Electrical Loads

The term 'load' refers to a device or bunch of devices that tap energy from the power system.
Load devices are categorized as;

(i) Motor loads which include single phase fractional horsepower motors used in appliances of various kinds, induction motor used in agricultural, commercial and industrial application and synchronous motor used for power factor correction

(ii) Heating loads which include house heating, household heating applications and industrial appliances heating like large space heaters, ovens, furnaces, welding devices ~~like~~

(iii) Lighting loads which includes various types of light like incandescent and fluroscent lamps, neon lamps, Mercury vapour, Sodium vapour, and metal halide lamps.

(iv) Electronic gadgets which include radio, television computers and digital devices, X-ray and laser equipments, rectifiers, oscillators, -- etc.

→ Very large consumers [having loads of a few ten of megawatts) → Supplied at primary transmission or secondary transmission voltage levels.

⇒ Consumers having loads ranging from a few hundred kilowatts to a few megawatts may be supplied at primary distribution levels.

→ Small consumers [having loads upto a few tens of kilowatts] → supplied at secondary transmission or

LOAD CURVE

Load on a situation always changes and thus the generation.

Load curve is a graphical representation of variation of load with respect to time in chronological order.

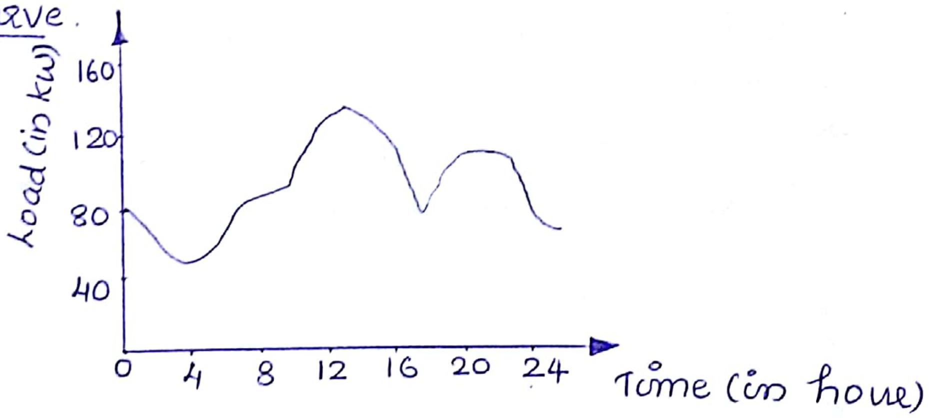
Load curve is called daily load curve; if the graph is for whole day.

If the time is one month, it is called monthly load curve.

The daily load curve for a situation is not the same for all the days. It differs from day-to-day & season to season.

Two load curves - one for winter and other for summer - used to calculate the base annual load.

Daily Load curve.



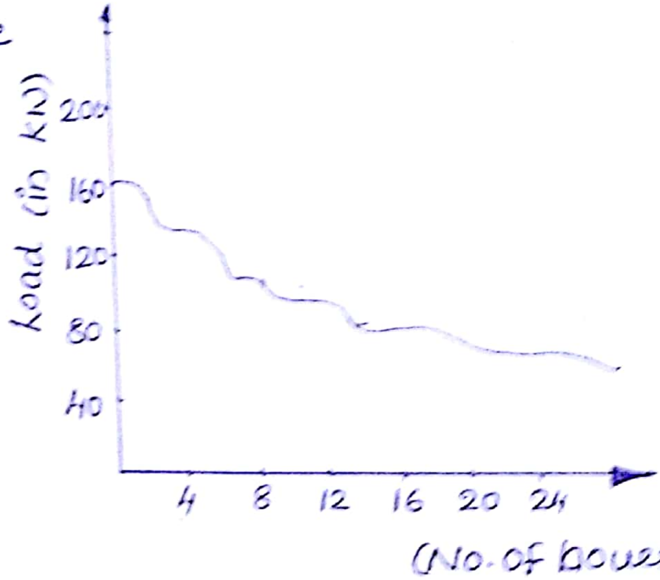
The load curves provides information such as

