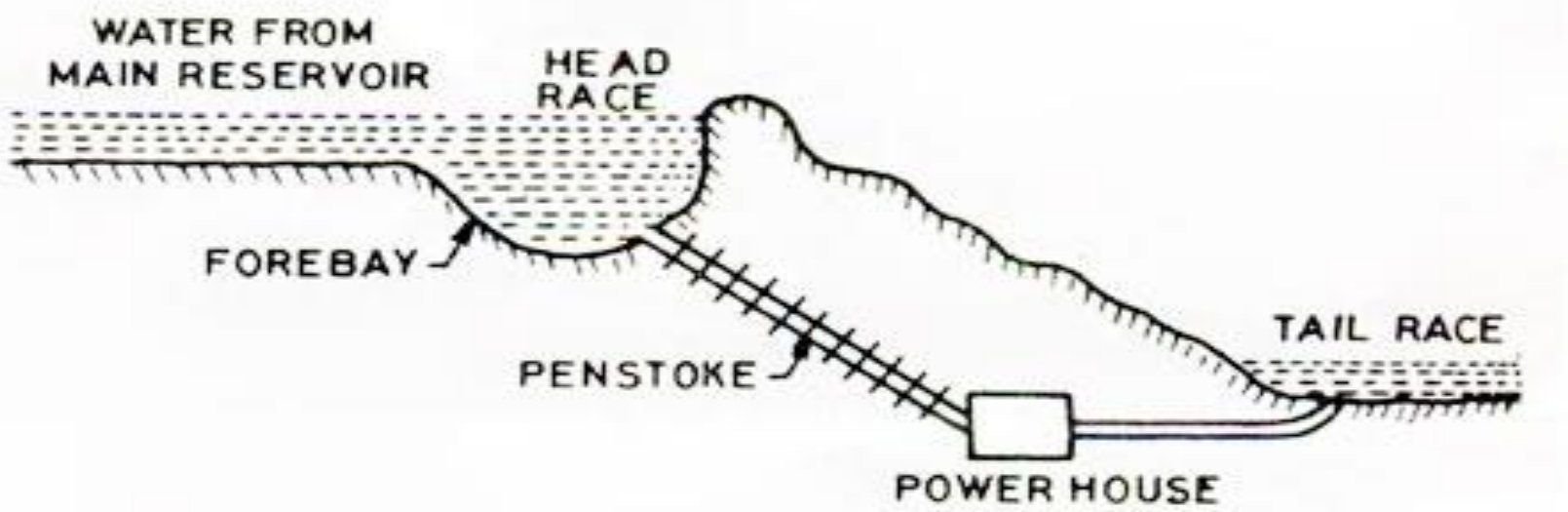


Source: www.electricalquizzes.com 12/19/2015

Medium head plants

- In this plants mainly water is carried through main reservoir to forebay and then to the penstock.
- In these plants fore bay acts as surge tank
- The turbines used will be Francis type of the steel encased variety.

