
Course: Sustainable Energy Technology1

12150310

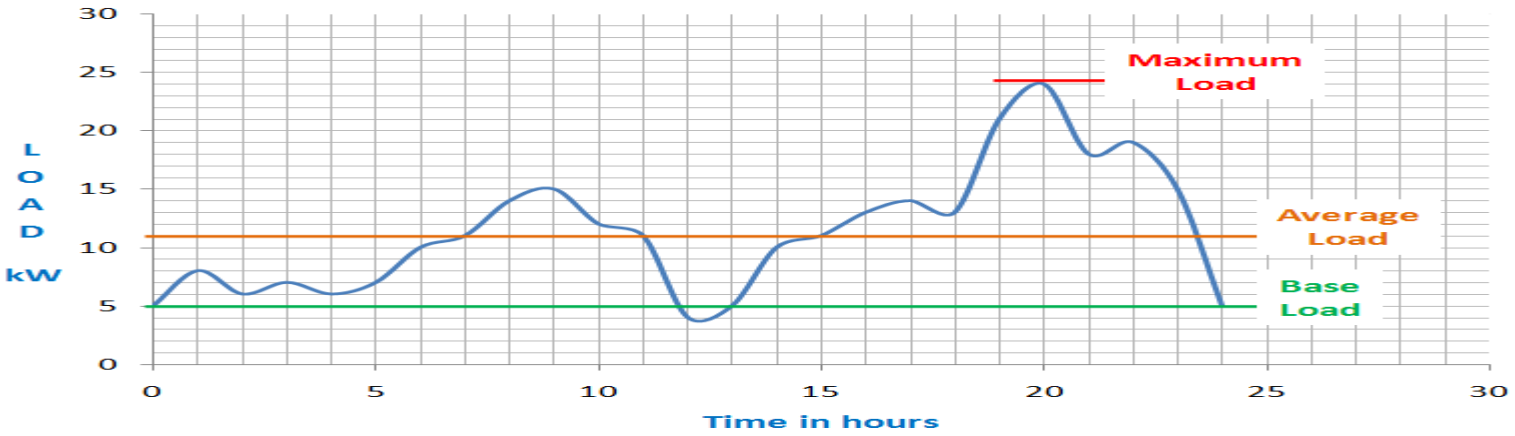
**Title: Tariff Systems & Load Curves -L2**

