

# Effect of Greenhouse Gas Emission on Solar PV Performance



Bhabani Patnaik, Sarat Ch. Swain,

**Abstract:** Renewable energy is a cleanest and reliable energy sector to the changing climate condition. This changing world needs a quick combination of renewable energy in the energy matrix of each region in such a climate, and it is a sustainable solution. So this study gives a brief idea of how solar photovoltaic (PV) technology performs with changing climatic condition. This system is reliable technology integration in the energy market of India and its statuses among all other renewable sources. To improve energy security and decrease the carbon dioxide emission in an atmosphere, renewable energy technologies have raised a rapid deployment over the past few years. Most of the countries are now changing the ways for economic growth through the development of the renewable energy sector. It is better to Investment in growth of the renewable energy sector because to increase income, to create the job, contribute to industrials development and improve trade balance it is necessary to generate more renewable energy source. The growth in population is directly proportional to energy demand, and again it is directly proportional to energy production due to which the more in carbon dioxide emission. In increasing demand for energy, it is indispensable to produce a renewable energy source, especially in India. Because nowadays solar PV is an excellent source of energy production .so here some study has done about the performance of solar PV on greenhouse gas emission.

**Keywords:** CO2 emission, CH4 emission, solar PV cell, Temperature.

## I. INTRODUCTION

In the world, basically in India, there is massive growth in population and significant variation of the regional scale [1]. And energy demand is there for the different energy-driven program, and it relates to quick urbanization and population growth. As per the review, it shows that 10% of the increase in demand since 2002, 5.7% in 2013, which is 4.4% of the beginning of the century [2] [3]. As a per-capita basis, the energy demand of India has grown by a more 46% since 2000 [4] [5]. The main reason for the demand is that in India, more than 20% of the population remains without modern electricity.

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Whereas from the supply side, the capacity of India is 290GW of power generation and from 60% of which is the largest share makes by coal and 15% from the hydropower [6] [7]. The economic growth of India depends on the energy demand as well as the growth of population. The only energy sector is a parameter by which all economic developments of Industrialization, globalization etc. increases. But huge energy demand is there due to rapid growth in a population [8]. IEA says the country's share of global energy demand will double by 2040, as oil and gas giant BP estimates. And coal will fulfil almost half of this new demand. Basically from 2012, the World net electricity generation increases rapidly .and it increases by 69% [9] as from 21.6 trillion kilowatt-hours (kWh) in 2012 to 25.8 trillion kWh in 2020 and 36.5 trillion kWh in 2040 [10]. In the entire electric power sector, the energy market is the most expensive area by which the economic development, which is called the gross domestic product of the country, will increase [11]. The most substantial growth in electricity generation is projected to occur among the developing, non-OECD nations. From the survey it is estimated in the year 2012-2040, the rate of average generation of electricity in a non-OECD country increases to 2.5% per years due to rising standard of living style, uses of home appliances, electronic devices and commercial services. In the year 2018-19, the total electricity generation which includes both utilities and no utilities of the country is 1547 TWh, and the gross electricity generated by utilities in India was 1,372 TWh, and the 1181 kWh per capita .below graph shows the world energy consumption of non-OECD and OECD countries and other countries from the year 2012 to 2040. [12]

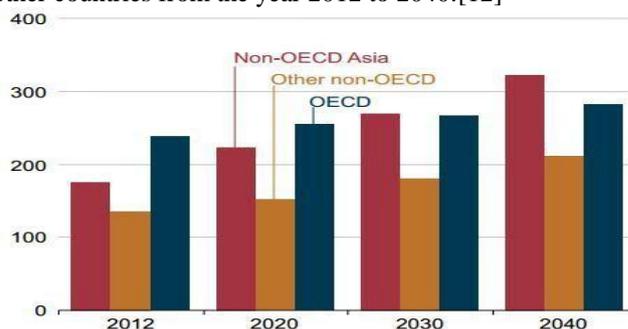


Fig. 1. World Energy consumption by country grouping (2012-40) [12]

For enhancing human well balanced and creating new employment the renewable-based energy system is the unique opportunity for climate-changing condition .it is a better decision that investment in the energy sector because it will help in the development and economic growth of a country.

