EE381 - Power Systems

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Overview

Power Systems

Indian Power Sector - An Overview

Syllabus

Books

Course Mechanics

Power Systems

Power systems have the following three components.

1. Generation - Source of Energy
2. Transmission - Transmission of Energy over long distance (close to the speed of light)
3. Distribution - Consumption of Energy

- Electric Energy is seldom used in its form.
- It is easy to convert from other forms and transmit from sources to loads.
- Power system is the most complex system on earth.
- In interconnected systems, the frequency has to be the same. In India, it is 50 Hz. In some countries, it is 60 Hz.

Generation

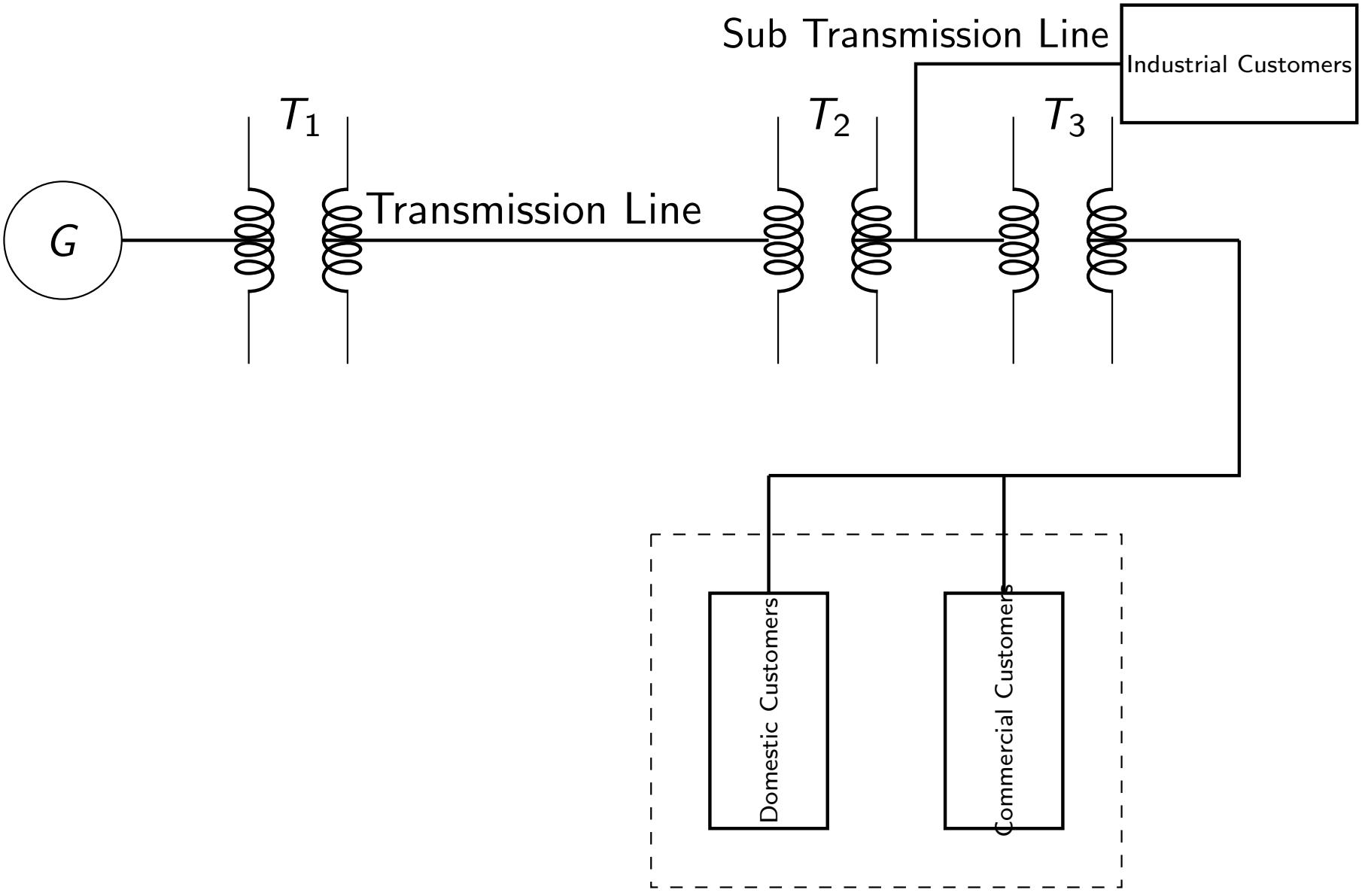
Electric energy is generated at generating stations by converting other forms of energy.

