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Energy Crisis and Recent Technological Development in India

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Abstract
Now-a-days demand of the electricity is increasing. India has struggled to resolve its energy shortage problems for decades. As the country is now facing an exotic energy crisis, the drive to find effective long-term energy solutions is stronger now than ever before. Renewable energy resources such as wind and solar energy are abundant in India. It is environmental friendly and also low cost. Renewable energy is only the root causes of this demand. The present situation of the electricity production and its consumption in the country were discussed. The solar energy generation potential of India in different sectors to produce energy is viewed. Energy crisis of solar energy has been reporting in MNRE (Ministry of New and Renewable Energy). In our nation, we are using some types of solar scheme. Under that scheme solar park and solar rooftop are popularly in practice to produce solar energy. The importance of utilization of solar energy resources for the production of electric power. The production rate is high in Tamil Nadu and Rajasthan, but low in Meghalaya and Puducherry. These renewable energy resources can play an effective and also considerable role in contributing toward energy security of the country. Developments of solar technology in before and after independent were presented and the future developments were discussed. Some prediction is made on the basis of preliminary observations. The flow chart of an estimated forecast of demand and supply of electricity for the next ten years is also projected in this paper.
Keywords: Renewable Energy, Solar Energy, Power Production, total installation, Renewable energy sources (RES), Ministry of New and Renewable Energy (MNRE), solar technology

1. Introduction

Solar energy is the most abundant & cleanest energy resource on earth. India is the fourth biggest energy consumption after China, USA and Russia. In the year 2013, the total primary energy consumption from crude oil (29.45%), natural gas (7.7%), coal (54.5%), nuclear energy (1.26%), hydroelectricity (5.0%), wind power, biomass electricity and solar power is 595 Mtoe (Million Tonnes of Oil Equivalent). (Ashish kumar 2015). In the year 2013, India's net imports are nearly 144.3 million tons of crude oil, 16 Mtoe of Liquefied Natural Gas (LNG) and 95 Mtoe coal totaling to 255.3 Mtoe of primary energy which is equal to 42.9% of total primary energy consumption. About 70% of India's electricity generation capacity is from fossil fuels. India is largely dependent on fossil fuel imports to meet its energy demands - by 2030; India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption. (Dongrong et al. 2015).

To overcome the problems associated with the generation of electricity from fossil fuels, renewable energy sources can participate in the energy mix. In the near future, due to the global population growth and industrialization, the demand for electric energy is expected to increase rapidly. World's net electricity generation is expected to rise from 23.5 trillion KWh in 2015 to 26.6 trillion KWh in2020 and 36.2 trillion KWh in 2035. (N.D.Mani et al. 2016).

Solar energy can be used mainly in three ways one is a direct conversion of sunlight into electricity through PV cells, the two others being concentrating solar power (CSP) and solar thermal collectors for heating and cooling (SHC). India is endowed with abundant solar energy, which is capable of producing 5,000 trillion KWh of clean energy. The country is blessed with around 300 sunny days in a year and solar insolation of 4-7 KWh/Sq.m/day. If this energy is harnessed efficiently, it can easily reduce our energy deficit scenario and that too with no carbon emission. Solar energy will have an enormous role to play in meeting India’s energy demand in near future. (Shri Santosh D 2016).

2. Solar Power in India and Power Generation capacity in India

308.83 GW as on 30 Nov 2016 is the installed capacity of utility power sector. Renewable power plants constituted 28.9% of total installed capacity. (https://en.wikipedia.org/wiki/Electricity_sector_in_India). The gross electricity generated by utilities is 1106 TWh which includes auxiliary power consumption of power generating stations. The installed capacity of captive power plants in industries (1 MW and above) is 166 TWh (Major Singh 2016). All India per capita consumption of Electricity is nearly 1010 KWh during the financial year 2014-15 (Major Singh 2016). The data of total installed power generation capacity of India by the ministry of power in Government of India (GOI) as on 14 December 2016 were shown in Table 1. and also shown in

Figure 1. and the sector-wise installed power were also tabulated in Table 2. (http://powermin.nic.in/en/content /power-sector-glance-all-india).