To get decarbonize energy and clean form of energy, renewable energy is the only solution because it is the green source of energy.

From many research, it is clear that, in the year 2012-2018[13], the energy consumption by renewable energy source is increased by an average of 2.6% per year. Because the use of non-fossil fuel is expected to grow faster than the consumption of fossil fuels .still, it is accounted that 78% of the energy used by fossil fuel consumption [14]. Natural gas is growing at a rate of 1.9% per year, and the slowest growing energy source that is coal is growing by only 0.6% per year. Energy consumption by a different source from the year 2012 to 2040 has shown in the below graph. In this graph, the unit of energy is B.T.U (British thermal unit) [15].

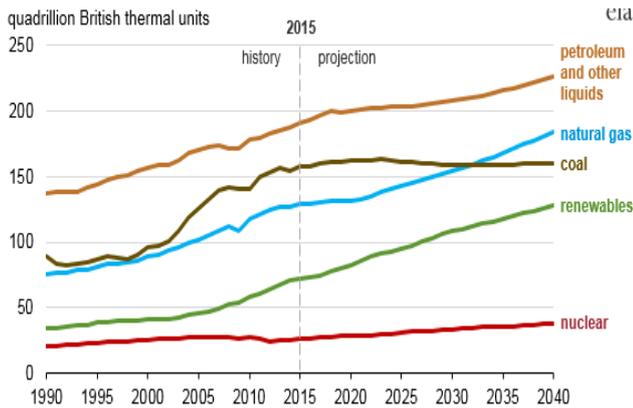


Fig. 2. World energy consumption by energy source (1990-2040) [15]

Growing population in the region for more energy demand .and due to energy demand there is more use of fossil fuels, and this causes the increase of carbon dioxide emission which is very dangerous for human being so to avoid this problem government of India is promised to increase the use of renewable energy source because these sources are the clean and green form of energy [16]. So India undertakes various large scale projects for sustainable energy sources. Another advantage of these projects is that it has the potential to create new employment in rural areas. So by the year 2022 MNRE (Ministry of New and Renewable Energy) has a target to produce 175GW of renewable energy source .from which 100GW will from the solar photovoltaic system[17], 60 GW from wind and rest from other renewable energy sources(bio, hydro)[18]. Investment of the entire energy sector of the year 2010 to 2017 has given below.

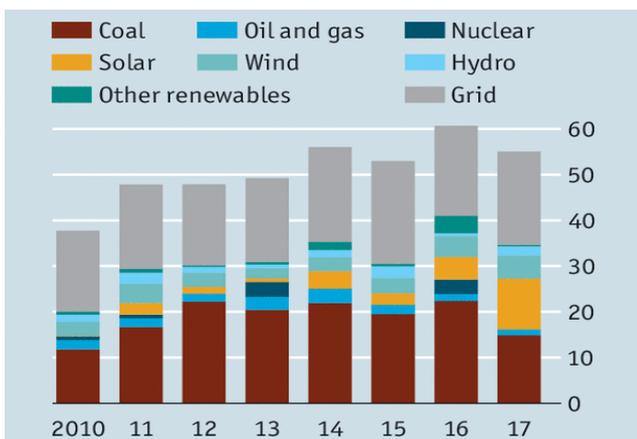


Fig. 3. India power sector investment[18]

Below figure shows the total renewable energy capacity in India till September 2019.

