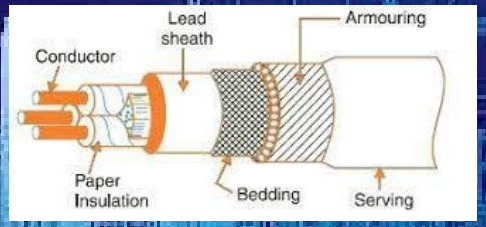
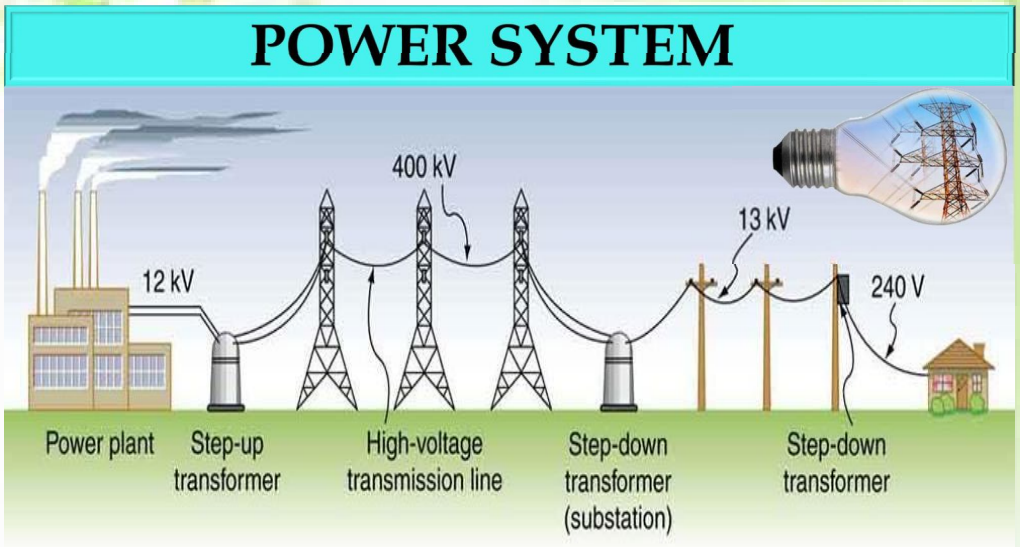
LECTURE 01: INTRODUCTION TO POWER SYSTEM





GENERAL QUERIES

Duration: 100 - 110 hr

Classes: Mon - Sat 6am - 10:30am → 6am - 8am, 8:30am - 10:30am

- → Live classes
- → daily assignment
- → work book (PDF)
- → weekly doubt session live
- → telegram doubt ← batch/course in app
- → lecture no. based quizzes

pre-requisites

1. N/W Analysis
2. Sync. m/c upto armature reac^{n} (PS-2)

RESOURCES

Theory : class notes

Practice:
- class Questions
- assignment ← mandatory
- PYQ ← Sundays (at least 10yrs) (2015-2024)
- workbook ← during rev.

Test
- course test
- subject test (1 week after end of subject)
- test series
  - part test (with course)
  - subject test (end of subject)

COURSE DURATION

100 TO 110 HOURS

→ Short notes : will be marked in class
  ↳ after lecture : make handwritten short notes