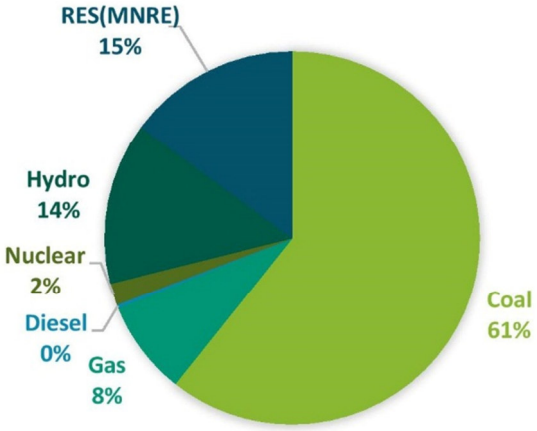

Figure 1. Total Installed Power Generation Capacity of India (as on 14-Dec-2016 ministry of power GOI)

Table 1. Total Installed Power Generation Capacity of India

Fuel	MW (31 Dec 2015)	MW (30 Aug 2016)	MW (14 Dec 2016)
Coal	1775238(64%)	186593(61.12%)	187,803 (60.8%)
Gas	24509(8%)	25057(8.18%)	25282 (8.2%)
Diesel	994(0.345%)	919(0.30%)	919 (0.30%)
Nuclear	5780(2%)	5780(1.89%)	5780 (1.9%)
Hydro	42663(14%)	42968(14.07%)	43133 (14.0%)
RES(MNRE)	38822(12%)	44237(14.44%)	45917 (14.9%)
Total	**288005**	**305554**	**308,834**

Table 2. Total Installed Power Generation Capacity of India

Sector	MW (31 Dec 2015)	MW (30 Aug 2015)	MW (14 Dec 2016)
State Sector	97951 (34%)	101946 (33%)	101,472 (33.1%)
Central Sector	74807 (26%)	76312 (25%)	76,182 (24.7%)
Private Sector	115248 (40%)	127296 (42%)	130,559 (42.3%)
Total	**2,88,005**	**305554**	**308,834**

2.1 Solar Energy

India's solar energy insolation is about 5,000 Trillian KWh/year (i.e. ~600 TW), far more than its current total primary energy consumption (Rachit.S et al 2015,). India's long-term solar potential could be unparalleled in the world because it has the ideal combination of both high solar insolation and a big potential consumer base density (Atul S. A 2016). With a major section of its citizen's still surviving off-rid, India's grid system is considerably underdeveloped. Availability of cheap solar can bring electricity to people, and detour the need of installation of expensive grid lines.

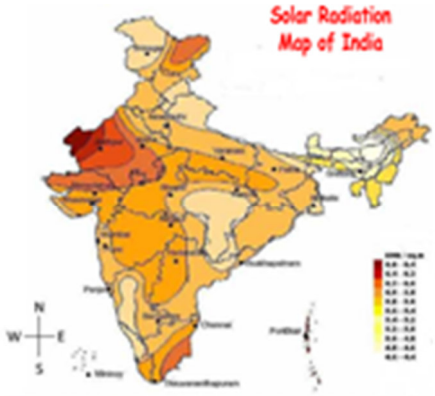

Figure 2. Solar Resource of India (Courtesy)

Solar resources of India according to the solar radiation were shown in Figure 2. 1.33 million MW

capacity solar plants can be installed in India on its 1% land (32,000 sq. km). There are vast tracts of land suitable for solar power in all parts of India exceeding 8% of its total area which is unfertile barren and devoid of vegetation. Part of waste lands (32,000 sq. km) when installed with solar power plants can produce 2000 Billion KWh of electricity (two times the total generation in the year 2013-14) with land productivity/yield of Rs. 1.5 million/acre (Rs. 6/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 units are not dependent on a 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 and crude oil) if all the marginally productive lands are occupied by solar power plants in future. The solar power 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. (Vinod.KG 2015).

