Electrical Power Generation & Renewable Energy

1st lecture INTRODUCTION

GENERAL

Energy is the basic necessity for the economic development of a country. Many functions necessary to present-day living grind to halt when the supply of energy stops. It is practically impossible to estimate the actual magnitude of the part that energy has played in the building up of present-day civilization. The availability of huge amount of energy in the modern times has resulted in a shorter working day, higher agricultural and industrial production, a healthier and more balanced diet and better transportation facilities. As a matter of fact, there is a close relationship between the energy used per person and his standard of living. The greater the per capita consumption of energy in a country, the higher is the standard of living of its people.

Energy exists in different forms in nature but the most important form is the *electrical energy*. The modern society is so much dependent upon the use of electrical energy that it has become a part and parcel of our life. In this chapter, we shall focus our attention on the general aspects of electrical energy.

IMPORTANCE OF ELECTRICAL ENERGY

Energy may be needed as heat, as light, as motive power etc. The present-day advancement in science and technology has made it possible to convert electrical energy into any desired form. This has given electrical energy a place of pride in the modern world. The survival of industrial undertakings and our social structures depends primarily upon low cost and uninterrupted supply of electrical energy. In fact, the advancement of a country is measured in terms of per capita consumption of electrical energy.

Electrical energy is superior to all other forms of energy due to the following reasons:

(***i***) **Convenient form.** Electrical energy is a very convenient form of energy. It can be easily converted into other forms of energy. For example, if we want to convert electrical energy into heat, the only thing to be done is to pass electrical current through a wire of high resistance *e.g*., a heater. Similarly, electrical energy can be converted into light (*e.g*. electric bulb), mechanical energy (*e.g.* electric motors) etc.

(***ii***) **Easy control.** The electrically operated machines have simple and convenient starting, control and operation. For instance, an electric motor can be started or stopped by turning on or off a switch. Similarly, with simple arrangements, the speed of electric motors can be easily varied over the desired range.

(***iii***) **Greater flexibility.** One important reason for preferring electrical energy is the flexibility that it offers. It can be easily transported from one place to another with the help of conductors.

(***iv***) **Cheapness.** Electrical energy is much cheaper than other forms of energy. Thus it is overall economical to use this form of energy for domestic, commercial and industrial purposes.

(***v***) **Cleanliness.** Electrical energy is not associated with smoke, fumes or poisonous gases. Therefore, its use ensures cleanliness and healthy conditions.

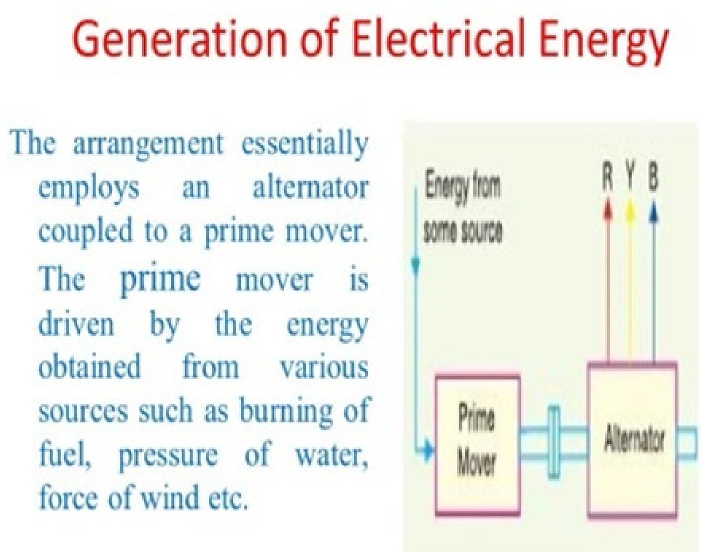
(***vi***) **High transmission efficiency.** The consumers of electrical energy are generally situated quite away from the centers of its production. The electrical energy can be transmitted conveniently and efficiently from the centers of generation to the consumers with the help of overhead conductors known as transmission lines.

GENERATION OF ELECTRICAL ENERGY

*The conversion of energy available in different forms in nature into electrical energy is known a*s **generation of electrical energy**.

Electrical energy is a manufactured commodity like clothing, furniture or tools. Just as the manufacture of a commodity involves the conversion of raw materials available in nature into the desired form, similarly electrical energy is produced from the forms of energy available in nature.

However, electrical energy differs in one important respect. Whereas other commodities may be produced at will and consumed as needed, the electrical energy must be produced and transmitted to the point of use at the instant it is needed. The entire process takes only a fraction of a second. This instantaneous production of electrical energy introduces technical and economical considerations unique to the electrical power industry. Energy is available in various forms from different natural sources such as pressure head of water, chemical energy of fuels, nuclear energy of radioactive substances etc. All these forms of energy can be converted into electrical energy by the use of suitable arrangements. The arrangement essentially employs (see Fig. 1.1) an alternator coupled to a prime mover.



