Module One

Introduction Part I

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Topics to be covered

- Introduction to power systems
- Structure of power systems

Introduction

- A power system consists of several generating stations and utilizers interconnected by transmission and distribution networks.
- Electrical power system components- generation, transmission, distribution and utilization of electrical energy.
- The objective of the power system is to generate electrical energy, to transmit and then distribute among different consumers in a reliable and economic manner.
- Electricity is the one of the greatest accomplishment, which has already transformed the living style of humankind.
- Electricity has become an inevitable part of every field as well as infrastructure.

Generation of electrical energy

- Electricity generation is the process of generating electric power from energy sources (conventional as well as non conventional)

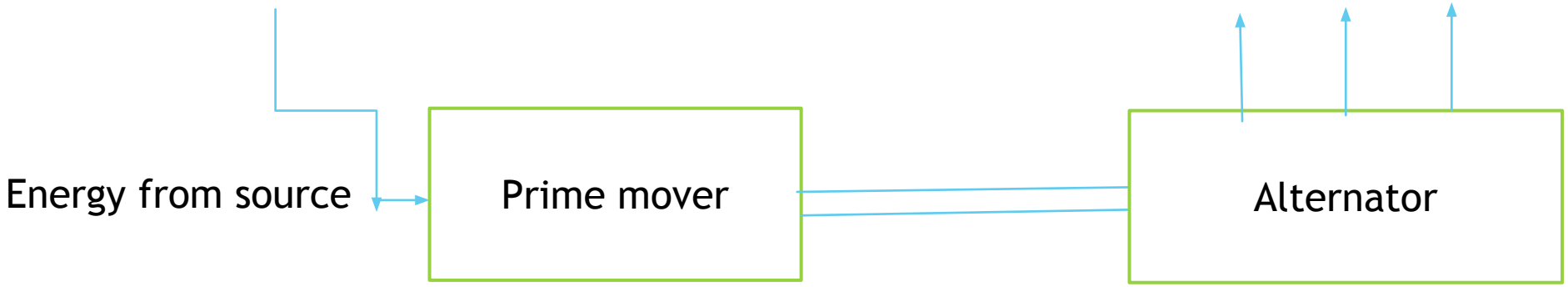
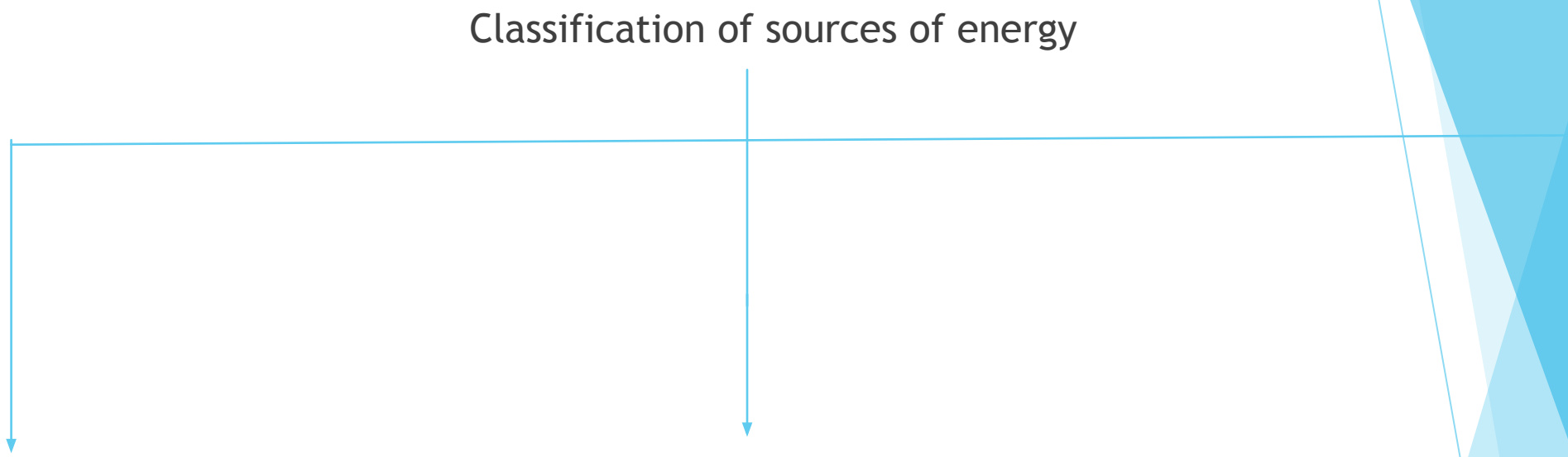