2.2 Current Status

India is ranked number one in terms of solar electricity production per watt installed, with an insulation of 1,700 to 1,900 KWh/KW peak. Government-funded solar electricity in India was approximately 6.4 MW/year as of 2005. (Gupta BL et al. 2012). 25.1 MW was added in 2010 and 468.3 MW in 2011. (Major Sing, 20014). As of 31 December 2015, the installed grid-connected solar power capacity is 4,879 MW. (Vikas K et al.2013) and India expects to install an additional 10,000 MW by 2017, and a total of 100,000 MW by 2022. (Amita U 2011). The State wise total installed solar power in India as on 30 September 2016 were tabulated in Table 3. (MNRE Sep 2016). The growth of installed solar power (photovoltaic (PV)) were shown in Figure 4. (MNRE Sep 2016) and their statistical report were shown in Table 4. ("State wise installed solar power capacity" 2016). According to state wise installed solar power in total Installed capacity as on 30.Sep.2016 has reaches 86.26 GW. Tamil Nadu ranked number one position in our nation and also Adani Group launches world's largest solar power plant in Tamil Nadu as shown in Figure 3.

Figure 3. Adani Group launches world's largest solar power plant in Tamil Nadu (Courtesy)

Table 3. State wise installed solar power-Total Installed capacity from Renewable has reach 86.26 GW as on 30.Sep.2016

S. No	State/UT	Total commissioned capacity till 30 Sep 2016 (MW)
1.	Andhra Pradesh	947.05
2.	Arunachal Pradesh	0.27
3.	Chhattisgarh	128.46
4.	Gujarat	1,136.32
5.	Haryana	15.39
6.	Jharkhand	16.19
7.	Karnataka	289.13
8.	Kerala	13..05
9.	Madhya Pradesh	810.37
11.	Odisha	66.92
12.	Punjab	571.20
13.	Rajasthan	1,294.60
14.	Tamil Nadu	1,555.41
15.	Telangana	961.79
16.	Tripura	5.00
17.	Uttar Pradesh	143.50
18.	Uttarahand	41.15
19.	West Bengal	11.77
20.	Andaman &Nicobar	5.10
21.	Delhi	23.87
22.	Lakshadweep	0.75
23.	Pondicherry	0.03
24.	Chandigarh	6.81
25.	Daman & Diu	4.00
26.	Bihar	90.10
27.	Others	102.22
Total		**8626.21**

Table 4. Statistical report for installed solar power in India

Installed PV capacity (in MW)		
YearEnd	**Total Capacity**	**Yearly installation**
2010	161	-
2011	461	300
2012	1,205	744
2013	2,319	1,114
March-2014	2,632	313
March-2015	3,744	1,112
Aug-2015	4,229	485
Nov 2015	4,680	-
Jan-2016	5,130	-
Mar 2016	6,762	-
Sep 2016	8,626	-

