

Power System Generation, Transmission and Distribution

UNIVERSITY OF ENERGY AND NATURAL RESOURCES



DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

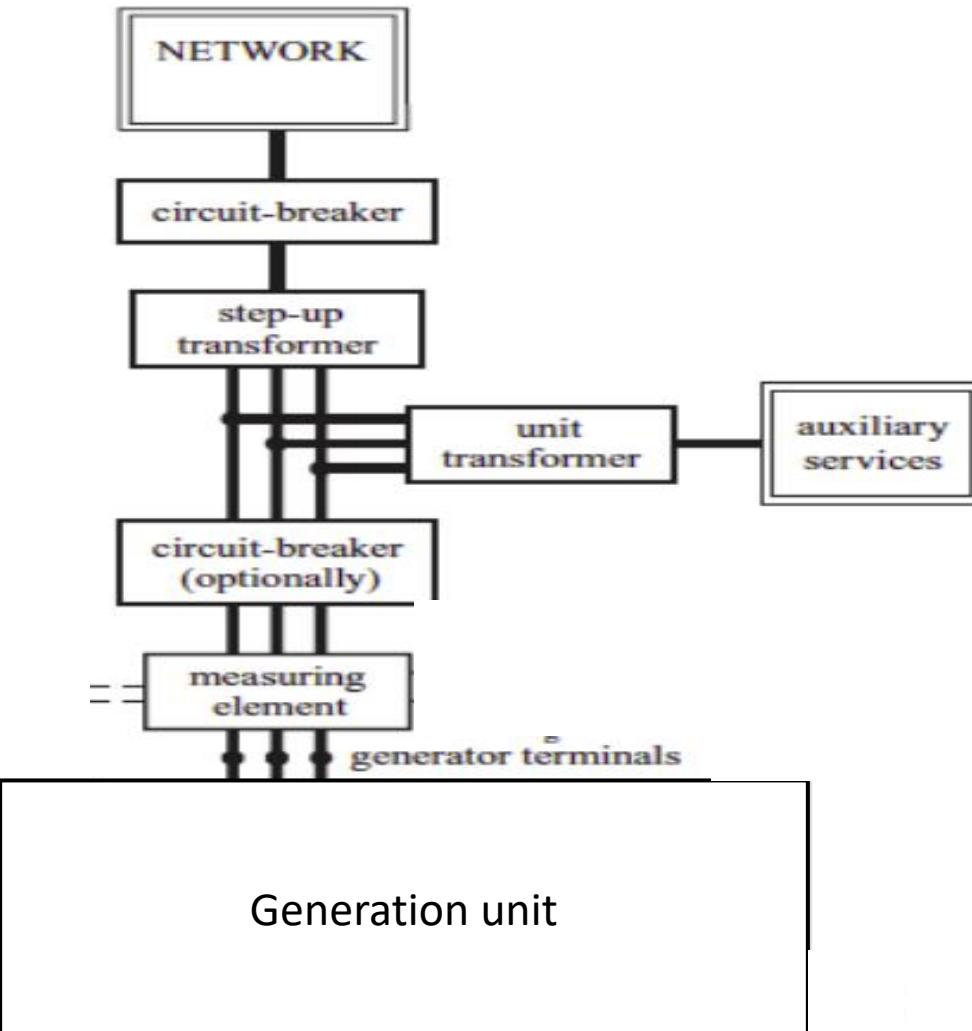
LECTURER

AWAAFO AUGUSTINE

Power generation

In our lecture 1, we already stated that power can be generated from both conventional and non-conventional sources.

- I believe that now you already know what it means by conventional and non-conventional sources.
- In this lecture we will be looking at how power is generated from these sources.