Figure 1.1: Simple arrangement for generation of electrical energy

Classification of sources of energy



Primary and secondary

Renewable and non renewable

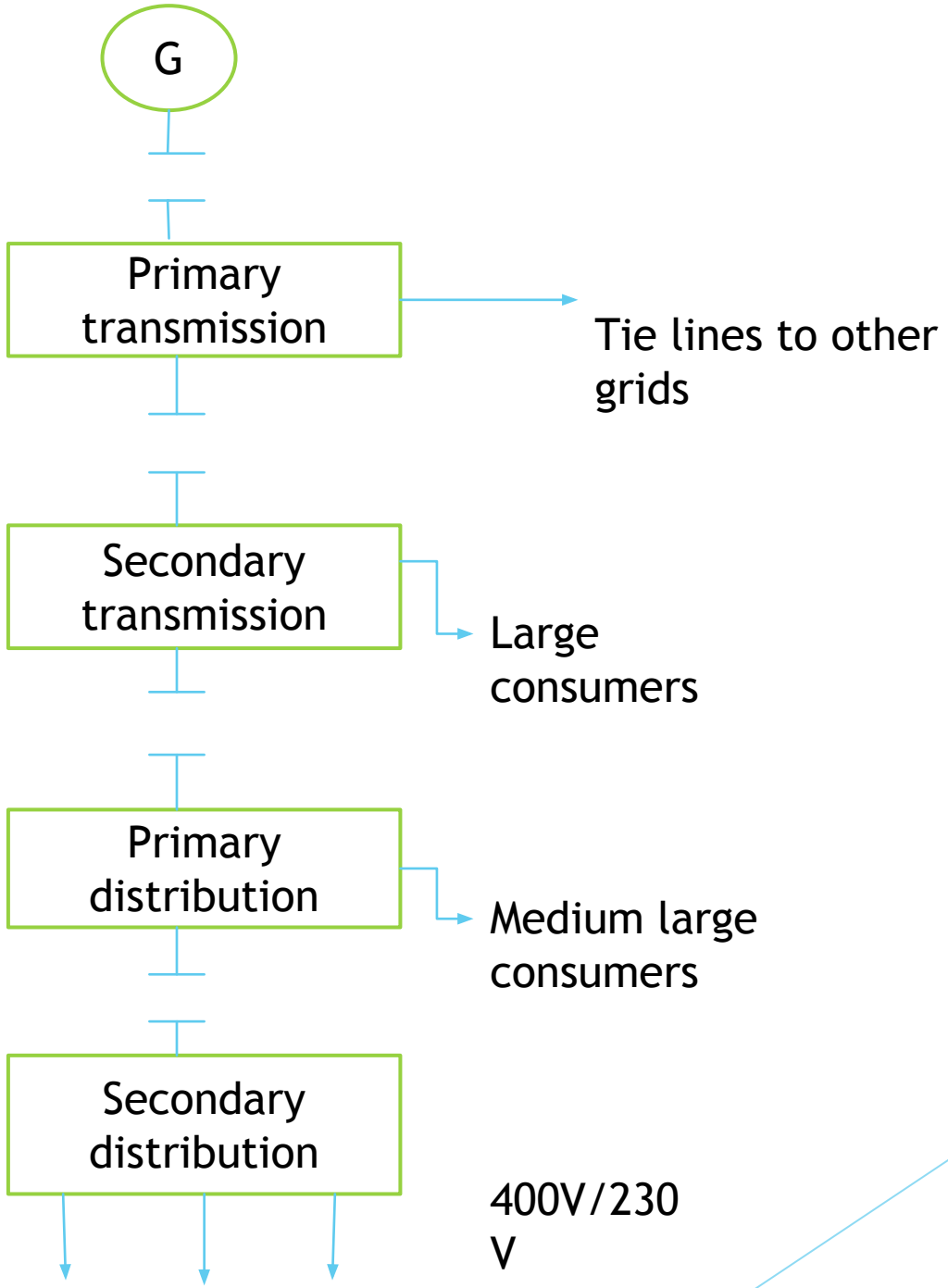
Commercial and non commercial

Structure of Power Systems

- The power system architecture is equitable like tree the foundations of which represent the generation system, the trunk represents transmission system, the branches represent distribution system and the leaves represent the consumers.
- Generating station
- Transmission systems-primary and secondary transmission
- Distribution systems-primary and secondary distribution
- Utilization

Components of Electric Power Systems

- Generators
- Transformers(Step up and step down)
- Transmission systems(primary and secondary/sub-transmission)
- Transmission lines
- Distribution systems(primary and secondary)
- Protection and control equipment(circuit breakers, relay etc.)


G
Primary transmission
Tie lines to other grids
Secondary transmission
Large consumers
Primary distribution
Medium large consumers
Secondary distribution
400V/230 V
Small

Transmission of electric power

- The transmission system transfers bulk power at a very high voltage level with the help of step up transformer to distribution substation
- Interconnects the neighbouring generating stations in to a power pool i.e., interconnection of two or more generating stations.
- Tolerance of transmission line voltage is ± 10% due to the variation of loads.

Primary and secondary transmission

- Primary transmission-The high voltage transmission lines transmit power from sending end substation to the receiving end substation.
- At the receiving end substation, the voltage is stepped down to a value of 66 or 33 or 22 KV using step down transformers.
- The secondary transmission line forms the link between the receiving end substation and the secondary station.

Distribution of electric power