→ Interview Q in few lectures

WEIGHTAGE OF TOPICS IN RECENT YEARS

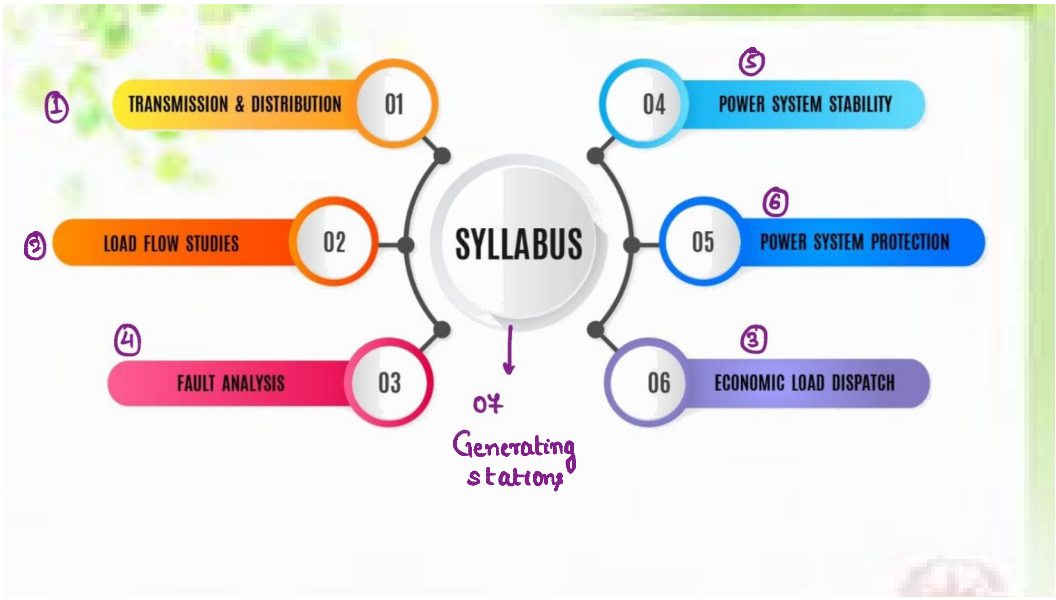
PS-1 : 5 marks

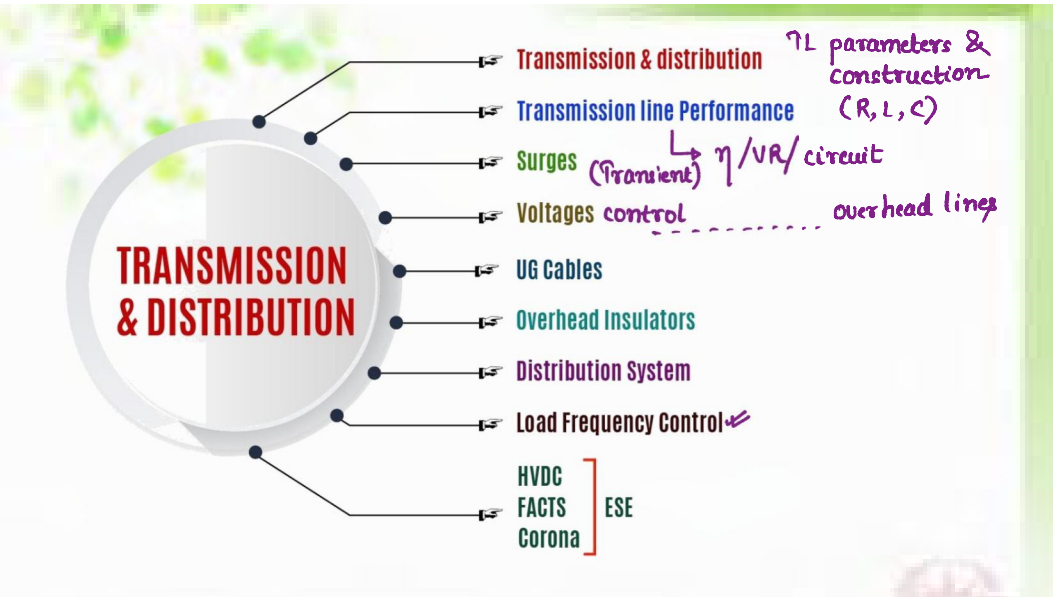
CHAPTER	2024	2023	2022	2021	2020	2019	2018	Average
Transmission and Distribution, Corona	2	1	2	0	0	2	2	1.29
Compensation Techniques	0	0	0	0	2	0	2	0.57
Distribution System, Cables, Insulators	1	0	0	1	0	0	0	0.29
Economics Load Dispatch	1	1	2	1	0	0	0	0.71
Fault	2	2	1	4	2	4	4	2.71
Stability	2	0	2	3	1	2	1	1.57
Protection	0	1	1	0	1	3	0	0.86
Generating Stations	0	0	0	0	0	0	0	0
Load Flow ← PS-1	0	3	0	3	3	1	3	1.86
HVDC	0	0	0	0	0	0	0	0
Per Unit System	0	0	0	0	0	0	0	0
Transients	0	0	0	0	0	0	0	0
TOTAL	8	8	8	12	9	12	12	9.86

