Variable Load on Power Station

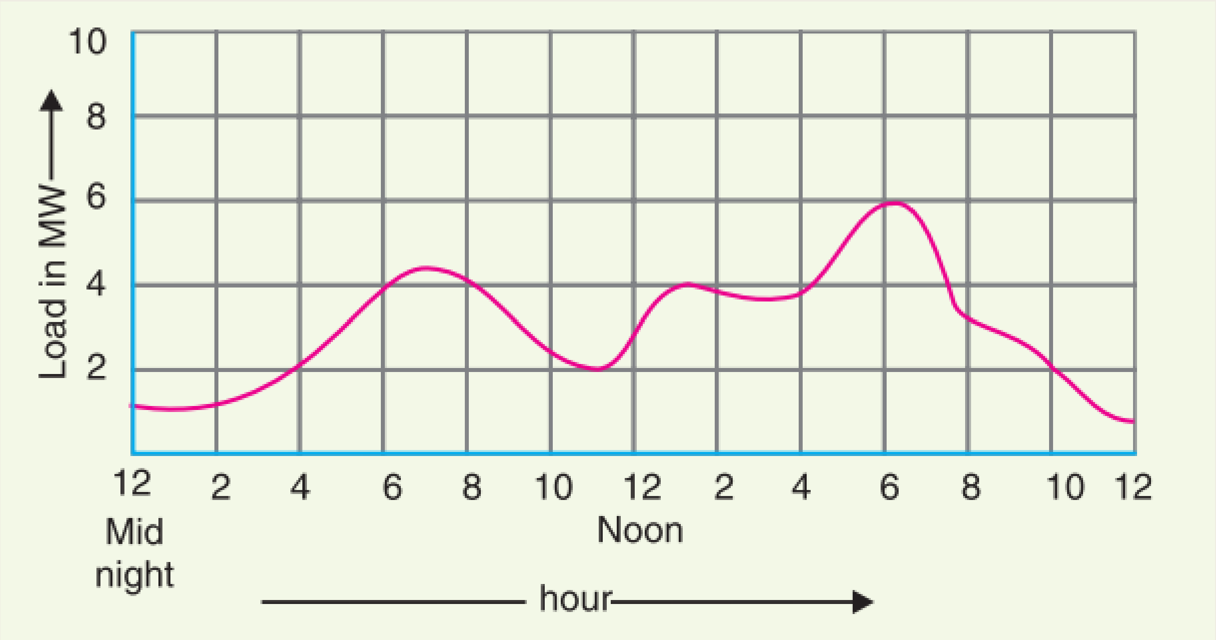
The load on a power station varies from time to time due to uncertain demands of the consumers and is known as **variable load on the station.**

Effects of Variable Load on Power Station:

- Need of additional equipment
- Increase in production cost

Load Curve

The curve showing the variation of load on the power station with respect to (w.r.t) time is known as a load curve.



Source: Mehta chapt 3

Importance of Load Curve

It shows the variations of load on the power station during different hours of the day

The area under the daily load curve gives the number of units generated in the day.

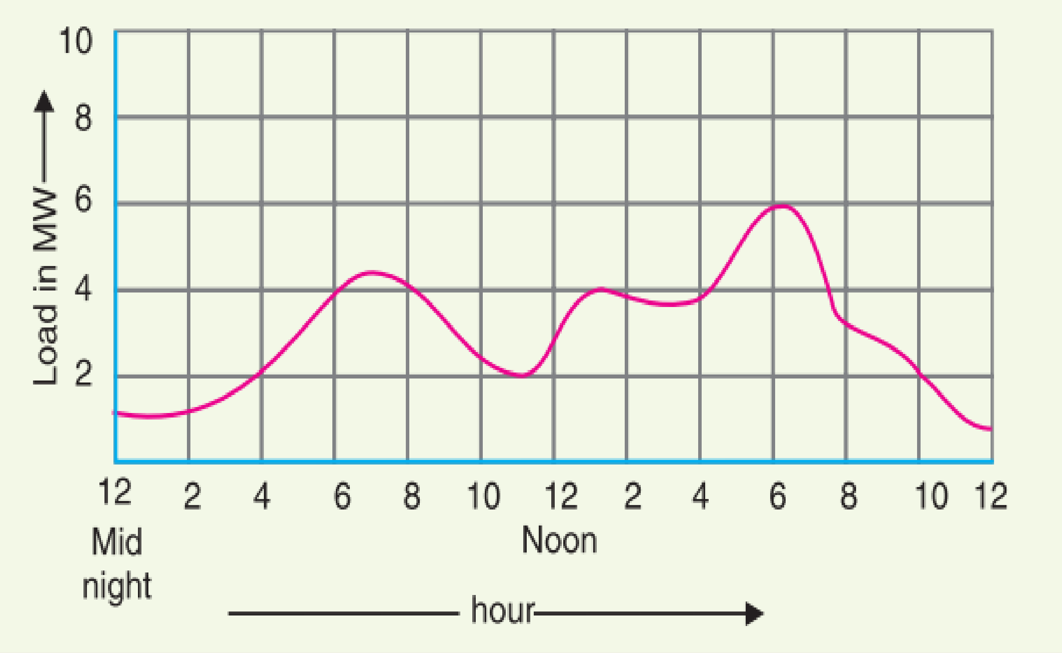
The load curve helps in selecting the size and number of generating units.