Medium Head Plant



Source: www.electricalquizzes.com 12/19/2015

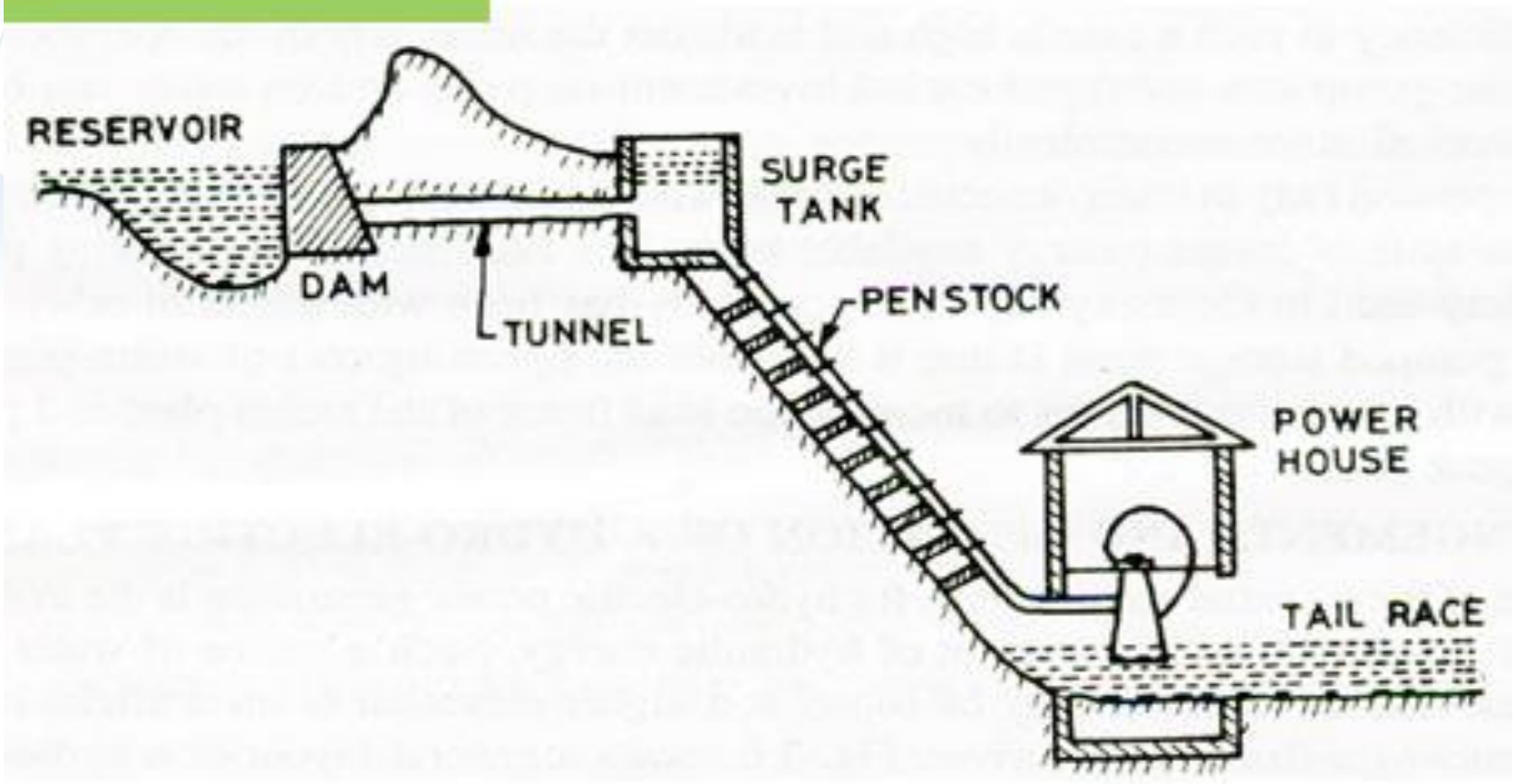
High head plants

- Mostly in these plants pressure tunnel is provided before the surge tank, which in turn connected to penstock.
- A pressure tunnel is taken off from the reservoir and water brought to the valve house at the start of the penstocks.
- The penstocks are big steel pipes which take large quantity of water from the valve house to the power house.

- The valve house contains main sluice gates and in addition automatic isolating valves which come into operation when the penstock bursts, cutting further supply of water.

- Mostly of dams Sluice gates are provided.
- The sluice gates are opened when dam level is below level and there is shortage water for irrigation.
- Normally the height of the head plants are 500 meters above and above head 500 meters Pelton wheels are used.