- The distribution substation handovers power to the distribution system of an area by stepping down the voltage levels, with the support of distribution transformer, appropriate for consumers.
- A distribution station distributes power to domestic, commercial and relatively small consumers.
- Primary and secondary distribution

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Introduction Part II

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Topics to be covered

- Classification of Voltage levels associated with power systems
- Interconnections and their advantages

Classification of Voltage levels associated with power systems

Voltage level	Level mark	Type of system	Section of power system
Low voltage	Below 1000V	AC	Secondary distribution
Medium voltage	1000V upto 33kV	AC	Primary distribution
High voltage	33kV-220kV	AC	Secondary/primary transmission
EHV	Above 220kV to 765kV	AC,HVDC	Primary transmission
UHV	>765kV	Preferably HVDC	Primary transmission

Voltage levels associated with power systems

- Table 1.2: Voltage levels associated with power systems

Genaration	11 kV to 25kV
Transmission	
Primary transmission	220kV/400kV/765kV
Secondary transmission	132kV/66kV
Distribution	
Primary distribution	33kV/11kV/6.6kV/3.3kV
Secondary distribution	400V/230V

Interconnections

- Power systems were small and simple in early stages
- Power systems expanded due to increase in load demand
- Large power systems were interconnected in order to derive economic and technical benefits
- Now-a days, usual practice and necessity to interconnect power systems
- The different grids are interconnected to form a regional grid and various regional grids are interconnected to form national grid.

Regional Grids of India

The country is divided into five regional grids

- Northern
- Western
- Eastern
- Southern
- Northern-Eastern

Each grid operates independently but during abnormal conditions, power can be transmitted from one grid to other grid.

