Load on power stations

- Load ***curves***

- Load ***factors*** and ***definitions***

- Load ***types***

- Advantages of ***Interconnected Grid System***

Load factors and definitions

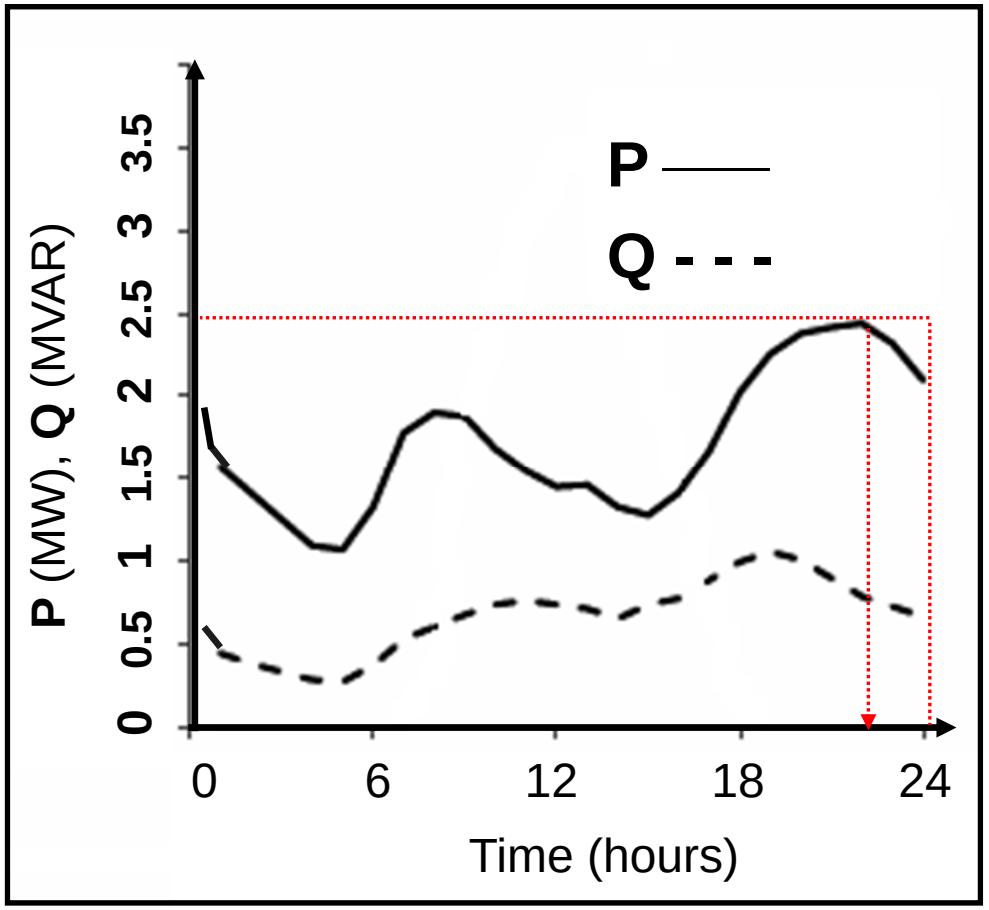
Connected load: It is the sum of the rating of all connected equipment supplied by the power plant

Maximum demand: It is the greatest load demand on the power plant during a given period. (The station should be capable of meeting this maximum demand)

Demand factor: It is the ratio of maximum demand to the connected load.

$$Demand\ Factor = \frac{\text{Maximum demand}}{\text{Connected Load}} \qquad (<1)$$

