Review of Power Sector Growth in India

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Abstract- Power is a fundamental requirement for all of our life phases. It is the essential infrastructure on which the socio-economic development of the country depends. The financial growth of the country and its global competitiveness pivots on the availability of reliable and quality power at the competitive rates. The power demand in India is enormous and is growing steadily. India is gifted with a wealth of rich natural resources and sources of energy. Power generation resources are erratically dispersed across the country. This paper gives an overview about various sources of power generation, power installed capacity of different states across the India and growth of power sector in India.

Keywords – Distribution generation systems, Renewable, Non renewable resources

I. INTRODUCTION

India is the world's fifth largest electricity generator with total installed capacity of 255681.46 MW. Out of this, 94753.20 MW is from state owned utilities, 91502.99 MW is from privately owned utilities and 69425.27 MW is from central owned utilities. The rate of investment from private players is considerable which shows an encouraging environment for the electricity sector.

India's energy demand has been growing rapidly by industrial growth as well as a rise in household consumption in the last two decades. India derives most of its electricity from fossil fuels; primarily from coal (India has 154170.89 MW of capacity on coal which is 60% of total capacity). India also derive considerable amount of electricity from hydro power sources. Currently, India has total 178341.89 MW of installed capacity on thermal, 40867.43MW of installed capacity on hydro, 31692.14 MW of installed capacity on Renewable Energy Sources (RES) and 4780 MW of installed capacity on nuclear energy. Thermal sources contribute nearly 70 % in the total capacity. The graphical representation of Indian power sector segregation as on December 2014 is presented in fig.1

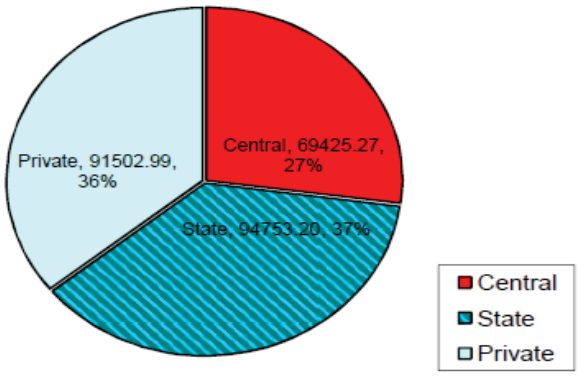

Fig.1 Segregation of Power Utilities

The rest of the paper is organized as follows. India Power Generation Scenario is explained in section II. Growth Of India Power Sectors are presented in section III. Concluding remarks are given in section IV.

II. INDIA POWER GENERATION SCENARIO

Power generation in india broadly classified into two types based on the fuel source as renewable or non-renewable.

A. *Non-renewable* resources can generally be separated into two main categories; fossil fuels and nuclear fuels.

Fossil Fuels: Over 70% of the India's electrical energy is generated by steam turbine generators burning fossil fuels as their source of energy and large scale fossil fuelled plants provide most of the India's base load generating capacity. There are three major forms of fossil fuels: coal, oil and natural gas. Fossil fuelled plants use either coal (86%), oil (2%) or gas (12%) in purpose designed combustion chambers to raise steam. Fossil fuelled power plant installed in India in various regions are given in below bar chart with capacity in fig.2

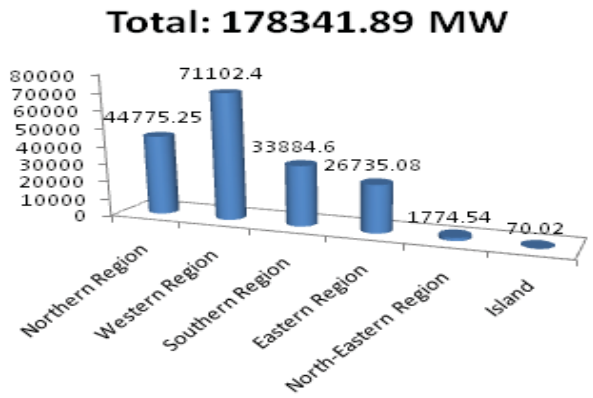

Fig.2 Installed fossil fuel power plant in Various region

Nuclear fuels: Nuclear power plants do not burn any fuel. Instead, they use uranium fuel, consisting of solid ceramic pellets, to produce electricity through a process called fission. Power generation by nuclear fuel has been growing rapidly in the recent years. Nuclear power plants contribute around 2% of the total installed capacity in India. Nuclear power plants installed in India in various regions are given in below bar chart with their generating capacity.