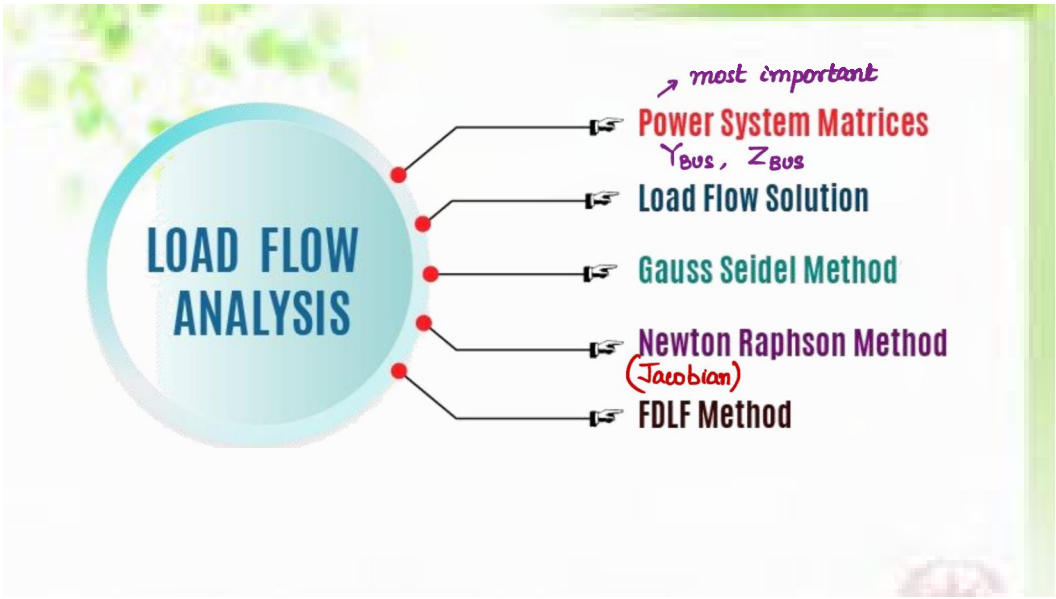
4

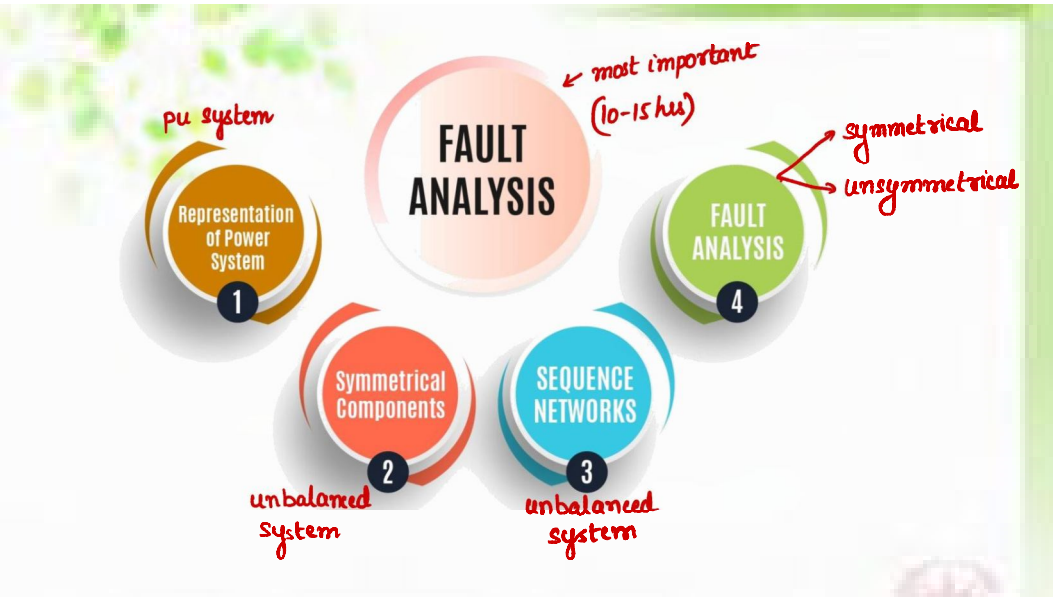
WEIGHTAGE OF TOPICS BY IIT ROORKEE

CHAPTER	2009	2017 Set 1	2017 Set 2
Transmission and Distribution	3	2	7
Economic Load Dispatch	0	0	0
Fault	0	2	0
Stability	2	2	2
Protection	2	0	0
Load Flow	2	4	2
Generation	1	0	0
TOTAL	10	10	11


SYLLABUS
01 TRANSMISSION & DISTRIBUTION
02 LOAD FLOW STUDIES
03 FAULT ANALYSIS
04 POWER SYSTEM STABILITY
05 POWER SYSTEM PROTECTION
06 ECONOMIC LOAD DISPATCH
04 Generating stations


TRANSMISSION & DISTRIBUTION
Transmission & distribution
TL parameters & construction
Transmission line Performance (R, L, C)
Surges (Transient) η/VR/ circuit
Voltages control
overhead lines
UG Cables
Overhead Insulators
Distribution System
Load Frequency Control
HVDC
FACTS
Corona
ESE


LOAD FLOW ANALYSIS
most important
Power System Matrices
YBUS, ZBUS
Load Flow Solution
Gauss Seidel Method
Newton Raphson Method
(Jacobian)
FDLF Method


FAULT ANALYSIS
most important
(10-15 hrs)
pu system
1 Representation of Power System
2 Symmetrical Components
unbalanced system
3 SEQUENCE NETWORKS
unbalanced system
4 FAULT ANALYSIS
symmetrical
unsymmetrical

POWER SYSTEM PROTECTION

more important

CIRCUIT BREAKERS AND SWITCHES

- Fuse ✓
- Load interrupter ✓
- Line isolator ✓
- CB
  - → arc ✓
  - → Terminology ← numerical
  - → Types

RELAYS

- Types of relays ✓
- Over current
- Distance
- Differemtial

(3 main schemes)

- Alternator
- Tx Line
- Transformer

ECONOMIC LOAD DISPATCH

↳ economic dispatch
↳ economic generation

(numerical)
(4-5 hrs)

POWER PLANT

- STEAM
- NUCLEAR
- GAS
- HYDRO
- DIESEL
- WIND
- SOLAR

(~4 hrs)

Schedule

Chapter	Lecture Hours	Questions
Transmission & Distribution	48 ✓	500 ✓
Load Flow Analysis	12 ✓	100
Fault Analysis	16 ✓	150
Stability	10 ✓	100
Protection	14 ✓	100
Economics & Generation	10 ✓	100

TRANSMISSION & DISTRIBUTION - 48 HOURS

Date	Lecture No.	Title	Time
26-Aug-24	Lecture-01	Introduction to Power System & Transmission Line	6:00 AM
26-Aug-24	Lecture-02	Construction of Transmission Line-I	8:30 AM
27-Aug-24	Lecture-03	Construction of Transmission Line-II	6:00 AM
27-Aug-24	Lecture-04	Transmission Line Parameters Part-I	8:30 AM
28-Aug-24	Lecture-05	Transmission Line Parameters Part-II	6:00 AM
28-Aug-24	Lecture-06	Transmission Line Parameters Part-III	8:30 AM
30-Aug-24	Lecture-07	Transmission Line Parameters Part-IV	6:00 AM
30-Aug-24	Lecture-08	Assignment Discussion	8:30 AM
31-Aug-24	Lecture-09	Transmission Line Performance and Short TL	6:00 AM
31-Aug-24	Lecture-10	Short Transmission Line	8:30 AM
02-Sep-24	Lecture-11	Medium Transmission Line and Assignment Discussion	6:00 AM
02-Sep-24	Lecture-12	Long Transmission Line	8:30 AM