National grid

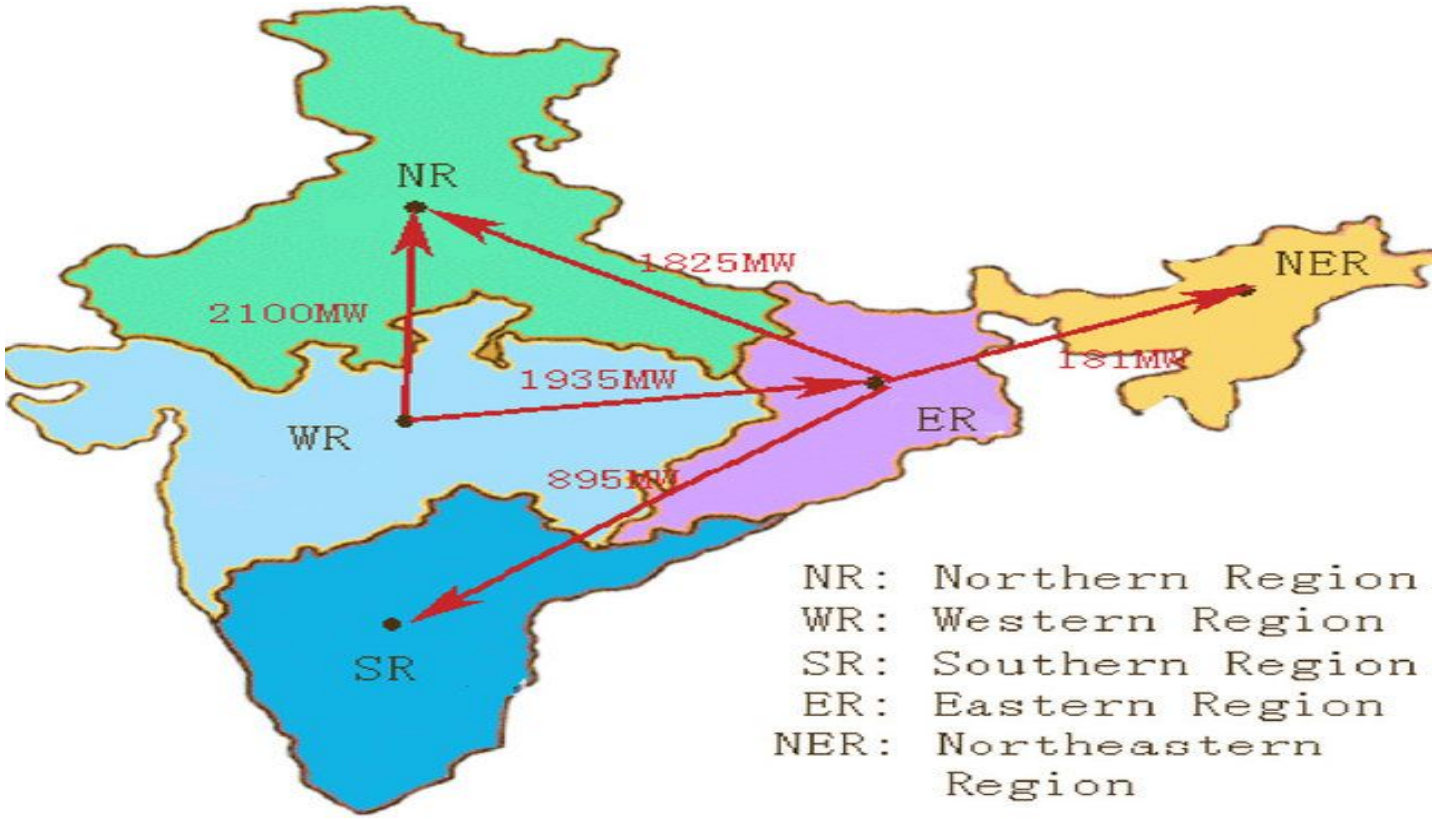

Figure 1.3 Indian map showing national grid

Advantages

- Reduction in generating capacity due to diversity of load demands
- Reduction in standby capacity
- Increase in the size of the generating sets, thereby reducing capital and operating costs
- Optimum utilization of the available plant capacity and transmission facilities
- Reliability of power supply
- Improvement in frequency

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Introduction Part III

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Topic to be covered

- Growth of power systems-Indian overview

Growth of power systems-Indian overview

- Rapid Growth in Indian economy would require an exponential growth in the power systems.