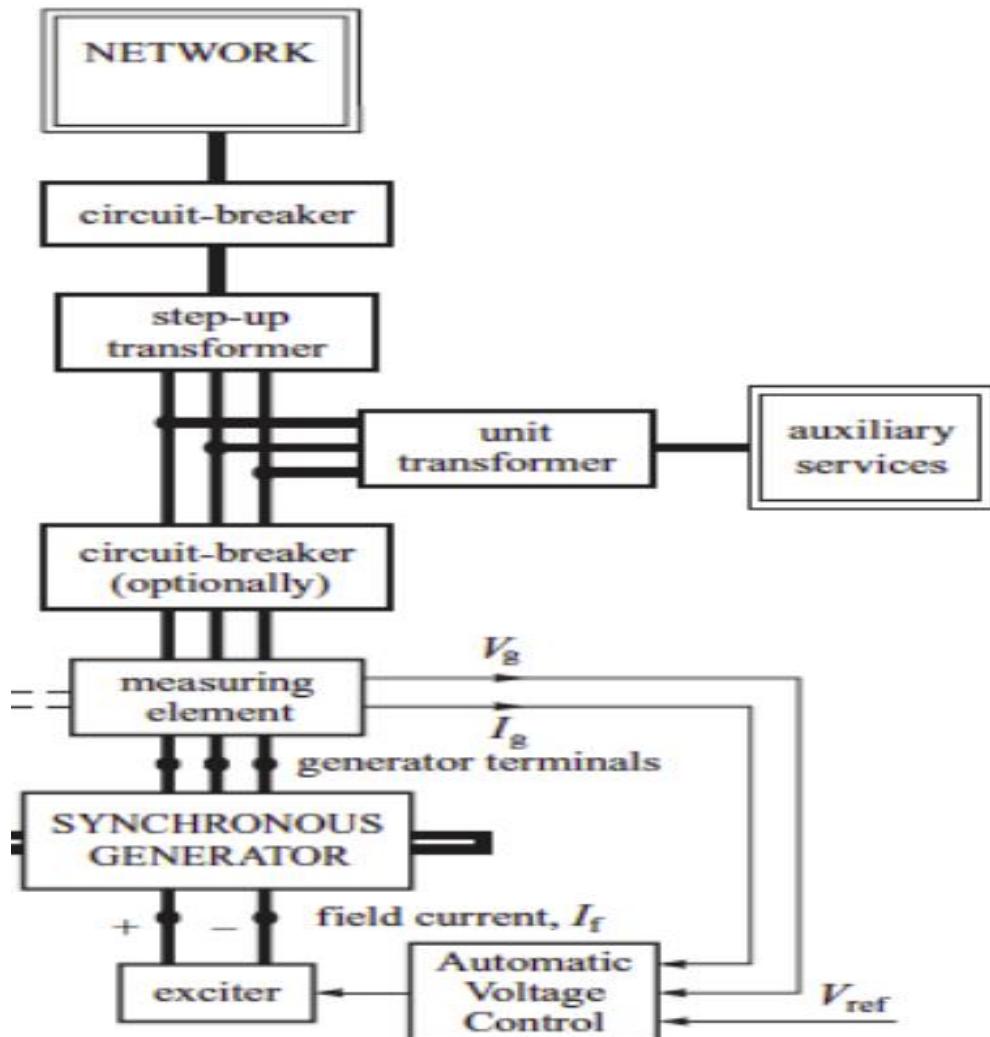
Design of Power Stations

- The design of power stations requires a wide range of experience
- Operation and maintenance of the station are greatly affected by the design

A good design takes into consideration:

- Choice of site
- Capacity of power station
- Design of cooling system
- Selection of generating unit
- Design of control and instrumentation

Capacity of Power Stations



Capacity of Power Stations

The capacity depends on

- the current demand
- the demand growth
- possibility of interconnection
- availability of fuel for the prime mover
- cost or economy of the station.

- The power has got to be economic as well as reliable; What is the use of power which is very cheap but goes off every minute?
- Now, when you say economic, economic does not necessarily mean cost minimization. What is economic is minimum pollution, and minimum loss. So, attributes to the economic need not be only cost.
- Any power generated by utility, which creates less pollution is more welcome than the power, cheaper, but creates more pollution.