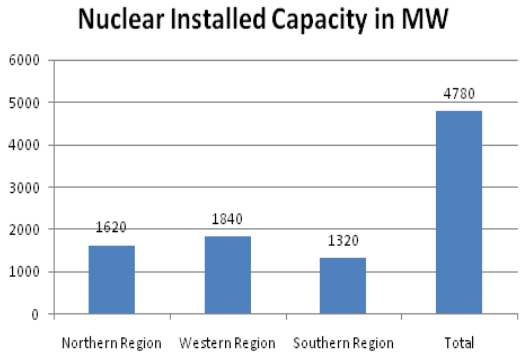

Fig.3 Installed Nuclear power plant in Various region

B. *Renewable energy source (RES)* plays a vital role in power generation. India fulfills its power demand by various renewable energy sources such as solar energy, wind energy ,Small hydro energy, Biomass energy etc., As per CEA report from December 2014, 31692.14 MW (12% of Total power generation Capacity) power generated in all over India by Renewable energy source (RES).

Wind Power:

Wind power describes the process by which the wind is used to generate mechanical power. This mechanical power can be used for electricity generation. A total capacity of 22,465 MW has been established up to December, 2014 in India, mainly in Tamil Nadu, Andhra Pradesh, Gujarat, Karnataka and Maharashtra. Wind electric generators of unit sizes between 225 kW and 2.1 MW have been deployed across the India. India now ranks 5th in the world after USA, China, Germany and Spain in grid connected wind power installations. A total power of over 179 billions units of electricity have been fed to the State Electricity Grids up to March, 2014. The below table gives installed capacity in various states from march'09 to march 2014 in Table-1

Table-1. Increase in Installed capacity of Wind power in different states

Installed Capacity per state (MW)						
State	**Mar-14**	**Mar-13**	**Mar-12**	**Mar-11**	**Mar-10**	**Mar-09**
Tamil Nadu	7275.68	7,162.18	6,987.60	5904.4	4907	4304.5
Karnataka	2323.85	2,135.15	1,933.50	1730	1473	1327.4
Maharashtra	4064.95	3,021.85	2,733.30	2310.8	2078	1938.9
Rajasthan	2783.45	2,684.65	2,070.70	1524.8	1088	738.4
Andhra Pradesh	783.35	447.65	245.5	200.2	236	122.5
Madhya Pradesh	423.4	386	376.4	275.5	229	212.8
Kerala	35.1	35.1	35.1	32.8	28	27
Gujarat	3447.28	3,174.58	2,966.30	2175.5	1864	1566.5
Others	4.3	4.3	3.2	0	4	1.1
Total	**21141.4**	**19,051.50**	**17365**	**14158**	**11807**	**10242**

Note: Source from http://www.inwea.org/

Solar:

Solar energy can be harnessed to supply thermal as well as electrical energy. India is endowed with rich solar energy resource. India has received an average intensity of solar radiation of 200 MW/km square (megawatt per kilometre square). Within geographical area of 3.287 million km square, this amounts to 657.4 million MW. The energy collected by 1 m square of a solar collector in a day is approximately equal to that released by burning 1 kg of coal or 1/2 litre of kerosene.

Solar energy technologies consists of

- solar thermal technologies, which utilize sun's thermal energy and
- solar photovoltaic technology, which convert solar energy directly in to electricity.

Table-2. Installed capacity in various states up to march 2013

States	Installed Capacity (MW)
Andhra Pradesh	23.15
Arunachal Pradesh	0.025
Chhattisgarh	4
Delhi	2.525
Goa & UT	1.685
Gujarat	824.09
Haryana	7.8
Jharkhand	16
Karnataka	14
Kerela	0.025
Madhya Pradesh	11.75
Maharashtra	34.5
Odisha	13
Punjab	9.325
Rajasthan	442.25

Tamil Nadu	17.055
Uttarakhand	5.05
Uttar Pradesh	12.375
West Bengal	2
Total	**1440.605**
Note : The data is compiled on the basis of information obtained from IREDA, NVVN, State Agencies and Project Developers	