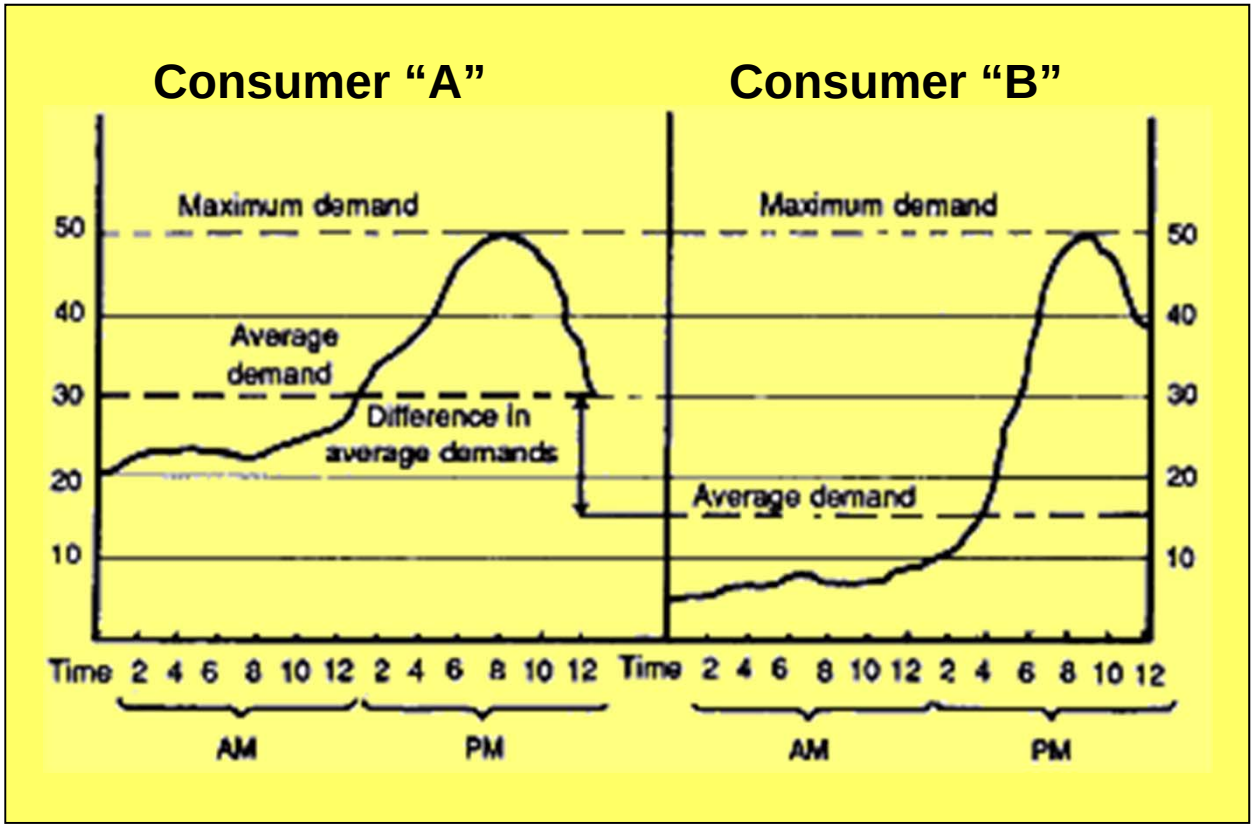
Daily Load Curve (Active power versus time)



- **Recorded hourly or half hourly**
- **Area under active power curve in MWh equals number of units generated per day**
- **The highest point on active power curve represents the maximum demand on the station on this specific day**
- **Average load on station equals area under daily load curve divided by total hours.**
- **Load factor equals the ratio of the area under the daily load curve to the total area of the rectangle in which the curve is contained**

$$Average\ Load = \frac{Area\ under\ daily\ load\ curve\ (MWh)}{Total\ number\ of\ hours\ (24)}$$

$$Load\ Factor = \frac{Average\ Load}{Maximum\ Demand}$$



$$L.F._A = \frac{30}{50} = 0.6 \qquad L.F._B = \frac{15}{50} = 0.3$$

Both consumers use ***same maximum demand*** and accordingly require ***same investment in capacity***, but each have ***different manner*** in using this capacity, indicated by their load factors.