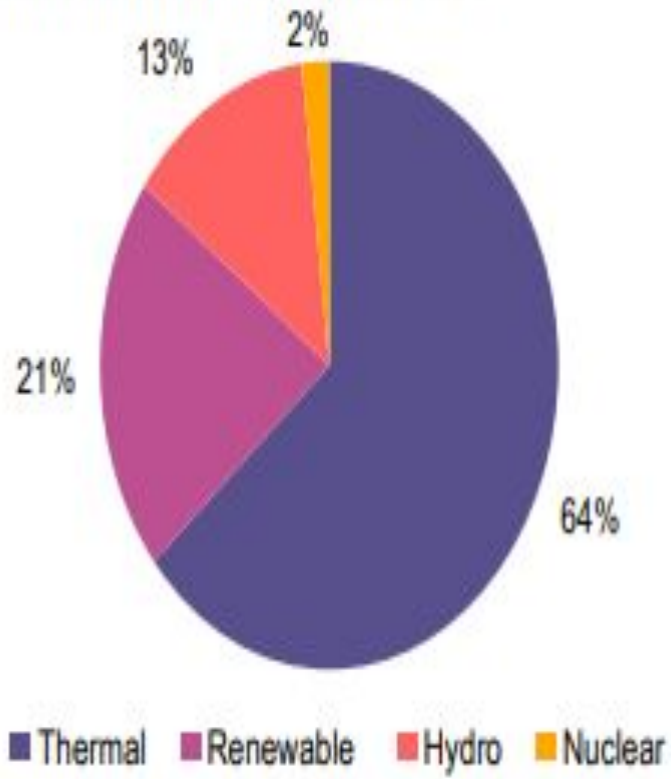
Table 1.3 : Percentage of various fuels for Power generation as per Jan,2019

Fuel	MW	% of total
Total thermal	2,23,028	63.9
Hydro	45,399	13.0
Nuclear	6,780	1.9
RES(MNRE)	74,082	21.2
Total	370.348	100