1. Conventional
   - Thermal
   - Hydro (Renewable)
   - Nuclear
2. Non Conventional (Renewable)
   - Solar
   - Wind
   - Biomass
   - Tidal
   - Geo-Thermal
   - Small Hydro
   - Waste

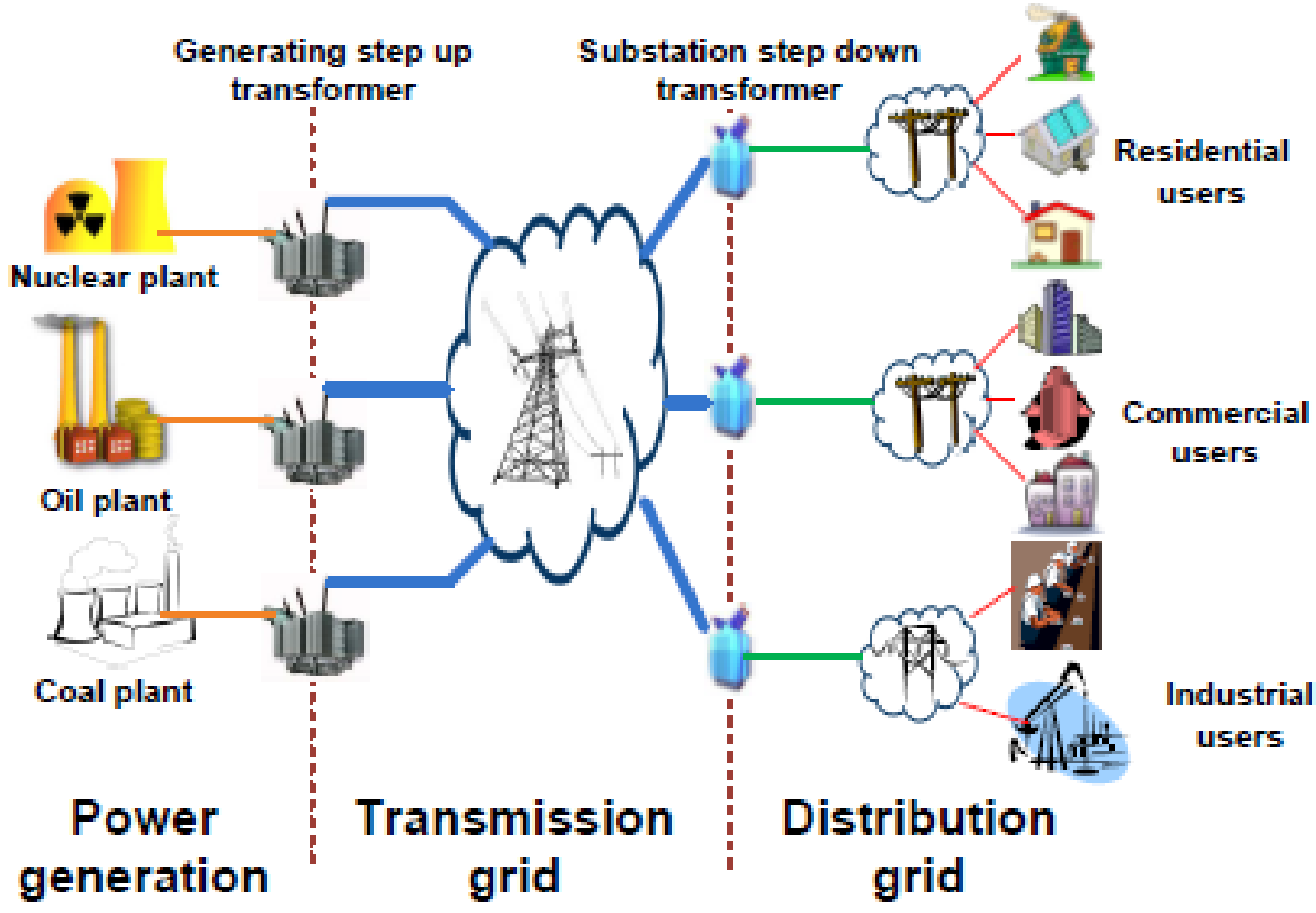
Renewable Energy Sources (RES)