TRANSMISSION & DISTRIBUTION - 48 HOURS

Date	Lecture No.	Title	Time
03-Sep-24	Lecture-13	Static Power Transfer Equation	6:00 AM
03-Sep-24	Lecture-14	Loading on a Transmission Line & Wave Propagation	8:30 AM
04-Sep-24	Lecture-15	Wave Propagation & Assignment Discussion	6:00 AM
04-Sep-24	Lecture-16	Surges in a Transmission Line	8:30 AM
05-Sep-24	Lecture-17	Surges Part-02 and Voltage Control	6:00 AM
05-Sep-24	Lecture-18	Voltage Control Part-II	8:30 AM
06-Sep-24	Lecture-19	Assignment Discussion	6:00 AM
06-Sep-24	Lecture-20	Underground Cables	8:30 AM
07-Sep-24	Lecture-21	Overhead Insulators	6:00 AM
07-Sep-24	Lecture-22	Corona and Load Frequency Control and Assignment Discussion	8:30 AM
09-Sep-24	Lecture-23	Distrbution Systems	6:00 AM
09-Sep-24	Lecture-24	HVDC and FACTS & Assignment Discussion	8:30 AM

LOAD FLOW ANALYSIS - 12 HOURS

Date	Lecture No.	Title	Time
10-Sep-24	Lecture-25	Power System Matrices Part -I	6:00 AM
10-Sep-24	Lecture-26	Power System Matrices Part -II	8:30 AM
11-Sep-24	Lecture-27	Power System Matrices Part -III and Load Flow Solution	6:00 AM
11-Sep-24	Lecture-28	Gauss Seidel and Newton Raphson Method Part-01	8:30 AM
12-Sep-24	Lecture-29	Assignment Discussion	6:00 AM
12-Sep-24	Lecture-30	Newton Raphson Method Part-02 and FDLF Method	8:30 AM

FAULT ANALYSIS - 16 HOURS

Date	Lecture No.	Title	Time
13-Sep-24	Lecture-31	Representation of power system and Assignment Discussion	6:00 AM
13-Sep-24	Lecture-32	Symmetrical components and Sequence Networks - Part -I	8:30 AM
14-Sep-24	Lecture-33	Symmetrical components and Sequence Networks - Part -II	6:00 AM
14-Sep-24	Lecture-34	Symmetrical Fault Analysis -Part-I	8:30 AM
16-Sep-24	Lecture-35	Assignment Discussion	6:00 AM
16-Sep-24	Lecture-36	Symmetrical Fault Analysis -Part-II	8:30 AM
17-Sep-24	Lecture-37	Unsymmetrical Fault Analysis	6:00 AM
17-Sep-24	Lecture-38	Practice on Fault Analysis and Assignment Discussion	8:30 AM

STABILITY - 10 HOURS

Date	Lecture No.	Title	Time
18-Sep-24	Lecture-39	Power System Stability Part-I	6:00 AM
18-Sep-24	Lecture-40	Power System Stability Part-II	8:30 AM
19-Sep-24	Lecture-41	Power System Stability Part-III	6:00 AM
19-Sep-24	Lecture-42	Assignment Discussion	8:30 AM
20-Sep-24	Lecture-43	Power System Stability Part-IV	6:00 AM

PROTECTION - 14 HOURS

Date	Lecture No.	Title	Time
20-Sep-24	Lecture-44	Circuit Breakers Part -I	8:30 AM
21-Sep-24	Lecture-45	Circuit Breakers Part -II	6:00 AM
21-Sep-24	Lecture-46	Assignment Discussion	8:30 AM
23-Sep-24	Lecture-47	Protective Relays Part-I	6:00 AM
23-Sep-24	Lecture-48	Protective Relays Part-II	8:30 AM
24-Sep-24	Lecture-49	Protective Relays Part-III and Assignment Discussion	6:00 AM
24-Sep-24	Lecture-50	Protective Relays Part-IV	8:30 AM

ECONOMICS & GENERATION - 10 HOURS

Date	Lecture No.	Title	Time
25-Sep-24	Lecture-51	Economic Load Dispatch	6:00 AM
25-Sep-24	Lecture-52	Economic Power Generation	8:30 AM
26-Sep-24	Lecture-53	Assignment Discussion	6:00 AM
26-Sep-24	Lecture-54	Power Plant Part-I	8:30 AM
27-Sep-24	Lecture-55	Power Plant Part-II and Assignment Discussion	6:00 AM