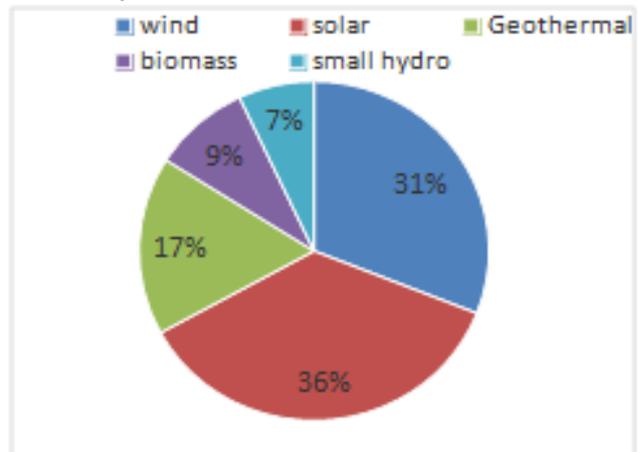


Fig. 4. Renewable Energy Installed capacity in 2019

According to the national plan on climate change (NAPC), India is a country where solar irradiation is available for a more extended hour per day.

So it has a great potential a future energy source. According to the international energy agency (IEA), solar energy could meet most of the demand for electrical energy by 2020 [19] [20].

Within 2035, the world ' renewable energy source could grow by at least 60percent and could be double by 2060. Renewable energy can supply up to four-time more energy than today.

Solar Photovoltaic system is the type of renewable energy technologies which show rapid advancement than other sources of energy. Before going through the use of the photovoltaic system, we should clear about the construction of this system.

## II. SOLAR PHOTOVOLTAIC SYSTEM

### A. Modelling of Solar PV System

A silicon cell which converts sunlight into DC is called a solar photovoltaic cell. Due to low weight volume ratio silicon is used to construct PV cell [21].

The **silicon** in a **solar cell** has impurities, so other atoms are purposefully mixed in with the **silicon** atoms to improve **silicon's** ability to capture the sun's energy. Combination of many PV cells known as PV module and combination by series and parallel of PV modules is called a solar array.

These PV arrays are used to produce maximum efficiency (15-20%) while connected with Maximum Power Point Track (MPPT). Then to get AC again it is connected to Inverter the primary input of this PV system is solar irradiation and temperature .to analyses correctly, here one single PV cell has taken and simulated this model in MATLAB 2017 software. The characteristics of this PV cell has shown in the result part of this paper.



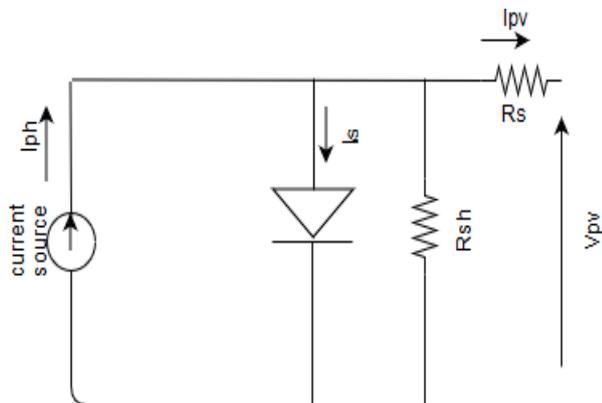


Fig. 5. Equivalent circuit of solar PV cell

Where  $I_{ph}$  is the light generated photocurrent

$I_s$  is the reverse saturation current

$R_{sh}$  is the shunt resistance

$R_s$  is the series resistance

$I_{pv}$  is the output of photovoltaic current

$V_{pv}$  is the output voltage

The PV module simulates for 249.6 W nominal maximum powers, and 72 cells are connected in series.

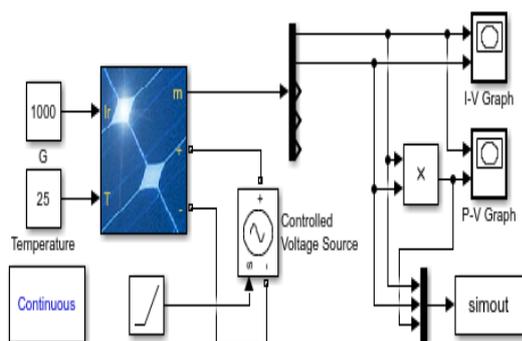


Fig. 6. Final simulation model of solar PV module

### B. Importance of Solar PV System in India

Now solar power is the fast-developing energy source in India .till 30 September 2019 India's solar installed capacity reaches up to 31.124 GW. To install solar power plants, India has the lowest capital cost per MW then other countries. In the year 2019, the installed capacity of Solar PV is average 3 times from 2015 [22] [23]. India has established 42 solar parks to make land available to the promoters of solar plants .as per IRENA country has added 3GW,5 GW and over 10 GW in the year 2015-16,2016-17,2017-18 respectively. And it is expected more than 20 GW at the end of 2020. State-wise increase in solar energy capacity in the year 2015 and year 2019 are given below [23].