High Head Plant

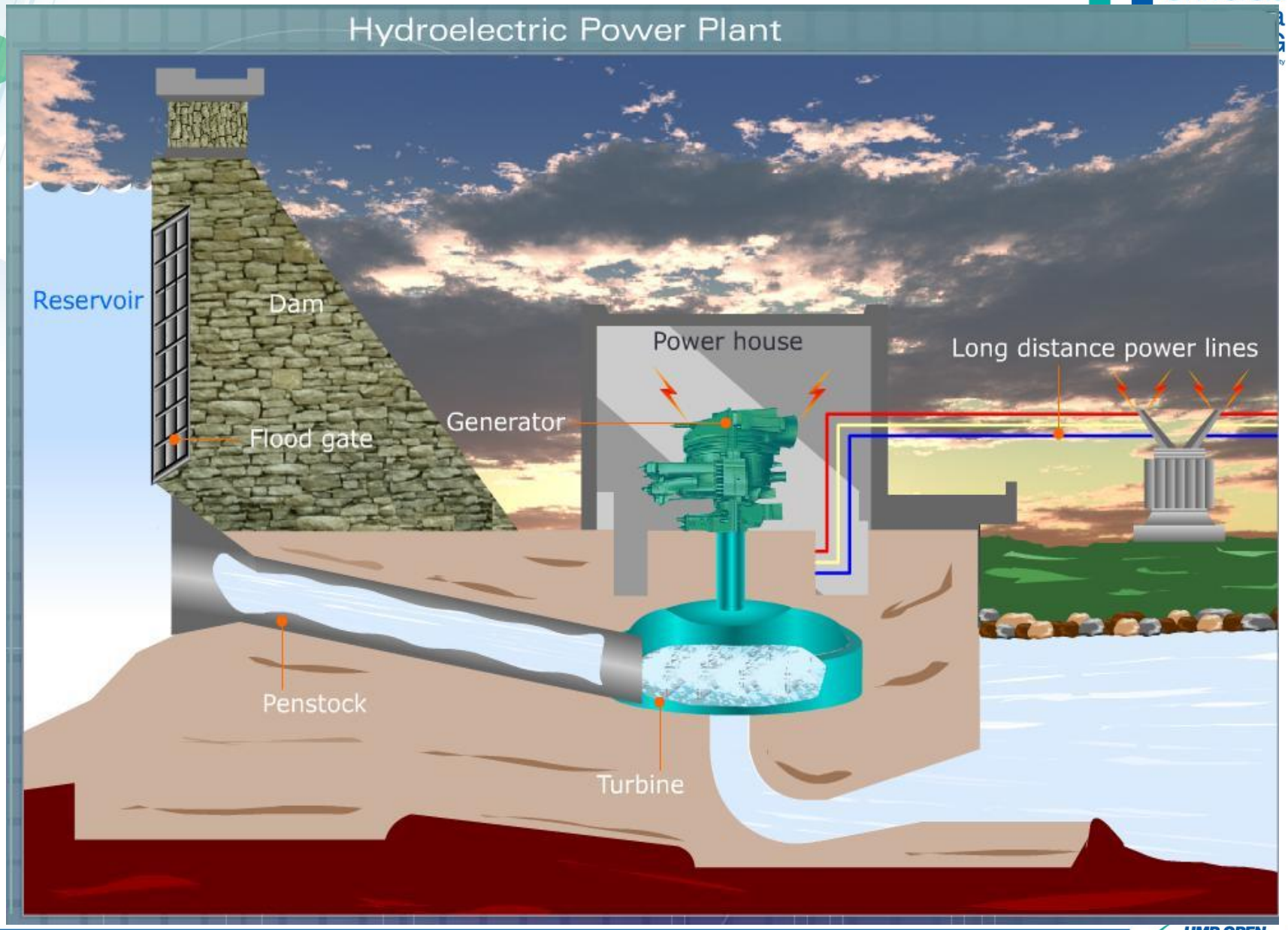


Source: www.electricalquizzes.com 12/19/2015

Components of hydel scheme

Principal components are:

1. Intake structure
2. Penstocks
3. Turbines
4. Power house
5. Draft tube
6. Surge tank
7. Tail race
8. Forebay



Source: www.youtube.com 12/19/2015

Forebay

- Main function to store water which is rejected by plant.
- Power house located closed to dam penstock directly take water from reservoir(forebay).