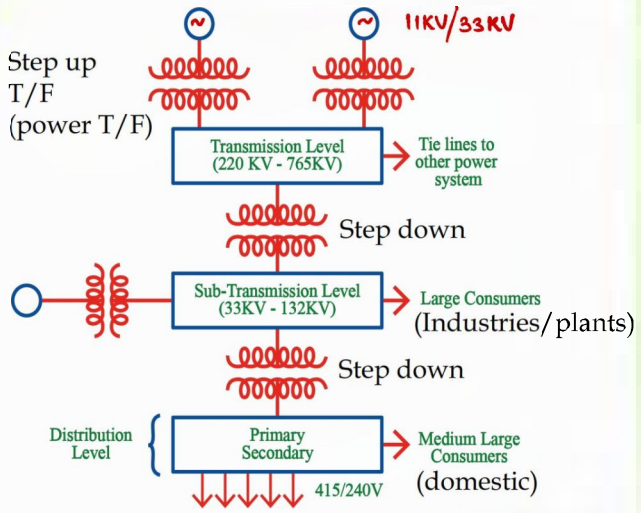
↳ 04-Oct

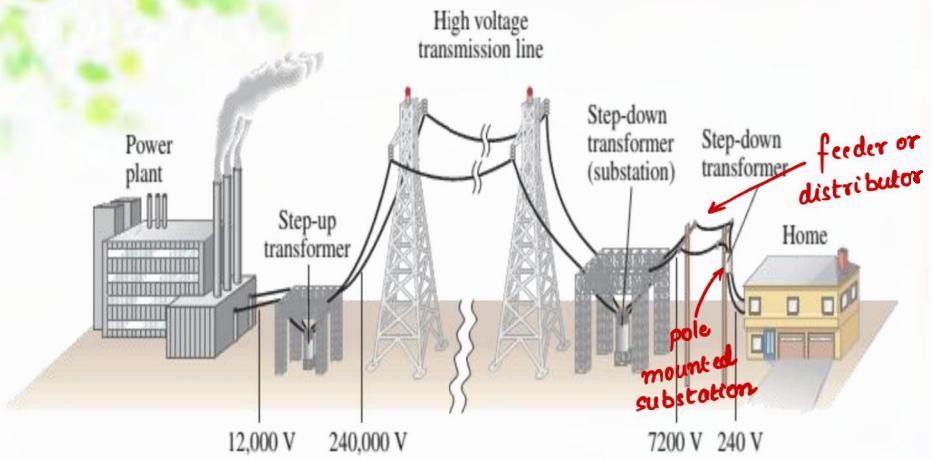
What is Power System ?

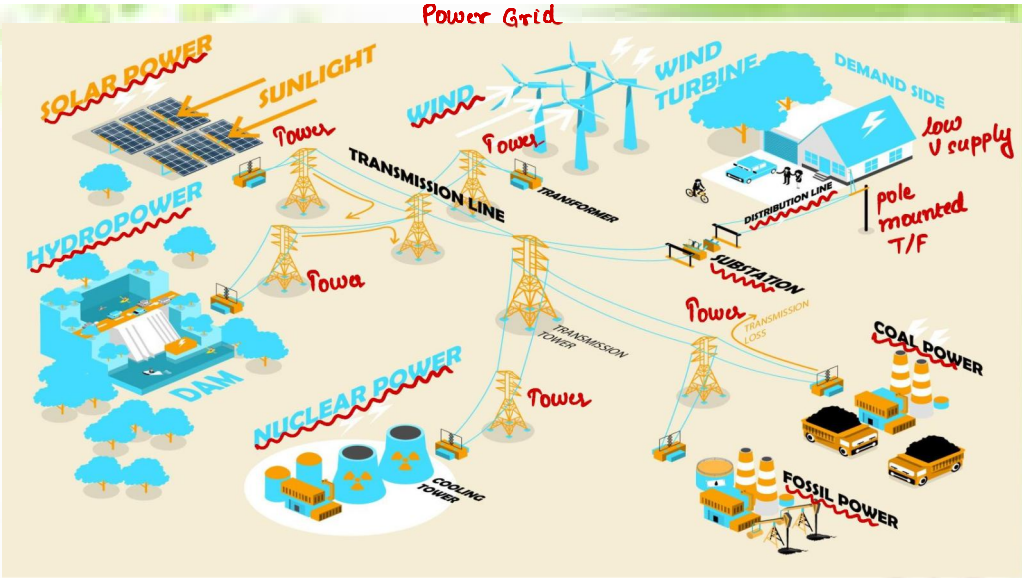
A system design to generate, transmit, distribute , and consume power.
Generation : Synchronous Generator
Transformer : Step up / Step down (transmission at higher voltage and consumption at lower voltage)
Transmission line : Transmit or Distribute
Load: Passive, Induction Motor

