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Renewable Source of Energy- Solar Energy in India

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Abstract: Renewable energy technologies are good source of energy to mitigate greenhouse gas emission, for reducing the global warming. Energy production from renewable energy sources is increasing drastically. Due to enhancement of pollution in world, there is a need to give attention on development of projects, policy framing, and operations in renewable energy technologies and their implementations.

Solar energy is a renewable source of energy with zero emission, which can be collected using variety of technologies. Solar energy is the solution for the long-lasting energy issues, which are currently a major problem for the world and countries like India which are still developing. Solar energy can help us to improve energy security in India. It can also help us to alleviate the concern regarding environment problems and creating huge market for renewable energy in country. The paper focuses on status of solar energy in India uses and its application.

I. INTRODUCTION

Solar energy is abundantly available in India for more hours a day with high intensity that means India has great potential of solar energy. Solar is currently an underutilized source in India which can provide an improved supply and the security of energy in country. Analysis of the data shows that almost 58% of the geographic area in the country is full of solar energy with more than 5 kW-h/m^2/day of the yearly average global solar irradiation. [2]

Solar energy is freely available in very large quantities, but the process of converting sunlight into electricity is a challenge. New solar technologies are emerging like concentrated solar power and hybrid technologies which produce electricity with improved efficiency to meet this challenge. PV-T hybrid system is more efficient since both the technology; photovoltaic and solar thermal technologies are used in this system that produces electrical and heat energy.

Photovoltaic technology saves electrical energy as chemical energy in batteries [3], while the CSP use Thermal Energy System (TES) to store solar energy in thermal energy form. [4][5] The significant effect of the temperature on the solar cells leads to the loss of photovoltaic efficiency. [6]

Solar cells made of crystalline silicon are more efficient, but are much more negatively affected at higher operating temperatures compared to the thin film photovoltaic. [7-9]

II. RENEWABLE ENERGY IN INDIA

Renewable Energy are seen as pollution free energy source and optimum use of these resources helps to reduce the environmental impact and to develop sustainably in accordance with the current social needs of the society.

Renewable Energy technologies provide a huge opportunity to reduce greenhouse gas emissions and reduce global warming by replacing conventional energy.

Renewable Energy will play significant role to create the pollution free environment throughout the globe, it is a reagent that can be used to generate energy with the help of solar, wind and biomass etc.

It generates huge energy with zero emission of pollution, by proper implementation it can reduces the pollution like PM2.5, PM10 etc. which are main sources of air pollution. Table 1 shows the renewable energy potential in India.

Table 1 Renewable energy potential (MW) in India [10]

SN	States	Wind Power	Small Hydro Power	Bio-Energy	Solar	Total
01	Rajasthan	5050	57	1094	142310	148518
02	Jammu & Kashmir	5685	1431	43	111050	118208
03	Maharashtra	5961	794	3424	64320	74500
04	Gujarat	35071	202	1683	35770	72726
05	Madhya Pradesh	2931	820	1442	61660	66853
06	Andhra Pradesh	14497	978	1001	38440	54916
07	Karnataka	13593	4141	1581	24700	44015
08	Himachal Pradesh	64	2398	144	33840	36446
09	Tamil Nadu	14152	660	1671	17670	34152
10	Orissa	1384	295	268	25780	27728
11	Uttar Pradesh	1260	461	3043	22830	27593
12	Telangana	-	-	-	20410	20410
13	Chhattisgarh	314	1107	260	18270	19951
14	Uttarakhand	534	1708	29	16800	19071
15	Jharkhand	91	209	100	18180	18580
16	North-East	620	2599	276	62300	65774
17	Union-Territory	489	8	140	2050	2677
18	Other	1096	1881	8888	32610	44475
	Total	102772	19749	25090	748990	896602

III. SOLAR ENERGY STATUS IN INDIA

India has total power generation from renewable resources is around 50068 MW as of December 31, 2016, which includes wind power of 28700 MW, Solar Power of 9013 MW, bio power of 8021 MW and small hydropower of 4334 MW as shown in Fig. 1 [10].

