EE1040: Electrical Fundamentals
Lecture 1 - Overview

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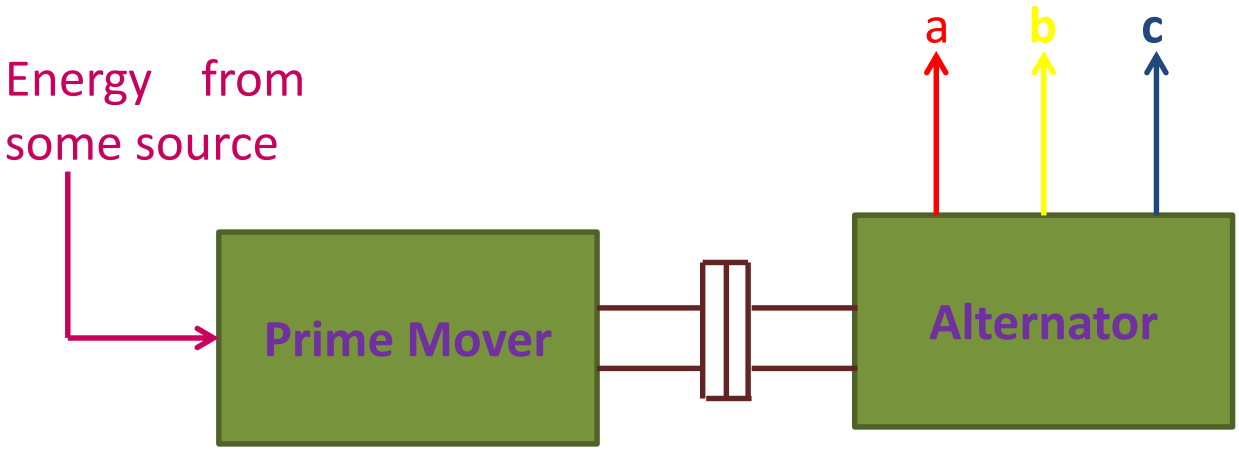
Introduction

- Energy is the basic necessity for the economic development of a country.
- Energy exists in different forms in nature, but energy in the form of ***electrical energy*** is of immense importance.
- Electrical energy;
  - A very convenient form of energy which can be easily converted into other forms of energy.
  - Electrically operated machines have simple and convenient starting, control and operation.
  - Can be easily transported from one place to another with the help of conductors.
  - Economical to use this form of energy for domestic, commercial and industrial purposes.

Generation of Electrical Energy

- Conversion of energy available in different forms in nature into electrical energy is known as generation of electrical energy.
- 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, wind energy, etc.
- The primary energy can be converted into electrical energy by the use of suitable arrangements.

