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POWER GENERATION, CONSUMPTION AND POWER SHORTAGE IN INDIA

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Abstract - *India is one of the fast- developing countries in the world and it required a good amount of energy for the demand. The primary source of energy in India is coal and India is the country that has the world's fifth- largest coal reserves. India is the world's third- largest producer and third-largest consumer of electricity. The national electric grid in India has an installed capacity of 368.79 GW as of 31 December 2019 but according to the ministry of power; PRS, it is 349.29 GW. Electricity generation is the process of generation of electric power from sources of primary energy. Production is carried out in the power stations (also called as "power plant"). India faces a daily power outage of 40,000 MW. This paper presents the power generation, consumption, and power shortage in India.*

***Key Words*: Power generation, energy source, coal, power plant, power demand, Power Shortage.**

1. INTRODUCTION

India is the fourth-largest energy consumer in the world after the United States, China, and Russia". The US Energy Information Administration (EIA) said in its latest report (for T2011) on energy outlook for India released here yesterday. According to the report, India was the fourth- largest consumer of oil and petroleum products in the world in 2011, after the US, China, and Japan.

India's electricity sector is dominated by fossil fuels, in particular coal, which during the 2018-19 fiscal year produced about three-quarters of the country's electricity. The government is making efforts to increase investment in renewable energy. The government's National Electricity Plan of 2018 states that the country does not need more non-renewable power plants in the utility sector until 2027, with the commissioning of 50,025 MW coal-based power plants under construction and addition of 275,000 MW total renewable power capacity after the retirement of nearly 48,000 MW old coal-fired plants.

2. ELECTRICITY GENERATION

Electricity generation is the process of generation of electric power from sources of primary energy. For utilities in the electric power industry, it is the stage prior to its delivery to end- users (generation, transmission, distribution, etc…) or its storage. A characteristic of electricity is that it is not freely available in nature in large amounts, so it must be "produced" (i.e., transforming other forms of energy to electricity). Production is carried out in power stations (also called as "power plant"). Electricity is most often generated power plant by electromechanical generators, primarily driven by heat engines fuelled by the combustion or nuclear fission but also by other means such as the kinetic energy of flowing water or wind. Other energy sources include solar photovoltaic, tidal power and geothermal power, etc...

3. HISTORY OF ELECTRICAL POWER

The fundamental principles of electricity generation were discovered in the 1820s and early 1830s by the British scientist Michael Faraday. His method, still used today, is for electricity to be generated by the movement of a loop of wire, or Faraday disc, between discs, between the poles of a magnet. Central power stations became economically practical with the development of alternating current (AC) in power transmission, using power transformers to transmit power at high voltage and with low loss.

The first power plant used thermal plants or coal. The thermal power depends on the temperature difference between a heat source and a cold source. The higher the difference, the more mechanical power can be efficiently extracted out of heat energy, as per Carnot's theorem. The efficiency of a thermal power cycle is limited by the maximum working fluid temperature produced or by the high heat of vaporization of the working fluid. The efficiency is not directly a function of the fuel used. Today a variety of energy sources are used, such as coal, nuclear, natural gas, hydroelectric, wind, oil and solar energy, tidal power, and geothermal sources. The power sector in India has undergone significant progress after independence. When India became independent in the year 1947, the country had a power generating capacity of 1,362 MW. Hydropower and coal-based thermal power have been the main sources of generating electricity.

3.1. City Got Electricity at first in India

Bangalore was the first city to get electricity in India in the year 1906 powered by hydroelectric power plant situated at Shivanasamudra.

Fig-1: City got Electricity at first in India

4. ENERGY SECTOR IN INDIA – AN OVERVIEW

The installation capacity in the country is around 365 GWe which is more than sufficient to meet the electrical demand of the country. This is the statement given by the Ministry of power and energy in the parliament in October 2019. Table 1**:** represents the installed generation capacity in MW (as of January 2019).

	Thermal	Nuclear	Hydro (renewable)	Renewable sources	Grand total
Total capacity	2,23,028	6,780	45,399	74,082	3,49,289
% of total capacity	63.9%	1.9%	13.0%	21.2%	100%

Table-1: Installed generation capacity in MW(as on January 2019) Source: Electricity Sector in India.

Power sector is the largest user of coal. In 2017-2018, 576 MT of coal was dispatched to the power sector (84% of the total coal dispatched in the country). Small Hydro, and Hydro projects are comes under Renewable sources.

4.1. State-wise Data

Table 2 below illustrates the power generation capacity and deficit data across states. Maharashtra has the maximum generation capacity across all states, followed by Gujarat and Tamil Nadu. The highest energy deficits have seen in the states of Jammu and Kashmir and Manipur, and in the Union Territory of Andaman and Nicobar Islands.