Units generated per Annum:

$$\text{Units generated per Annum} = \text{Average Load} \times \text{Hours in a year}$$

$$\textit{Units generated / Annum} = \textit{Maximum Demand} \times \textit{L.F.} \times 8760$$

Monthly and yearly Load Curves

- Monthly load curve could be obtained from averaging the daily load curves of a month at different hours or half hours.

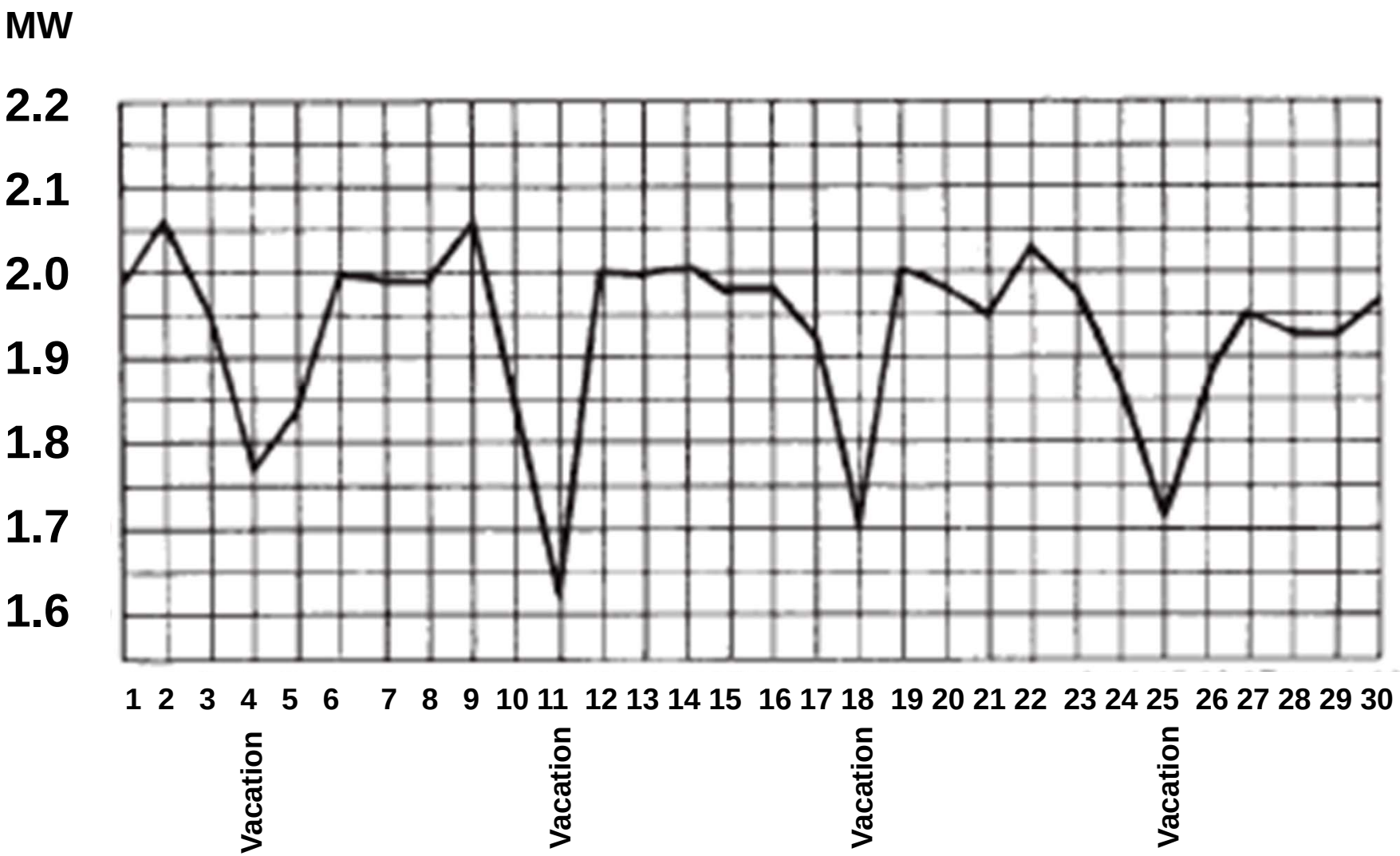
- Monthly load curves are used to fix the rates of energy.