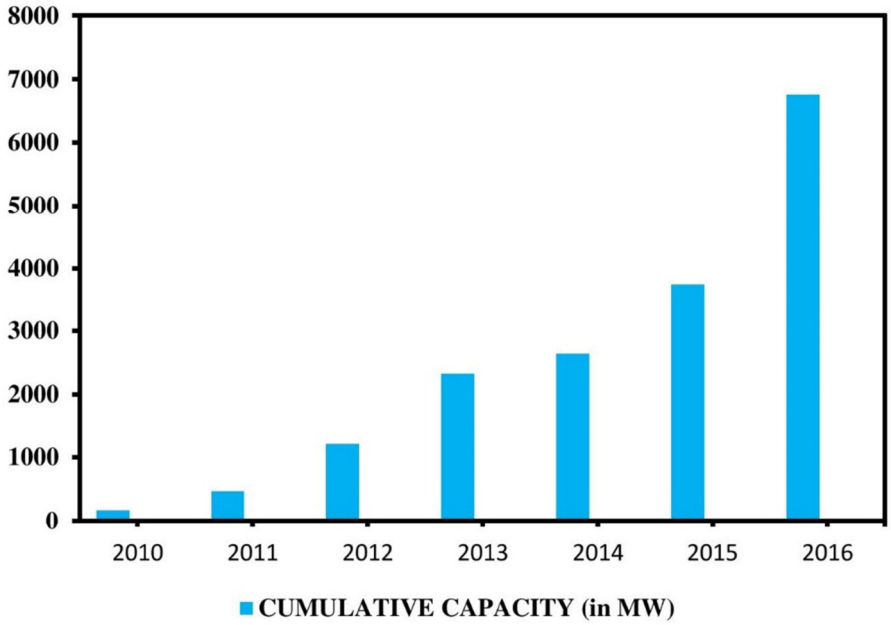

Figure 4. Installed solar PV on 30-Sep-2016

2.3 The electricity consumption and generation forecasts of India as part of the emerging economies

Growth in net electricity consumption is expected to be most rapid among the emerging economies of the world, including India. Emerging economies are projected to more than double their net electricity consumption, from 4,645 billion kilowatt hours in 2002 to 11,554 billion in 2025. The projected growth in net electricity consumption for emerging market economies is driven in large part by gross domestic product (GDP) and population growth assumption. Because of the links between reliable electricity supply, GDP growth, and living standards, many of the nations with emerging economies are attempting to increase access to reliable electricity supply. The world electricity consumption and generation by region 2002 to 2025 were shown in Figure 5. and Figure 6. (http://www.eia.gov/oiaf/archive/ieo05/electricity.html).

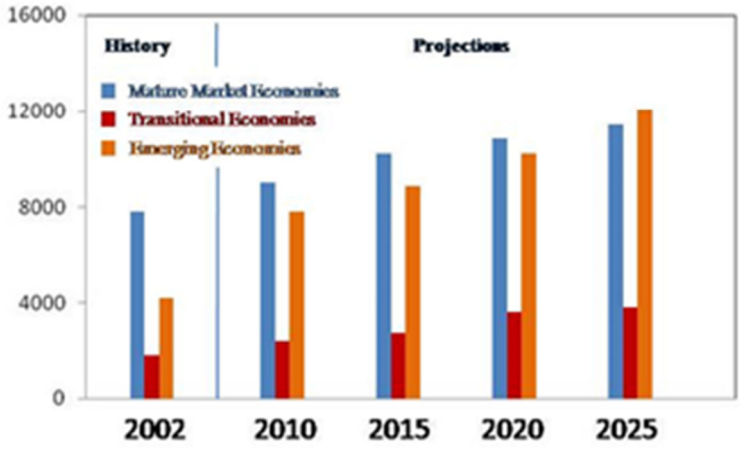

Figure 5. World Net Electricity Consumption by Region, 2002-2025 (Courtesy)

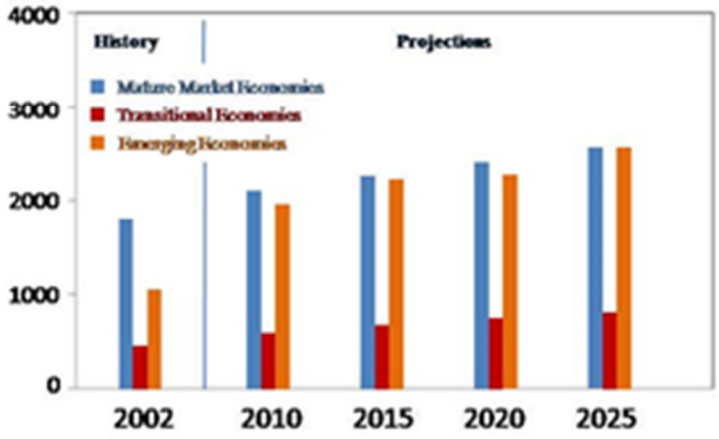

Figure 6. World Electricity Generation Capacity by Region, 2002-2025 (C0urtesy)

2.4 Solar Scheme

To strengthening the presence of renewable energy technologies in India does not lie in any one solution to these challenges. So, a number of approaches have been discussed to address the roadblocks. Solar Park, Rooftop solar is some of the solar scheme mainly available in India.

a. Solar Park: Solar park capacity was highest in Andhra Pradesh and Rajasthan. It has a capacity of 4000 and 3551 MW. State-wise proposed solar park schemes were reported in Table 5. (http://www.seci.gov.in/content/innerpage/statewise-solar-parks.php).
b. *Rooftop Solar:* The commercial and industrial consumer segments are exhibiting strong signs of adopting rooftop solar power at a large scale. The MNRE has recently tasked TERI (The Energy and Resources Institute) to estimate the total potential of rooftop solar power that can be installed at locations and premises of all ministries of the Central government across the country.