RES have unlimited resources. But they are intermittent.

Structure of a Power System



Practical System



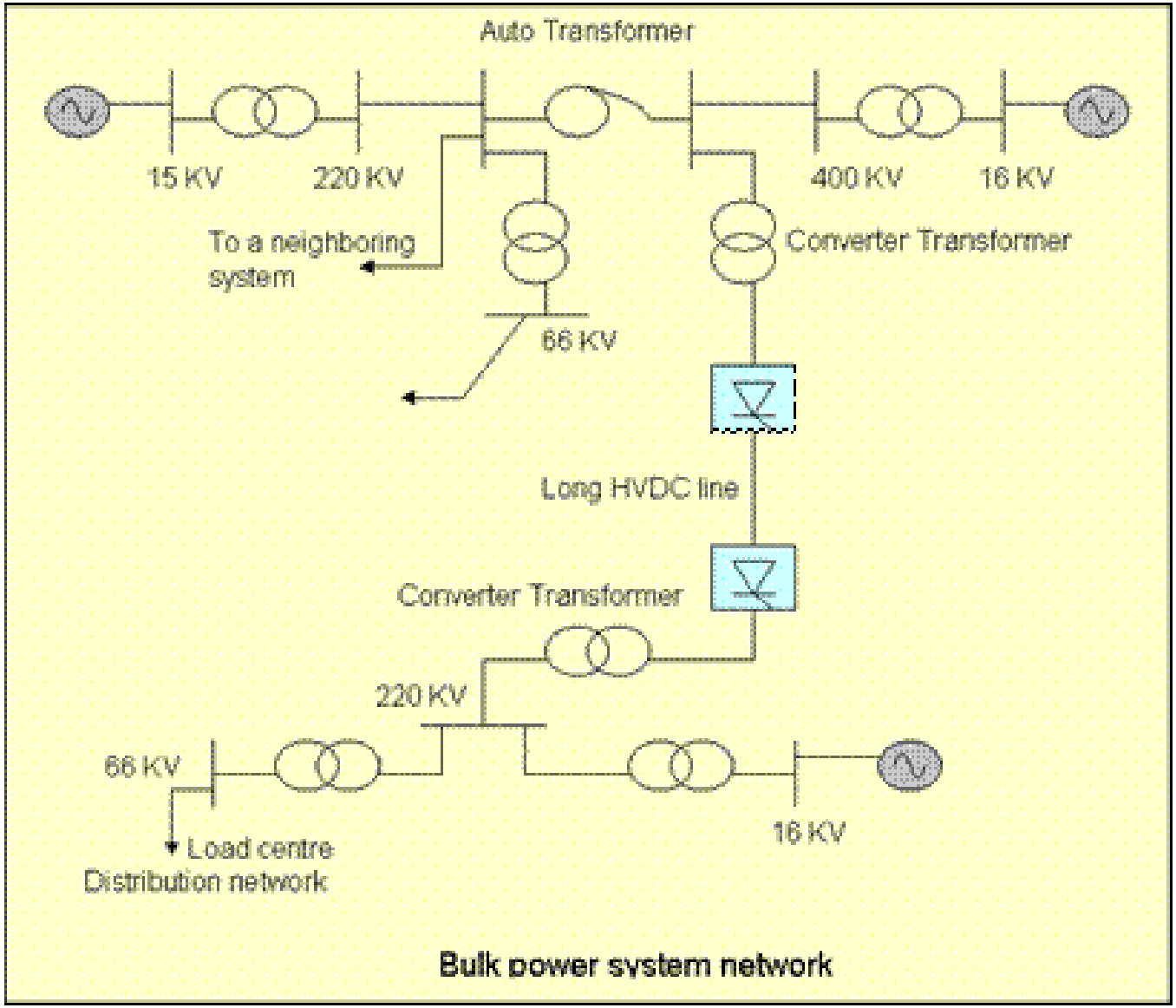
Interconnected Systems

Reasons for interconnections

1. To improve reliability
2. To improve economy

- Several power systems are interconnected to form a grid.
- Several regional grids are interconnected to form a national grid.