The prime mover is driven by the energy obtained from various sources such as burning of fuel, pressure of water, force of wind etc. For example, chemical energy of a fuel (*e.g.*, coal) can be used to produce steam at high temperature and pressure. The steam is fed to a prime mover which may be a steam engine or a steam turbine. The turbine converts heat energy of steam into mechanical energy which is further converted into electrical energy by the alternator. Similarly, other forms of energy can be converted into electrical energy by employing suitable machinery and equipment.

SOURCES OF ENERGY

Since electrical energy is produced from energy available in various forms in nature, it is desirable to look into the various sources of energy. These sources of energy are:

(i) The Sun,

(ii) The Wind,

(iii) Water,

(iv) Fuels,

(v) Nuclear energy.

Out of these sources, the energy due to Sun and wind has not been utilized on large scale due to a number of limitations. At present, the other three sources *viz.*, water, fuels and nuclear energy are primarily used for the generation of electrical energy.

(i) **The Sun.**

The Sun is the primary source of energy. The heat energy radiated by the Sun can be focused over a small area by means of reflectors. This heat can be used to raise steam and electrical energy can be produced with the help of turbine-alternator combination. However, this method has limited application because:

(*a*) it requires a large area for the generation of even a small amount of electric power

(*b*) it cannot be used in cloudy days or at night

(*c*) it is an uneconomical method.

Nevertheless, there are some locations in the world where strong solar radiation is received very regularly and the sources of mineral fuel are scanty or lacking. Such locations offer more interest to the solar plant builders.

(*ii*) The Wind.

This method can be used where wind flows for a considerable length of time. The wind energy is used to run the wind mill which drives a small generator. In order to obtain the electrical energy from a wind mill continuously, the generator is arranged to charge the batteries. These batteries supply the energy when the wind stops. This method has the advantages that maintenance and generation costs are negligible. However, the drawbacks of this method are (***a***) variable output,

(***b***) unreliable because of uncertainty about wind pressure and

(***c***) power generated is quite small.

(*iii*) Water.

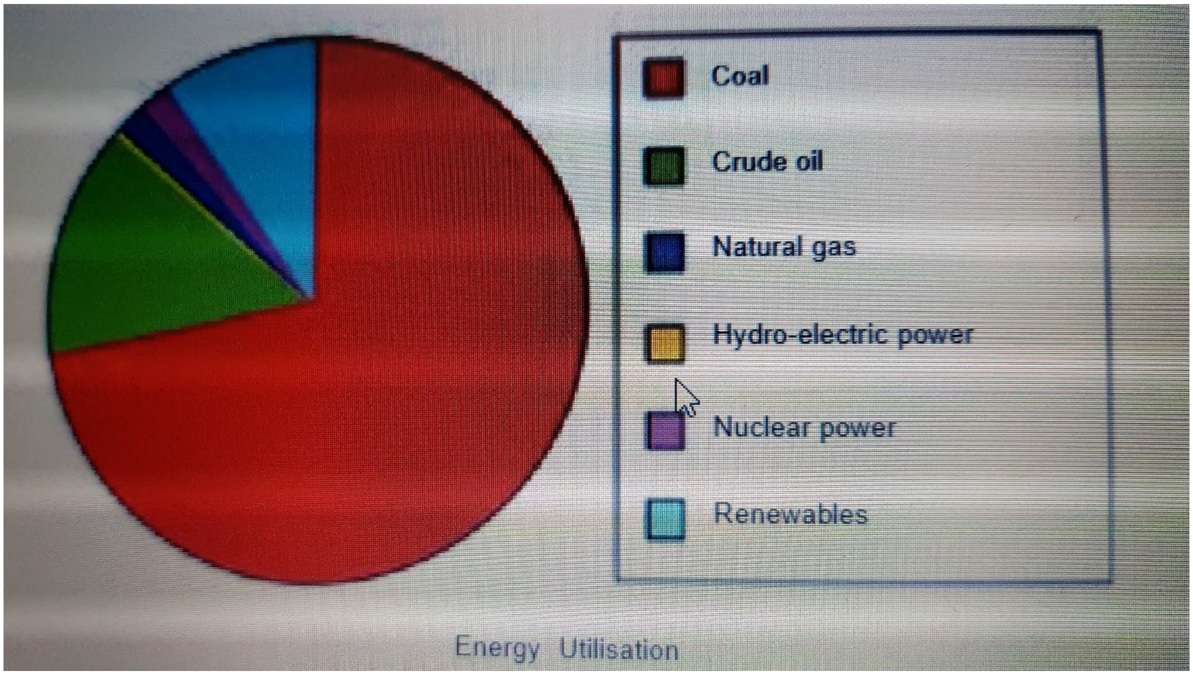
When water is stored at a suitable place, it possesses potential energy because of the head created. This water energy can be converted into mechanical energy with the help of water turbines. The water turbine drives the alternator which converts mechanical energy into electrical energy. This method of generation of electrical energy has become very popular because it has low production and maintenance costs.

