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ENERGY SECTOR IN INDIA: WITH SPECIAL REFERENCE TO SOLAR ELECTRICITY SECTOR

VIVEK TRIPATHI

D. Phil. Scholar, Nehru Gram Bharati

ABSTRACT

The demand for electricity in the country has been growing at a rapid rate and is expected to grow further in the years to come. The Indian power sector is one of the most diversified in the world, compared to many developing countries where crude oil and natural gas and renewable (solar power) play a major role.

Keywords: Country, Energy sector, Electricity production, Consumer, Renewable Energy

INTRODUCTION

Energy in India describes energy and electricity production, consumption and import in India. Energy policy of India describes the policies and strategies of India for achieving sustainable energy security to its people. Electricity sector in India is the main article of electricity in India. The Ministry of NE and Renewable Energy provides data regarding progress in the non-conventional energy sector.

Since 2013, total primary energy consumption in India has been the third highest in the world after China and the United States. India is the second top coal consumer in the year 2015 after China. India ranks third in oil consumption with 195.5 million tons in 2015 after the United States and China. India is net energy importer to meet nearly 45% of its total primary energy.

Table 1.

Energy in India

	Population million	Prim. energy TWh	Production TWh	Import TWh	Electricity TWh	CO_2-emission Mt

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2004	1,080	6,662	5,430	1,230	494	1,103
2007	1,123	6,919	5,244	1,745	610	1,324
2008	1,140	7, 222	5,446	1,836	645	1,428
2009	1,155	7,860	5,844	2,116	690	1,586
2010	1,171	8,056	6,032	2,110	755	1,626
2012	1,241	8,716	6,291	2,483	835	1,745
2012R	1,237	9,166	6,333	2,829	940	1,954
2013	1,250	9,018	6,086	2,962	979	1,869
Change 2004–10	8.4%	20.9%	11.1%	72%	53%	47%

Mtoe = 11.63 TWh, Prim. energy includes energy losses that are 2/3 for nuclear power[6]

2012R = CO2 calculation criteria changed, numbers updated

Source: CEA Reports of various years.

Coal:

India was the third top coal producer in 2015 with 283.9 Mtoe (7.4% global share). Nearly 80% of total electricity generated (utility and captive) in India is from coal. According to Greenpeace the largest coal belt in India is at Jharia. Before coal mining Jharia had forests inhabited by tribes. In 1971 the coal mines were nationalised. Bharat Coking Coal Limited (BCCL) took over Jharia coal mines.

India accounts for the world's greatest concentration of coal seam fires. Mine area suffers from pollution of air, water and land.

Oil and Natural Gas:

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India was the fourth top net crude oil (including crude oil products) importer of 163 Mt in 2015. India has 4.561 million barrels per day (5.7% of the world) crude oil refinery capacity which is ranked 4th globally.

Liquified Petrolium Gas:

Nearly 8.9 million tons Liquefied Petroleum Gas (LPG) was consumed during April to September 2016 (six months) in domestic sector mainly for cooking. The number of domestic connections are 215 million (one connection for six people) with a circulation of more than 250 million LPG cylinders whose net aggregate length would form a 125,000 km long pipe line which is more than the length of total railway track laid in India. Most of the LPG requirement is imported. Piped city gas supply in India is not yet developed on major scale.

Biomass and charcoal:

Biomass is a renewable energy source and its use for energy generation is carbon-neutral fuel. It is carbon neutral because it would also release global warming green house gasses like methane and carbon dioxide when it is left to degenerate without using as energy source. Presently, only 40% of house holds in India use biomass and charcoal for cooking purpose as LPG use for cooking purpose is rising rapidly. In addition biomass is also used marginally in commercial cooking, electricity generation, process industries, etc. The total biomass use in India is nearly 177 Mtoe in the year 2013. Substantial surplus crop residue is also burnt in agriculture fields for clearing the land for the next crop. Nearly 750 million tons of non edible (by cattle) biomass is available annually in India which can be put to use for higher value addition.