State/UT	Installed generation capacity (in MW, as on December 31, 2018)				Energy deficit (2017-18)	Peak deficit (2017-18)
	State	Private	Central	Total	(in%)	(in %)
Andhra Pradesh	6,968	14,707	2,052	23,726	-0.2%	-0.1%
Arunachal Pradesh	107	5	188	301	-1.3%	0.0%
Assam	433	45	1,097	1,575	-3.5%	-4.2%
Bihar	781	536	3,024	4,341	-1.5%	-0.1%
Chhattisgarh	2,411	9,014	2,101	13,527	-0.3%	-6.8%
Goa	0	50	500	550	0.0%	-0.2%
Gujarat	7,714	19,356	4,312	31,382	0.0%	0.0%
Haryana	4,032	4,628	2,600	11,261	0.0%	-1.4%
Himachal Pradesh	951	1,600	1,498	4,049	-0.6%	0.0%
Jammu and Kashmir	1,534	60	1,795	3,389	-20.0%	-20.0%
Jharkhand	554	762	455	1,771	-1.9%	-5.4%
Karnataka	8,890	14,782	3,527	27,199	-0.2%	-0.5%
Kerala	2,170	998	1,915	5,083	-0.4%	-0.6%
Madhya Pradesh	6,528	10,200	5,144	21,873	0.0%	-0.3%
Maharashtra	13,901	22,458	7,420	43,779	-0.2%	-0.2%
Manipur	41	3	198	242	-5.2%	-3.5%
Meghalaya	353	0	212	565	-0.3%	-0.3%
Mizoram	36	0	159	196	-1.8%	-8.6%
Nagaland	31	1	128	159	-2.9%	-5.8%
Odisha	2,488	3,427	1,733	7,648	-0.3%	-5.4%
Punjab	4,636	6,558	2,239	13,432	0.0%	0.0%
Rajasthan	7,574	11,242	3,017	21,833	-0.8%	-1.3%
Sikkim	412	399	151	962	-0.2%	0.0%
Tamil Nadu	7,145	17,182	6,119	30,447	-0.2%	-0.2%
Telangana	8,403	5,427	2,115	15,944	-0.1%	-0.1%
Tripura	186	0	548	733	-1.8%	0.0%

Uttarakhand	1,320	1,160	920	3,399	-0.2%	0.0%
Uttar Pradesh	6,218	12,375	6,468	25,061	-1.5%	-10.%
West Bengal	6,578	2,774	1,171	10,523	-0.4%	-0.3%
Andaman and Nicobar Islands	45	1	5	52	-9.1%	-6.9%
Chandigarh	-	32	163	195	-0.6%	0.0%
Dadra and Nagar Haveli	-	5	250	255	0.0%	0.%
Daman and Diu	-	13	177	190	0.0%	0.0%
Delhi	1,935	1,153	4,146	7,234	-0.1%	-0.4%
Lakshadweep	-	1	-	1	0.0%	0.0%
Puducherry	33	2	334	369	-0.3%	-0.8%
Total	**1,04,408**	**1,60,958**	**83,922**	**3,49,288**	**-0.7%**	**-2.0%**

Table-2: Power Generation Capacity and Deficit Data across states. Source: Central Electricity Authority; Power Finance Corporation; PRS.

4.2. Varies Sources of Generating Electricity

- ✓ Renewable Resources(Non-conventional energy)
- ✓ Non-Renewable Resources(Conventional energy)

4.2.1 Conventional or Non-renewable Energy Sources:

1) The conventional energy sources also called non-renewable energy sources. A non-renewable resource is natural resources that cannot be readily place by natural means at a quick enough pace to keep up with consumption.

2) Some examples of Non-Renewable Energy Sources are

- Natural Gas
- Coal
- Petroleum

However, being non-renewable resources, these sources will eventually run out. Further, they create a lot of pollutants in the environment.

4.2.2 Non-conventional or Renewable Energy Sources:

The Non-conventional energy sources also called renewable energy sources. A renewable resource is a resource that can use repeated and replaced naturally. Due to the increasing population and a subsequent increase in demand for energy, the energy industry of India has been facing a crunch for many years. As a result, there has been a step rise in oil prices, making it costlier for the normal individual. It is evident, that conventional sources alone cannot solve India's energy crisis. Therefore, in such a scenario, it is imperative that we explore alternative sources of energy-renewable energy sources.

Some Examples of Renewable Energy Resources are:

- Bio Gas
- Bio-Energy
- Biomass
- Solar Energy
- Small Hydropower
- Wind Power

Electric power is an important aspect of the economic development of a country. It has both commercial and non-commercial uses. Commercially, electric power is used in industries, agriculture, and also transport, etc.