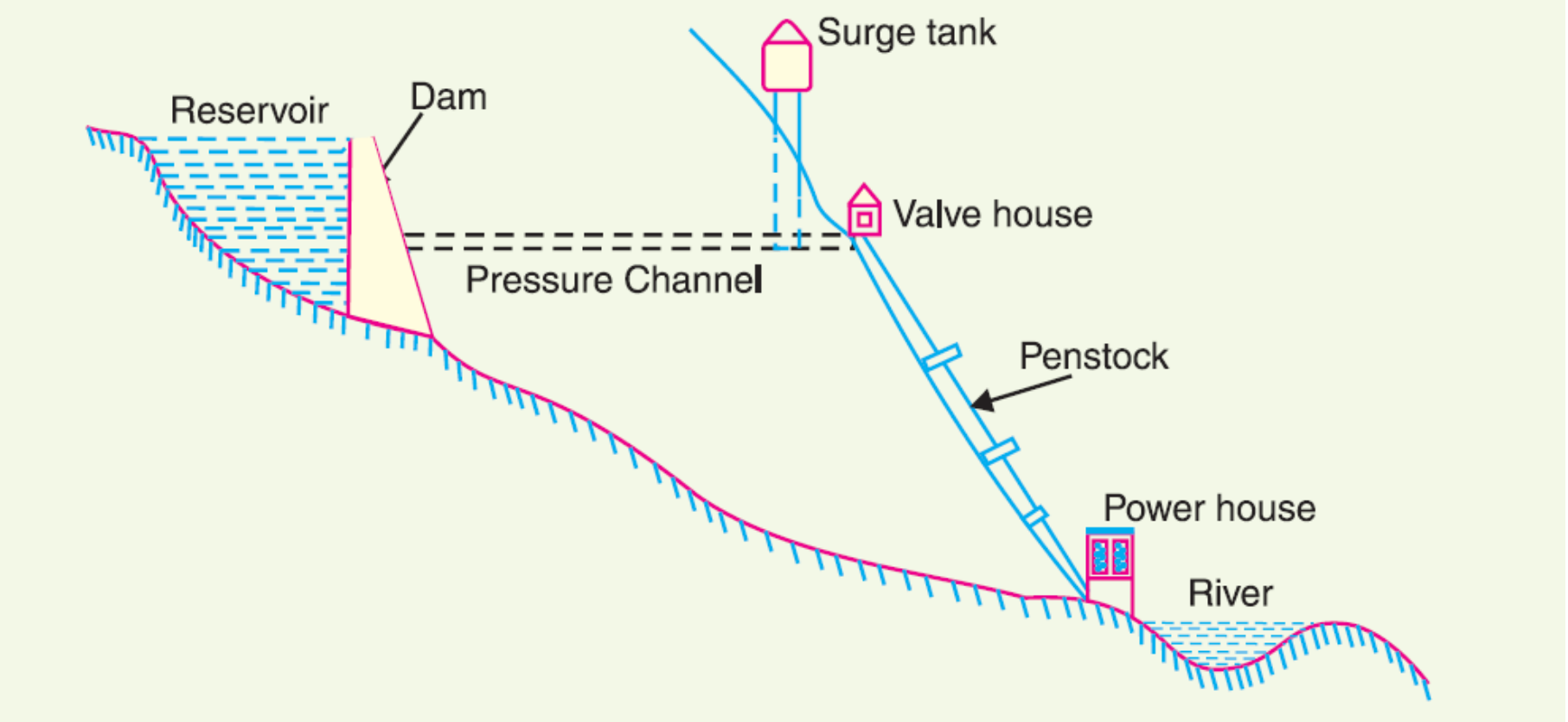


Sources of Energy

- **Water**
  - Stored water at a suitable place possesses potential energy because of the head created.
  - This water energy can be converted into mechanical energy with the help of water turbines.
  - Water turbine drives the alternator which converts mechanical energy into electrical energy.

Let's see the operation of a hydro power plant
https://www.youtube.com/watch?v=OC8Lbyeyh-E

Schematic Arrangement of a Hydro Power Plant



Source: V. Mehta, R. Mehta; “Principles of Power Systems”

Sources of Energy

- **Fuels**
  - Main sources of energy are fuels; 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 turbines, internal combustion engines, etc.
  - The prime mover drives the alternator which converts mechanical energy into electrical energy.

Let's see the operation of a coal power plant
https://www.youtube.com/watch?v=GxHQHcpCWa8

Sources of Energy

- **Nuclear Energy**
  - 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.

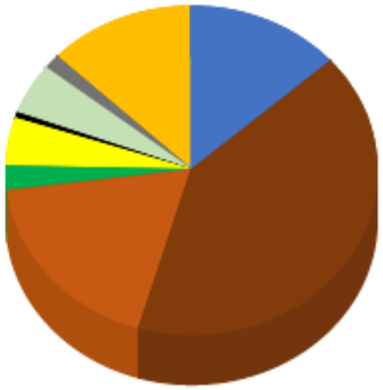
- **Solar Energy**
- **Wind Energy**
- **Geothermal Energy**
- **Wave Energy**

Energy Mix

DAILY NET ELECTRICITY GENERATION

Date: Friday, April 21, 2023

Total Net Energy	47.47 GWh	Peak Demand	2212.9 MW
• Renewable	13.12 GWh (27.63%)	• Renewable	655.6 MW (29.6%)
• Fossil Fuel	34.36 GWh (72.37%)	• Fossil Fuel	1557.3 MW (70.4%)