(*iv*) Fuels.

The main sources of energy are fuels *viz*., solid fuel as coal, liquid fuel as oil and gas fuel as natural gas. The heat energy of these fuels is converted into mechanical energy by suitable prime movers such as steam engines, steam turbines, internal combustion engines etc. The prime mover drives the alternator which converts mechanical energy into electrical energy. Although fuels continue to enjoy the place of chief source for the generation of electrical energy, yet their reserves are diminishing day by day. Therefore, the present trend is to harness water power which is more or less a permanent source of power.

(vi) **Nuclear energy.**

Towards the end of Second World War, it was discovered that large amount of heat energy is liberated by the *fission* of uranium and other fissionable materials. It is estimated that heat produced by 1 kg of nuclear fuel is equal to that produced by 4500 tons of coal. The heat produced due to nuclear fission can be utilized to raise steam with suitable arrangements. The steam can run the steam turbine which in turn can drive the alternator to produce electrical energy. However, there are some difficulties in the use of nuclear energy. The principal ones are (a) high cost of nuclear plant (b) problem of disposal of radioactive waste and dearth of trained personnel to handle the plant.



COMPARISON OF ENERGY SOURCES

The chief sources of energy used for the generation of electrical energy are water, fuels and nuclear energy. Below is given their comparison in a tabular form:

S.No.	Particular	Water-power	Fuels	Nuclear energy
1.	*Initial cost*	High	Low	Highest
2.	*Running cost*	Less	High	Least
3.	*Reserves*	Permanent	Exhaustable	Inexhaustible
4.	*Cleanliness*	Cleanest	Dirtiest	Clean
5.	*Simplicity*	Simplest	Complex	Most complex
6.	*Reliability*	Most reliable	Less reliable	More reliable

UNITS OF ENERGY

The capacity of an agent to do work is known as its energy. The most important forms of energy are mechanical energy, electrical energy and thermal energy. Different units have been assigned to various forms of energy. However, it must be realised that since mechanical, electrical and thermal energies are interchangeable, it is possible to assign the same unit to them. This point is clarified in Art 1.6.

(i) Mechanical energy. The unit of mechanical energy is newton-metre or joule on the M.K.S. or SI system.

The work done on a body is one newton-metre (or joule) if a force of one newton moves it through a distance of one metre i.e.,

Mechanical energy in joules = Force in newton × distance in metres

(ii) Electrical energy. The unit of electrical energy is watt-sec or joule and is defined as follows: One watt-second (or joule) energy is transferred between two points if a p.d. of 1 volt exists between them and 1 ampere current passes between them for 1 second i.e.,

Electrical energy in watt-sec (or joules)

= voltage in volts × current in amperes × time in seconds

Joule or watt-sec is a very small unit of electrical energy for practical purposes. In practice, for the measurement of electrical energy, bigger units viz., watt-hour and kilowatt hour are used.

1 watt-hour = 1 watt × 1 hr

= 1 watt × 3600 sec = 3600 watt-sec

1 kilowatt hour (kWh) = 1 kW × 1 hr = 1000 watt × 3600 sec = 36 x 10^5 watt-sec.

(iii) Heat. Heat is a form of energy which produces the sensation of warmth. The unit* of heat is calorie, British thermal unit (B.Th.U.) and centigrade heat units (C.H.U.) on the various systems.

(The SI or MKS unit of thermal energy being used these days is the joule—exactly as for mechanical and electrical energies. The thermal units viz. calorie, B.Th.U. and C.H.U. are obsolete.)*

Calorie. It is the amount of heat required to raise the temperature of 1 gm of water through 1ºC i.e.,

1 calorie = 1 gm of water × 1ºC

Sometimes a bigger unit namely *kilocalorie* is used. A kilocalorie is the amount of heat required to raise the temperature of 1 kg of water through 1ºC i.e.,

$$1 \text{ kilocalorie} = 1 \text{ kg} \times 1^{\circ}\text{C} = 1000 \text{ gm} \times 1^{\circ}\text{C} = 1000 \text{ calories}$$

B.Th.U. It is the amount of heat required to raise the temperature of 1 lb of water through 1ºF i.e.,

$$1 \text{ B.Th.U.} = 1 \text{ lb} \times 1^{\circ}\text{F}$$

C.H.U. It is the amount of heat required to raise the temperature of 1 lb of water through 1ºC i.e.,

$$1 \text{ C.H.U.} = 1 \text{ lb} \times 1^{\circ}\text{C}$$

RELATIONSHIP AMONG ENERGY UNITS

The energy whether possessed by an electrical system or mechanical system or thermal system has the same thing in common i.e., it can do some work. Therefore, mechanical, electrical and thermal energies must have the same unit. This is amply established by the fact that there exists a definite relationship among the units assigned to these energies. It will be seen that these units are related to each other by some constant.