- Interconnections are done at Transmission networks.
- In interconnected systems, the frequency of generation must be the same.

Power System



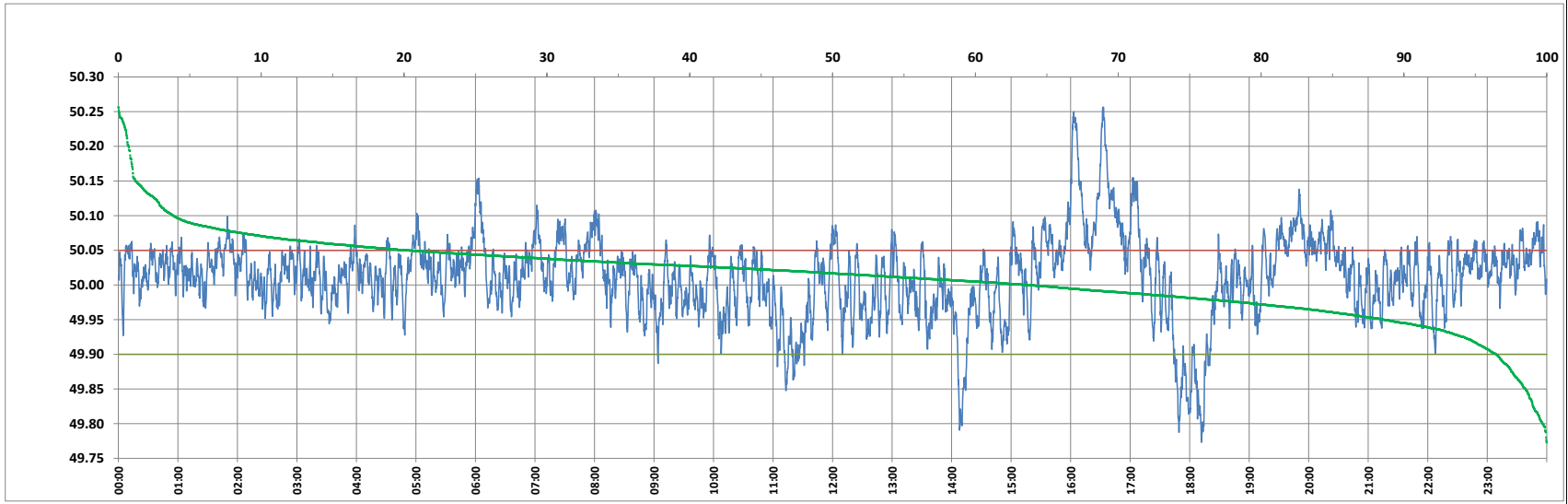
Source : NPTEL

Grid Frequency

GRID CONTROLLER OF INDIA LIMITED

NATIONAL LOAD DESPATCH CENTRE, NEW DELHI

Frequency profile for 23-Jul-2023 (Sunday)