Table- I: Solar PV capacity of different states

Name of the States	Till March 2015	Installed solar pv power (MW) till 2019
Gujarat	1,000.05	2,440.13

Maharashtra	360.75	1,633.54
Chhattisgarh	7.6	231.35
Madhya Pradesh	558.58	1,840.16
Dadra and Nagar Haveli	0	5.46
Goa	0	3.92
Daman and Diu	0	14.47
Tamil Nadu	142.58	2,575.22
Andhra Pradesh	137.85	3,085.68

Table- II: Solar PV capacity of different states

Name of the States	Till March 31 2015	installed solar PV power (MW)till 2019
Rajasthan	942.1	3,226.60
Punjab	185.27	905.62
Uttar Pradesh	71.26	960.1
Uttarakhand	5	306.75
Haryana	12.8	503.68
Delhi	5.47	126.89
Jammu and Kashmir	0	14.83
Chandigarh	4.5	34.71
Himachal Pradesh	0	22.68

Table- III: Solar PV capacity of different states

state	Till March 31 2015	installed solar pv power (MW)till march2019
Telangana	167.05	3,592.09
Kerala	0.03	138.59
Karnataka	77.22	6,095.56
Puducherry	0.2	3.14
Bihar	0	142.45
Odisha	31.76	394.73
Jharkhand	16	34.95
West Bengal	7.21	75.95
Sikkim	0	0.01

Table- IV: solar PV capacity of different states

State	Till March 31 2015	Installed solar energy (MW)till March 2019
Assam	0	22.4
Tripura	5	5.09
Arunachal Pradesh	0.03	5.39
Mizoram	0	0.5
Manipur	0	3.44
Meghalaya	0	0.12
Nagaland	0	1
Andaman and Nicobar	5.1	11.73
Lakshadweep	0.75	0.75

### C. Cost-effectiveness of Solar PV System

The demand for solar PV energy is increasing due to its cost-effective nature.

In 2019, the solar energy Price drop to 18% from before which is below the average price of the coal-fired counterpart [24], over the time window the price drops around 73% from 2010 price.

So to increase the Gross domestic product of the country, it is needed to consumption of energy from the lower-cost energy source. Cost of the solar system depends on basically the cost of the panel [25]. .how the solar panel price decreases year to year has shown in the below graph.

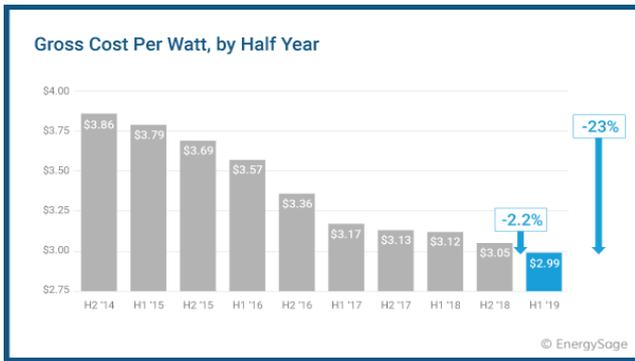


Fig. 7. Solar Panel Cost over Time [26]

III. EFFECT OF GREENHOUSE GAS EMISSION ON SOLAR PV PERFORMANCE

Due to increase of population and more energy demand, the concentration of Greenhouse gas is increasing .this gas absorb and emits thermal radiations.by this process the earth surface is getting warm From past decades, the global climate is changing, and the temperature of the earth is increasing gradually. So temperature is directly proportional to the emission of greenhouse gas. The components of this gas are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (NO) and water vapour. But carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) are the gases which have more concentration and there effect is more to the atmosphere.so in this paper we consider only these two gases (CO<sub>2</sub> and CH<sub>4</sub>) [27] [28].