1. Area under the curve gives the actual unit generated required during the period.
2. The ratio of area under the curve to the total area under the rectangle in which it is contained gives the load factor for the period
3. The peak of the curve gives the maximum demand on the station during the period

LOAD DURATION CURVE

Load duration curve is a rearrangement of all the load elements of load curve in descending order with the greatest load on the left hand

Load duration curve

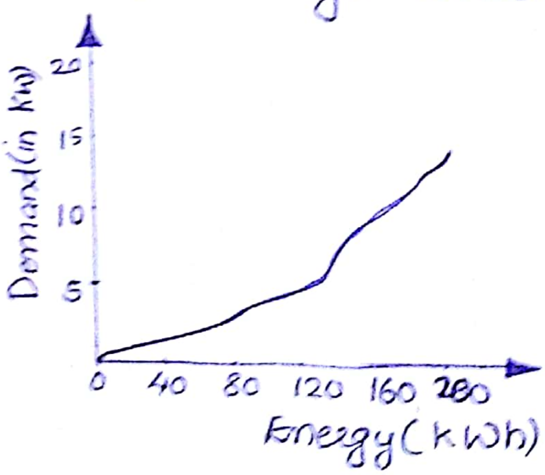


Energy Load curve

For hydroplants it is necessary to know the amount of energy between different demand levels. This is obtained by plotting energy curve which can be derived from chronological curve or load duration curve.

→ If energy and demand are plotted in terms of percentage, it is called peak percentage curve.

Energy Load curve



Connected Load

Each device at consumers terminal has its rated capacity.
The connected load is the sum of the continous rating of the entire load consuming apparatus and outlets connected to the system.

Maximum demand

The maximum demand of a consumer means the maximum power that the circuit likely to draw at any time

OR

Maximum demand of an installation or system is the greatest of all demands that have occured during the specified period of time, which may be daily, montly or yearly.

→ Consumers do not use all the devices and outlets at full load simultaneously and the max. demand is always less than the connected load.

Demand factor

The demand factor is the ratio of maximum demand to the connected load.

$$\text{Demand factor} = \frac{\text{Maximum demand}}{\text{Connected load}}$$

Demand factor lies between 0.5 & 0.8

Load factor

Load factor of a plant or system is the ratio of the average load to the peak load for a certain period of time.

If period considered is a day, load factor is the daily load factor and is month, load factor is monthly load factor

$$\text{Load factor} = \frac{\text{Average demand}}{\text{Maximum demand}}$$

$$= \frac{\text{Energy generated in a given period of time}}{\text{Maximum demand} \times \text{hours of operation in the given period}}$$

→ Load factor is always unity.
For better performance, the load factor should be high as possible.

Diversity factor

Ratio of the sum of maximum demands of all subdivision or group or consumers to the maximum demand of the whole subdivisions or groups or consumers.

$$\text{Diversity factor} = \frac{\text{Sum of individual maximum demands}}{\text{Maximum demand of whole}}$$

→ Diversity factor between transformers, between feeders, and between substations can be combined into single term ~~co~~ and is referred to as Peak diversity factor.

$$\text{Peak diversity factor} = \frac{\text{Maximum demand of a consumer group}}{\text{Demand of consumer group at the time of system Peak demand}}$$

Plant capacity factor

→ The plant capacity factor (plant factor) is the ratio of average annual load to the power plant capacity (installed capacity) during given period.

$$\text{Plant capacity factor} = \frac{\text{Average annual load}}{\text{Plant rated capacity}}$$

$$= \frac{\text{Energy produced in a year}}{\text{Plant rated capacity} \times 8760}$$

Capacity factor indicate the extent use of the generating station.

→ It is different from load factor because of reason that the rated capacity of each plant is always greater than expected maximum load due to some reserve capacity.

$$\text{Capacity factor} = \frac{\text{Maximum load}}{\text{Plant capacity}} \times \text{Load factor}$$

Plant use factor

→ It is the ratio of actual energy produced to the multiplication of plant capacity and time (in hrs) of the plant operation.

$$\text{Plant use factor} = \frac{\text{Actual energy produced}}{\text{Plant capacity} \times \text{plant operation time in hours.}}$$

The two important observations can be made & saying that ideal condition for cheap electric connection.

a) The installed capacity and hence corresponding capital cost of generating plant is low.

b) The daily output of each generator.