(i) Electrical and Mechanical

$$1 \text{ kWh} = 1 \text{ kW} \times 1 \text{ hr}$$

$$= 1000 \text{ watts} \times 3600 \text{ seconds} = 36 \times 10^5 \text{ watt-sec. or Joules}$$

$$\therefore \quad 1 \text{ kWh} = 36 \times 10^5 \text{ Joules}$$

It is clear that electrical energy can be expressed in Joules instead of kWh.

(ii) Heat and Mechanical

(a) $$1 \text{ calorie} = 4{\cdot}18 \text{ Joules} \qquad \text{(By experiment)}$$

(b) $$1 \text{ C.H.U.} = 1 \text{ lb} \times 1^{\circ}\text{C} = 453{\cdot}6 \text{ gm} \times 1^{\circ}\text{C}$$

$$= 453{\cdot}6 \text{ calories} = 453{\cdot}6 \times 4{\cdot}18 \text{ Joules} = 1896 \text{ Joules}$$

$$\therefore \quad 1\text{C.H.U.} = 1896 \text{ Joules}$$

(c) $$1 \text{ B.Th.U.} = 1 \text{ lb} \times 1^{\circ}\text{F} = 453{\cdot}6 \text{ gm} \times 5/9\ ^{\circ}\text{C}$$

$$= 252 \text{ calories} = 252 \times 4{\cdot}18 \text{ Joules} = 1053 \text{ Joules}$$

$$\therefore \quad 1 \text{ B.Th.U.} = 1053 \text{ Joules}$$

It may be seen that heat energy can be expressed in Joules instead of thermal units *viz.* calorie, B.Th.U. and C.H.U.

(ii) Electrical and Heat

(a) 1 kWh = 1000 watts × 3600 seconds = 36×10^5 Joules

$$= \frac{36\times10^5}{4\cdot18} \text{ calories } 860 \times 10^3 \text{ calories}$$

∴ 1 kWh = 860×10^3 calories or 860 kcal

(b) 1 kWh = 36×10^5 Joules = 36 × 105/1896 C.H.U. = 1898 C.H.U.

[1 C.H.U. = 1896 Joules]

∴ 1 kWh = 1898 C.H.U.

(c) 1 kWh = 36×10^5 Joules = $\frac{36\times10^5}{1053}$ B.Th.U. = 3418 B.Th.U.

[1 B.Th.U. = 1053 Joules]

∴ 1 kWh = 3418 B.Th.U.

The reader may note that units of electrical energy can be converted into heat and vice-versa. This is expected since electrical and thermal energies are interchangeable.

EFFICIENCY

Energy is available in various forms from different natural sources such as pressure head of water, chemical energy of fuels, nuclear energy of radioactive substances etc. All these forms of energy can be converted into electrical energy by the use of suitable arrangement. In this process of conversion, some energy is lost in the sense that it is converted to a form different from electrical energy. Therefore, the output energy is less than the input energy. The output energy divided by the input energy is called energy efficiency or simply efficiency of the system.

$$\text{Efficiency, } \eta = \frac{OUTPUT\ ENERGY}{INPUT\ ENERGY}$$

As power is the rate of energy flow, therefore, efficiency may be expressed equally well as output power divided by input power i.e.,

$$\text{Efficiency, } \eta = \frac{OUTPUT\ POWER}{INPUT\ POWER}$$

CALORIFIC VALUE OF FUELS

The amount of heat produced by the complete combustion of a unit weight of fuel is known as its **calorific value**.

Calorific value indicates the amount of heat available from a fuel. The greater the calorific value of fuel, the larger is its ability to produce heat. In case of solid and liquid fuels, the calorific value is expressed in cal/gm or kcal/kg. However, in case of gaseous fuels, it is generally stated in cal/litre or kcal/litre. Below is given a table of various types of fuels and their calorific values along with composition.