Table 5. State-wise proposed solar park schemes

S.No.	State	Capacity (MW)
1.	Andhra Pradesh	4000
2.	Arunachal Pradesh	100
3..	Assam	69
4.	Chhattisgarh	500
5.	Gujarat	700
6.	Haryana	500
7.	Himachal Pradesh	1000
8.	Jammu & Kashmir	100
9.	Karnataka	2000
10.	Kerala	200
11.	Madhya Pradesh	2750
12.	Maharashtra	1500
13.	Meghalaya	20
14.	Nagaland	60
15.	Odisha	1000
16.	Rajasthan	3351
17.	Tamil Nadu	500
18.	Telangana	500
19.	Uttarahand	50
20.	Uttar Pradesh	600
21.	West Bengal	500
21 States and 43 solar parks		**20,000**

2.5 Renewable Power Capacity in India

The increased use of indigenous renewable resources is expected to reduce India's dependence on expensive imported fossil fuels. India has an estimated renewable energy potential of about 900 GW from commercially exploitable sources viz. Wind – 102 GW (at 80-meter mast height) ; Small Hydro – 20 GW; Bio-energy – 25 GW and 750 GW solar power, assuming 3% wasteland. Table 6 shows the installed Grid Interactive Renewable

Power Capacity in India as on November 30, 2016 by Renewable Energy society in Ministry of New and Renewable Energy (RES MNRE). (Physical Progress2016) The target set for the various renewable energy sources for the next three years were tabulated in Table 7. (Press Information Bureau 2016).

Table 6. Installed Grid Interactive Renewable Power Capacity in India as on November 30, 2016 (RES MNRE)

Source	Total Installed Capacity (MW)
Wind Power	28419.40
Solar Power	8874.87
Biomass Power	4932.33
Waste-to-Power	114.08
Hydro Power	4324.85
Total	**46665.53**

Table 7. The target set for the various renewable energy sources for the next three years

Source	2016-17	2017-18	2018-19
Solar Power	12000	15000	16000
Wind	4000	4600	5200
Biomass	500	750	850
SHP	225	100	100
Grand Total	16725*	20450*	22150*

*(Capacities in MW) and SHP – Small Hydro Power

2.5.1 Government support for solar resources

The Government of India has set a target of 175 GW renewable power installed capacity by the end of 2022. This includes 60 GW from wind power, 100 GW from solar power, 10 GW of biomass power and 5 GW from small hydropower.

A target of 16660 MW grid renewable power (wind 4000 MW, solar 12000 MW, small hydro power 250 MW, bio power 400 MW and waste to power 10 MW), has been set for 2016-17. Besides, under an off-grid renewable system, targets of 15 MW eq. waste to energy, 60 MW biomass on bagasse cogeneration, 10 MW biomass gasifiers and 1.0 MW small wind/hybrid systems, 100 MW solar MW small wind/hybrid systems, 100 MW solar photovoltaic systems, 1.0 MW micro hydel and 100,000 nos. family size biogas plants have been set for 2016-17 (http://www.eai.in/ref/ae/sol/policies.html) the ambition target of generating 100 GW of solar power by the year 2021-22 under the National Solar Mission.

Table 8. Government support for solar resources

Year	Total (Rs crore)	Total fund requirement (Rs crore)
2015-16	500	505
2016-17	1125	1136.25
2017-18	1125	1136.25
2018-19	1125	1136.25
2019-20	1125	1136.25
Total	**5000**	**5050**

It is expected to generate 60 GW ground mounted grid connected solar power and 40 GW through roof-top grid interactive solar power to fulfill the 100 GW of solar power. Government approves Rs. 5050 crore funding to push solar projects on 20th January, 2016. The funding will be used for setting up 5,000 MW capacities of grid linked solar power projects. Year-wise scheduled for the total fund requirement of solar resources by the government were tabulated in Table 8. (http://www.eai.in/ref/ae/sol/policies.html). Solar Cells Capacities and Solar Module Capacities in India were shown in Table 9. (Sunil Kumar Gupta, .2016).