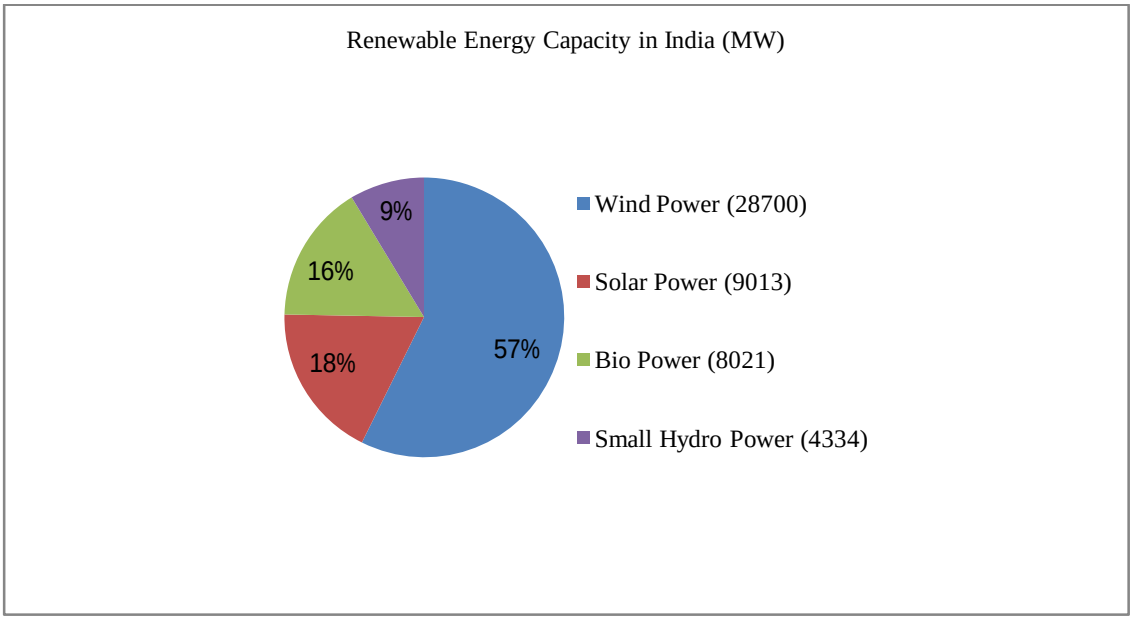

Fig. 1 Renewable Energy Capacity in India

India has the potential to produce great solar power but currently solar energy is an underutilized source of energy in India. Proper utilization of solar energy can improve the energy security in India. Although highest annual solar energy is received in Rajasthan and northern Gujarat, but Maharashtra, Madhya Pradesh and Andhra Pradesh, also receives fairly amount of solar energy. A

package has been introduced for solar power sector which can lead India to production of 20 GW-h by 2020 according to the initial phase of the solar mission and in final phase of the solar mission India hopes to produce 100GW solar power [11]. Year wise growth of solar energy from 2009 to 2016 can be seen in Fig. 2.