A. World Carbon dioxide gas Emission

Carbon dioxide emissions have increased 32.2 billion metric ton in the year 2012 to 35.6 billion metric ton in the year 2019.it is expected that increase value of 43.2 billion metric ton min 2040.which is approximately 34% more than 2020 carbon emission due to power sector demand .as energy demand increases the demand of fossil fuel increases. From past data, it had shown that before industrial age the co2 concentration was 280 ppm (parts per million), but now it increases nearly 48% more than before which is 400-410 ppm, and it is increasing gradually[29].so it was evident that within 10 to 15 years the concentration of carbon dioxide will reach up to 500-550 ppm. Emission of carbon dioxide from different fuel has shown below.

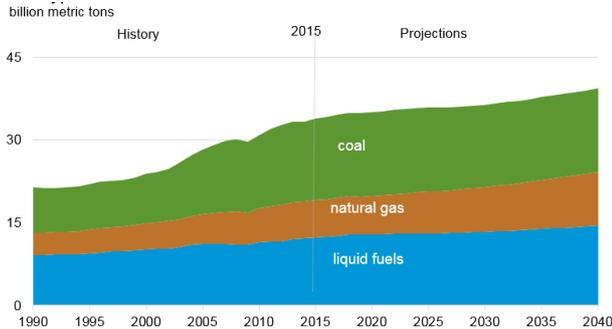


Fig. 8. Carbon dioxide emission by fuel type [29]

B. World Methane gas Emission

Methane gas has placed a vital role in global greenhouse gas effect .it has a higher warming potential because of higher heat-absorbing capacity as compared to carbon dioxide. Industrial CH<sub>4</sub> emission has increased the atmospheric

methane concentration up to 3.2 billion metric ton.it is more potent because it is 28 times more penetrate then carbon dioxide. Now the concentration of methane is 1800 ppb (parts per billion).how the emission of methane is increasing as shown in fig-8.

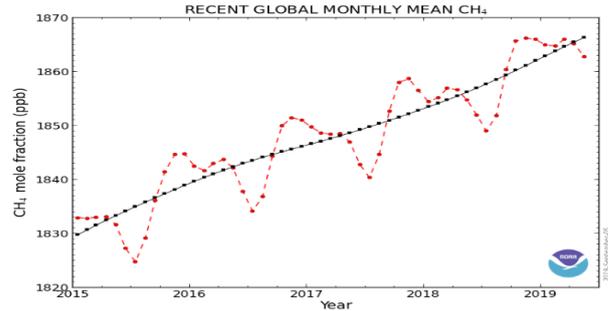


Fig. 9. Methane emission until 2019 [29]

India has a target to increase the consumption of renewable energy source, but it is likely to miss them. In this current year, 60% of energy consumption was made from fossil fuel. In the last year, the country's energy demand was led by coal and oil. Where coal is for power generation and oil is for transport. India has a target to reduce carbon emission but simultaneously has continued to build new coal plant and imports oil to fulfil the energy demands.

IV. EFFECT OF INCREASE OF GHG ON PHOTOVOLTAIC SYSTEM

The increase of greenhouse gas is hazardous to the atmosphere .due to its effect oceans get warmer, and partially glaciers will start melt and because of this the sea level rise. So as we know, there is a massive effect of temperature on solar PV efficiency .because temperature is inversely proportional to the efficiency of the panel. So at standard test condition, the PV panel gives the highest efficiency. For different material of the PV panel, specific standard test condition value are there. By these conditions, only the PV panel gives maximum output power compared to other conditions. The test conditions are of three types these are -irradiation should 1000 W/m<sup>2</sup>, the temperature should be 25°C, Air mass should be 1.5.so at this condition the PV panel will give the maximum efficiency.