Huge quantity of imported coal is being used in pulverised coal-fired power stations. Raw biomass is not suitable for use in the pulverised coal mills as they are difficult to grind into fine powder due to caking problem. However 100% biomass can be fired after Torrefaction in the pulverised coal mills for replacing imported coal. Torrefied biomass plants can be integrated with existing pulverised coal-fired power stations using the available hot flue gas as heat source. Cofiring dry biomass up to 20% heat input with coal is also possible directly in pulverised coal-fired power stations without facing caking problem. North west and southern regions can replace imported coal use with biomass where surplus agriculture/crop residue biomass is burnt in the fields causing pollution problems. As traditional use of biomass is being replaced by LPG at faster pace, biomass burning in agriculture fields would become major source for causing higher level air pollution.

Bio gas which is mainly methane/natural gas can also be used for generating protein rich cattle, poultry and fish feed in villages economically by cultivating Methylococcus capsulatusbacteria culture with tiny land and water foot print. The carbon dioxide gas produced as by product from

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these plants can be put to use in cheaper production of algae oilfrom algae particularly in tropical countries like India which can displace the prime position of crude oil in near future. Union government is implementing many schemes to utilise productively the agro waste or biomass in rural areas to uplift rural economy and job potential.

Electricity:

India was the third top electricity producer in the world 1272 TWh in FY 2014–15. By 2013, India became the world's third largest producer of electricity with 4.8% global share, surpassing Japan and Russia. India ranks 7th globally in hydropower generation during the year 2015. India has 60 GW installed capacity Renewable energy, bidding process for the further 115 GW will be completed by the end of FY 2019-20 to achieve 175 GW total installed capacity, and the centre govt has set up US$350 million fund to finance the solar projects (January 2018).

The total installed utility power generation capacity as on 30 April 2017 with sector wise & type wise break up is as given below.

Table 2.

Sector	Thermal (MW)				Nuclear (MW)	Renewable (MW)		Total (MW)	%
	Coal	Gas	Diesel	Sub-Total Thermal		Hydro	Other Renewable		
Central	55,245.00	7,490.83	0.00	62,735.83	6,780.00	11,651.42	0.00	81,167.25	25
State	65,145.50	7,257.95	363.93	72,767.38	0.00	29,703.00	1,963.80	104,447.28	32
Private	74,012.38	10,580.60	473.70	85,066.68	0.00	3,240.00	55,283.33	143,590.01	43
All India	194,402.88	25,329.38	837.63	220,569.88	6,780.00	44,594.42	57,260.23	329,204.53	100

Source: CEA Reports

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Captive power:

The installed captive power generation capacity (above 1 MW capacity) in the industries is 50,289 MW as on 31 March 2017. Another 75,000 MW capacity diesel power generation sets (excluding sets of size above 1 MW and below 100 kVA) are also installed in the country.[37][38] In addition, there are innumerable DG sets of capacity less than 100 kVA to cater to emergency power needs during the power outages in all sectors such as industrial, commercial, domestic and agriculture.

Table 3.

Captive Power Generation

Source	Captive Power Capacity (MW)	Share
Coal	29,888	59.43%
Hydroelectricity	54	0.11%
Renewable energy source	Included in 'Oil'	
Natural Gas	6,061	12.05%
Oil	14,285	28.41%
Total	**50,289**	**100.00%**

Source: CEA Reports.

Electricity Generation:

India's electricity generation from 1950 to 1985 were very low when compared to developed nations. Since 1990, India has recorded faster growth in electricity generation. India's electricity generation has increased from 179 TW-hr in 1985 to 1,057 TW-hr in 2012. Power generation by coal fired plants and non conventional renewable energy sources (RES) has mainly contributed

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to the growth in the total electricity generation, whereas the contribution from natural gas, oil and hydro plants has decreased in the last five years (2012-2017). The gross utility electricity generation (excluding imports from Bhutan) is 1,236 billion kWh during the year 2016-17 against the corresponding actual generation of 1,168 billion Kwh during the year 2015-16 with 5.81% annual growth. The CEA generation data is nearly 5% more than the NLDC data which is based on prompt data on daily basis.

Table 4.