The load curve helps in preparing the operation schedule of the station.

Important Terms and Factors

(i) **Connected load:** It is the sum of continuous ratings of all the equipment connected to supply system. Example: 5 lamp having 100W rating each and 1KW heater.

(ii) **Maximum demand :** It is the greatest demand of load on the power station during a given period.



Source: Mehta chap 3

Important Terms and Factors

(*iii*) **Demand factor.** It is the ratio of maximum demand on the power station to its connected load.

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

(iv) Average load. The average of loads occurring on the power station in a given period (day or month or year) is known as **average load** or **average demand.**

$$\text{Daily average load} = \frac{\text{No. of units (kWh) generated in a day}}{\text{24 hours}}$$

$$\text{Monthly average load} = \frac{\text{No. of units (kWh) generated in a month}}{\text{Number of hours in a month}}$$

$$\text{Yearly average load} = \frac{\text{No. of units (kWh) generated in a year}}{\text{8760 hours}}$$

Source: Mehta chap 3

Important Terms and Factors

(v) **Load factor.** The ratio of average load to the maximum demand during a given period is known as **load factor.**

$$\text{Load factor} = \frac{\text{Average load}}{\text{Max. demand}}$$

If the plant is in operation for T hours,

$$\text{Load factor} = \frac{\text{Average load} \times \text{T}}{\text{Max. demand} \times \text{T}}$$

$$= \frac{\text{Units generated in T hours}}{\text{Max. demand} \times \text{T hours}}$$

(vi) **Diversity factor.** The ratio of the sum of individual maximum demands to the maximum demand on power station is known as **diversity factor.**

$$\text{Diversity factor} = \frac{\text{Sum of individual max. demands}}{\text{Max. demand on power station}}$$

Source: Mehta chap 3

Important Terms and Factors

(v) **Plant capacity factor:**

$$\text{Plant capacity factor} = \frac{\text{Actual energy produced}}{\text{Max. energy that could have been produced}}$$

$$= \frac{\text{Average demand} \times \text{T}^{**}}{\text{Plant capacity} \times \text{T}}$$

$$= \frac{\text{Average demand}}{\text{Plant capacity}}$$

(vi) **Reserve capacity**:

$$\text{Reserve capacity} = \text{Plant capacity} - \text{Max. demand}$$

(vii) **Plant use factor:**

$$\text{Plant use factor} = \frac{\text{Station output in kWh}}{\text{Plant capacity} \times \text{Hours of use}}$$

Source: Mehta chap 3

Units Generated per Annum

It is often required to find the kWh generated per annum from maximum demand and load factor. The procedure is as follows :

$$\text{Load factor} = \frac{\text{Average load}}{\text{Max. demand}}$$

$$\therefore \quad \text{Average load} = \text{Max. demand} \times \text{L.F.}$$

$$\text{Units generated/annum} = \text{Average load (in kW)} \times \text{Hours in a year}$$

$$= \text{Max. demand (in kW)} \times \text{L.F.} \times 8760$$

Source: Mehta chap 3

Examples

Example 3.1. *The maximum demand on a power station is 100 MW. If the annual load factor is 40% , calculate the total energy generated in a year.*