CONVENTIONAL POWER GENERATION

When we talk of conventional sources of electrical energy, there are only three conventional generation sources in the whole world. They are

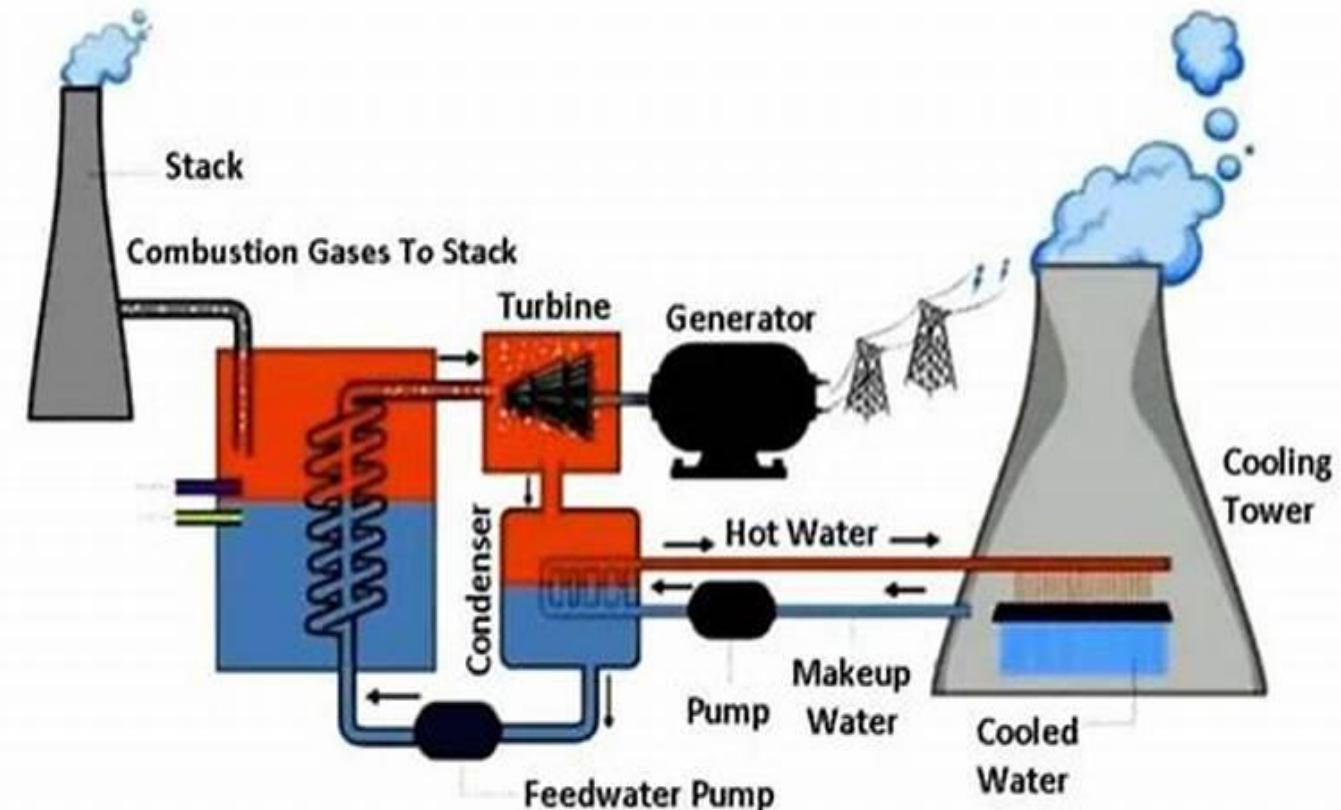
- Thermal, that is coal, gas, or oil;
- Hydro is only water;
- The third is nuclear

THERMAL POWER GENERATION

Now, when we talk of thermal power stations, it is

- steam-based
- or gas based.