S.No.	Particular	Calorific value	Composition
1.	**Solid fuels**		
	(*i*) Lignite	5,000 kcal/kg	C = 67%, H = 5%, O = 20%, ash = 8%
	(*ii*) Bituminous coal	7,600 kcal/kg	C = 83%, H = 5·5%, O = 5%, ash = 6·5%
	(*iii*) Anthracite coal	8,500 kcal/kg	C = 90%, H = 3%, O = 2%, ash = 5%
2.	**Liquid fuels**		
	(*i*) Heavy oil	11,000 kcal/kg	C = 86%, H = 12%, S = 2%
	(*ii*) Diesel oil	11,000 kcal/kg	C = 86·3%, H = 12·8%, S = 0·9%
	(*iii*) Petrol	11,110 kcal/kg	C = 86%, H = 14%
3.	**Gaseous fuels**		
	(*i*) Natural gas	520 kcal/m^3	CH_4 = 84%, C_2H_6 = 10% Other hydrocarbons = 5%
	(*ii*) Coal gas	7,600 kcal/m^3	CH_4 = 35%, H = 45%, CO= 8%, N = 6% CO_2 = 2%, Other hydrocarbons = 4%

ADVANTAGES OF LIQUID FUELS OVER SOLID FUELS

The following are the advantages of liquid fuels over the solid fuels:

(i) The handling of liquid fuels is easier and they require less storage space.

(ii) (ii) The combustion of liquid fuels is uniform.

(iii) (iii) The solid fuels have higher percentage of moisture and consequently they burn with great difficulty. However, liquid fuels can be burnt with a fair degree of ease and attain high temperature very quickly compared to solid fuels.

(iv) (iv) The waste product of solid fuels is a large quantity of ash and its disposal becomes a problem. However, liquid fuels leave no or very little ash after burning.

(v) (v) The firing of liquid fuels can be easily controlled. This permits to meet the variation in load demand easily.

ADVANTAGES OF SOLID FUELS OVER LIQUID CFUELS

The following are the advantages of solid fuels over the liquid fuels:

(i) In case of liquid fuels, there is a danger of explosion.

(ii) Liquids fuels are costlier as compared to solid fuels.

(iii) Sometimes liquid fuels give unpleasant odours during burning.

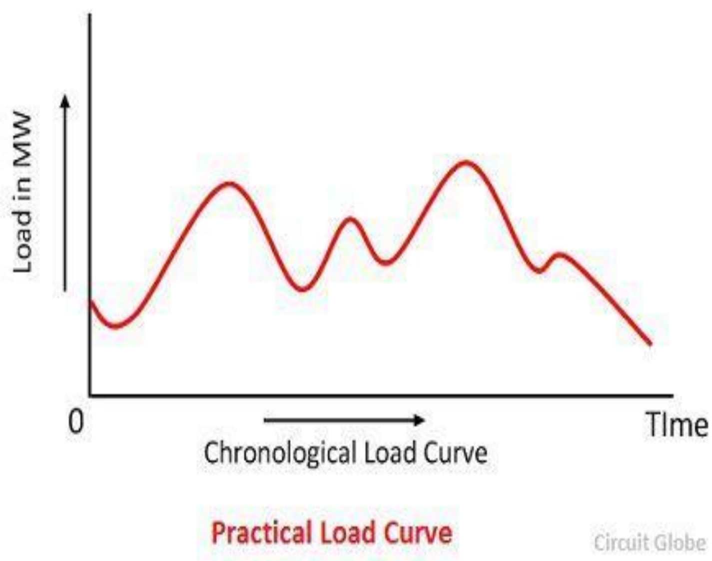
(iv) Liquid fuels require special types of burners for burning.

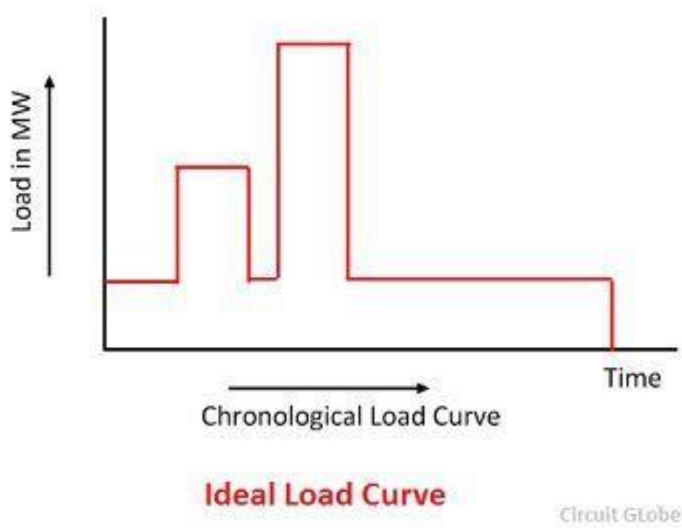
(v) Liquid fuels pose problems in cold climates since the oil stored in the tanks is to be heated in order to avoid the stoppage of oil flow.

In this modern world, the dependence one electricity is so much that it has become a part and parcel of our life. The ever increasing use of electric power for domestic, commercial and industrial purposes necessitates to provide bulk electric power economically. This is achieved with the help of suitable power producing units, known as *Power plants or Electric power generating stations.* The design of a power plant should incorporate two important aspects. Firstly, the selection and placing of necessary power-generating equipment should be such so that a maximum of return will result from a minimum of expenditure over the working life of the plant. Secondly, the operation of the plant should be such so as to provide cheap, reliable and continuous service. In this chapter, we shall focus our attention on various types of generating stations with special reference to their advantages and disadvantages.