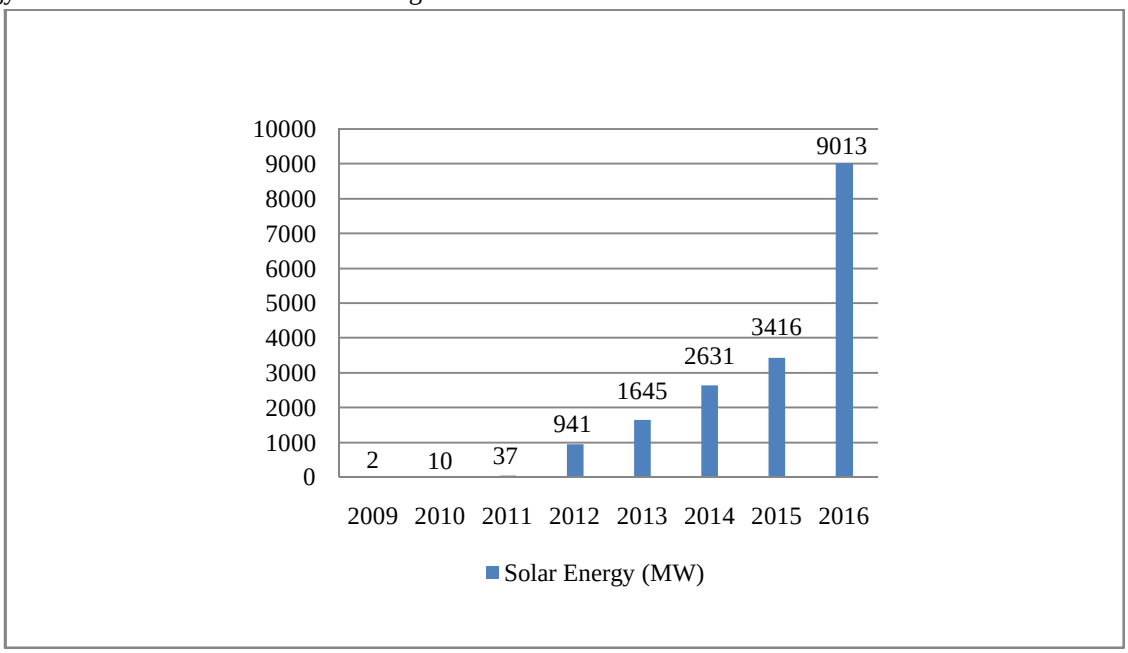

Fig. 2 Year wise growth of solar energy in India [10]

IV. NATIONAL SOLAR POLICIES

A. Jawaharlal Nehru National Solar Mission

Jawaharlal Nehru national solar mission (JNNSM) which was launched in 2010 was great achievement in the history of renewable energy in India with 2 MW in 2009 and after that country's grid connected solar power capacity grew to 10MW in 2010, 37MW in 2011, 941MW in 2012, 1645MW in 2013, 2631MW in 2014, 3416MW in 2015 and 9013MW in 2016 but the country has a long way to achieve 100 GW by 2022. The main objective of JNNSM was to improve energy security in India and to make India a worldwide leader in solar power through making policies for its dispersal across the country rapidly. The government of India intended to install 20GW solar power capacity until the end of 2022 as per the original plan. It was planned in three phases, first phase from 2010 to 2013 (12^{th} five-year plan), second phase from 2013-2017 and third phase 2017-2022 (13^{th} five-year plan). The goals of the first phase were to achieve 1.4GW, 11-15GW by the end of second phase and 20GW by the end of third phase. [10] On July 1, 2015, government of India changed the target for the JNNSM from 20GW to 100GW and to achieve this target the yearly targets from onward 2015-16 were also increased. [10] Year-wise target are shown in table 2. Various laws and steps taken by government for enhancing the solar energy in India are as follows: National Tariff Policy (2006) National Rural Electrification Policies (2006), National Electricity Policy (2005) and Electricity Act (2003) [12]

Table 2 Year-wise targets (in MW) [10]

SN	Category	Rooftop Solar	Ground Mounted Solar projects	Total
1	2015-16	200	1,800	2000
2	2016-17	4,800	7,200	12,000
3	2017-18	5,000	10,000	15,000
4	2018-19	6,000	10,000	16,000
5	2019-20	7,000	10,000	17,000
6	2020-21	8,000	9,500	17,500
7	2021-22	9,000	8,500	17,500
	Total	40,000	57,000	97,000

V. VARIOUS SOLAR TECHNOLOGIES

Solar energy can be harnessed using variety of technologies which include solar photovoltaic, solar thermal and hybrid technologies as shown in Fig. 3. Solar hybrid technology uses more than two technologies at a time; these solar hybrid systems are more efficient than other two technologies.