And chemical energy is converted to mechanical energy, which in turn is converted to electrical energy.



Thermal Power Plant

THERMAL POWER GENERATION

In thermal power generation the following processes take place.

- Heat is released by burning coal, oil or gas
- The heat is converted to rotational energy in heat engines with internal combustion such as gas turbines
- Or the heat is used to produce steam in a boiler.
- The steam is used to turn a turbine attached to a generator
- The output of the generator depends on the heat being produced or the fuel being burned.

THERMAL POWER GENERATION

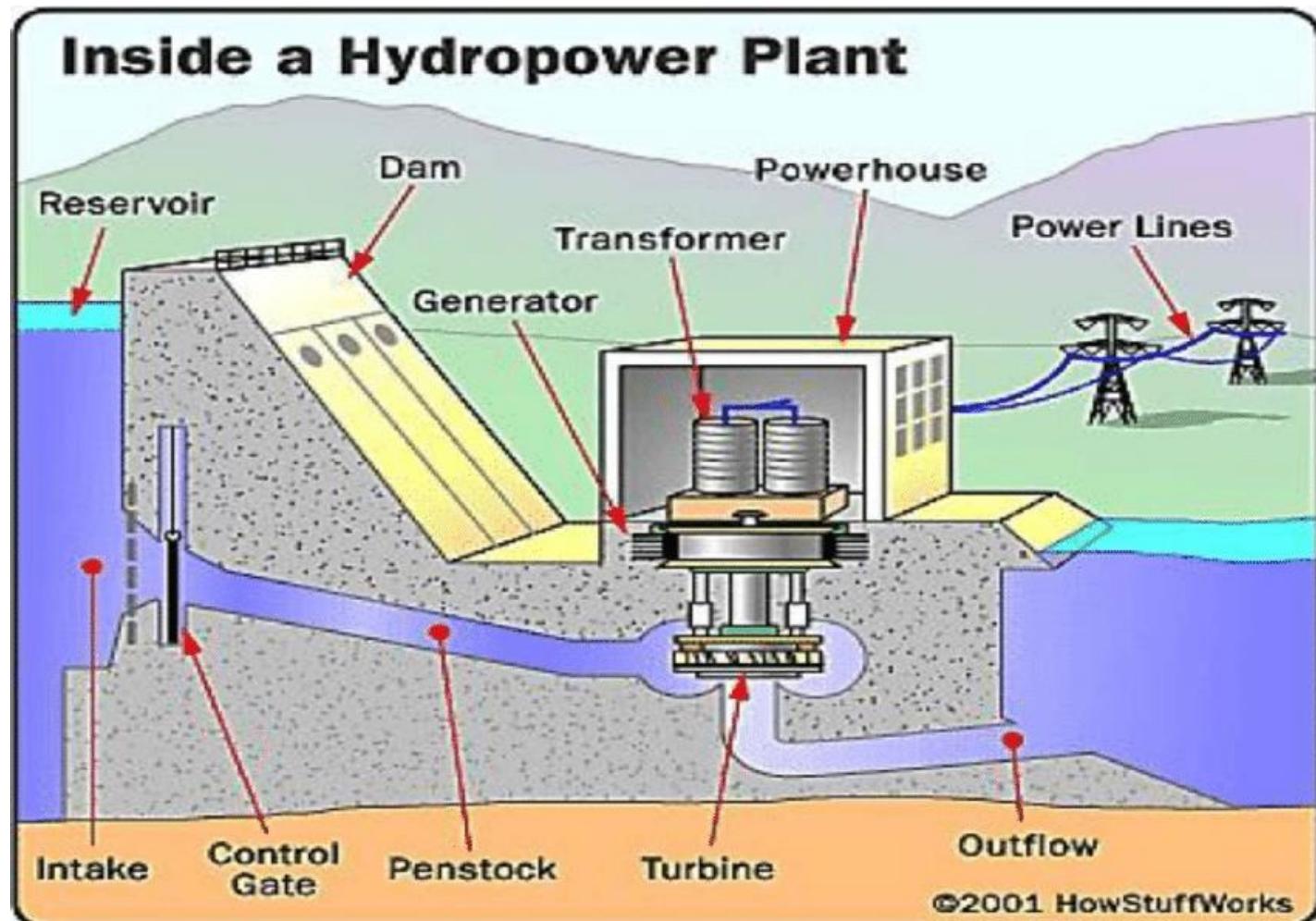
In Ghana, thermal power generation constitutes about 69% of the total generation.