Load Curve

Load curve or chronological curve is the graphical representation of load (in kW or MW) in proper time sequence and the time in hours. It shows the variation of load on the power station. When the load curve is plotted for 24 hours a day, then it is called daily load curve. If one year is considered then, it is called annual load curve.





Maximum Load (Peak Load)

It represents the maximum power that consumed by the load during a specific given time. It is also equal to the maximum actual power generated by the plant when the transmission losses are neglected.

Load Factor

It is the ratio of the average load to the maximum load for a certain period of time. The load factor is called ***daily load factor*** if the period of time is a day, and if the period of time is a month, the load factor is called ***monthly load factor***, and similarly for the ***year load factor***.

$$\text{Load Factor} = \frac{\text{Average Load}}{\text{Max. Load}}$$

Average Load

It is the average power that consumed by the load during a certain period of time and it is equal to the average power that generated by the plant during the same period of time when neglecting transmission line losses.

$$\text{Average Load} = \frac{\text{Area under the load curve (kWh)}}{\text{no. of hours (h)}} \qquad \text{(kW)}$$

Installed Capacity (Plant Capacity, nameplate capacity)

It represents the maximum possible power that could be produced (generated) from the power plant. The value of the installed capacity depends on the plant design.

$$\text{Installed Capacity} = \text{Nominal power value of the plant} \qquad \text{(kW or MW)}$$

Reserve Capacity

$$\text{Reserve Capacity} = \text{Installed Capacity} - \text{Max. Demand} \qquad \text{(kW or MW)}$$

Plant Capacity Factor

The capacity factor of a power plant is the ratio of its average output power over a period of time, to its maximum possible power that could be produced. It can be determined as below:

$$\text{Plant Capacity Factor} = \frac{\text{Average Demand (kW)}}{\text{Installed Capacity (kW)}}$$

Utilisation Factor

$$\text{Utilisation Factor} = \frac{\text{Max. Demand (kW)}}{\text{Installed Capacity (kW)}}$$

is defined as the ratio of the maximum generator demand to the generator capacity.

Plant Use Factor

$$\text{Plant Use Factor} = \frac{\text{Actual energy produced (kWh)}}{\text{Installed Capacity (kW)} \times \text{no. of operation hours(h)}}$$

Or

$$\text{Plant Use Factor} = \frac{\text{Average Demand} \times \text{T}}{\text{Installed Capacity} \times \text{no. of operating hours}}$$

Where

$T = 24\text{ h}$ if the time is a day

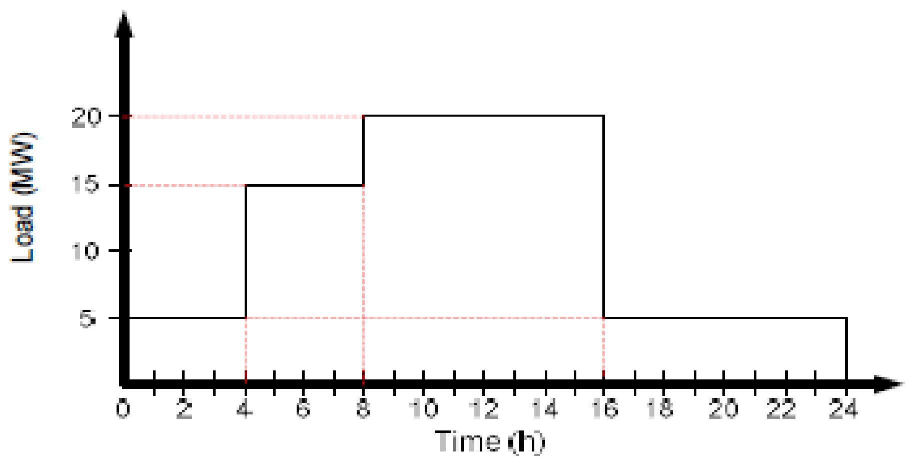
$T = 24 \times 30\text{ h}$ if the time is a Month