Table 9. Solar Cells Capacities and Solar Module Capacities

Solar Cells Capacities			
S. No	Name of Company	Present Status Cell Capacity	
		As on 30-06-2016	As on 30-06-2016
		Installed (In MW)	Operational (In MW)
1	BEL	10	5
2	Baharat Heavy Electricals Limited	10	10
3	Central Electronics Limited	10	0.05
4	Dev Solar	3	3
5	Euro Multi-vision Limited	50	50
6	Indo-solar Ltd	250	200
7	Jupiter Solar Pvt. Ltd	280	280
8	Lanco Solar	0	0
9	Maharishi Solar Technology	10	0
10	Moser Baer Solar Limited	250	100
11	Mundra Solar PV Limited(Adani Group)	0	0
12	Premier Solar Systems Ltd	75	75
13	Solar Semiconductor(Renewsys India)	30	30
14	Surana Solar	120	100
15	Synergy Solar	0	0
16	Tata Power Solar Systems Limited	180	140
17	Udhaya Energy Photovoltaics Pvt Ltd	10	10
18	Waaree Energies Pvt Ltd	0	0
19	Websol Energy System Limited	120	120
20	XL Energy Ltd	60	NA
		1468	1123.05
Solar Module Capacities			
S. No	Name of Company	Present Status Module Capacity	
		As on 30-06-2016	As on 30-06-2016
		Installed (In MW)	Operational (In MW)
1	Access Solar Limited	18	NA
2	Agrawal Solar	40	NA
3	Ajit Solar Pvt. Ltd	35	20
4	Alpex Exports Pvt. Ltd	200	150
5	AMV Energy systems Private Limited	10	NA
6	Andromeda Energy Technologies Pvt. Ltd	30	15
7	Andslite	20	0.75
8	Arion Solar	5	5
9	AVI	15	15
10	BEL	10	10
11	Bharat Heavy Electricals Limited	26	26
12	Blue Bird	0	20
13	Brawn Battery	25	NA
14	Central Electronics Limited	42	3.8
15	Deity Fuel PV	20	20
16	Dev Solar	3	5
17	Electrona/Zynergy	36	35
18	Emmvee Photovoltaics Pvt. Ltd	175	175
19	Empire Photovoltaic	36	36
20	Enfield Solar	20	15
21	Enkay Solar	20	20
22	Evergreen Solar Systems	20	20
23	Gautam Solar Pvt. LTd	65	65
24	Genus Solar	20	10
25	Goldi Green Technologies Pvt. Ltd	125	125
26	Green Brilliance Energy Pvt. Ltd	50	50

27	Greentek	25	10
28	H.R. Solar Solution Pvt. Ltd	15	10
29	HBL Power	20	NA
30	HHV Solar Technologies Pvt. Ltd	100	90
31	Icon Solar Pvt. Ltd	50	24
32	Integrated Solar	25	20
33	Jain Irrigation Systems Ltd	55	55
34	Jakson Solar	60	50
35	JP Solar	20	NA
36	Jyoti Solar	25	NA
37	Jyoti-tech Solar LLP	35	28
38	Krishma Solar	20	NA
39	Kohima Solar	55	20
40	Kotak Urja Pvt. Ltd	75	36
41	Lanco Solar Pvt. Ltd	175	175
42	Maharishi Solar Technology	15	4
43	Mas Solar	20	5
44	Microsol Power P Ltd	60	15
45	Microsun solar	60	60
46	Modern Solar Pvt. Ltd	40	32
47	Moser Baer Solar Limited	230	50
48	MX Power	10	10
49	Navitas Green Solutions Pvt. Ltd	75	50
50	Neety Euro Asia Solar Energy	15	12
51	Novergy Energy Solutions P. Ltd	45	45
52	Nucifera	15	15
53	Photon Energy Systems Ltd	50	50
54	Photonix Solar Pvt. Ltd	40	40
55	Plaza Solar	20	NA
56	Premier Solar Systems Ltd	100	100
57	Prosun	5	3
58	PV Power Technologies	50	50
59	Raajratna Ventures	30	30
60	Radiant Solar	80	30
61	Rhine Solar	40	20
62	Rajasthan Electronics & Instruments Limited	20	19
63	Reliance Industries Ltd – Solar	30	NA
64	Renewsys India	180	80
65	Ritika Systems Pvt. Ltd	40	40
66	Rolta Power Pvt. Ltd	60	50
67	Saatvik Green Energy	175	175
68	Savitri Solar	80	NA
69	Seemac Pvt, Ltd	40	40
70	Shan Solar Pvt. Ltd	30	30
71	Shukra Solar	5	NA
72	SLG Solar System	8	NA
73	Solarmaxx	15	12
74	Solex	30	25
75	Sonali Energiees Pvt. Ltd	100	100
76	Sova Power Limited	100	100
77	Stellar Solar	20	NA
78	Sun Solar Techno Limited	30	18
79	SunFuel	15	1
80	Sunshine Power	10	10
81	Surana Solar	120	120
82	Synergy Solar	50	50