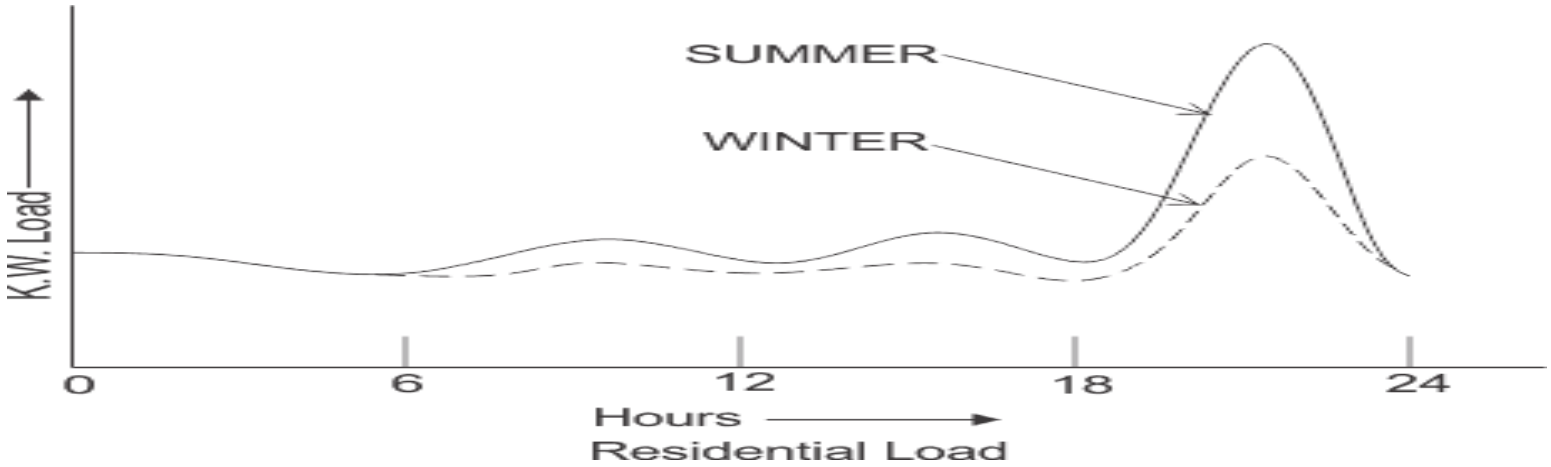
Dr. Mahmoud Ismail

# Electric Load Characteristics

## Load Curve:

is a graphical plot showing the variation in demand for energy of the consumers on a source of supply with respect to time .



# Electric Load Characteristics

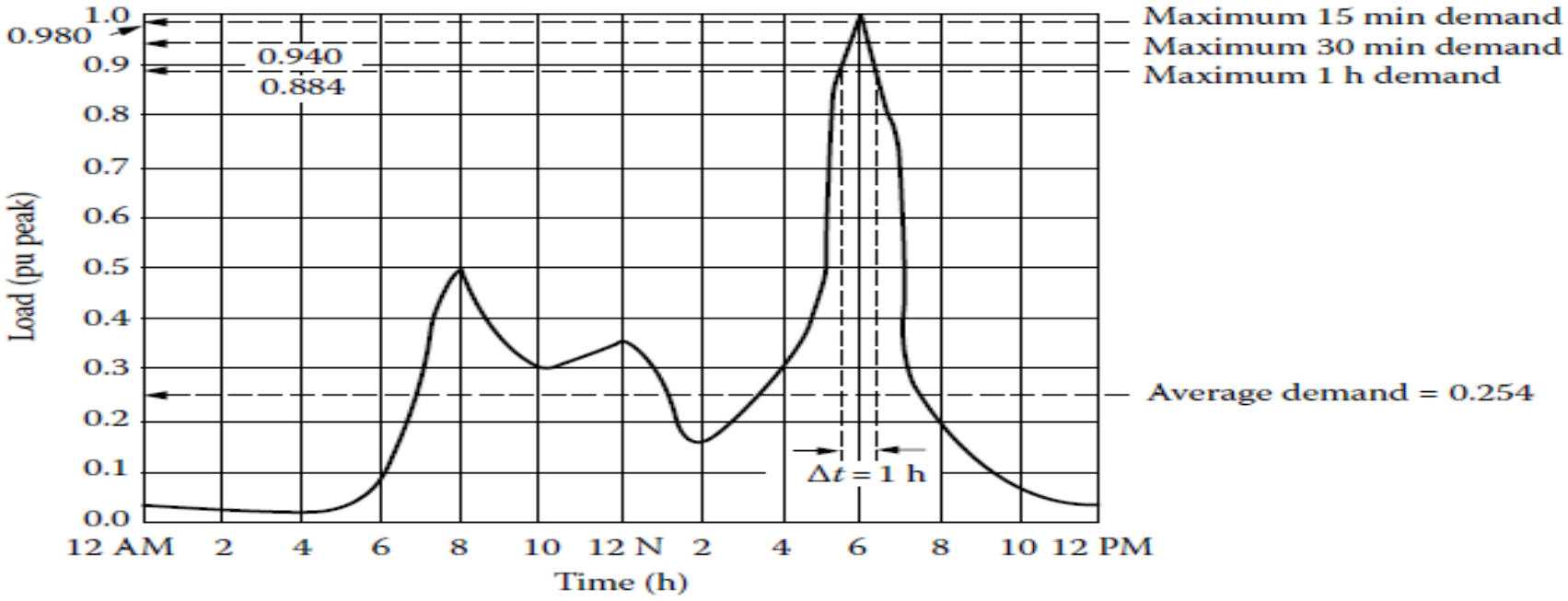
## Load Curve (Demand Variation Curve):

1) They are helpful in deciding the total installed capacity of the plant that should be capable of meeting the peak load demand.
2) They are helpful in deciding the most economical size of various generating units.
3) They are helpful in deciding the operating schedule of the power plant, i.e. how, when and in what sequence, the various units should be started, run and shut down.

The decision on whether to shut down certain sets or continue their operation at reduced load is to be made in the light of minimum losses. For optimizing the operation, the load curves should be considered in the analysis.