Diversity Factor

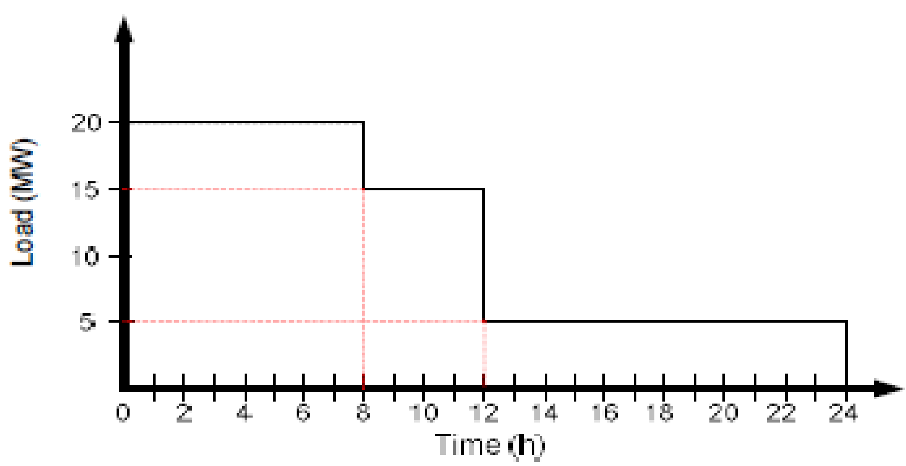
$$\text{Diversity Factor} = \frac{\text{Sum of Individual Max. Demand (kW)}}{\text{Max. Demand on power Plant (kW)}}$$

Load curve and operation curve

In this curve, the load elements of a load curve are arranged in order of descending magnitudes. So, the area under the load duration curve and the area under the load curve are equal. The following figure shows an example of the load curve and the load duration curve.



Load Curve



Load Duration Curve

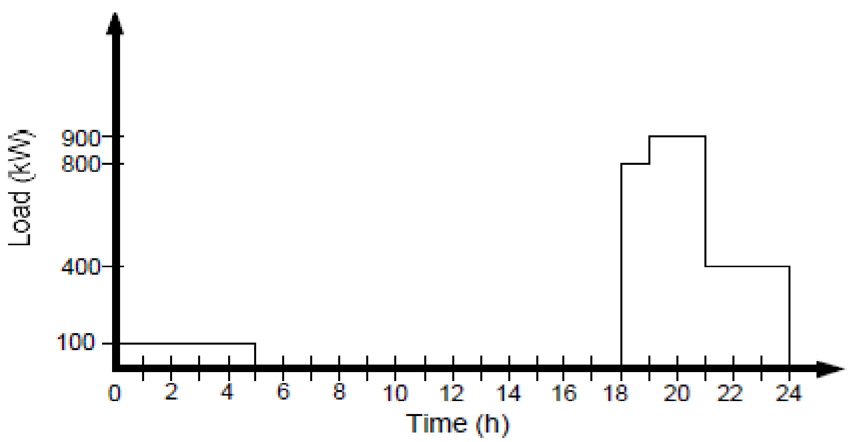
EX: A generation station of 1MW supplied a region which has the following demands:

From	To	Demand (kW)
midnight	5 am	100
5 am	6 pm	No-load
6 pm	7 pm	800
7 pm	9 pm	900
9 pm	midnight	400

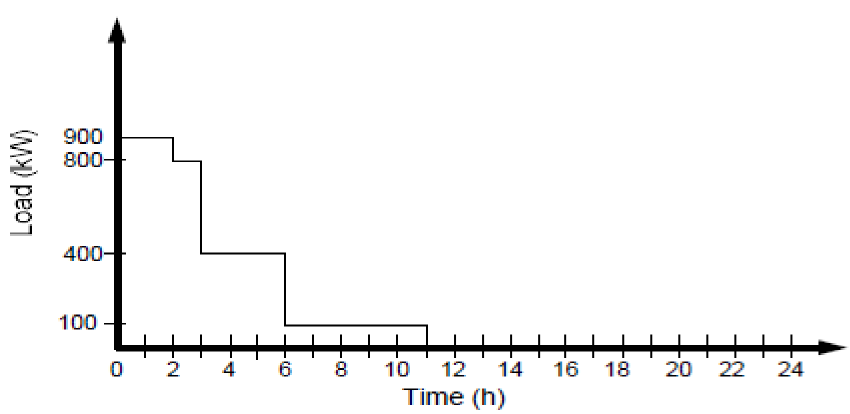
Neglect transmission line losses and find the following:

1. Plot the daily load curve and the load duration curve.
2. Find the load factor, the reserve capacity, plant capacity factor, plant use factor, the hours that the plant has been off and utilization factor.