Yearly gross electricity generation by source (GWh)

Year	Fossil Fuel			Nuclear	Hydro*	Sub total	RES						Utility and Captive Power			
	Coal	Oil	Gas				Mini hydro	Solar	Wind	Biomass	Other	Sub total	Utility	Captive	Misc	Total
2011-12	612,497	2,649	93,281	32,286	130,511	871,224	na	na	na	na	na	51,226	922,451	134,387	na	1,056,838
2012-13	691,341	2,449	66,664	32,866	113,720	907,040	na	na	na	na	na	57,449	964,489	144,009	na	1,108,498
2013-14	746,087	1,868	44,522	34,228	134,847	961,552	na	3,350	na	na	na	59,615	1,021,167	156,643	na	1,177,810
2014	835,	1,4	41,	36,1	129,	1,043,66	8,0	4,6	28,	14,	41	61,	1,105,44	166,	na	1,271,87

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-15	838	07	075	02	244	6	60	00	214	944	4	780	6	426		2
2015-16	896,260	406	47,122	37,413	121,377	1,102,578	8,355	7,450	28,604	16,681	269	65,781	1,168,359	183,611	na	1,351,970
2016-17	944,861	275	49,094	37,916	122,313	1,154,523	7,673	12,086	46,011	14,159	213	81,869	1,236,392	197,000	na	1,433,392

Source: CEA Reports.

Solar Power:

India is endowed with vast solar energy. The solar radiation of about 5,000 trillion kWh per year is incident over its land mass with average daily solar power potential of 0.25 kWh per m^2 of used land area with the available commercially proven technologies. As of 31 January 2017, the installed capacity was 9 GW meeting 1% of the utility electricity generation. New solar installations in India is expected to be 4.8 GW in 2016-17 with nearly 21 GW development in pipeline.

Installation of solar power plants require nearly 2.4 hectares (0.024 km^2) land per MW capacity which is similar to coal-fired power plants when life cycle coal mining, consumptive water storage & ash disposal areas are also accounted and hydro power plants when submergence area of water reservoir is also accounted. 1.33 million MW capacity solar plants can be installed in India on its 1% land (32,000 square km). There are vast tracts of land suitable for solar power in all parts of India exceeding 8% of its total area which are unproductive barren and devoid of vegetation. Part of waste lands (32,000 square km) when installed with solar power plants can produce 2,000 billion Kwh of electricity (two times the total generation in the year 2013-14) with land annual productivity/yield of ₹1.0 million (US$15,000) per acre (at 4 Rs/kWh price) which is at par with many industrial areas and many times more than the best productive irrigated agriculture lands. Moreover, these solar power plants are not dependent on supply of any raw material and are self productive. There is unlimited scope for solar electricity to replace all fossil fuel energy requirements (natural gas, coal, lignite, nuclear fuels and crude oil) if all the marginally productive lands are occupied by solar power plants in future. The solar power

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potential of India can meet perennially to cater per capita energy consumption at par with USA/Japan for the peak population in its demographic transition.

Indian solar PV power tariff has fallen to 2.44 (3.7¢ US) per kWh in May 2017 which is lower than any other type of power generation in India. In the year 2017, the levelized tariff in US$ for solar electricity has fallen to 1.79 cents/kWh which is far cheaper than the fuel cost incurred by coal based power plants in India.

Solar thermal power plants with thermal storage are emerging as cheaper (US 5 /kWh) and clean load following power plants compared to fossil fuel power plants. They can cater the load/ demand round the clock perfectly and work as base load power plants also when the extracted solar energy is found excess in a day. Proper mix of solar thermal and solar PV can fully match the load fluctuations without the support of costly battery storage or costly non solar power plants with dispatchability and reliability.

Land acquisition is a challenge to solar farm projects in India. Some state governments are exploring means to address land availability through innovation; for example, by exploring means to deploy solar capacity above their extensive irrigation canal projects, thereby harvesting solar energy while reducing the loss of irrigation water by solar evaporation. The state of Gujarat was first to implement the Canal Solar Power Project, to use 19,000 km (12,000 mi) long network of Narmada canals across the state for setting up solar panels to generate electricity. It was the first ever such project in India.

CONCLUSION

Ever since Thomas Edison fired up his power station in Lower Manhattan, the world has become progressively more electrified. In the developed part of the world it is taken for granted and yet the world cannot operate without it. For developing countries, shortages of electricity take their toll on people's lives and on economic growth. India one of the world's biggest green house gas emitter after US and China, when emphasizes on solar and wind power is also expected to strengthen the country's standing at global climate change negotiations. Meeting future electricity needs means challenging and sometimes wrenching decisions about the choice of fuel required to keep the lights on and power flowing.

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