Source: Ministry of power;PRS

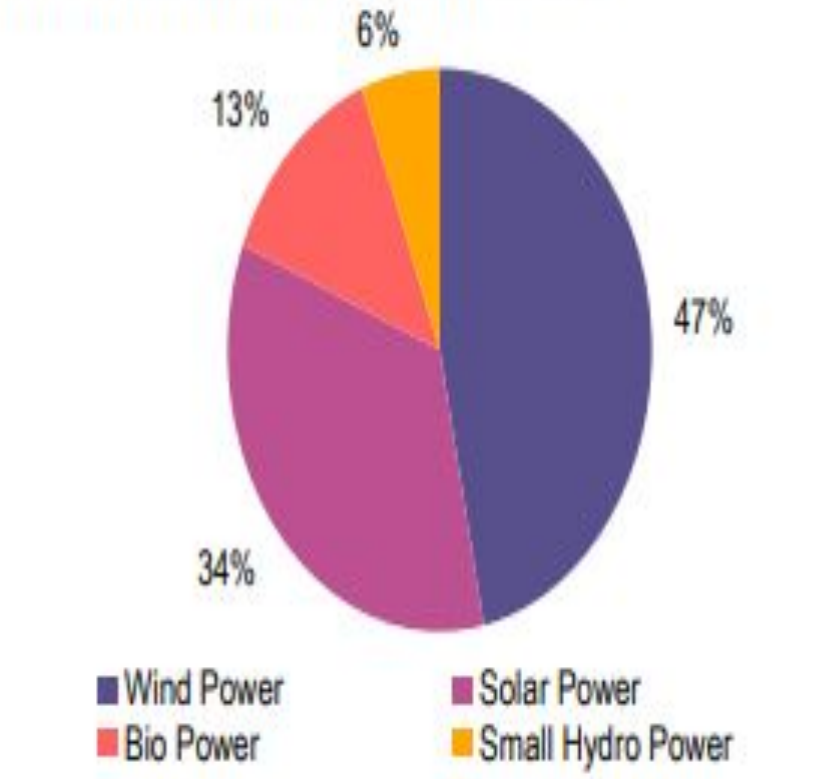
Sector wise power generation capacity

Figure All India power generation capacity (as on January 2019)



Sources: Ministry of Power; PRS.

Figure Grid interactive renewable power capacities (as on January 2019)



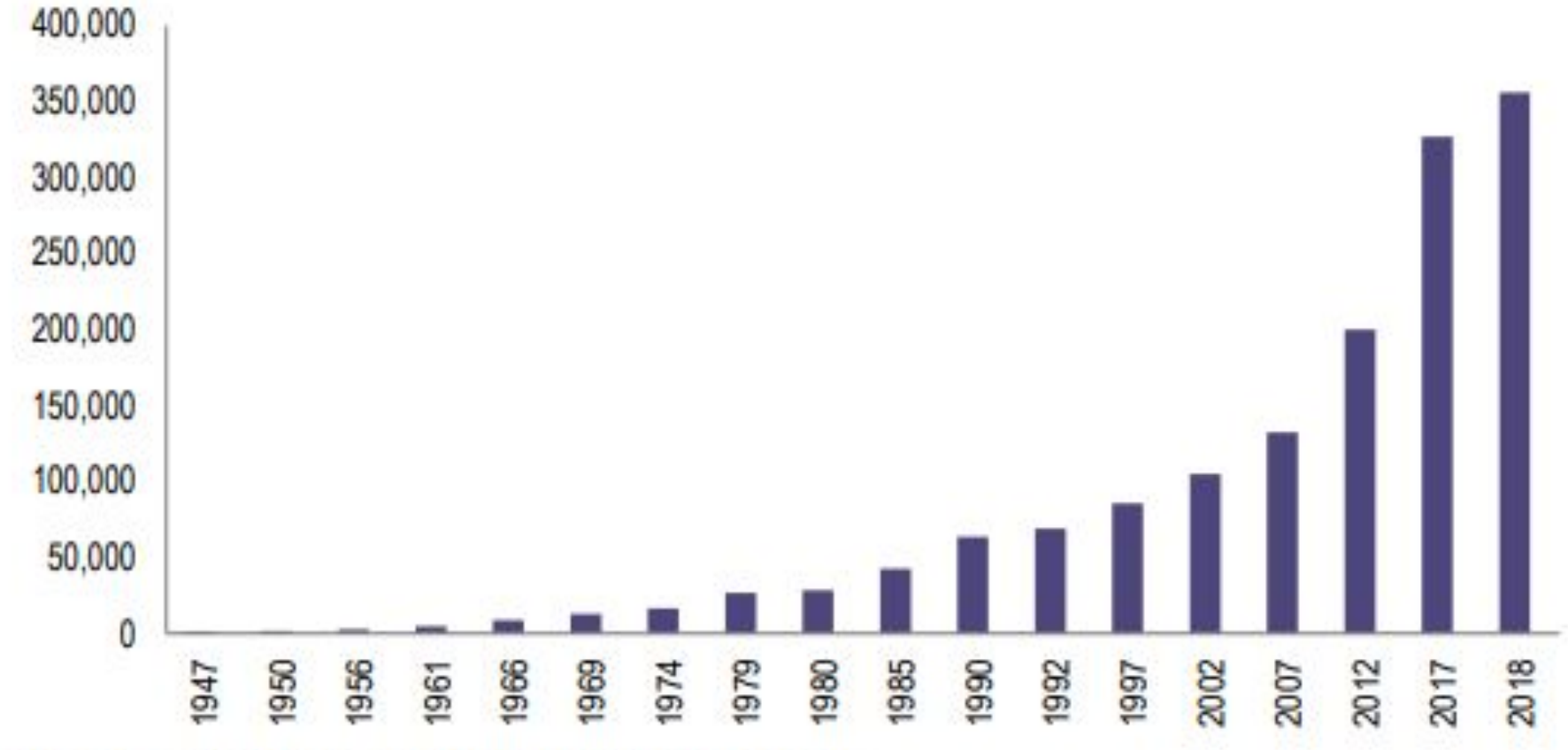
Sources: Ministry of New and Renewable Energy; PRS.