The reduction in costs with good load factor is due to the fact that overall working cost/unit become low.

Utilization factor

→ Defined as the ratio of maximum demand to the rated capacity of plant

$$\text{Utilization factor} = \frac{\text{Maximum demand}}{\text{Rated Capacity}}$$

Utilization factors of efficient generators are high & is more than unity due to overloading of the plant

$$\text{Plant capacity factor} = \text{Load factor} \times \text{utilization factor}$$

Q Maximum demand of a generating station is 100 MW, a load factor is 65%. The plant capacity factor and plant use factor are 50% & 80% respe. Determine (a) The daily energy produced b) Installed capacity of plant (c) Reserve capacity of plant (d) Maximum energy that could be produced daily if the plant running all the time (e) The maximum energy that could be produced daily if the plant is running at full load (f) utilization factor.

Soln:- Average demand = maximum demand × load factor

$= 100 \times \cdot 65$

$= 65 \text{ MW}$

(a) Daily energy Produced = (Average demand) × 24

$= 65 \times 24$

$= \underline{\underline{1560 \text{ MWh}}}$

(b) Plant rated capacity $= \dfrac{\text{Average load}}{\text{Plant capacity factor}}$

$= \dfrac{65}{0.5}$

$= \underline{\underline{130 \text{ MW}}}$

(c) Reserve capacity = Installed capacity - max. demand

$= 130 - 100$

$= \underline{\underline{30 \text{ MW}}}$

(d) Maximum energy that could be produced if plant is running all the time will be

Installed capacity × 24 = 130 × 24 = $\underline{\underline{3120 \text{ MWh}}}$

(e) Maximum energy (if plant is running at full load)

$= \dfrac{\text{Actual energy produced}}{\text{Plant use factor}}$

$= \dfrac{1560}{0.80} = \underline{\underline{1950 \text{ MWh}}}$

(f) Utilization factor $= \dfrac{\text{Maximum load}}{\text{Rated capacity}} = \dfrac{100}{130} = \underline{\underline{0.769}}$

Base load & peak load

→ Load is changing throughout the year & generators must cope up the varying demand.
→ Peak load on station is relatively for small duration
→ Some generators is used to peak load, its energy will be expensive, as load factor will be low.
→ Base load plants which operate most of the time & have high load factor.

Operation of power plant depends on.

1. Cheaper electricity generating unit should be used as a base load power plant
2. Highest starting time generating plant is also used as base load plants.
3. Size on plant is also a decisive factor

Base load & Peak load power stations

Type of generating plant	Normal nature of operation
Run-of-river	Base load plant
Nuclear	Base load plant
Pondage	Base load plant
Steam	Both peak & base load plant
Pump storage	Peak load plant
Diesel	Peak load Plant.

Interconnection of power stations

The advantage of interconnection forces the regulators to connect the power system

Advantages

1. Total reserve capacity can be ~~f~~ reduced
2. In an interconnected system, it is possible to have larger generator rating and thus reduce capital cost of the system.

3. It is possible to run most effective units at higher load factor and inefficient station can be used at peak hours only.

4. Increases the reliability of the system.

Drawbacks of interconnections are

1. Fault in one system gets transferred to other parts of the system

2. High switch gear rating is to be employed at different point of the system

3. proper management is required to dispatch them

TARIFFS

→ Two different types of charges
Fix charges and running charges.

→ Fixed charges includes (a) capacity related : Interests and depreciation, cost of plant, building, transmission and distribution networks, parts of salaries of staff.
(b) consumer related : cost of meter, billing, collection, service, - - - etc.

→ Running charges includes fuel cost, operation and maintance cost, & some wages and also known as varible cost.