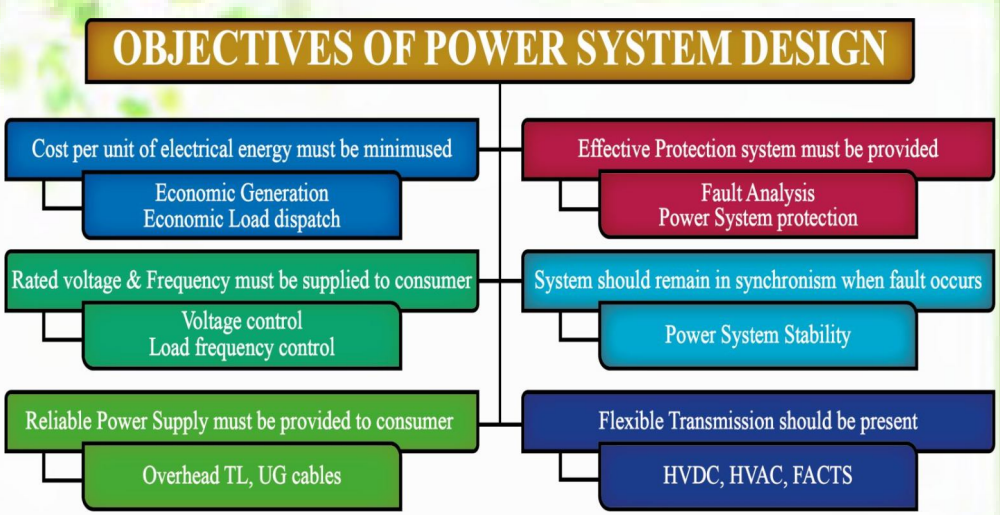
Schematic Diagram

The schematic diagram of Power System is shown as,









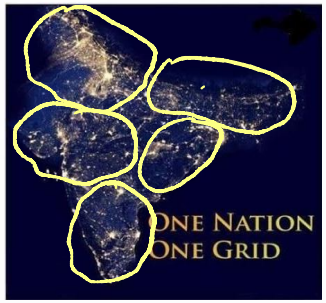
HISTORY OF POWER SYSTEM IN INDIA

- IN 1890, first hydroelectric plant was commissioned.
- In 1975, central government entered in the field of generation through (NTPC etc.)
- In 1989, power grid corporation of India (PGCIL) was formed.
  - ↳ power transmission
- In 1990, first HVDC bi-pole line was formed .
- In 1998, first 765kVline was erected. Now upto 1200 kV is available.

Regional Grid in India

- Five regional grid in India.
- Northern
- Eastern
- North-Eastern
- Western
- Southern

} early connected together

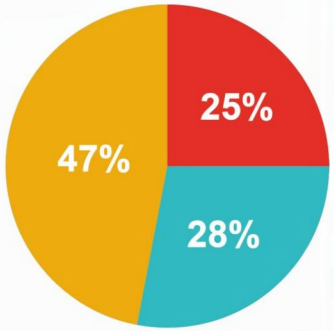


In August 2006 Northern ,Eastern, North-Eastern, Western grid were connected to form central grid .

- On 31 December 2013 Southern grid was also connected to other 4 grids in synchronous mode

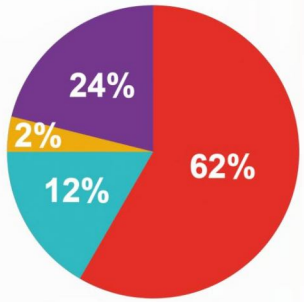
Installed Capacity

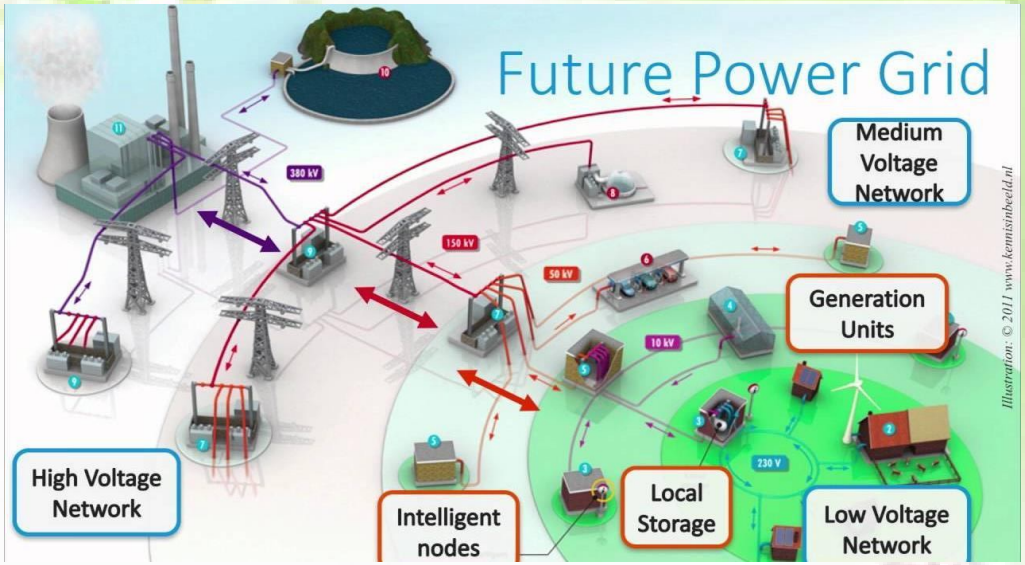
SECTOR	MW	% OF TOTAL
CENTRAL SECTOR	94,027	25.2%
STATE SECTOR	1,03,617	27.8%
PRIVATE SECTOR	1,75,050	47%
TOTAL	3,72,693	