<49.7	<49.90	<49.97	49.7-49.8	49.8-49.9	49.9-50.0	50.0-50.1	50.1-50.2	49.90-50.05	49.7-50.2	49.97-50.03	50.05-50.1	>50	>50.03	>50.05	>50.2	<49.95	49.95-50.05	49.90-49.95
0.00	3.53	19.03	0.29	3.24	32.77	59.85	3.13	76.24	99.27	43.82	16.38	63.70	37.15	20.23	0.73	11.41	68.36	7.88

Average Frequency : 50.012	Frequency Variation Index : 0.0341	Standard Deviation : 0.0575	Mileage: 48.9	FDI: 23.8

Instantaneous Frequency		
Max	50.257	16:33:00
Min	49.773	18:11:50

15 minute Average Frequency		
Max	50.170	16:45:00
Min	49.841	18:15:00

No. of excursions	
above 50.03 Hz	227
below 49.97 Hz	128
above 50.00 Hz	178
below 50.00 Hz	177

Average time freq per excursion remains	
below 49.97	0:02:08
above 50.03	0:02:21

No. of hours freq outside 49.9-50.05 Hz	5:42:10

Source : AGRA 10 Sec. (8640 samples)

Source : POSOCO

Indian Power Sector - An Overview

- India is the third largest producer of electricity (more than 1 TU[1] a year) in the world.
- India is also the third largest consumer of electricity in the world.
- T& D losses are 20 %.
- However , the per capita energy consumption is 1,255 kWh per person per year.
- It is low compared to many countries. For example, US : 12,154 & China : 5,885
- It is even lower than the world average (3,081 kWh).

[1] 1 TU = 1,000,000,000,000 kWh

Installed Capacity

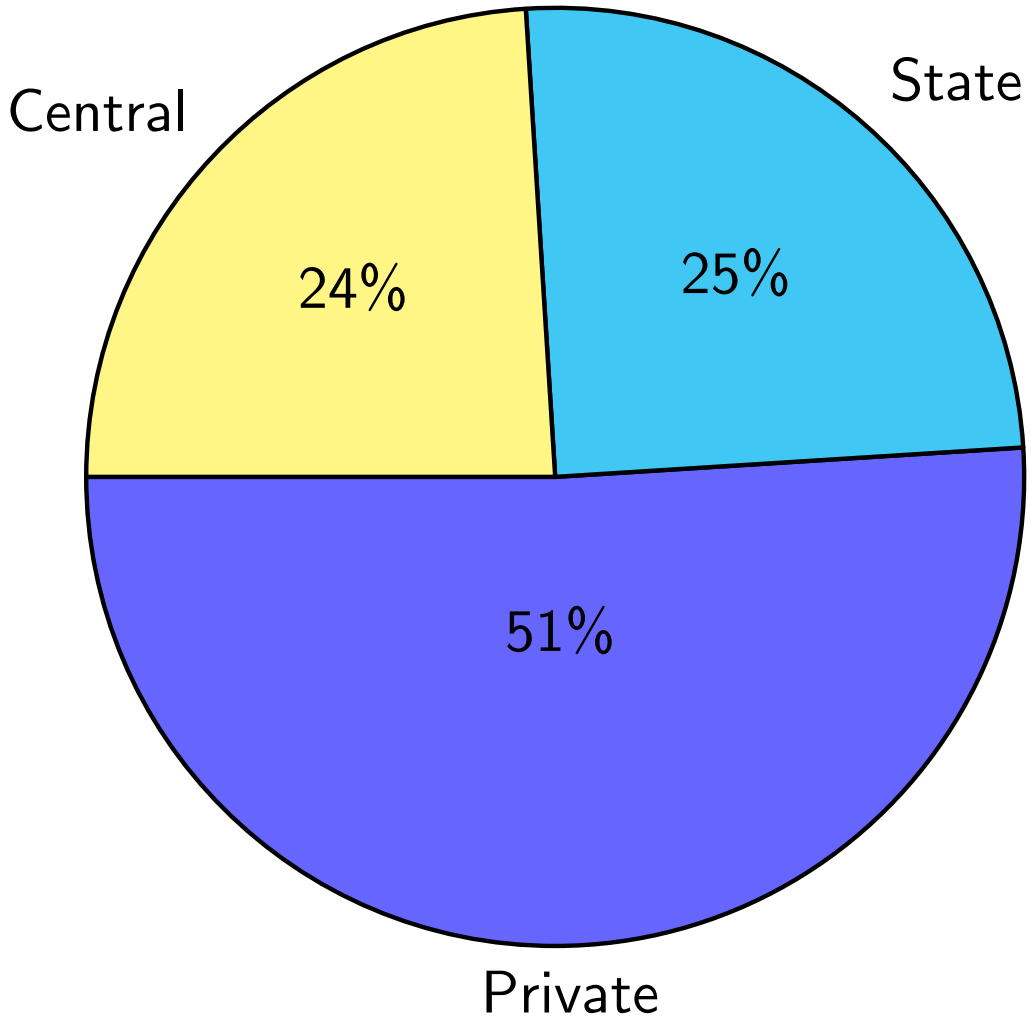
The installed capacity as on 30-06-2023 is **422 GW**.