Main Objectives of Tariffs

a) The consumers must readily understand the tariffs
b) The tariffs must be equitable as amongest different consumers.
c) The tariffs should also be such as to encourage consumers to improve the power factor.
d) Tariffs can be modified by time to time
e) Use of electricity is encouraged so that the economy of utilities is improved

Classification of Tariffs

1. Domestic consumers use electricity for domestic purpose
2. Agricultural consumers use electricity of agricultural purpose such as irrigation, thrashing, ...etc.
3. Industrial consumers use electricity for industrial production such as heavy industries, manufacturing companies
4. Commercial consumers use electricity for commercial purpose such as hospitals, muncipalies, ..etc.

The general form of tariff is

$$a\,kWh + b\,kW + c.$$

Flat rate tariffs

→ The ~~total~~ b&c are zero.

→ The ~~efficiency~~ of electricity charge is directly multiplication of energy consumption and factor. a

Two-part tariffs

→ The total charge under this tariffs is split into two compoents.

a) Fixed charge based on maximum demand

b) Varible charge based on actual energy consumption

The main objection of the two part tariffs scheme is that consumer has to pay even if his consumption is nil.

Block rate tariffs

→ Different blocks of energy consumption are charged at different rates.

Eg:- First 50 Units Rs. 4.00/unit
next 50 Units Rs. 3.00/unit
and for additional unit @ Rs. 200 per unit

Maximum demand Tariffs

→ In the scheme of tariff, the charges are calculated based on the maximum demand only.

→ The co-efficients 'a' & 'c' are zero.

Power factor tariffs

→ In AC system, the size of plant not only depends on the kW but also on power factor.

→ Power factor tariffs are devised to differentiate between good power factor users & poor power factor users.

The three main classes are

1. KVA maximum demand tariff

Insted of charging the maximum real power (kW) demand, maximum KVA demand is charged in addition to the charge corresponding to the energy.

2. kWh & KVArh tariff

Both kWh (real power energy) & KVArh (reactive power consumption) are charged separately.

3. Sliding scale or average power factor tariffs

→ There is some extra charge if the power factor is worsening from the set value.

Eg:- Let pf is set to 0.8 lagging, if pf is 0.9, some discount will be offered and if pf is 0.7 some extra charges are taken

Scanned by CamScanner

Q Load factor of a consumer is 35% and the monthly consumption is 504 kWh. If the rate of electricity is Rs. 180 per kW of maximum demand plus Rs. 2.00 per kWh, find

(a) The monthly bill and the average cost per kWh

(b) The overall cost per kWh if the consumption is increased by 20% with the same load factor.

(c) The overall cost per kWh if the consumption remains same but load factor is increased to 40%.

Soln:

$$\text{Maximum demand} = \frac{\text{average monthly consumption}}{\text{Load factor} \times 24 \times 30}$$

$$= \frac{504}{.35 \times 24 \times 30}$$

$$= \underline{\underline{2\ kW}}$$

a) Monthly Bill (Rs) $= (2 \times 180) + (2 \times 504)$

$= \underline{1368}$

overall cost per kWh $= \frac{1368}{504} = \underline{\underline{Rs.\ 2.71}}$

b) New consumption $= 504 \times 1.20$

$= \underline{\underline{604.8\ kWh}}$

Since load factor is same,

Maximum demand $= \frac{604.8}{0.35 \times 24 \times 30} = \underline{\underline{2.4\ kW}}$

monthly Bill (Rs) $= (2.4 \times 180) + (2 \times 604.8)$

$= \underline{\underline{₹1641.6}}$

Overall cost per kWh $= \frac{1641.6}{604.8} = \underline{\underline{Rs.\ 2.71}}$

c) Since load factor is 40%.

Max demand $= \frac{504}{0.40 \times 24 \times 30} = \underline{\underline{1.75\ kW}}$

Monthly Bill (Rs.) = $(1.75 \times 180) + (2 \times 504) = \underline{\underline{1323}}$

Overall cost per kWh = $\frac{1323}{504} = \underline{\underline{\text{Rs. } 2.63}}$

? Home work

Q A generating station has a maximum demand of 80MW, a load factor of 65%, a plant capacity factor of 40% and plant use factor of 85%. Find (a) Daily energy produced (b) Reserve capacity of plant (c) Maximum energy that could be produced daily if the plant was running all the time (d) Maximum energy that could be produced daily if the plant was running as per operating schedule