- One motivation factor for thermal power generation is that it is relatively cheap.
- Thermal is considered a pollution-intensive power generation source. These pollutants are
 1. Solid pollutants (ash)
 2. Gaseous pollutants (GHG)

One other issue about thermal plants is that it takes long to start. It takes 6 to 8 hours to start a thermal plant.

HYDROELECTRIC POWER GENERATION

- Hydro is the oldest and cheapest method of power generation.
- 12000-megawatt hydro plant in Brazil, is the biggest hydropower Plant in the world.



HYDROELECTRIC POWER GENERATION

There are different types of hydropower plants. These are;

1. Run of the river; It means use water as it comes, no harm, you have a grid; generate whatever power you can feed it to the grid.
2. Pondage: Pondage is a medium head, water comes all the time, but you cannot store it. So, it is called bondage hydropower station.
3. Reservoir: the reservoir is of course of high-head storage

We also have cascaded hydropower plants known as the series hydro plant. In Cascaded plants, The outflow of the number one plant becomes the inflow to the second plant.

Another interesting type of hydropower plant is the pump storage which uses reversible pumps and motors to pump water upstream during off-peak hours.

HYDROELECTRIC POWER GENERATION

There are 3 main types of turbines used in hydro stations. These are;

- Pelton: Pelton is suitable for storage reservoir.
- Francis: Francis is suitable for bondage.
- Kaplan: Kaplan is suitable for run of the river.

HYDROELECTRIC POWER GENERATION

- Hydropower stations convert the energy of moving water into electrical energy.
- To generate power from the hydro station;
 1. The moving water turns a hydraulic turbine coupled to a synchronous generator
 2. The power from the waterfall depends on its height and rate of flow
- The power from the water is given by;

$$P = 981\rho q h \text{ (watts)}$$

Where

ρ is the density of the water in $(1000 \frac{\text{kg}}{\text{m}^3})$, q is the water flow rate through the turbine in $\frac{\text{m}^3}{\text{s}}$ and h is the head of the water in (m)

HYDROELECTRIC POWER GENERATION

Hydro can be classified as;

- micro hydro: Micro is less than 1 megawatt
- Pico hydro: Pico hydro is a few Watts
- Mini hydro: mini is 1 to 5 megawatts
- Small hydro: small is anything less than 15 megawatts.
- Large hydro: more than 15 megawatts

HYDROELECTRIC POWER GENERATION

Disadvantages of large hydropower plants.

- It is also noted to be the highest investment cost per megawatt
- Vast land requirement.
- Displacement of human settlement.
- Ecological damage
- Heavy civil engineering construction for the dam, reservoir and so on and the gestation period is very high. It takes 5 to 8 years.