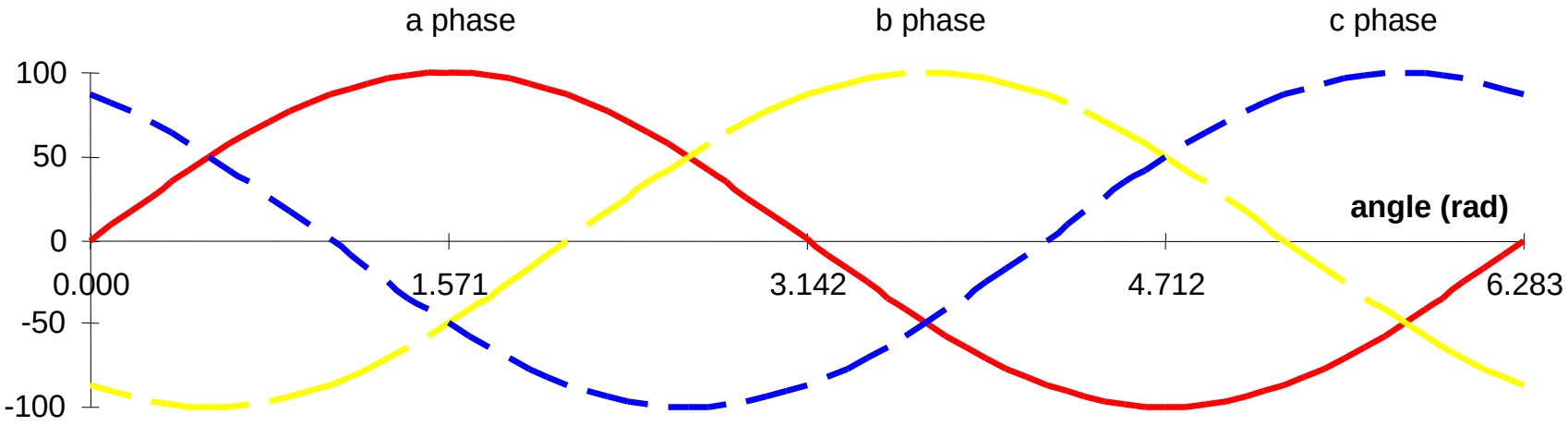
CEB Hydro	6.41 GWh
CEB Thermal Coal	19.48 GWh
CEB Thermal Oil	8.75 GWh
CEB Wind	1.15 GWh
SPP Solar [1]	2.22 GWh
SPP Biomass [2]	0.27 GWh
SPP Minihydro	2.38 GWh
SPP Wind	0.69 GWh
IPP Thermal Oil	6.13 GWh

Source: https://ceb.lk/

Structure of Electric Power Systems

- Function of an electric power system is to connect the power station to the consumer's loads by means of an interconnected system of transmission and distribution networks.
- An electric power system consists of three principle sections: **power stations (generation), transmission and distribution.**
- Transmission lines are the connecting link between the power stations and the distribution systems.
- A distribution system connects all the individual loads in a given locality to the transmission lines.
- Single-line diagram:
  - Three-phase alternators at the power stations are designed to produce balanced voltages.
  - A balanced 3-phase circuit can be represented by a single-phase equivalent circuit.
  - The diagram showing the single-phase equivalent of the power system using standard symbols is called **single-line diagram**.

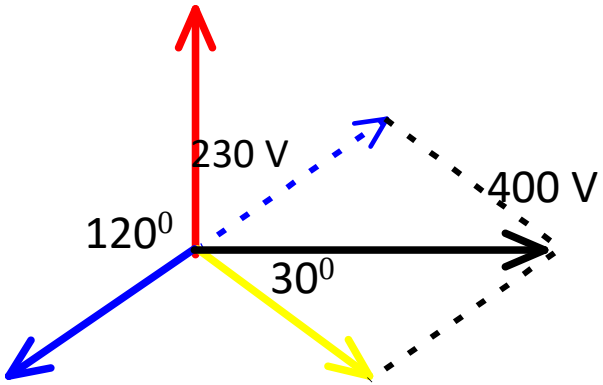
What is a Balanced Three-Phase System?