Example 3.2. *A generating station has a connected load of 43MW and a maximum demand of 20 MW; the units generated being* $61 \cdot 5 \times 10^6$ *per annum. Calculate* (*i*) *the demand factor and* (*ii*) *load factor.*

Example 3.3. *A 100 MW power station delivers 100 MW for 2 hours, 50 MW for 6 hours and is shut down for the rest of each day. It is also shut down for maintenance for 45 days each year. Calculate its annual load factor.*

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$$\text{Diversity factor} = \frac{\text{Sum of individual max. demands}}{\text{Max. demand on power station}}$$

Examples

Example 3.5. *A diesel station supplies the following loads to various consumers :*

Industrial consumer = 1500 kW ; Commercial establishment = 750 kW

Domestic power = 100 kW; Domestic light = 450 kW

If the maximum demand on the station is 2500 kW and the number of kWh generated per year is 45×10^5, determine (i) the diversity factor and (ii) annual load factor.

Example 3.10. *A generating station has the following daily load cycle :*

Time (Hours)	0—6	6—10	10—12	12—16	16—20	20—24
Load (M W)	40	50	60	50	70	40

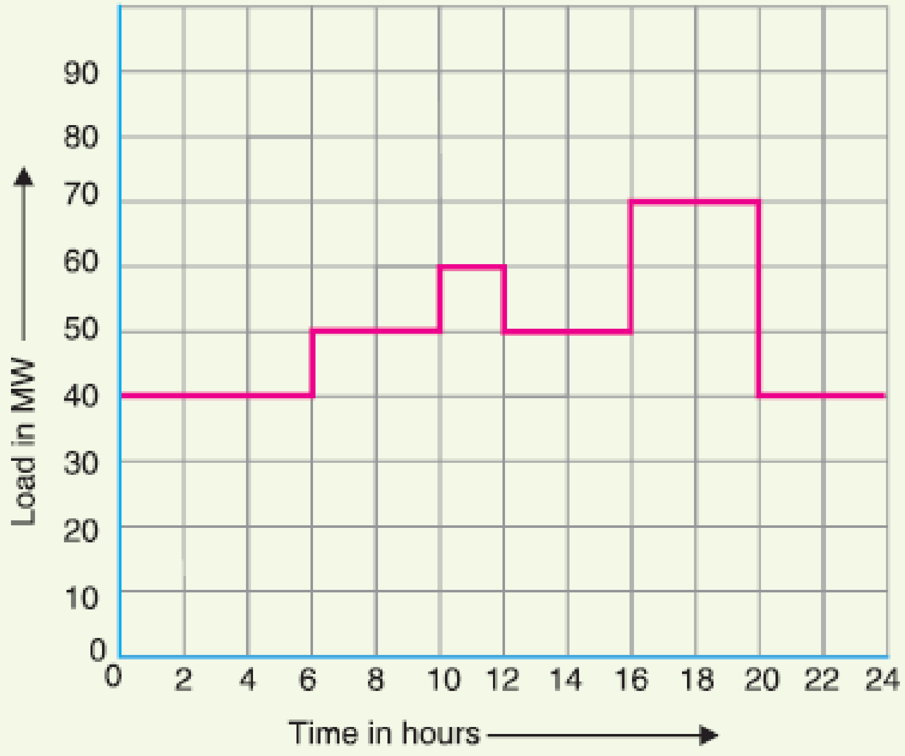
Draw the load curve and find (i) maximum demand (ii) units generated per day (iii) average load and (iv) load factor.

Source: Mehta chapt 3

Example 3.10. *A generating station has the following daily load cycle :*

Time (Hours)	0—6	6—10	10—12	12—16	16—20	20—24
Load (MW)	40	50	60	50	70	40

Draw the load curve and find (i) maximum demand (ii) units generated per day (iii) average load and (iv) load factor.



(ii) Units generated/day = Area (in kWh) under the load curve

$$= 10^3 [40 \times 6 + 50 \times 4 + 60 \times 2 + 50 \times 4 + 70 \times 4 + 40 \times 4]$$

$$= 10^3 [240 + 200 + 120 + 200 + 280 + 160] \text{ kWh}$$

$$= 12 \times 10^5 \text{ kWh}$$

(iii) $$\text{Average load} = \frac{\text{Units generated / day}}{24 \text{ hours}} = \frac{12 \times 10^5}{24} = 50{,}000 \text{ kW}$$

(iv) $$\text{Load factor} = \frac{\text{Average load}}{\text{Max. demand}} = \frac{50{,}000}{70 \times 10^3} = 0.714 = 71.4\%$$

Example 3.11. *A power station has to meet the following demand :*

Group A : 200 kW between 8 A.M. and 6 P.M.