Small Hydro Power:

Hydropower represents use of water resources towards inflation free energy due to absence of fuel cost with mature technology characterized by highest prime moving efficiency and Spectacular operational flexibility. Hydro power projects are generally categorized in two segments i.e. small hydro and large hydro. While Ministry of Power, Government of India deals with large hydro power projects and Ministry of New and Renewable Energy (MNRE) deals with small hydro development . In India, hydro projects up to 25 MW station capacity have been categorized as SHP projects. The potential of SHP projects is estimated at about 20,000 MW. Of this, 6,474 potential sites with an aggregate capacity of 19,749 MW have been acknowledged. Out of the total power generation installed capacity in India of 2,23,868 MW (March, 2013), hydro power contributes about 17.5 per cent of the total capacity i.e. 39,491 MW. A capacity addition of 88,000 MW is predicted from different conventional sources during 2012-2017 in the 12th Plan, which contains 10,897 MW from large hydro projects. In addition to this, a capacity addition of 30,000 MW is predicted from renewable with 2,100 MW from small hydro power upto 25 MW station capacity. The below table represents state wise capacity of SHP projects as on March 2014

Table.3- State wise capacity of SHP projects as on March 2014

STATE WISE NUMBERS AND AGGREGATE CAPACITY OF SHP PROJECTS (UPTO 25 MW) POTENTIAL, INSTALLED & UNDER IMPLEMENTATION (as on31.03.2014)						
State	**Potential**		**Projects Installed**		**Projects under Implementation**	
	Nos	**Total Capacity (MW)**	**Nos**	**Capacity (MW)**	**Nos**	**Capacity (MW)**
Andhra Pradesh	387	978.4	68	221.03	13	32.04
Arunachal Pradesh	677	1341.38	149	103.905	44	22.23
Assam	119	238.69	6	34.11	3	12
Bihar	93	223.05	29	70.7	5	17.7
Chattisgarh	200	1107.15	9	52	4	115.25
Goa	6	6.5	1	0.05	-	-
Gujarat	292	201.97	5	15.6	-	-
Haryana	33	110.05	7	70.1	2	3.35
Himachal Pradesh	531	2397.91	158	638.905	33	76.2
J&K	245	1430.67	37	147.53	7	17.65
Jharkhand	103	208.95	6	4.05	8	34.85
Karnataka	834	4141.12	147	1031.66	23	173.09
Kerala	245	704.1	25	158.42	11	52.75
Madhya Pradesh	299	820.44	11	86.16	3	4.9
Maharashtra	274	794.33	58	327.425	9	43.7
Manipur	114	109.13	8	5.45	3	2.75
Meghalaya	97	230.05	4	31.03	3	1.7
Mizoram	72	168.9	18	36.47	1	0.5

Nagaland	99	196.98	11	29.67	3	3.2
Orissa	222	295.47	10	64.625	4	3.6
Punjab	259	441.38	47	156.2	11	19.45
Rajasthan	66	57.17	10	23.85	-	-
Sikkim	88	266.64	17	52.11	1	0.2
Tamil Nadu	197	659.51	21	123.05	-	-
Tripura	13	46.86	3	16.01	-	-
Uttar Pradesh	251	460.75	9	25.1	-	-
Uttarakhand	448	1707.87	99	174.82	46	174.04
West Bengal	203	396.11	23	98.4	17	84.25
A&N Islands	7	7.91	1	5.25	-	-
Total	**6474**	**19749.44**	**997**	**3803.68**	**254**	**895.4**
* Soucre from mnre.gov.in						

Bio energy:

Bio energy is renewable energy made available from materials obtained from biological sources. Biomass is any one of the organic material which has stored sunlight in the form of chemical energy. As a fuel it may include straw, manure, wood, wood waste, sugarcane, and many other byproducts from a variety of agricultural processes. About 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs. Biomass materials used for power generation include bagasse, straw, cotton stalk, coconut shells, rice husk, soya husk, jute wastes, groundnut shells, de-oiled cakes, coffee waste, saw dust etc. Currently in India, availability of biomass is estimated at about 500 million metric tons per year. Studies sponsored by the Ministry has estimated surplus biomass availability at about 120 – 150 million metric tons per annum covering agricultural and forestry residues corresponding to a potential of about 18,000 MW. The Ministry has been implementing biomass power/co-generation programme since middle of nineties. A total of 288 biomass power and cogeneration projects aggregating to 2665 MW capacity have been installed in the country for feeding power to the grid consisting of 130 biomass power projects aggregating to 999 MW and 158 bagasse cogeneration projects in sugar mills with surplus capacity aggregating to 1666 MW. In addition, around 30 biomass power projects aggregating to about 350 MW are under various stages of implementation. Around 70 Cogeneration projects are under implementation with surplus capacity aggregating to 800 MW. States which have taken leadership position in implementation of bagasse cogeneration projects are Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Uttar Pradesh. The leading States for biomass power projects are Maharashtra, Madhya Pradesh, Andhra Pradesh, Chattisgarh, Gujarat and Tamil Nadu.

II. GROWTH OF INDIA POWER SECTOR

Growth of Power Sector infrastructure in India since its Independence has been noteworthy making India the third largest producer of electricity in Asia. Generating capacity has grown manifold from 1,362 MW in 1947 to 255681 MW (as on December 2014). The below gives the growth of power generation between 6th plan to 11th plan (as on December 2014)

Table.4 – Growth in India's power Sector

Plan / Year	Thermal				Nuclear	Hydro	RES (MNRE)	Total
	Coal	Gas	Diesel	Total				
End of 6th Plan	26310.83	541.5	177.37	27029.7	1095	14460	0	42584.7
End of 7th Plan	41237.48	2343	165.09	43745.57	1565	18307.6	18.14	63636.3
End of 8th Plan	54154.48	6561.9	293.9	61010.28	2225	21658.1	902.01	85795.4
End of 9th Plan	62130.88	11163.1	1134.83	74428.81	2720	26268.8	1628.39	105046
End of 10th Plan	71121.38	13691.7	1201.75	86014.84	3900	34653.8	7760.6	132329
End of 11th Plan	112022.4	18381.1	1199.75	131603.2	4780	38990.4	24503.5	199877
End of December '14	154170.9	22971.3	1199.75	178341.9	4780	40867.4	31692.1	255682

All India generating installed capacity in MW as on 31.12.12014 is shown in below pie chart

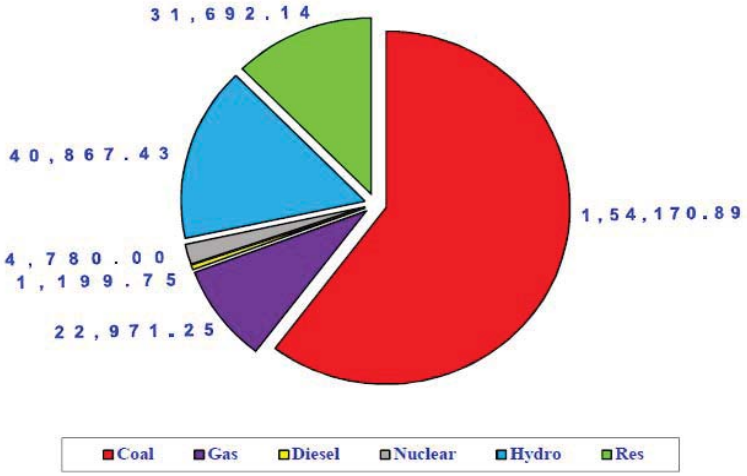

Fig.4 Installed capacity of various sources of power generation across India

IV.CONCLUSION

From the analysis, it is concluded that power generation growth in India is drastically increasing every year. However, as growth in the Industrial sector picks up, the power demand is also expected to increase at a faster pace. The power demand will be increased by 4 to 5 times of the currently installed capacity by 2030.The power generation and demand gap is to be bridged by revising the energy policy. Energy policy should be reliable to meet the demand for energy services of all sectors including the lifeline energy needs of susceptible households in all parts of the Indian country with secure, clean and convenient energy at the economical price. This must be done in an environmentally sustainable, technically efficient and economically feasible manner using different fuels and forms of energy from conventional and non-conventional sources, as well as new emerging energy sources to ensure supply at all times with a prescribed confidence level. Energy policy is to provide energy security to all.

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