$$v_a(t) = V_m \sin(\omega t), \qquad \omega = 2\pi f$$

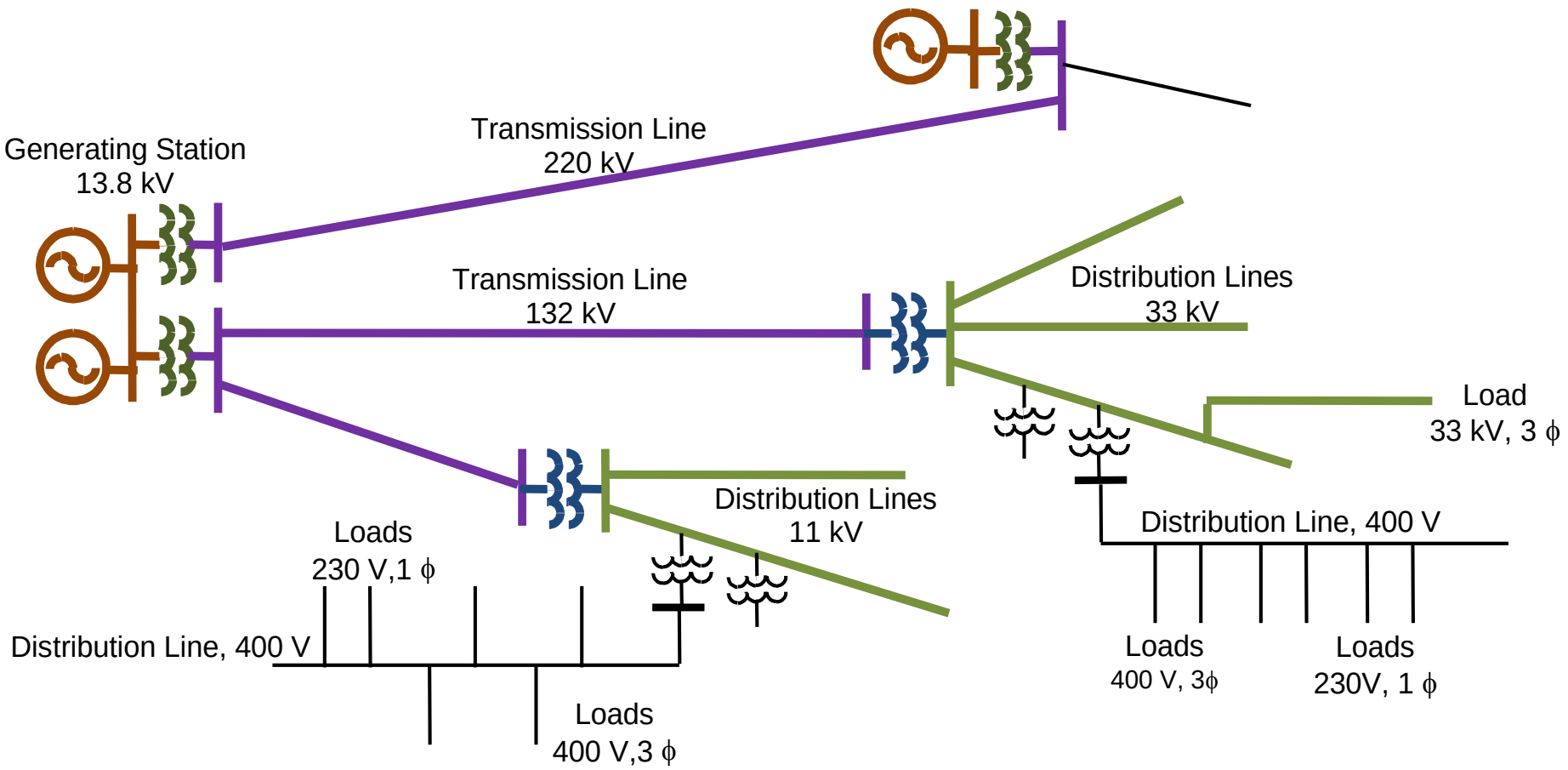
$$v_b(t) = V_m \sin\left(\omega t - \frac{2\pi}{3}\right)$$