Group B : 100 kW between 6 A.M. and 10 A.M.

Group C : 50 kW between 6 A.M. and 10 A.M.

Group D : 100 kW between 10 A.M. and 6 P.M. and then between 6 P.M. and 6 A.M.

Plot the daily load curve and determine (i) diversity factor (ii) units generated per day (iii) load factor.

Solution. The given load cycle can be tabulated as under :

Time (Hours)	0—6	6—8	8—10	10—18	18—24
Group A	—	—	200 kW	200 kW	—
Group B	—	100 kW	100 kW	—	—
Group C	—	50 kW	50 kW	—	—
Group D	100 kW	—	—	100 kW	100 kW
Total load on power station	100 kW	150 kW	350 kW	300 kW	100 kW

7. A power station has to meet the following load demand :

Load *A*	50 kW	between	10 A.M. and 6 P.M.
Load *B*	30 kW	between	6 P.M. and 10 P.M.
Load *C*	20 kW	between	4 P.M. and 10 A.M.

Plot the daily load curve and determine (*i*) diversity factor (*ii*) units generated per day (*iii*) load factor.

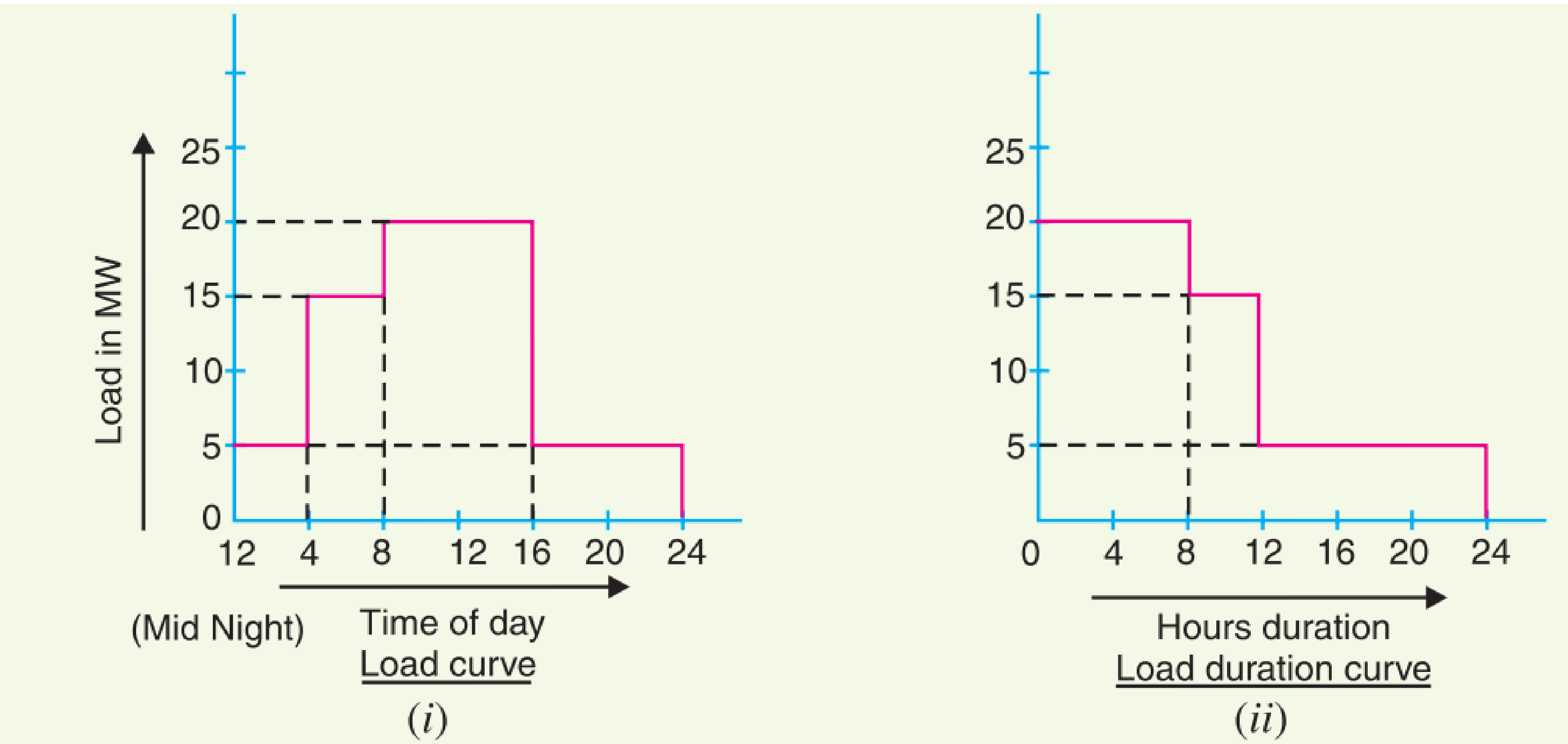
[(*i*) 1·43 (*ii*) 880 kWh (*iii*) 52·38%]