83	Tata Power Solar Systems Limited	300	300
84	TITAN Energy Systems Ltd	100	100
85	Topsun Energy Limited	75	60
86	Udhaya Energy Photovoltaics Pvt. Ltd	7	7
87	USL Photovoltaics Pvt. Ltd	7	NA
88	Vikram Solar Pvt. Ltd	500	400
89	Vinova Energy SystemsPvt. Ltd	10	2
90	Vipul Solar	25	NA
91	VRV Solar	25	NA
92	Waaree Energies Pvt. Ltd	500	500
93	Websol Energy System Limited	90	90
94	XL Energy Ltd.	210	NA
		5848	**4307.05**

*NA-Information Not Available

2.6 Technological development in solar

Solar technology history spans from the 7th century B.C. to today. It started out concentrating the sun's heat with glass and mirrors to light fires. Today, we have everything from solar-powered buildings to solar powered vehicles. (Mathias Aarre Maehlum, 2013). The technological developments of solar were tabulated in Table 10. (G.M. Pillai 2015).

Table 10. Technological development in solar

Year	Evaluation of solar
700 B.C	Sunlit Fires
214–212 B.C.	Archimedes' Heat Ray
1767	The First Solar Oven
1839	The Discovery of the Photovoltaic Effect
1873	Photoconductivity in Selenium
1876	Electricity from Light
1883	The First Design of a Photovoltaic Cell
1918	Single-Crystal Silicon
1954	The Birth of Photovoltaics

2.6.1 Evaluation in solar technology before independent

As early as 7th to 2nd century B.C, Greeks and Romans used the magnifying glass to concentrate sun's rays to make fire and to burn. They were used the reflective properties of bronze shields to focus sunlight and to set a fire. Use of burning mirrors to light torches for religious purposes by Chinese in 20 A.D. In 1st to 12th century A.D, had a large south facing windows to let in the sun's warmth. The milestones in the historical development of solar technology from 1767 to 1891. Swiss scientist Horace de Saussure was credited with building the world's first solar collector, later used by Sir John Herschel to cook food during his South Africa expedition in the 1830s. Later in 1816, a solar thermal electric technology that concentrates the sun's thermal energy in order to produce power.

In 1839, French scientist Edmond Becquerel discovers the photovoltaic effect while experimenting with an electrolytic cell made up of two metal electrodes placed in an electricity-conducting solution electricity generation increased when exposed to light. Willoughby Smith discovered the photoconductivity of selenium in 1873. Although selenium solar cells failed to convert enough sunlight to power electrical equipment in 1876. The first solar cells made from selenium wafers in 1883. In 1887, the discovered of ultraviolet light altered the lowest voltage capable of causing a spark to jump between two metal electrodes. The commercial solar water heater was first patented in 1891. In the year of 1914, the existence of a barrier layer in photovoltaic devices was noted. Experimental proof of the photoelectric effect was done in 1916. Polish scientist Jan Czochralski developed a way to grow single-crystal silicon in 1918. In 1932, Audibert and Stora discover the photovoltaic effect in cadmium sulfide (CdS), (Mathias Aarre Maehlum, 2013).