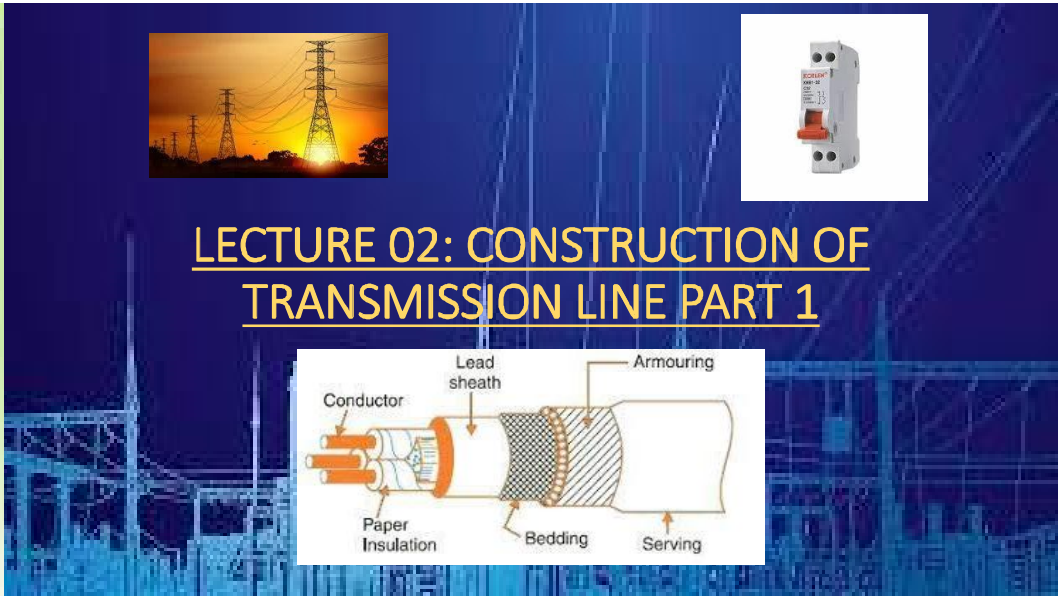


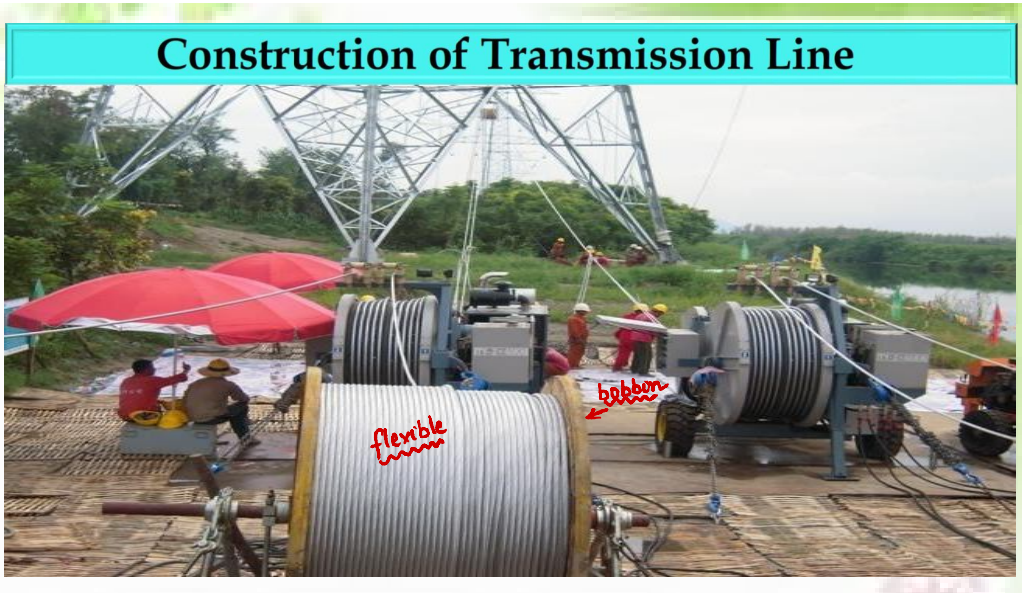
Power Generation

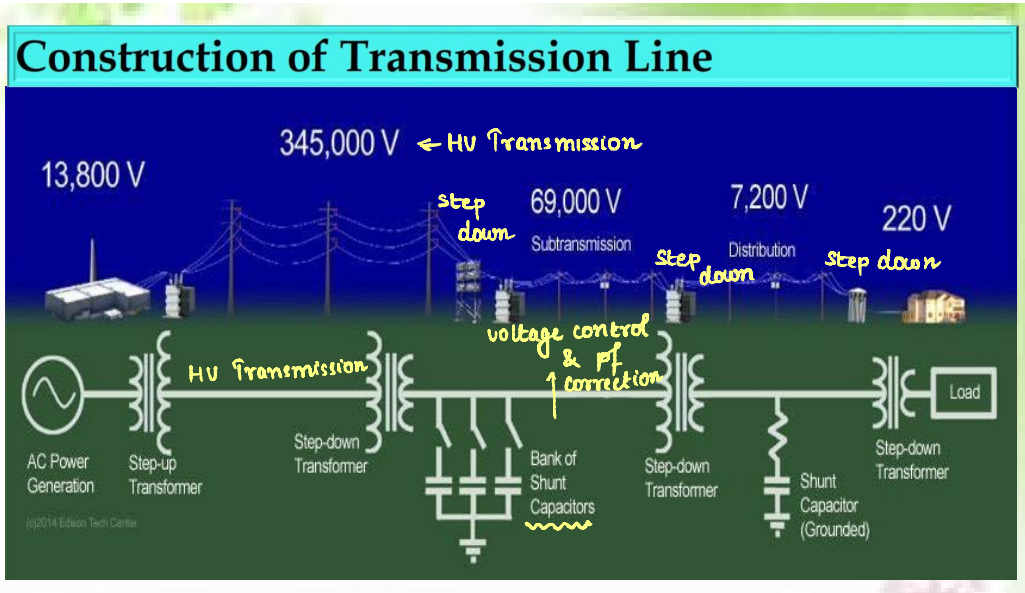
SECTOR	MW	% OF TOTAL
THERMAL POWER	2,31,421	62.1%
HYDROELECTRIC POWER	45,699	12.3%
NUCLEAR	6,780	1.8%
RENEWABLE	88,793	23.8%
TOTAL	3,72,693	