Type	**Capacity (GW)**	**% of Total**
Thermal [2](Coal, Oil & Gas)	238	56 %
Hydro	47	11 %
Nuclear	7	2 %
RES	130	31 %
Total	**422**	

Source : Central Electricity Authority, Ministry of Power, GoI

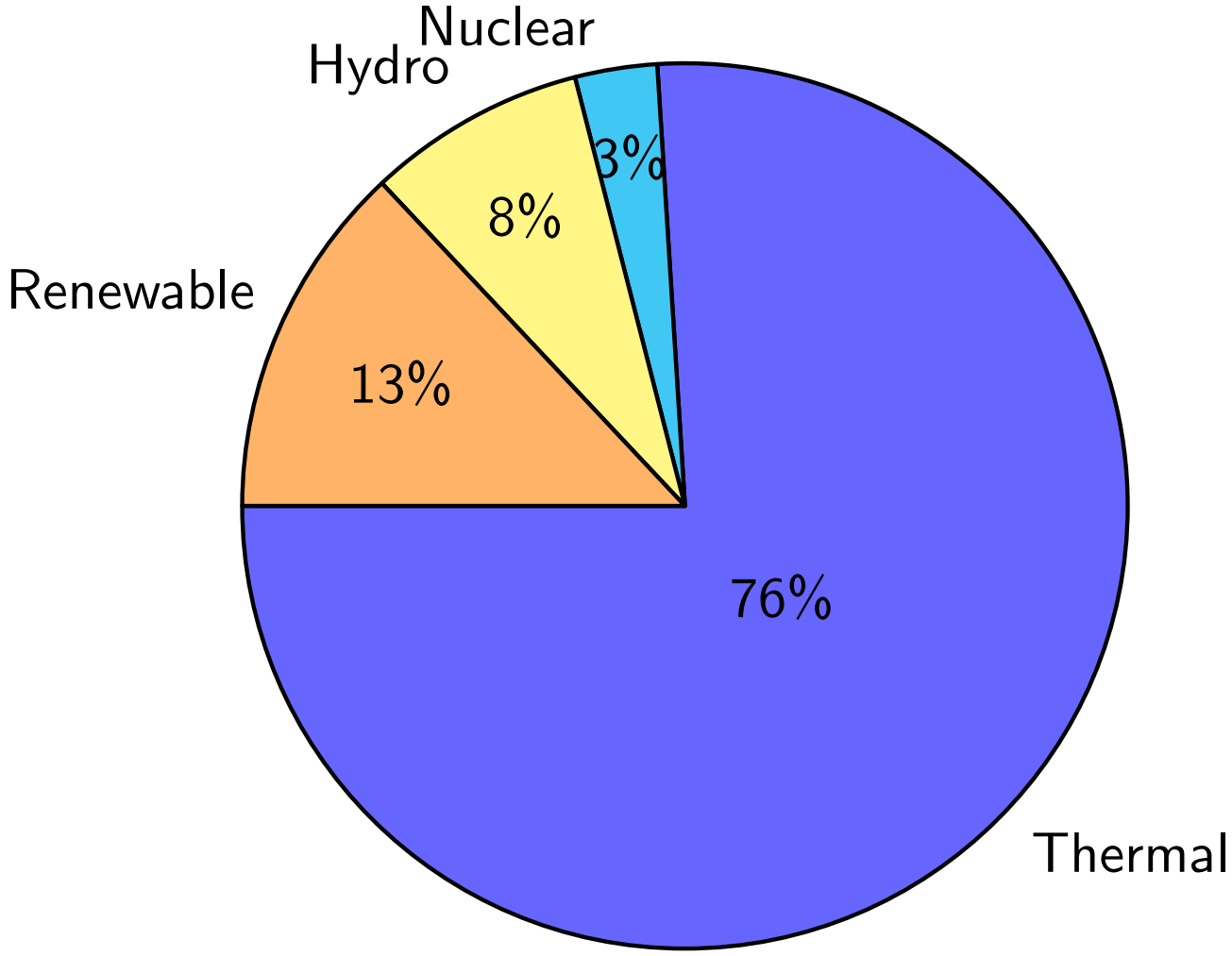
[2]Coal based power plants account for 90 %