- Yearly load curve could be obtained in a similar fashion from the monthly load curves of this specific year.

- Yearly load curve is used to obtain the annual load factor.

$$Monthly\ Average\ Load = \frac{No.of\ \ generated\ units\ in\ a\ month}{No.of\ \ hours\ in\ that\ month\ (672,696,720,744)}$$

$$Yearly\ Average\ Load = \frac{No.of\ \ generated\ units\ in\ a\ \ year}{No.of\ \ hours\ in\ that\ \ year\ (8760,8784)}$$

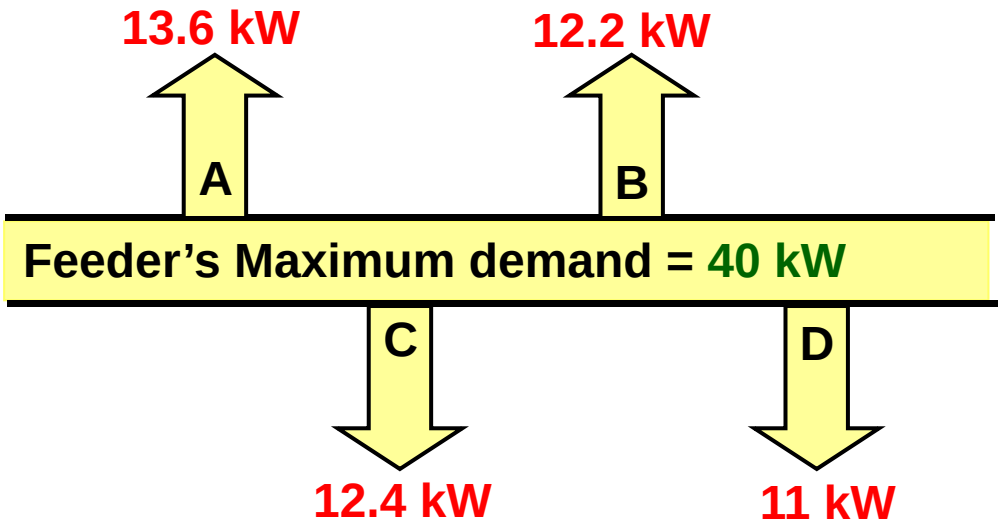


This is **not** a Monthly load curve; just a **daily peak load for a month**

Diversity Factor:

As consumers' maximum demands are not simultaneous; The power station's maximum demand is less than the sum of individual consumers' maximum demands.

$$Diversity\ Factor = \frac{\text{Sum of individual Maximum demands}}{\text{Maximum demand on power station}}$$