Solution



Load Curve



Load Duration Curve

When the transmission line losses are neglected, $P_g = P_L$, and the demand = load

Installed capacity = 1 MW = 1000 kW and max. load = max. demand = 900 kW

$$\text{Average Load} = \frac{\text{Area under the load curve (kWh)}}{\text{no. of hours (h)}}$$

$$\text{Average Load} = \frac{(5 \times 100) + (13 \times 0) + (1 \times 800) + (2 \times 900) + (3 \times 400)}{24}$$

$$\text{Average Load} = \frac{4300 \text{ kWh}}{24 \text{ h}} = 179.16 \text{ kW}$$

$$\text{Load Factor} = \frac{\text{Average Load}}{\text{Max. Load}} = \frac{179.16 \text{ kW}}{900 \text{ kW}} = 0.199 = 19.19\%$$

$$\text{The Reserve Capacity} = \text{Installed Capacity} - \text{Max. Demand}$$

$$= 1000 - 900 = 100 \text{ kW}$$

$$\text{Plant Capacity Factor} = \frac{\text{Average Demand}}{\text{Installed Capacity}} = \frac{179.16 \text{ kW}}{1000 \text{ kW}} = 0.1791 = 17.91\%$$

$$\text{Plant Use Factor} = \frac{\text{Actual Energy Produced in (kWh)}}{\text{Plant Capacity} \times \text{no. of hours}} = \frac{4300 \text{ kWh}}{1000 \text{ kW} \times 11 \text{ h}}$$

$$\text{Plant Use Factor} = 0.3909 = 39.09\%$$

$$\text{Utilisation Factor} = \frac{\text{Max. Demand}}{\text{Installed Capacity}} = \frac{900 \text{ kW}}{1000 \text{ kW}} = 0.9 = 90\%$$

EX: A generation station has a maximum demand of 20 MW, a load factor of 60%, plant capacity factor of 48% and plant use factor of 80%. Find:

1. The daily energy produced
2. The reserve capacity
3. The number of operating hours per daily
4. The maximum energy that could be produced daily if the generation station was running all the time.

Solution:

1) Find the daily energy produced

$$\text{Load Factor} = \frac{\text{Average Load}}{\text{Max. Load}}$$

$$0.6 = \frac{\text{Average Load}}{20\ \text{MW}} \qquad \textit{and then} \qquad \text{Average Load} = 0.6 \times 20\ \text{MW} = 12\ \text{MW}$$

$$\text{Average Load} = \frac{\text{Area under the load curve (kWh)}}{\text{no. of hours (h)}}$$

The time for daily energy produced is 24 h

$$\text{Area under the load curve} = \text{energy produced} = 12 \times 24 = 288\ \text{MWh}$$

2) Find the reserve capacity

$$\text{Plant Capacity Factor} = \frac{\text{Average Demand}}{\text{Installed Capacity}}$$

$$\text{Installed Capacity} = \frac{\text{Average Demand}}{\text{Plant Capacity Factor}} = \frac{12}{0.48} = 25\ \text{MW}$$

$$\text{Reserve Capacity} = \text{Installed Capacity} - \text{Max. Demand}$$

$$\text{Reserve Capacity} = 25 - 20 = 5\ \text{MW}$$

3) Find the number of operating hours per daily

$$\text{Plant Use Factor} = \frac{\text{Average Demand} \times \text{T}}{\text{Installed Capacity} \times \text{no. of operating hours}}$$

$$0.8 = \frac{12 \times 24}{25 \times \text{no. of operating hours}}$$

$$\text{no. of operating hours} = \frac{12 \times 24}{25 \times 0.8} = 14.4\ \text{h}$$

4) Find the maximum energy that could be produced daily if the generation station was running all the time.

$$\text{The maximum energy that could be produced daily} = \text{Installed Capacity} \times 24$$

$$= 25 \times 24 = 600\ \text{MWh}$$

$$= 25 \times 24 = 600\,000\ \text{kWh}$$

EX: A generation station of 10MW supplied two regions (A and B) which have the following demands:

Region A		
From	**To**	**Demand (kW)**
midnight	9 am	600
9 am	12 noon	2500
12 noon	5 pm	800
5 pm	6 pm	5000
6 pm	7 pm	No-load
7 pm	midnight	4000

Region B		
From	**To**	**Demand (kW)**
midnight	8 am	800
8 am	1 pm	5000
1 pm	2 pm	800
2 pm	5 pm	5000
5 pm	midnight	800

Find the diversity factor.

Solution:

Regions A+B		
From	**To**	**Demand (kW)**
midnight	8 am	600+800=1400
8 am	9 am	600+5000=5600
9 am	**12 noon**	**2500+5000=7500**
12 noon	1 pm	800+5000=5800
1 pm	2 pm	800+800=1600
2 pm	5 pm	800+5000=5800
5 pm	6 pm	5000+800=5800
6 pm	7 pm	0+800=800
7 pm	midnight	4000+800=4800

$$\text{Max. Demand on power Plant} = 7500 \text{ kW}$$

$$\text{Diversity Factor} = \frac{\text{Sum of Individual Max. Demand (kW)}}{\text{Max. Demand on power Plant (kW)}}$$

$$\text{Diversity Factor} = \frac{5000\ (\text{kW}) + 5000\ (\text{kW})}{7500\ (\text{kW})} = 1.333$$