- Environmental sustainability is one of the major concerns with regard to thermal power generation across the world.
- The Ministry of Environment, Forest and Climate Change (MoEFCC) had issued certain environmental guidelines for thermal power plants in December 2015.
- As on January 2019, the share of renewable energy (including hydro) in power generation is 34%. This share has to be increased up to 40% by 2030, and simultaneously the share of thermal power has to decrease .

Targets set by Govt. of India

- Achieving 40% of electric power installed capacity from non-fossil fuel by 2030
- Generating 175 GW of renewable energy by 2022, and increasing capacity under the National Solar Mission from 20 to 100 GW
- Development of a National Smart Grid Mission & Green Energy Corridor for efficient transmission & distribution network
- Reduction in fossil fuel subsidies
- Providing tax free infrastructure bonds introduced for renewable energy.

Total installed generation capacity(MW)



Note: Generation figures are for the end of the financial year.
Sources: Central Electricity Authority; PRS.

Figure 1.5: Total installed generation capacity in MW

Length of Transmission lines (in circuit km)

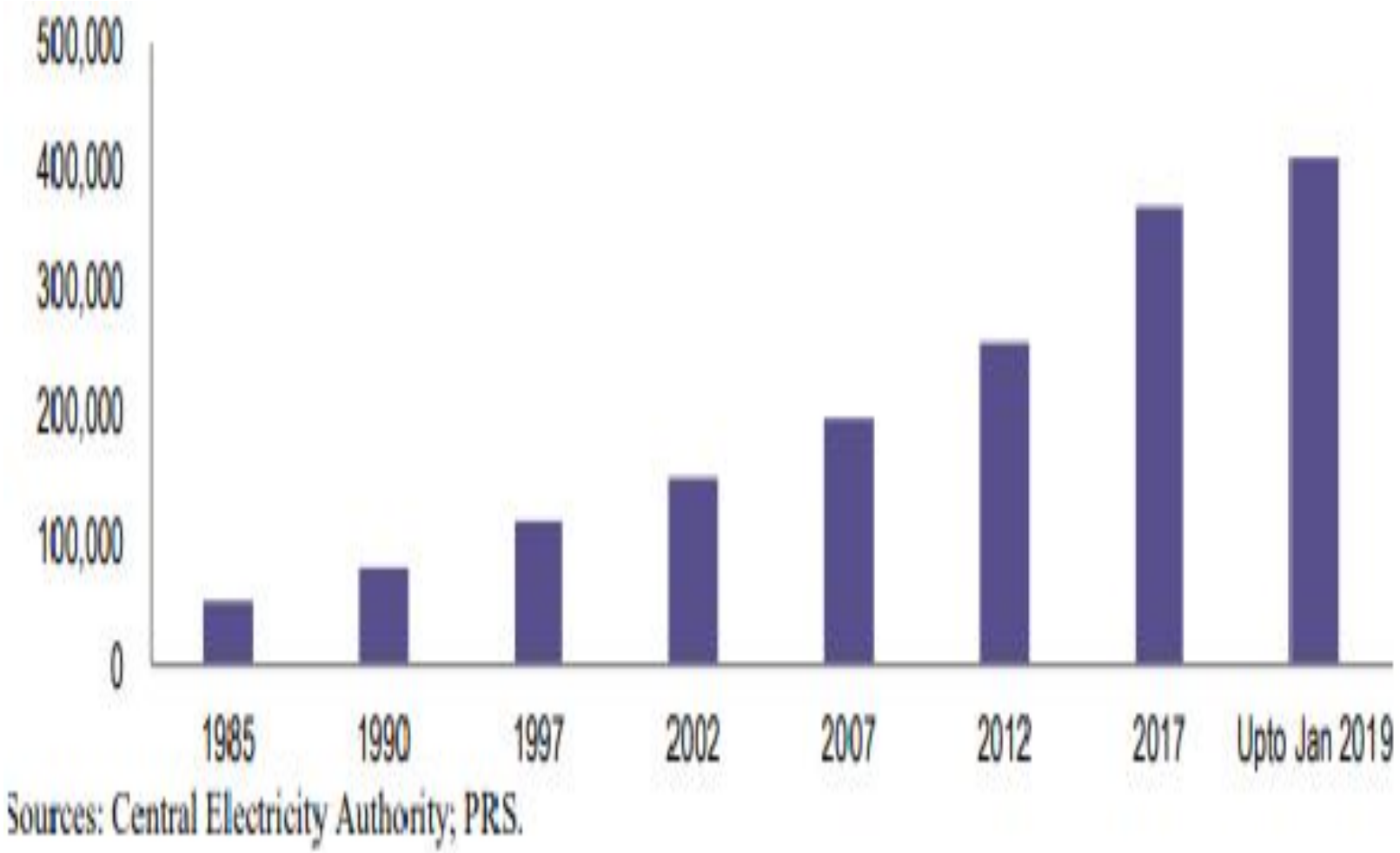


Figure 1.6: Length of transmission lines in circuit km

- As of January 2019, the all India transmission lines are 4.07 lakh circuit km long. 54% of the transmission lines are with the state governments, 38% with the centre, and remaining are with private companies.

Renewable energy

- Renewable energy is seen to be becoming the driving force behind addition of power transmission capacity.
- As of December 2019, India had installed 86 gigawatts (GW) of renewable energy capacity, 2 more than doubling in the last four years.