# Electric Load Characteristics

## Load Curve




The hour-to-hour load on a system changes over a wide range.

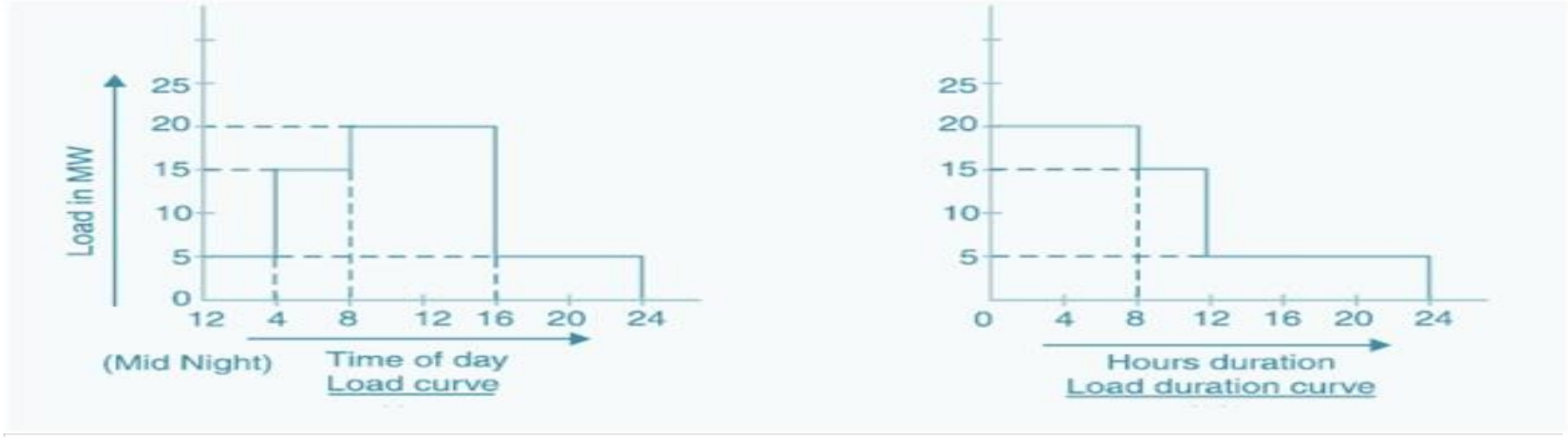
For example, the daytime peak load is typically double the minimum load during the night.

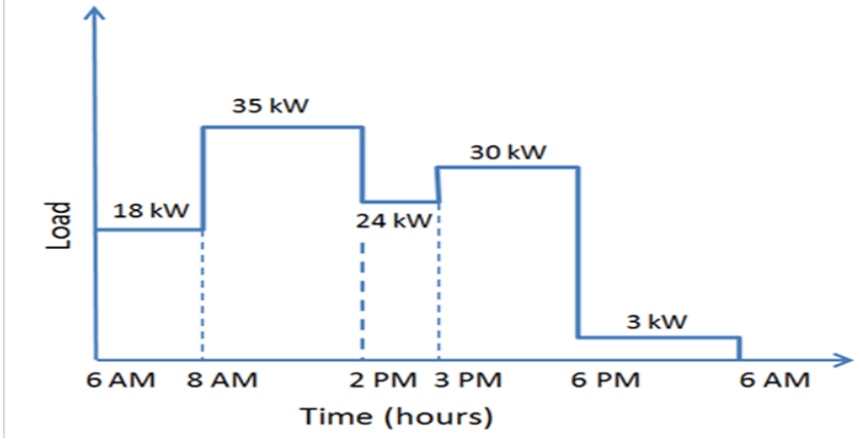
Usually, the annual peak load is, due to seasonal variations, about three times the annual minimum.