Installed Capacity - Sector Wise



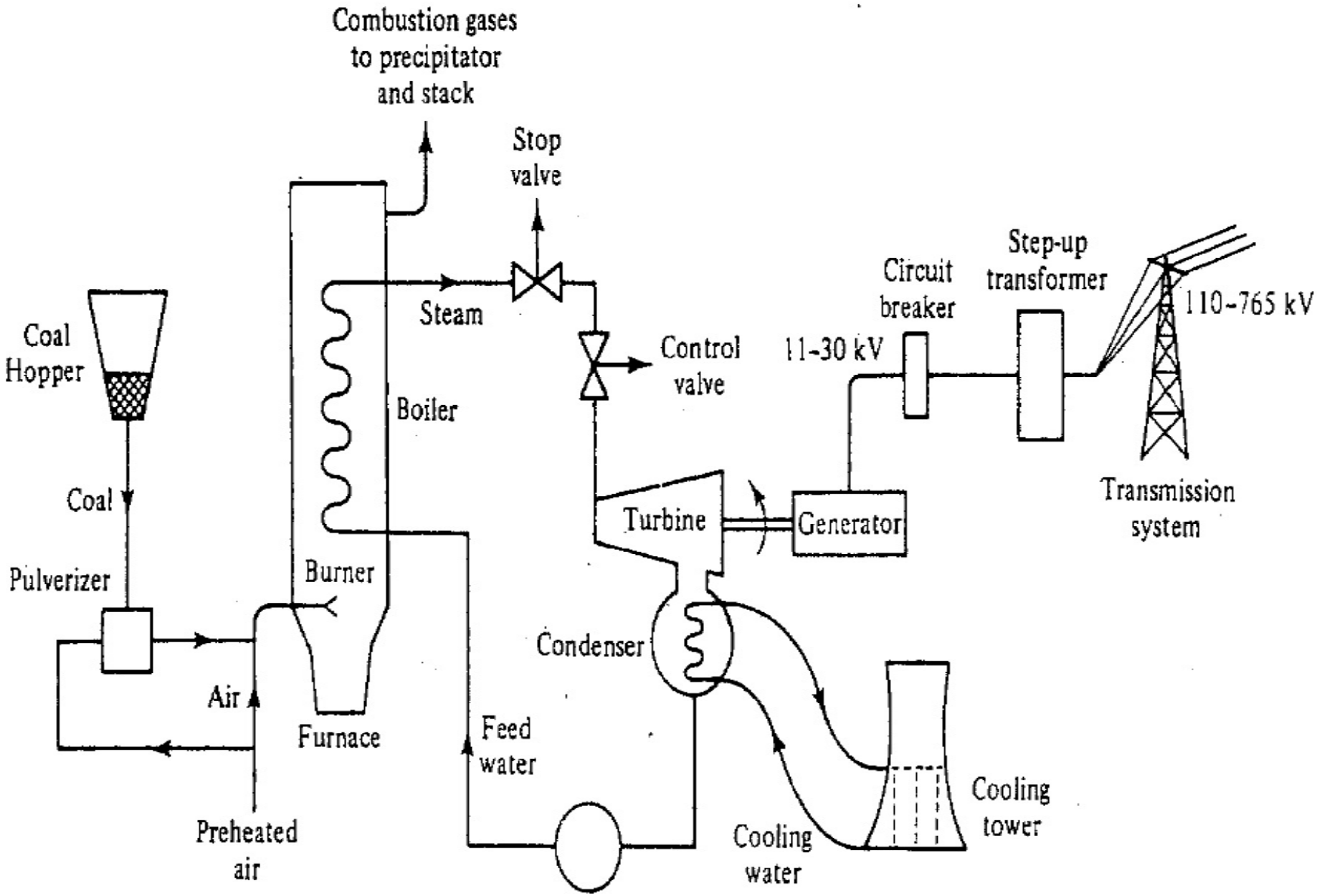
Electricity Generation in May 2023

Total electricity generation in May 2023 was 145.63 BU.



Most of the energy is still from Thermal.

Thermal Power Plant



What We will study in EE381..

We will analyze power systems under

- steady state conditions
- abnormal conditions

In order to analyze, every component of power systems has to be modeled.

- Generator
- Transformer
- Transmission line
- Load

Since the steady state model of synchronous machines and transformers have already been studied in EE280, we will only model the following in this course.

- Transmission line

Loads are usually considered as

1. Constant power
2. Constant impedance
3. Constant current

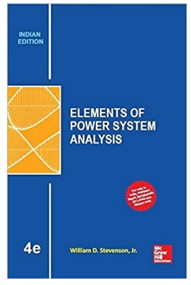