5. ALL INSTALLED CAPACITY

India is the world's third largest producer and the third largest consumer of electricity. National electric grid in India has an installed capacity of 365 GW as of 31 December 2019. The Renewable power plants, which also include large hydroelectric plants, constitute 34.86% of India's total installed capacity. Table-3 shows the installed capacity in central, state and private sector.

Sector	MW	% of TOTAL
Central Sector	92,797	25.3
State Sector	103,815	28.5
Private Sector	170,668	46.6
Total	**3,67,281**	**100**

Table 3: Installed capacity in central, state and private sector. Source: Central Electricity Authority (CEA).

6. PERFORMANCE OF CONVENTIONAL GENERATION

Table-4 shows the electricity generation target of conventional sources for the year 2019-20 and has fixed as 1330 Billion Unit (BU). Growth of around 6.46% over actual conventional generation of 1249.337 BU for the previous year (2018-19). The conventional generation during 2018-19 was 1249.337 BU as compared to 1206.306 BU generated during 2017-18, representing a growth of about 3.57%.

Year	Energy Generation from Conventional Sources (BU)	% of growth
2009-10	771.551	6.6
2010-11	811.143	5.56
2011-12	876.887	8.11
2012-13	912.056	4.01
2013-14	967.150	6.04
2014-15	1048.673	8.43
2015-16	1107.822	5.64
2016-17	1160.141	4.72
2017-18	1206.306	3.98
2018-19	1249.337	3.57
2019-20*	1053.612	0.05

Table 4: Generation and growth in conventional generation in the country during 2009-10 to 2019-20. Source: Central Electricity Authority (CEA).

6. 1 POWER REQUIREMENT, AVAILABILITY SURPLUS/DEFICTS AND ITS PEAK VALUE

In India, energy requirement, availability, and its surplus/ deficits during 2009 to 2020 tabulated below in the table-5. Source: Wikipedia & CEA.

Table-5: Energy requirement, availability, surplus/deficts during 2009-10 to 2019-20.

Year	Energy			
	Requirement	Availability	Surplus(+)/ Deficts(-)	
	(MU)	(MU)	(MU)	(%)
2009-10	8,30,594	7,46,644	-83,950	-10.1
2010-11	8,61,591	7,88,355	-73,236	-8.5
2011-12	9,37,199	8,57,886	-79,313	-8.5
2012-13	9,95,557	9,08,652	-86,905	-8.7
2013-14	10,02,257	9,59,829	-42,428	-4.2
2014-15	10,68,923	10,30,785	-38,138	-3.6
2015-16	11,14,408	10,90,850	-23,558	-2.1
2016-17	11,42,929	11,35,334	-7,595	-0.7
2017-18	12,13,326	12,04,697	-8,629	-0.7
2018-19	12,74,595	12,67,526	-7,070	-0.6
2019-20	8,81,018	9,75,793	-5,225	-0.5

In India, with respect to energy values the peak values are varied during the year 2009-10 to 2019-20. Table-6 shows the peak demand, peak met and its surplus/deficts during 2009-2010 to 2019-2020.

Table-6: Peak demand, peak met and its surplus/deficts during 2009-10 to 2019-20. Source: Power Sector at a Glance.

Year	Peak			
	Peak Demand	Peak Met	Surplus(+) / Deficts(-)	
	(MW)	(MW)	(MW)	(%)
2009-10	1,19,166	1,04,009	-15,157	-12.7
2010-11	1,22,287	1,10,256	-12,031	-9.8
2011-12	1,30,006	1,16,191	-13,815	-10.6
2012-13	1,35,453	1,23,294	-12,159	-9.0
2013-14	1,35,918	1,29,815	-6,103	-4.5
2014-15	1,48,166	1,41,160	-7,006	-4.7
2015-16	1,53,366	1,48,463	-4,903	-3.2
2016-17	1,59,542	1,56,934	-2,608	-1.6
2017-18	1,64,066	1,60,752	-3,314	-2.0
2018-19	1,77,022	1,75,528	-1,494	-0.8
2019-20	1,83,804	1,82,533	-1,271	-0.7

7. STRUCTURE OF POWER SYSTEM

The transmission system often termed as the backbone of the electrical network. In general, an electric power is generated at a voltage level of 11KV. To reduce the transmission line losses, the generated voltage are stepped up the in the range of 11KV/220KV. For a very long distance of over 600 Km transmission , AC transmission is preferred. In sub transmission system, the transmission voltages reduced in the range of 220KV/33KV. Large industrial consumers are directly supplied from the sub- transmission system. In small power systems, the sub- transmission level may coincide with the distribution level. The sub-transmission system may also receive power from any generator bus.