$$v_c(t) = V_m \sin\left(\omega t + \frac{2\pi}{3}\right)$$



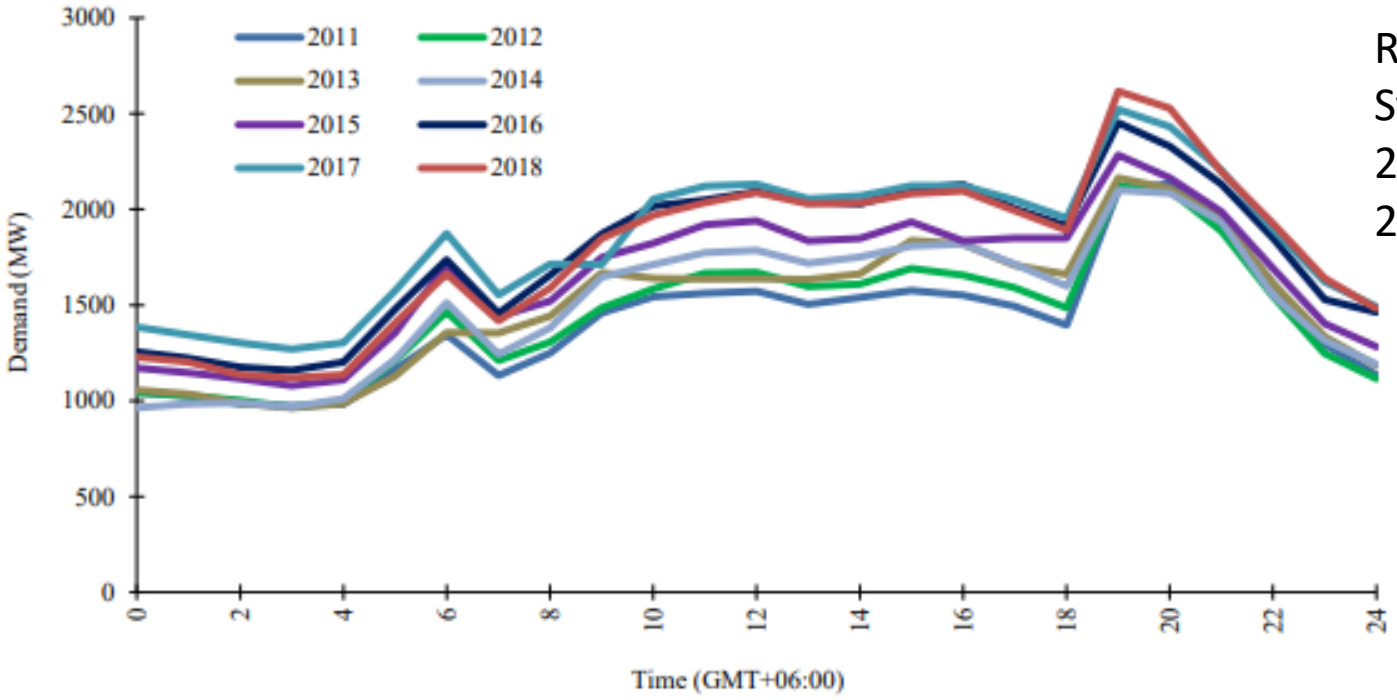
$$\underline{V_a} = \frac{V_m}{\sqrt{2}}\angle 0^0, \underline{V_b} = \frac{V_m}{\sqrt{2}}\angle(-120^0), \underline{V_c} = \frac{V_m}{\sqrt{2}}\angle(120^0)$$

Single-Line Diagram of an Electric Power System



Demand of an Electric Power System

- 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.
- The curve showing the variation of load with respect to time is known as a **load curve**.
- The daily load curve of Sri Lanka;