$$D.F. = \frac{49.2\ kW}{40\ kW} = 1.23$$

Plant Capacity

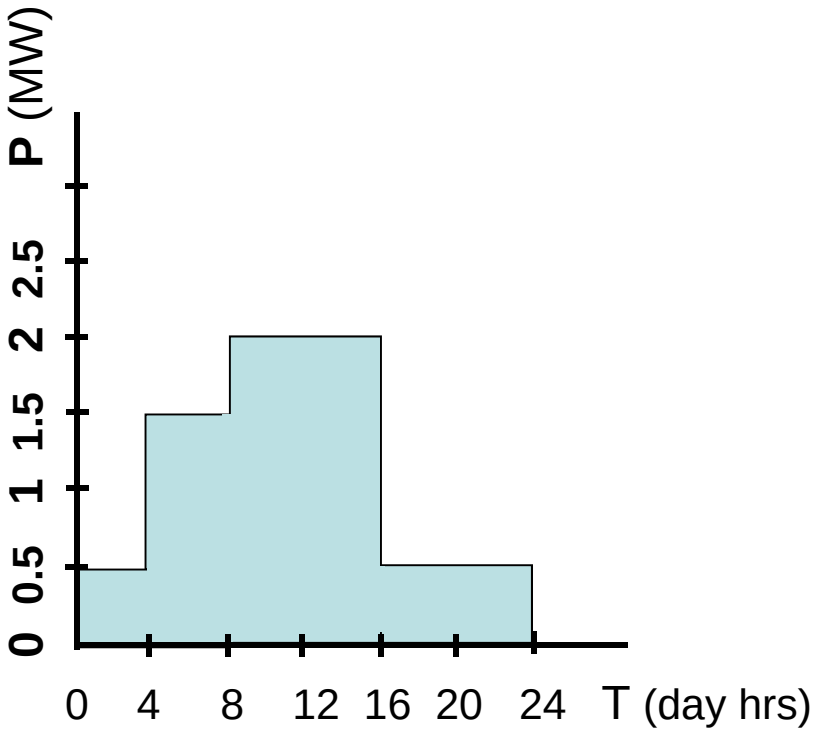
$$Plant\ Capacity\ Factor = \frac{Actual\ Energy\ produced}{Maximum\ Energy\ that\ coud\ have\ been\ produced}$$

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

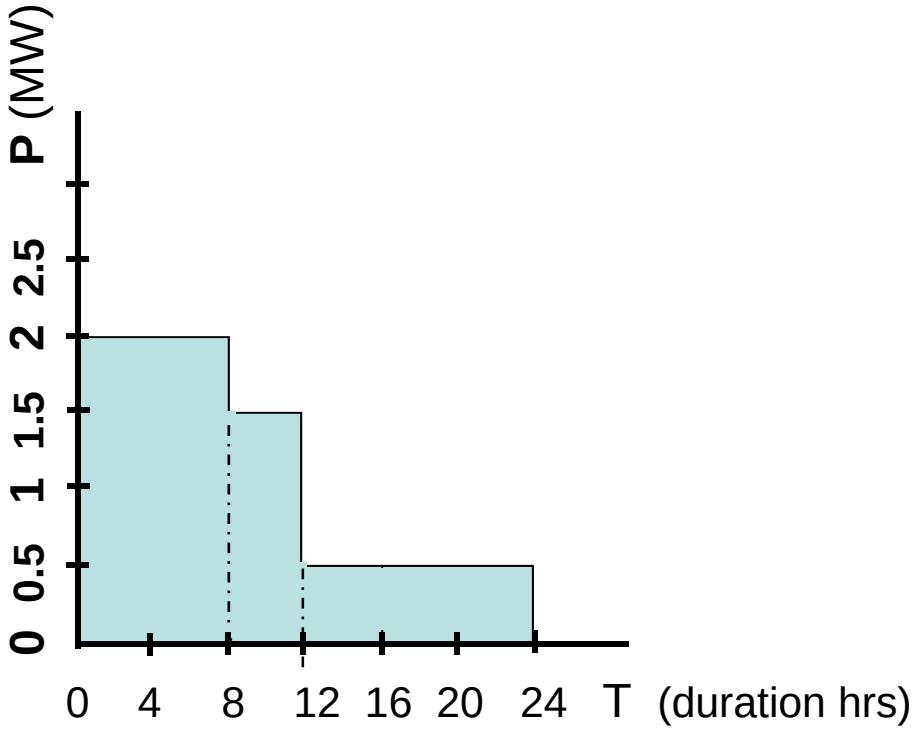
Reserve capacity = Plant capacity – Maximum demand

$$Plant\ Use\ Factor = \frac{\text{Station output}}{\text{Plant capacity} \times \text{Hours of use}}$$

Load Duration Curve



Example of a Load curve



Obtained Load duration curve

- A Load Duration Curve is obtained by arranging magnitudes of the corresponding load curve elements in a descending order

- The area under both curves are equal

Types of loads from utilization view point:

1. **Domestic load:** ***Limited occurrence → Low Load Factor (10 – 20%)***

(i) Domestic appliances (Fans, refrigerators, heaters, TV, pumps) (ii) Lighting

2. **Commercial load:** ***Higher occurrence , seasonal variations***

(i) Appliances (Fans, refrigerators, air conditioners, heaters) (ii) Lighting

3. **Industrial load:** ***Type dependent; (Low 25 kW, med. 100 kW, high > 500 kW***

(i) Large induction motors (ii) other industrial processes; heater,…etc

4. **Municipal load:** **(i) Street lighting (night constant) (ii) Water supply & drainage (off peak re-pumped; improves load factor)**

5. **Irrigation load:** ***Supplied 12 hours during night***

6. **Traction load:** ***Wide variations***

(i) Trams (ii) Trolley bus (iii) electric railways

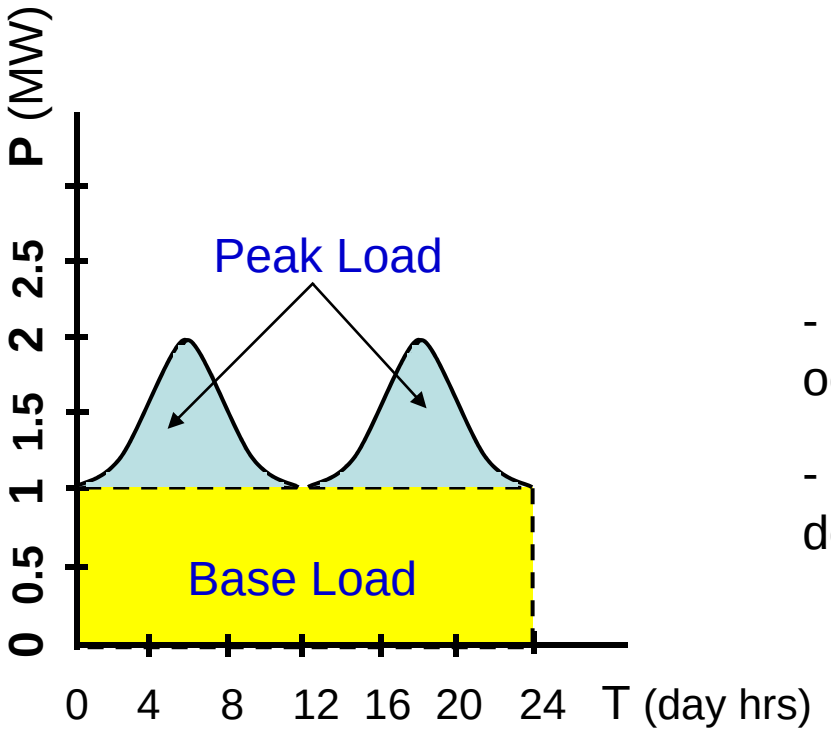
Typical demand factors

Type of consumer	**Type of Load**	Demand Factor
Residential (lighting)	¼ kW	1.00
	½ kW	0.6
	>1 kW	0.5
Commercial (lighting)	Restaurants	0.7
	Theaters	0.6
	Hotels	0.5
	Schools	0.55
	Small industry	0.6
	Store	0.7
General power service	0 -10 HP	0.75
	10 – 20 HP	0.65
	20 – 100 HP	0.55
	> 100 HP	0.5

Typical diversity factors

	Residential (lighting)	Commercial (lighting)	General power service
Between consumers	3 - 4	1.5	1.5
Between Transformers	1.3	1.3	1.3
Between feeders	1.2	1.2	1.2
Between substations	1.1	1.1	1.1