Example 3.12. *The daily demands of three consumers are given below :*

Time	Consumer 1	Consumer 2	Consumer 3
12 midnight to 8 A.M.	No load	200 W	No load
8 A.M. to 2 P.M.	600 W	No load	200 W
2 P.M. to 4 P.M.	200 W	1000 W	1200 W
4 P.M. to 10 P.M.	800 W	No load	No load
10 P.M. to midnight	No load	200 W	200 W

Load Duration Curve

When the load elements of a load curve are arranged in the order of descending magnitudes, the curve thus obtained is called a **load duration curve.**



Source: Mehta chapt 3

Example 3.15. *A power station has the following daily load cycle :*

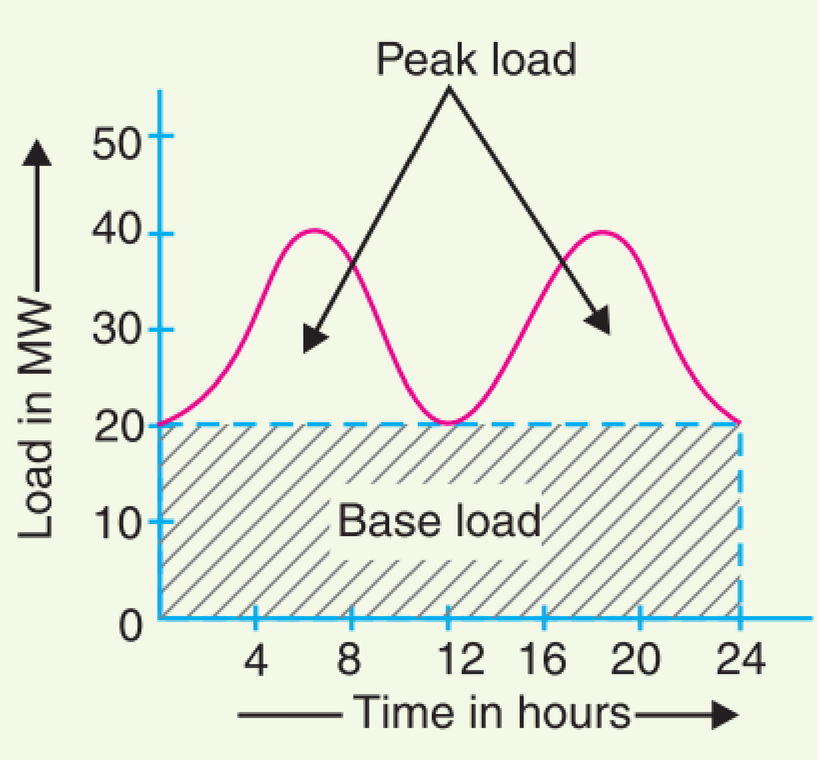
Time in Hours	6—8	8—12	12—16	16—20	20—24	24—6
Load in MW	20	40	60	20	50	20

Plot the load curve and load duratoin curve. Also calculate the energy generated per day.

Base Load and Peak Load

(i) **Base load.** The unvarying load which occurs almost the whole day on the station is known as base load.