Recorded Maximum System Peak

2017 → 2523 MW

2018 → 2616 MW

Source: Long Term Generation Expansion Plan 2020 – 2036, CEB

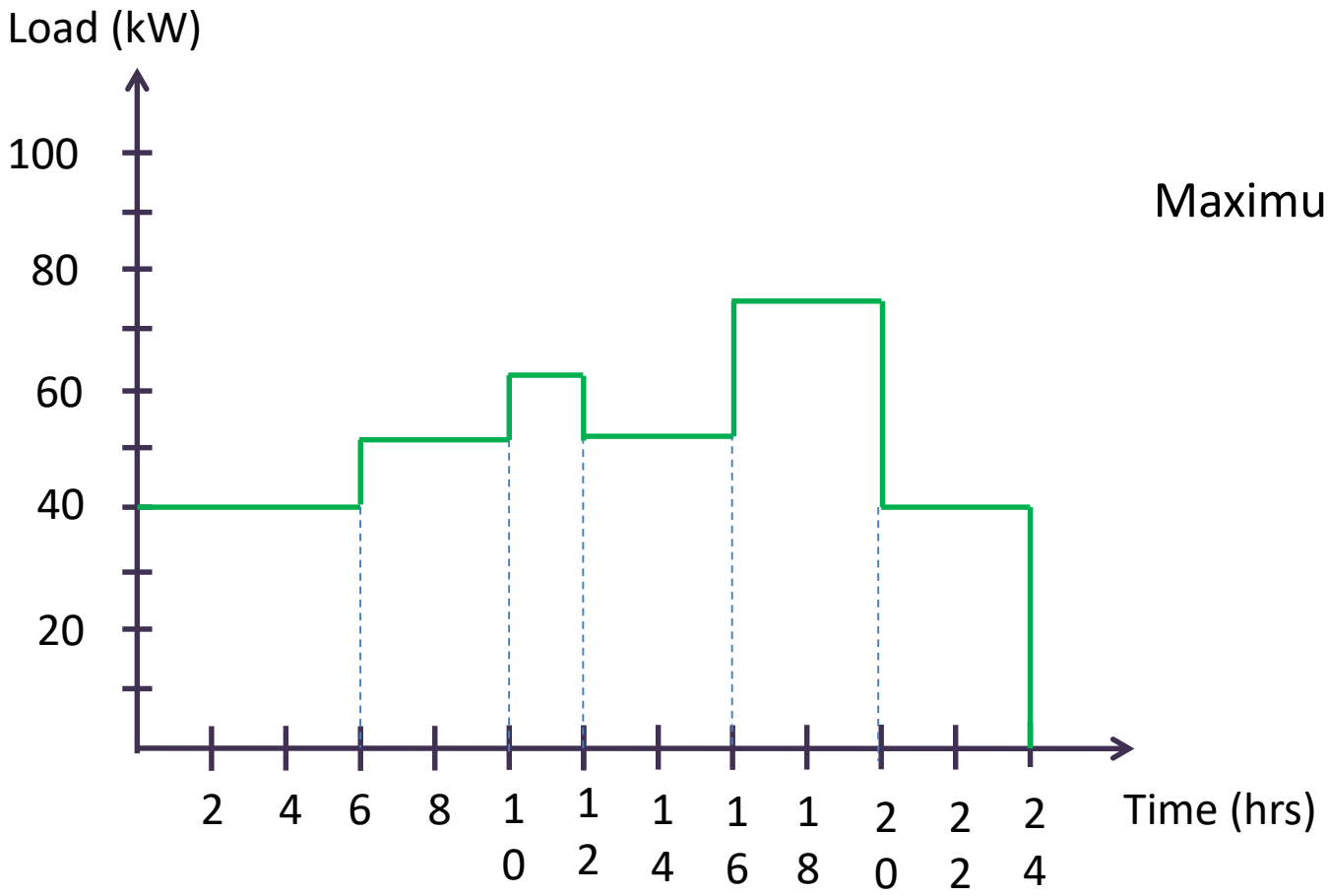
Example

- A factory has the daily load cycle given below:

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

Draw the load curve and find the maximum demand, total energy required per day and average demand .

Example



Maximum demand = 70 kW

Daily energy requirement $= (40 \times 6) + (50 \times 4) + (60 \times 2) + (50 \times 4) + (70 \times 4) + (40 \times 4) = 1200\ kWh$

Average demand $= \frac{1200}{24} = 50\ kW$

Conditions to be Met

- A power system must maintain the balance between the total generation and total demand at every instant of time.

$$\sum \boldsymbol{Generation} = \sum \boldsymbol{Load} + \sum \boldsymbol{Losses}$$

  - System frequency must lie within the limits $(50Hz \pm 1\%)$
  - System voltage must lie within the limits $(230\ V \pm 6\%)$
  - Power system elements must not overload

- Providing a reliable electricity supply to consumers is a challenging task.