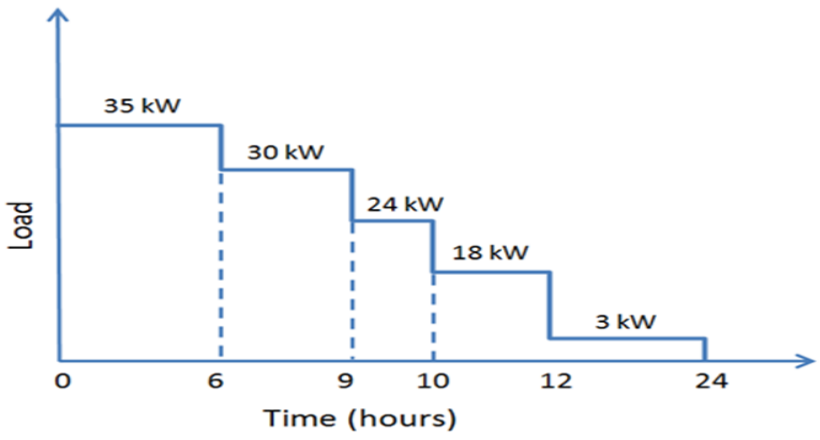
# Electric Load Characteristics

## Load Curve and Load Duration Curve

Load Duration Curve is the plot of Load versus time duration for which that load was persisting

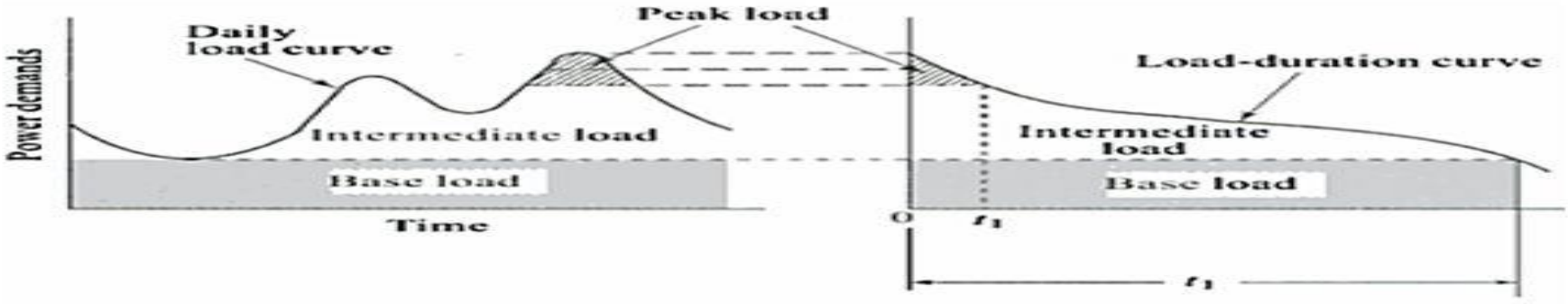


# Electric Load Characteristics

## Base load and Peak Load plants




Power plant load duration curve

The base load plant should be run at high load factor.

The peak load plant should be of smaller capacity and higher startup times to reduce the cost of generation.

It could be a gas turbine unit, pumped hydro-system, compressed air energy storage system or a diesel engine depending on the size and scope of availability.

# Electric Load Characteristics

Definitions:

**Demand**: The demand of an installation or system is the load at the receiving terminals averaged over a specified interval of time.

**Demand interval**: It is the period over which the load is averaged. This selected $\Delta t$ period may be 15 min, 30 min, 1 h, or even longer. Of course, there may be situations where the 15 and 30 min demands are identical.

**Maximum Demand**: It is the greatest of all demands which have occurred during the specified period of time.

**Connected Load:** Sum of continuous rating of all equipment connected to supply system.

**Demand Factor(DF)**: It is the ratio between the maximum Demand and the total connected load.

DF = Maximum Demand / Total Connected Demand

# Electric Load Characteristics

## Definitions:

**Utilization factor(Fu):** It is the ratio of the maximum demand of a system to the rated capacity of the system.

Fu = Maximum demand / Rated system capacity

**Average Load:** Area in (kWh) under daily load curve / 24 hr

**Load Factor($F_{LD}$):** It is "the ratio of the average load over a designated period of time to the peak load occurring on that period

FLD=Units served (or generated) / (Peak load (Max.Demand) × T)

# Electric Load Characteristics

## Definitions:

**Capacity (Plant)(Use) factor(Fu):** It is the ratio of the total actual energy produced or served over a designated period of time to the energy that would have been produced or served if the plant (or unit) had operated continuously at maximum rating.