We usually simplify any analysis at the cost of accuracy....

Syllabus

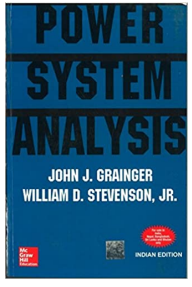
- Basic Concepts
- Line Parameter Calculation
- Performance of Transmission lines
- Per unit calculation
- Network Matrices
- Load Flow
- Economic Dispatch
- Fault Analysis
- Power System Stability

Books

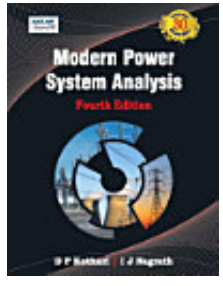
- Text Books
  1. W. D. Stevenson, Jr., Elements of Power System Analysis, Tata McGraw-Hill, 4e, 2008.



- Reference Books
  1. J. J. Grainger and W. D. Stevenson, Jr., Power System Analysis, Tata McGraw-Hill, 2008.



  2. D. P. Kothari and I. J. Nagrath, Modern Power System Analysis, Tata McGraw-Hill, 4e, 2011.



Course Mechanics

- Two Quizzes - 20 %
- Mid Sem - 30 %
- End Sem - 50 %

Course Page

`https://www.iitp.ac.in/~siva/2023/ee381/index.html`