2.7 Evaluation in solar technology after independent

In the year 1954, Photovoltaic technology is born in the United States when Daryl Chapin, Calvin Fuller, and Gerald Pearson develop the silicon photovoltaic (PV) cell at Bell Labs-the first solar cell capable of converting enough of the sun's energy into power to run every day electrical equipment. Bell Telephone Laboratories produced a silicon solar cell with 4% efficiency and later Hoffman Electronics achieves 14% efficient photovoltaic cells in 1960. In 1966, NASA launches the first Orbiting Astronomical Observatory, powered by a

1 KW photovoltaic array, to provide astronomical data in the ultraviolet and X-ray wavelengths filtered out by the earth's atmosphere.

The coast of the solar cell started to decrease in the 1970s. Solar cells begin to power navigation warning lights and horns on many offshore gas and oil rigs, lighthouses, railroad crossings and domestic solar application. In 1978, world's first village PV systems are used to provide for water pumping and residential electricity until 1983. The 20% efficiency barrier for silicon solar cells under sun conditions were found in 1985. Thin film power module was found in 1986 and 15% efficiency for the thin film PV were achieved in 1992. The National Renewable Energy Laboratory develops a solar cell made from gallium indium phosphide and gallium arsenide that becomes the first one to exceed 30% conversion efficiency in 1994. The remote-controlled, solar-powered aircraft, "Pathfinder" sets an altitude record of 80,000 feet on its 39th consecutive flight in 1998. Cumulative worldwide installed photovoltaic capacity reaches 1000 megawatts in 1999. The new world record for non-rocket solar powered aircraft of 96,863 feet with more than 18 miles high by NASA during 2001. Much solar power station was newly launched during the year of the 1990s to 2000s. The installation capacity was increasing year by year due to the requirement of power. (Mathias Aarre Maehlum, 2013).

2.7.1 Future of solar power

There are 10 technologies that shaping the future of solar power. They are (G.M. Pillai 2015).

1. Bio-solar cells
2. A new way for converting solar energy into electricity
3. Reshaping solar spectrum to turn light into electricity
4. Water Nest
5. Floating panels, floating solar farms
6. Transmitting solar power wirelessly from space
7. Solar energy harvesting trees
8. Squeezing more out of the sun
9. Ways to boost solar power
10. Concentrated PV cells

2.7.2 Solar technology

Photovoltaic (PV) technology and concentrated Solar Power (CSP) technology are the two main technologies using in India. Solar Photovoltaic (PV) cells alter solar light directly to electricity. Photovoltaic can literally be translated as light-electricity. A thin film is a new technology when compare to crystalline silicon. CSP systems generate solar power by using mirrors or lenses to concentrate a large area of sunlight onto a small area. Our country mostly using Photovoltaic solar cell. There are many types of the solar cell beyond that polycrystalline solar cell and Dye Sensitized solar cells (DSSC) were mainly used in our country. (https://en.wikipedia.org/wiki/Electricity-sector-in-India).

3. Conclusion

In the past several years, the Indian economy has experienced tremendous growth. For the Indian economy to continue this trajectory, India needs to address its energy challenges, which cross all sectors and impact among all citizens. Both in terms of quality and access to electricity is a key challenge. The quality of the current electricity supply is hindering India's economic growth. Issues such as voltage fluctuation, frequency variation, spikes, black-outs, brown-outs and other disruptions impact of industrial, commercial, and residential consumers. The addition of grid-tied renewable power may help to resolve these issues. India needs more than double its current installed capacity to over 300 GW by 2017, to provide adequate electricity for population. Also, India's demand for oil in 2016 is expected to be 42% higher than in 2007 and almost 150% higher in 2030 needed primarily to feed a growing transportation sector. The Indian government is aware of the importance of the challenges that success will depend on structural changes in the industry, new technologies and business models. Solar technology is the rapidly developing technology in our nation. However photovoltaic is the main technology used in our nation. Usage of grid solar cell is maximum in India when compare to the off-grid solar cell. Recently, many industries are struggling to increase the efficiency of solar cell to make new solar technology. Investigation on today sustainable energy technologies will pave the way towards a secure energy future for tomorrow.

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