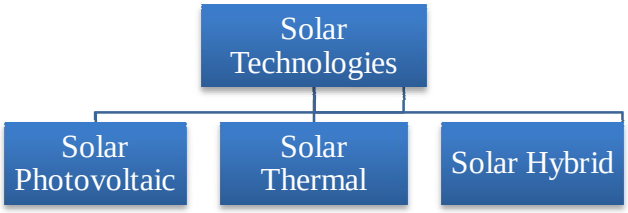

Fig. 3 Various Solar Technologies

A. Solar Photovoltaic

Photovoltaic is a technology that reliably converts solar radiation into electricity. There are different types of modules depending on power ratings. Every module has a number of solar cells. Solar cells are fabricated by means of semiconductors such as silicon. Photovoltaic cells generate electricity in clean and reliable manner which is the prime concern for today's environment. Variation in temperature affects the efficiency of solar module [13]. Due to these variations, photovoltaic technology faces enormous challenges in its power quality performance [14]. Integration of renewable energy is also a tedious process [15]. Photovoltaic is a kind of technology which converts the sunlight directly into electricity. When bunch of light energy (i.e. solar radiation) strikes the panel (which consist of number of cell) then, the photons of sufficient energy dislodged the electrons from the atoms of cell as a result free electrons move through cell, which is creating and filling the holes in the cell. Due to this process (i.e. electrons and holes movement) it generates electricity. Capacity of sun to supply energy is so huge that it can feed all energy demand of the world. Generally, till now the conversion efficiency of solar energy into useful form of energy (i.e. electrical energy) is in between 15 to 20 percent [16]. Due to high investment cost needed in manufacturing process of the Si cells prevented them from their widespread use. There are also few drawbacks of Si cells that it is toxic in nature so, to eliminate these drawbacks a huge research and money is needed. Luckily energy provided by sun is huge, which is ten thousand times more than that the total energy needs, means converting 0.1% of the incident solar energy radiation with 10% efficiency can fulfill global energy needs. Concentrating photovoltaic is a new method for production of electricity by harvesting the sun's energy. To concentrate the solar light at a particular, angle the varieties of solar concentrator (parabolic mirror) are used which are mounted on solar tracker system so that the focal point remains constant while sun changes its position across the sky [17]. Recently the developments of the 2-axis tracking systems are become useful in concentrating photovoltaic [18]. By using this technology electrical output of the photovoltaic module can be improved.

B. Solar Thermal

Solar thermal technology is used to generate large amount of green energy (solar energy) which help to mitigate the pollution and consequently give a good living condition for human. Solar thermal energy also help to mitigate the use of fossil fuels which is primarily factor responsible for enhancing the temperature of atmosphere on earth. A solar thermal power plant produces electric power by converting large amount of sunlight energy (photons) into the high temperature heat energy with the help of various mirrors configurations [17]. Solar thermal power plant plants are used to work efficiently over a 20-year period. India can have solar thermal power plants of 5-6 GW capacity by 2020. Large amount of solar thermal power plant output is consumed by various states in North-Eastern part of India [18].

C. Solar Hybrid

A PV-T hybrid is a mixture of photovoltaic and thermal technologies, hybrid technologies can not only produce electricity but can also produce high temperature thermal heat. As we know that demand f electricity is increasing, it is very important to develop such devices which can produce both solar electricity and solar heat which can further be converted into electricity. When sunlight strike at the Photovoltaic cells the parts of incident rays of light are used to produce the electric energy and the rest is converted into heat energy. If temperature of the photovoltaic module increases after a certain value, the efficiency of the photovoltaic module start decreases. So, by developing methods to cool the module can improve overall efficiency of PV-T integration. PV-T system has better way to utilize solar energy as they can provide higher overall efficiency than other solar power systems. Poly-crystalline (pc-Si), mono-crystalline (c-Si), thin-film solar cells or multi-junction cells can be used as a photovoltaic material. There are many

researches and development work has been carried out in this field and also there are many researches and development is going on PV-T hybrid. Due to the dual characteristics of PV-T hybrid it has huge scope in future. There are few features of the Photovoltaic-Thermal (PV-T) hybrid systems are as follows [19]:

1) Double purpose: single device used to generate electricity as well as heat output.
2) Efficiency and Flexibility: It is experimentally proved that the effectiveness of PV-T hybrid is always higher than the device which operate on photovoltaic and thermal technologies independently and hybrid can be used where space is limited.
3) Wide applications: The heat energy output produced by PV-T hybrid can be used for various purposes,
4) Low cost and practical in nature: PV-T hybrid can easily be combined or integrated with buildings and its cost is also affordable. [20]

VI. CONCLUSION

In India energy shortage is a big problem, so it needs huge additions in energy capacities especially in renewable energy capacities to meet the surging energy demand. By developing solar energy, we can improve energy security in India which can help India to be energy independent, it can also help in reduction of the fuel prices. In India, many of the undeveloped states have great potential for solar energy they can develop solar power systems with the help of government to use solar energy.PV-T solar hybrid system can fulfill the energy needs in India as they efficiently convert incident solar energy into electrical and thermal energy and it can also help in slowing down the increasing rate of pollution. PV-T hybrid technology can be enhanced by improvisation in the design, area of the design and development in the field of exergy output of the system. PV-T hybrid technology can be used for industrial and personal applications, i.e. solar heat pump, water purification, solar cooling and solar greenhouse.