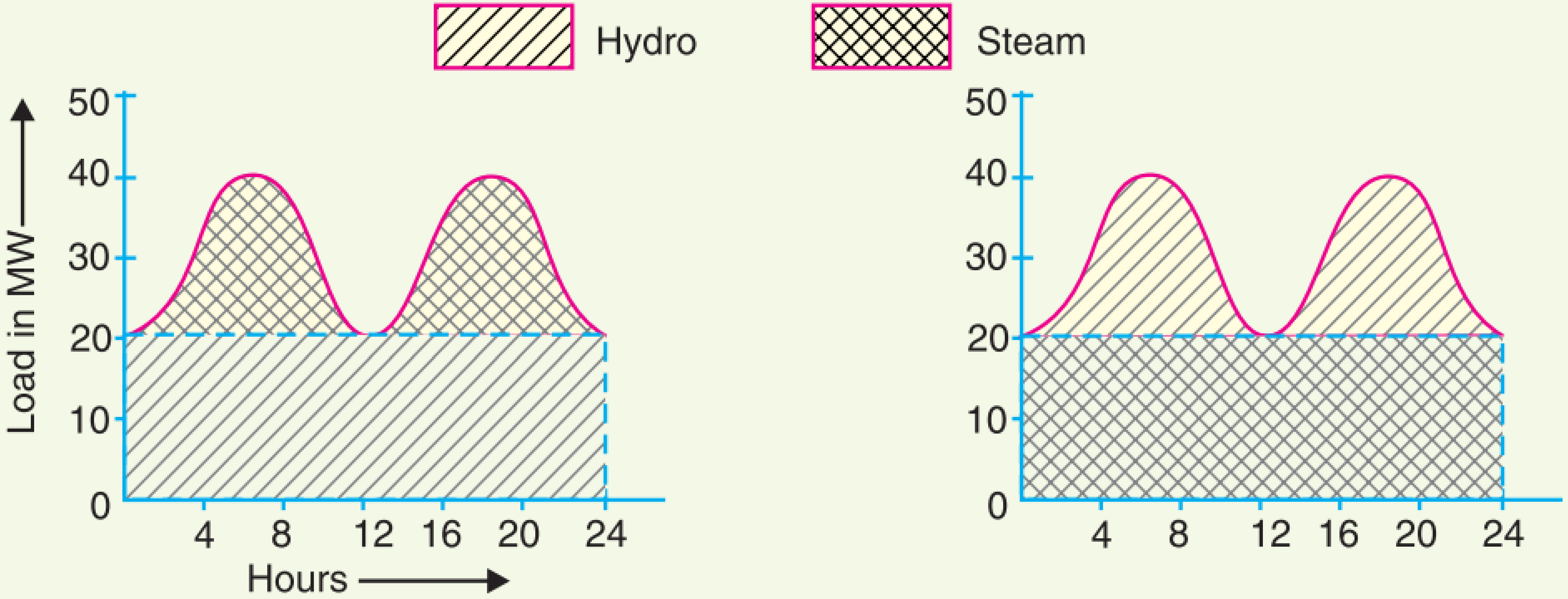
(ii) **Peak load.** The various peak demands of load over and above the base load of the station is known as peak load.



- In order to achieve overall economy, the best method to meet load is to interconnect two different power stations.
- The more efficient plant is used to supply the base load and is known *as base load power station*.
- The less efficient plant is used to supply the peak loads and is known as *peak load power station*.

Source: Mehta chapt 3

Base Load and Peak Load



Load division on Hydro-steam system.