Intake structure

- Water conveyed from forebay to penstocks through intake structures.
- Main components are trash rack(prevent entry of debris) and gate.

Penstocks

- Open or closed conduits which carry water to the turbines.
- Concrete penstocks are suitable for low heads less then 30mtrs.
- Thickness of penstocks increases with head or water pressure

Surge tank

- Extra storage near to turbine, usually provided in high head plants.
- Located beginning of the penstock.
- As the load on the turbine decreases the surge tank provides space for holding water.

Turbines

- Turbines generally convert the energy water of falling water into mechanical energy.
- Water turbine is a rotary engine that takes energy from moving water.
- Flowing water is directed on to the blades of a turbine runner, creating a force on the blades.

Principal of turbines are:

1) Impulse turbine
2) Reaction Turbine

Impulse turbines:

The entire pressure of water is converted into kinetic energy in a nozzle and the velocity of the jet drives the blades of turbine.

Reaction turbines (low and medium head plants).

- In reaction turbine the water enters the runner partly with pressure energy and partly with velocity head.
- In reaction turbine put pressure occurs in both fixed and moving blades.

- **Francis turbine** and **Kaplan turbine** are the examples of the reaction turbines .

Francis

Kaplan

Source: en.wikipedia.org 12/19/2015

Draft tube

- Pipe gradually enhancing cross sectional area, which connect to the exit to tail race.
- It deceased high velocity of water released by the turbine.
- Draft tube allow turbines to be installed at a higher level than the tail race level, which help the maintaince of turbines.

Power house

Power house contains the electro mechanical equipment :

- Hydro power turbine,
- Generator,
- Excitation system,
- Main inlet valves,
- Transformers,
- Switchyard,
- DC systems,
- Governor,
- Step up transformers,
- Step down transformers

Tail race

- Important criteria of designing the tail race is kind of draft tube, the gross head and geographical situation of the area.
- Tail race is designed in such a way that water hammer is minimizes when water leaves the draft tube.

Hydropower Plants Also Vary in Size

Large power plants that produce hundreds of megawatts of electricity which is used to serve thousands of families.

There are also small and micro hydropower plants that individuals can operate for their own energy needs.