The distribution system represents the final stage in the transfer of power to the consumers. The transmission voltages are further stepped down to the range of 33KV/6.6KV. The distribution system is further classified into primary distribution and secondary distribution. The high-tension consumers are termed as primary distributors and consume energy between 6.6KV/400Vor 230V. Fig-2 represents the Structure of the Power System.

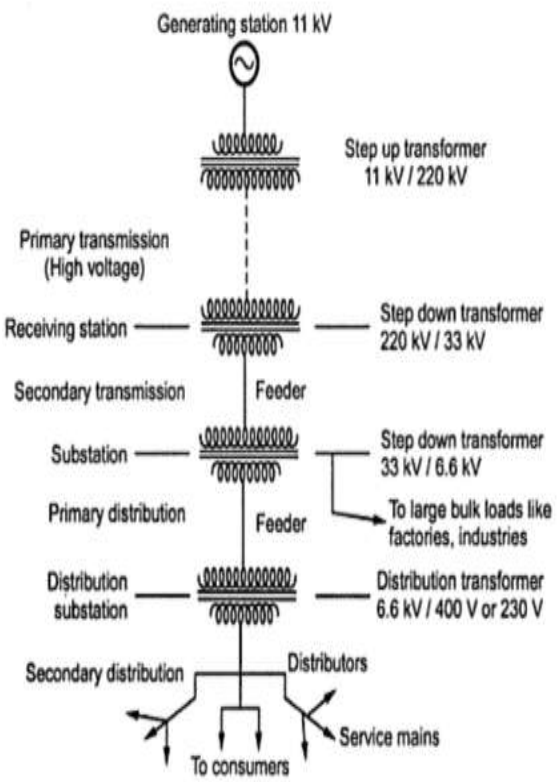

Fig.2. STRUCTURE OF THE POWER SYSTEM

7.1 Power Quality Description

Power quality refers to the ability of electrical equipment to consume the energy being supply to it. A number of power quality issues including electrical harmonics, poor power factor, voltage instability and imbalance impact on the efficiency of electrical equipment. This has a number of consequences including:

- Higher energy usage and costs
- Higher maintenance costs
- Equipment instability and failure

Energy conservation and management is an important consideration for any industry and business, and it is assessed as part of any energy management strategy.

7.2 Overview of Power System Operation and Control

In any power system, the electric energy is generated at one place and transmitted over a long distance to supply the consumers through distribution systems. To meet the variable load, all the generations in an area are interconnected together to form a grid and this leads to the formation of national-level grid. The advantages of interconnection are:

- It enables getting power from the neighboring area during the unexpected turn of events such as a sudden increase in load or loss of generation.
- It reduces reserve generation capacity. This interconnection makes the operation of the entire system very sensitive to the operating conditions.

For the satisfactory operation of the interconnected system, the following requirements are to be met:

- The system must be able to meet the load demand
- The system should supply energy with minimum cost
- Supply 'quality' of power to the consumers

The 'quality' in the sense, the frequency and voltage are to maintained constant throughout the system and reliability of the supply is to be maintained.

7.3 Why Constant Voltage?

The performance of the electrical apparatus is affected by the variable voltage supply

- When the electric motors fed with over-voltage, it will tend to run on over speed resulting vibration and mechanical damage
- Over- voltage may also cause insulation failure
- For a specified power rating, the lower voltage results in more current this will lead to heating problems
- The voltage variation must be limited to + or – 5% from the specified value

7.4 Why Constant Frequency?

- Speed of AC motors proportional to the frequency
- Turbine blades are designed to operate in a narrow band of frequencies. Any frequency deviation will cause a change in speed and it will lead to mechanical damage
- For synchronization, frequency of the system is to be maintained constant.
- A change in frequency will cause the change in impedance of the electric circuit
- The frequency must be kept around the specified value of 50 Hz with a tolerance of +or- 0.5Hz

8. POWER SHORTAGE IN INDIA

At present India is facing a very serious power crisis and the generation of power is insufficient to meet the demand. The demand for electricity power has been increasing in India from agriculture, industries, domestic, etc. There is a gap between demand and generation [(14)]. Oone reason is India's independence the quality of Power generation, transmission and distribution is poor. Due to a shortage of electricity, power cuts are common throughout India and this has affected our economic growth rate.

9. CONCLUSION

The government is making efforts to increase investment in renewable energy. The year 2018 National Electricity Plan of 2018 states that the country does not need more non-renewable power plants up to 2027 [(15)]. In India, the commissioning of 50,000 MW coal-based power plants under construction. An addition of 275,000 MW renewable power capacities is also under commission. The Indian government should take a number of serious steps to achieve a good capacity in renewable energy by 2022 which includes solar and wind.

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