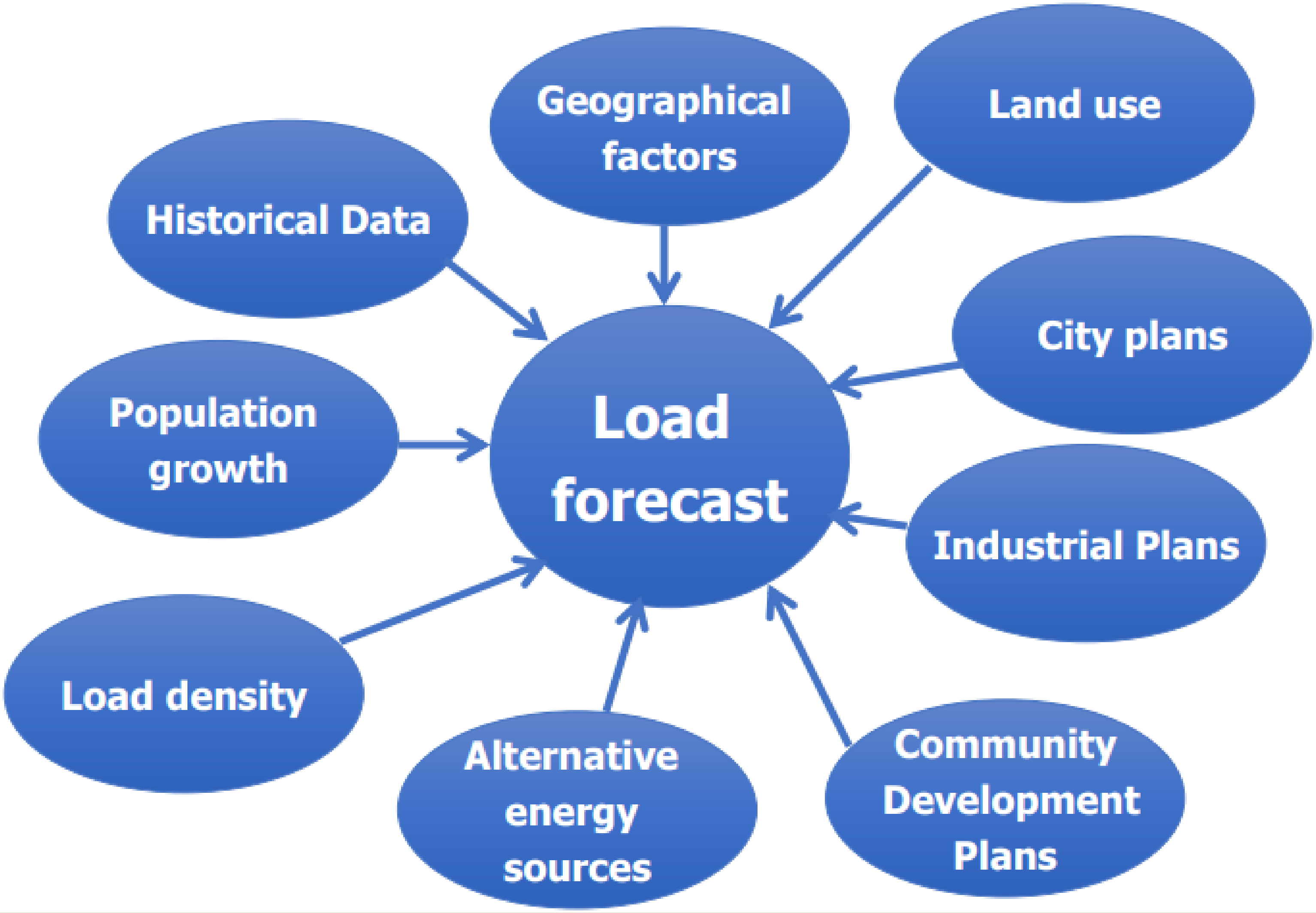
(i) High Flow day (ii) Low Flow day

Source: Mehta chapt 3

Load Forecasting

- Electrical Load Forecasting is the estimation for future load by an industry or utility company.
- Load forecasting is essential for determining which power plants to be kept online.

Load Forecasting: Factors affecting



Classification of Load Forecasting

Load Forecasts

- Short term forecasts (one hour to a week)
- Medium forecasts (a month up to a year)
- Long term forecasts (over one year)

Classification of Load Forecasting

- Short-term load forecasts usually requires the following data/ variables: seasonal input variables, weather forecast variables, and historical load data.
- Short-term load forecasts usually aim at providing the daily, hourly, or half-hourly load and the peak load (day, week) although even smaller time intervals occur.

- Medium-term load forecasts usually incorporate several additional influences – especially demographic and economic factors. These forecasts often provide the daily peak and average load, although hourly loads are also sometimes given.

- In the case of long-term load forecasts, even more indicators for the demographic and economic development have to be taken into account. These are for instance the population growth and the gross domestic product. Long-term load forecasting usually aims at predicting the annual load and the peak load.

Short Term Load Forecasting

The short term load forecasting methods are

- Similar Day Lookup Approach
- Regression Based Approach
- Time Series Analysis
- Artificial Neural Network
- Expert System
- Fuzzy logic
- Support Vector Machines