- Target of 175GW of variable renewable energy by 2022, rising to 450GW by 2030.
- Estimated the requirement of 1.1 lakh ckm of new transmission lines to cater to annual peak load demand of 225.7 GW by the end of 2022.

Renewable energy capacity 2015-2019

Table 1.5: Renewable energy capacity during 2015-2019

		Central	State	Private	Total
2019-20 (up to Dec 2019)	GW	1.6	2.3	81.9	85.9
	Share (%)	2%	3%	95%	100%
	% Growth				
2018-19	GW	1.6	2.3	73.6	77.6
	Share (%)	2%	3%	95%	100%
	% Growth	9%	17%	12%	12%
2017-18	GW	1.5	2.0	65.5	69.0
	Share (%)	2%	3%	95%	100%
	% Growth	-	1%	19%	21%
2016-17	GW	0	1.9	55.2	57.2
	Share (%)	0%	3%	97%	100%
	% Growth	-	2%	50%	47%
2015-16	GW	0	1.9	36.8	38.8
	Share (%)	0%	5%	95%	100%
	% Growth	-	-49%	32%	22%

Source: CEA

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Introduction Part IV

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Per unit value

- It is the ratio of the actual value of that quantity to the base value of that quantity.
- Base value is arbitrarily selected value for calculations
- Per unit value is dimensionless as both per unit and base value both are having same units.
- It is denoted by p.u.

Advantages of p.u. system

- If any particular value is missing from data sheet of an equipment, it is easier to assume its per unit value than numerical value
- This representation gives significant information about relative magnitudes
- System parameters fall in narrow range, so erroneous data can be identified easily
- If base value selection is proper, impedance of transformer on both sides is equal
- Per unit values of transformer don’t depend upon the type of the connections but base values do

Per unit impedance of two winding transformer