HYDROELECTRIC POWER GENERATION

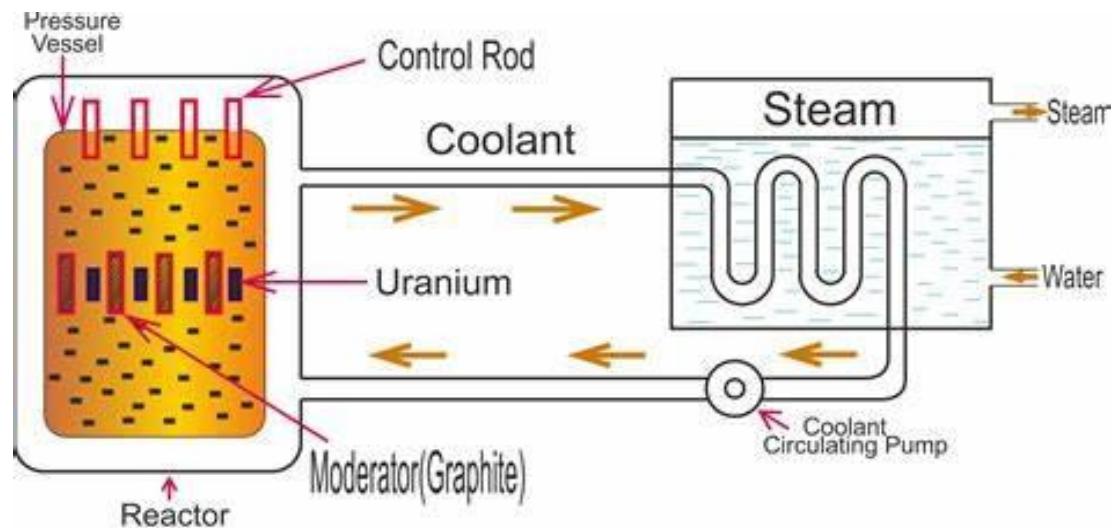
Advantages of hydropower plants.

- Hydro power plant is ideal for peak load. This is because of the quick-starting nature of hydropower plants. It takes about 5 minutes to start a hydro plant.
- No fuel cost
- No GHG emission

NUCLEAR POWER GENERATION

This is the practical alternative source of large-scale electric energy

- generation. Why it is practical? It is already happening.
- Why it is an alternative? It is an alternative to thermal and hydro and if somehow you do not want hydro, if you do not have hydro, or if you do not have coal, then nuclear is the only choice



Nuclear Reactor

NUCLEAR POWER GENERATION

Let us explain briefly how nuclear generates power.

- U 235, the uranium, you know their atoms and bombarded with neutrons, creating a fission process, which also generates neutrons and further these neutrons can be used.
- Steam is produced at a particular temperature and pressure
- Steam is used to turn turbines coupled to generators to produce power
- This is a chain reaction, more fission, but can you control speed.
- So, it is a regenerative process and that is why the fuel required is very little and this generates the heat energy and hereafter you know what to do with the heat energy
- we need to reduce the speed to a critical value by using certain agents.

NUCLEAR POWER GENERATION

- For reaction control, the control rods made of neutron-absorbing material are inserted in the reaction vessel.
- Boron steel is one such material, which absorbs extra neutrons so that the speed gets limited to a desired critical value
- However, control is possible only within a narrow range.
- Because of this nuclear power stations can only be used as the base load station because variation is not possible.
- If it is generating 500 megawatts, it is 500 mega watts all the time.

NUCLEAR POWER GENERATION

What are the merits of the nuclear power station?

- It is devoid of any air pollution.
- There is no air pollution
- No CO_2 gets into the sky, into the environment, no NOX, nothing.
- Very little fuel is required by volume as well as weight; therefore, it poses no transportation problem.
- You do not need railways; do not need wagons, and not much money is spent on the transportation of the fuel.
- Land per megawatt is very small and hence there are no siting problems.

NUCLEAR POWER GENERATION

There have to be certain demerits in whatever plant you are talking. So, what are the problems or demerits of this nuclear power station?

- The biggest one, which we always talk about is radioactive fuel rays disposal. This is a serious environmental hazard and it is said even when the nuclear power station has stopped working, we have declared it that it cannot be used anymore
- It can only be used as a base plant
- Danger when there is loss of coolant