Power Station Base load & Peak load



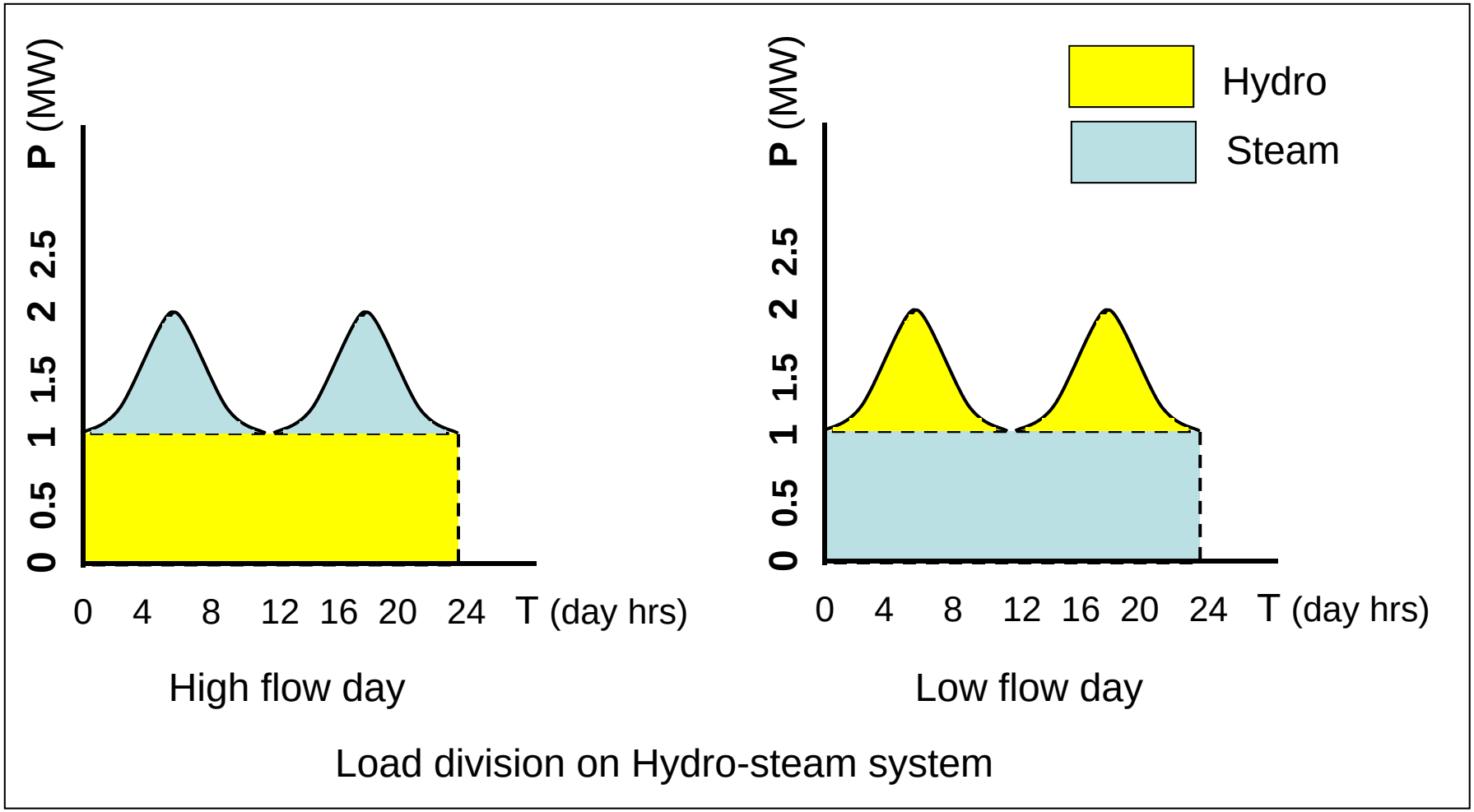
Station Load curve

- **Base Load:** is the unvarying load that occurs almost all the day on the station (>)

- **Peak Load:** is the various peak demands over and above the base load (<)

Meeting the Load:

Interconnecting two power stations, the more efficient plant is assigned the base load, while the less efficient one is assigned the peak load.



Load division on Hydro-steam system

Advantages of ***Interconnected Grid System***

1. Ensures ***economic operation*** through:

   - **Exchange of peak load**

   - Increase of diversity factor

   - Reduction of plant reserve capacity

   - Use of older plants

2. Increases ***Supply's Reliability***