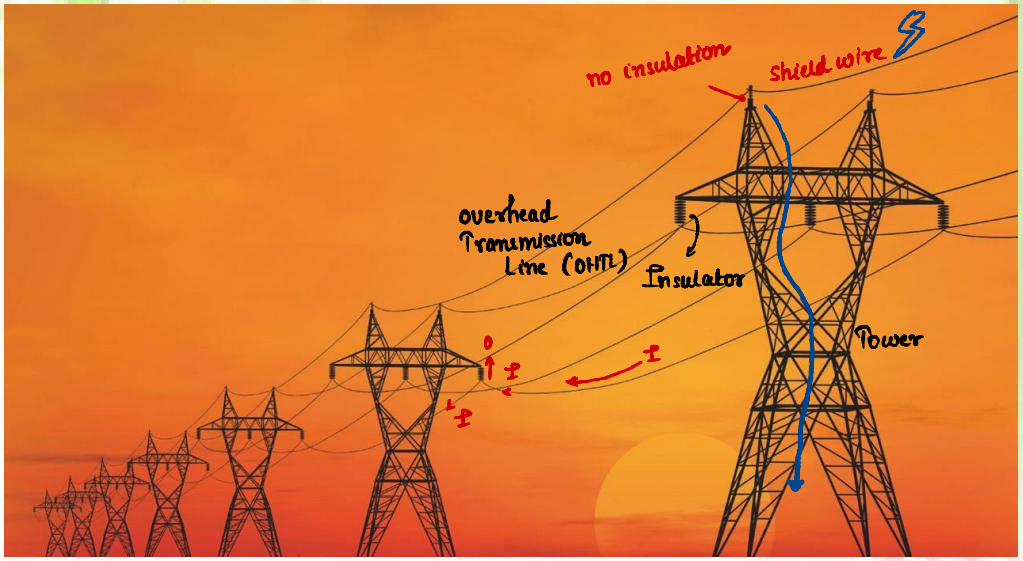



Future Power Grid
Medium Voltage Network
Generation Units
High Voltage Network
Intelligent nodes
Local Storage
Low Voltage Network
380 kV
150 kV
50 kV
10 kV
230 V
Illustration: © 2011 www.kennisinbeeld.nl


LECTURE 02: CONSTRUCTION OF TRANSMISSION LINE PART 1
Conductor
Lead sheath
Armouring
Paper Insulation
Bedding
Serving


Construction of Transmission Line
flexible
bekban


Construction of Transmission Line
13,800 V
345,000 V
HV Transmission
step down
69,000 V
Subtransmission
7,200 V
Distribution
220 V
Step down
Step down
HV Transmission
voltage control & pf correction
Load
AC Power Generation
Step-up Transformer
Step-down Transformer
Bank of Shunt Capacitors
Step-down Transformer
Shunt Capacitor (Grounded)
Step-down Transformer



Transmission Line

- TL is a power carrier or link between 2 buses (comparable to nodes in network theory) in a power system network.
- Should be made from a conducting material : Cu, Al, Au, Ag

$$\sigma_{Ag} > \sigma_{Au} > \sigma_{Cu} > \sigma_{Al}$$

** SN

Al is preferred in transmission lines because

i. Lighter in weight so preferable in overhead TL → tower can easily handle weight of TL
ii. Lower cost a compared to other materials
iii. $\rho_{Al} > \rho_{Cu}$ ($\sigma_{Cu} > \sigma_{Al}$)
iv. Al is more readily available

Transmission Line

For same resistance of Cu & Al conductor ** SN (same ohmic loss)

$R_{Cu} = R_{Al}$

$$\frac{\rho_{cu} \times l}{A_{cu}} = \frac{\rho_{Al} \times l}{A_{Al}}$$

$$\frac{A_{Al}}{A_{cu}} = \frac{\rho_{Al}}{\rho_{cu}} > 1$$

$A_{Al} > A_{cu}$

$r_{Al} > r_{cu}$: r = radius

** SN

l : depends on distance of power transmission

electric field of line charge

$$E = \frac{P_L}{2\pi\epsilon r}$$

P_L : line charge density

r : distance from line charge

Transmission Line

- For same resistance & losses we need thicker Al conductor as compared to Cu but still Al conductor is cheaper & lighter than Cu.

Electric field due to line charge

$E = P_L / 2\pi\epsilon r$, r distance from axis

** SN

As radius of conductor ↑ E↓ (at surface)

Less corona loss in Al

Due to charge & electric field of a conductor air around conductor break down & I flows through air leading to losses.