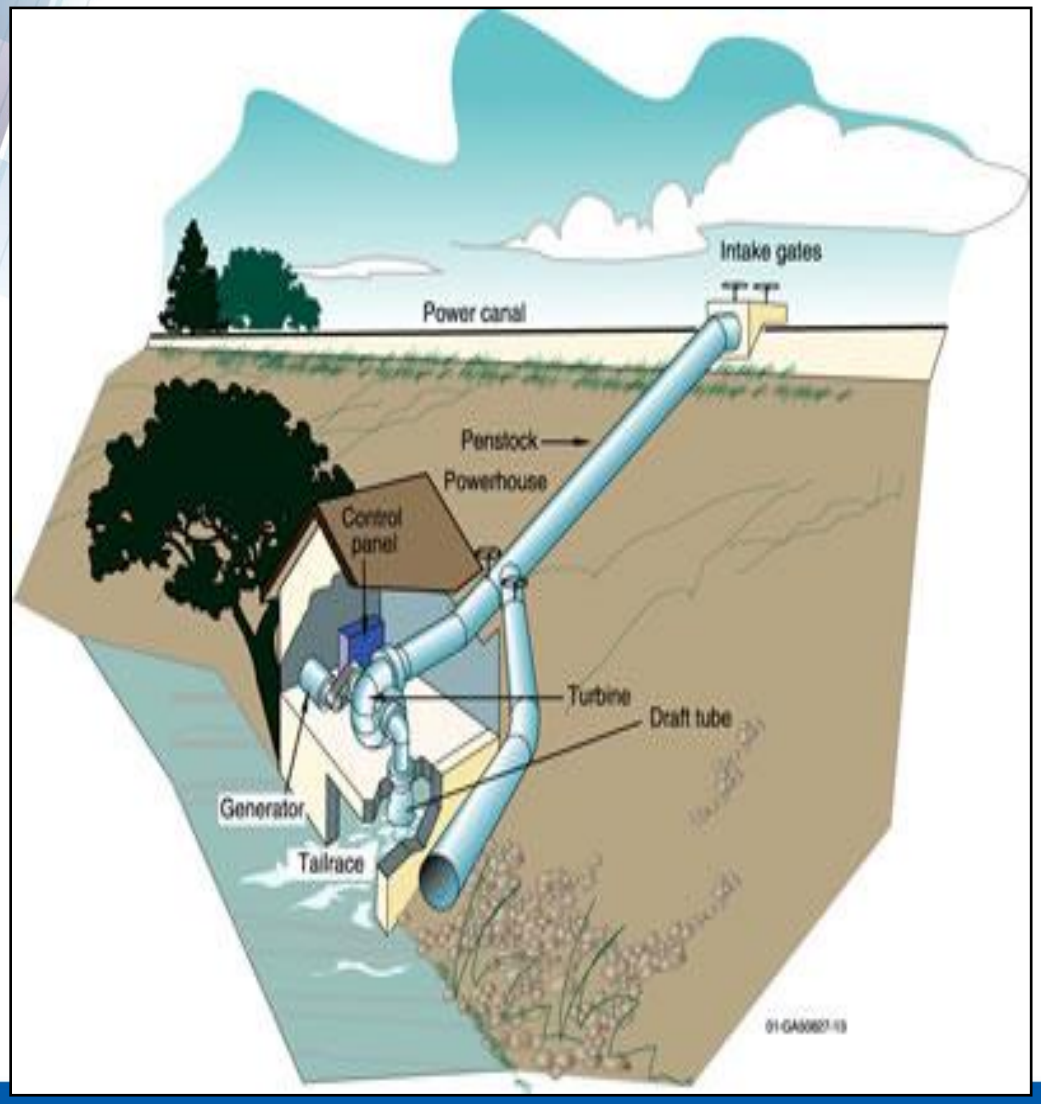
Large Hydropower

A large hydropower has the capacity to generate more than 30,000 kilowatts (kW) of electricity. Large hydropower systems typically require a dam.

Small Hydropower

Small hydropower facilities can generate 100 – 30,000 kilowatts (kW) of electricity. Small hydropower facilities may provide a small dam, or be a diversion of the main stream, or be a run-of-the-river system.

Micro Hydropower



Micro hydropower plants have the capacity to generate 100 kilowatts (kW) or less.

Micro-hydro facilities typically use a run-of-the-river system.

Source: www.dsoelectric.com
12/19/2015

ENVIRONMENTAL IMPACT

Benefits…

- Environmental Benefits of Hydro
  - No operational greenhouse gas emissions
  - Savings (kg of CO2 per MWh of electricity):
    - Coal 1000 kg
    - Oil 800 kg
    - Gas 400 kg
  - No SO2 or NOX
- Non-environmental benefits
  - flood control, irrigation, transportation, fisheries and
  - tourism.

Disadvantages

- The loss of land under the reservoir.
- Interference with the transport of sediment by the dam.
- Problems associated with the reservoir.
  - Climatic and seismic effects.
  - Impact on aquatic ecosystems, flora and fauna.

Loss of land

- A large area is taken up in the form of a reservoir in case of large dams.

- This leads to inundation of fertile alluvial rich soil in the flood plains, forests and even mineral deposits and the potential drowning of archeological sites.

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ECONOMICS OF HYDRO POWER

- *Global & Local HP Economics*
- *Construction Costs*
- *Production Costs*

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Thank you