Plant factor (Plant Capacity Factor) = Average demand /Plant Capacity

= Actual energy produced or served / (Maximum plant rating ×T)

**Reserve Capacity =** Plant Capacity – Maximum Demand

# Electric Load Characteristics

## Definitions:

**Diversity Factor($F_D$):** It is the ratio of the sum of maximum demands of individual loads connected to the system to the simultaneous maximum demand of the system itself.

$F_D$ = Sum of individual maximum demands / Coincident maximum demand

$$F_D = \frac{D_1 + D_2 + D_3 + \cdots + D_n}{D_g} \qquad F_D = \frac{\sum_{i=1}^{n} D_i}{D_g} \qquad \text{DF} = \frac{\text{Maximum demand}}{\text{Total connected demand}}$$

**Demand Factor(DF)**

$D_i$ is the maximum demand of load $i$, disregarding time of occurrence

$D_g = D_{1+2+3+\cdots+n}$

= coincident maximum demand of group of $n$ loads

**Coincidence Factor($F_C$):** It is the reciprocal of diversity factor

$$F_c = \frac{D_g}{\sum_{i=1}^{n} D_i} \qquad F_c = \frac{1}{F_D}$$

# Electric Load Characteristics

## Types of loads

Domestic load. It consists of lights, fans, refrigerators, heaters, television, small motors for pumping water etc. Most of the residential load occurs only for some hours during the day. For this reason, the load factor is low (10% to 12%).

Commercial load. Commercial load consists of lighting for shops, fans and electric appliances used in restaurants etc. This class of load occurs for more hours during the day as compared to the domestic load. The commercial load has seasonal variations due to the extensive use of air conditioners and space heaters.

Industrial load. The magnitude of industrial load depends upon the type of industry. Thus small scale industry requires load up to 25 kW, medium scale industry between 25kW and 100 kW and large-scale industry requires load above 500 kW. Industrial loads are generally not weather dependent.

Municipal load. Municipal load consists of street lighting, power required for water supply and drainage purposes.

Irrigation load. This type of load is the electric power needed for pumps driven by motors to supply water to fields.

Traction load. This type of load includes tram cars, trolley buses, railways etc. This class of load has wide variation.

# Electric Load Characteristics

Examples:

**.EXAMPLE2**

1. **The maximum demand on power station is 100 MW. If the annual load factor is 40%, calculate the total energy generated in a year.**

Energy generated in a year or Unit Generated/Annum

= Maximum Demand (in kW) X Load Factor X Number of hours in a Year

$= (100 \times 10^3) \times 0.4 \times 8760 \quad = 3504 \times 10^5$ kWh

**.EXAMPLE3**

2. **A generating station has a connected load 120MW & it supplies maximum demand 60 MW. The numbers of units generated in a year are 48 X $10^7$ Calculate load & demand factor of generating station.**

$$\text{Load Factor} = \frac{\text{Total number of units Generated in a Year}}{\text{Maximum Demand X Number of hours in a Year}} = \frac{48 \times 10^7}{60 \times 10^3 \times 8760} = 0.9132$$

$$\text{Demand Factor} = \frac{\text{Maximum Demand}}{\text{Connected Load}} = \frac{60 \times 10^3}{120 \times 10^3} = 0.5$$

**EXAMPLE**

**Example for Practice:** A 100 MW Power Station delivers 100 MW for 2 Hours, 50MW for 6 Hours, and is shut down for the rest of each day. It is also shut down for maintenance off 45 days each year calculates its annual load factor.

**Energy supplied each day = 100X2+50X6=500MWh**
**Energy generated per year = 500 X320=160GWh**
**Annual Load Factor=160000/(100X320X24)=20.8%**

# Electric Load Characteristics

Examples:

**.EXAMPLE4:a generating station is to supply four regions of loads with peak values 10 MW, 8 MW, 5 MW, 7 MW. The diversity factor is 1.5 with average annual load is factor is 60%.**

**Find:**

**1- Maximum demand:**

$$F_D = \frac{D_1 + D_2 + D_3 + \cdots + D_n}{D_g}$$ , so Maximum demand = (10+8+5+7)/1.5 = 20 MW

**2- Annual Energy Generated**

= Maximum demand * Load factor * 8760 = 20 * 0.6 * 8760 MWh

**3- Installed Capacity**

= 120% * Pmax = 1.2 *20 = 24 MW.