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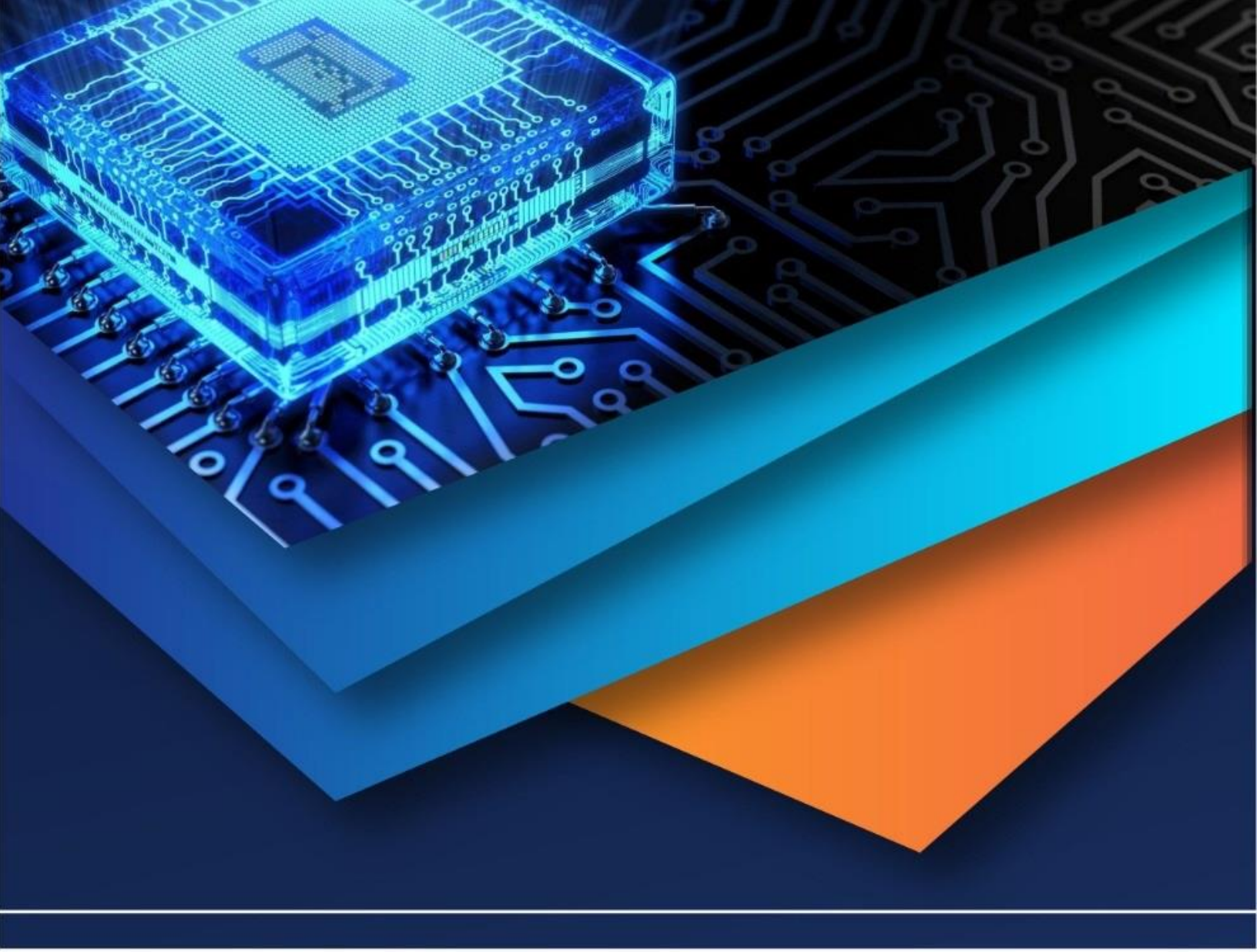

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