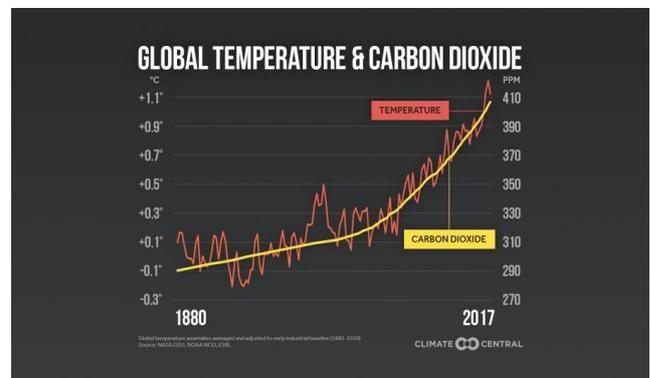


Fig. 10. The relation between carbon dioxide and temperature[29]



So the above image shows that with the increase of CO<sub>2</sub>, there is the increase of temperature. but a small increase in temperature affect much on the efficiency of the solar PV system.

### V. SIMULATION RESULT & DISCUSSION

The simulation result has shown voltage, current and power characteristics of the effect of irradiation and effect of temperature.

#### A. Simulation result of solar PV model with different irradiation at a constant temperature.

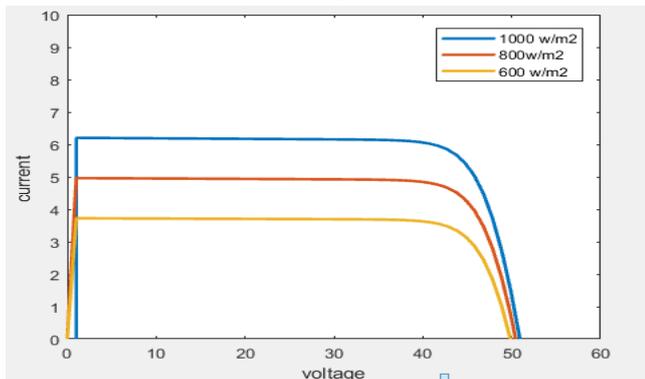


Fig. 11. V-I characteristics of simulated PV module at various irradiation

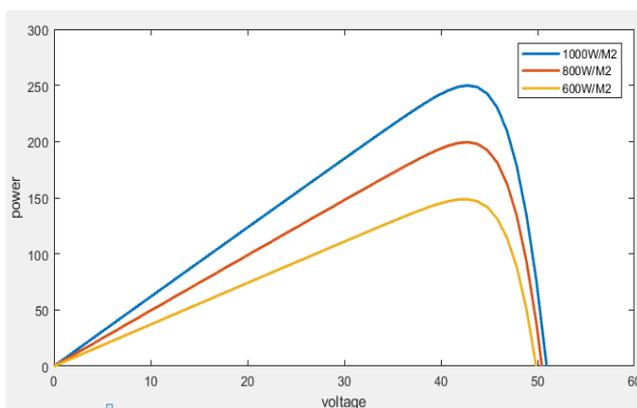


Fig. 12. P-V characteristics of simulated PV module at various irradiation

Above are the V-I and P-V characteristics at standard test condition of simulated PV module at various irradiation .as above said, more irradiation gives better efficiency but at standard temperature condition.

#### B. Simulation result of PV model with the effect of various temperature.

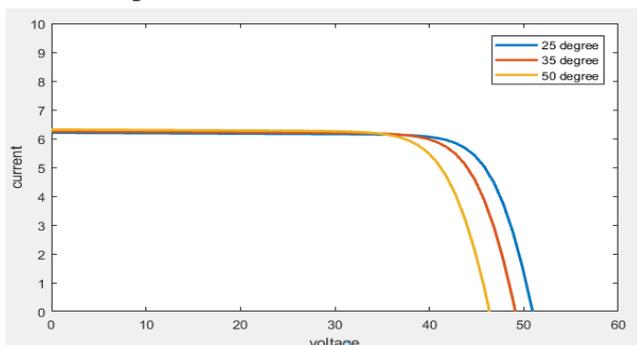


Fig. 13. I-V characteristics of the solar PV model with various temperature.

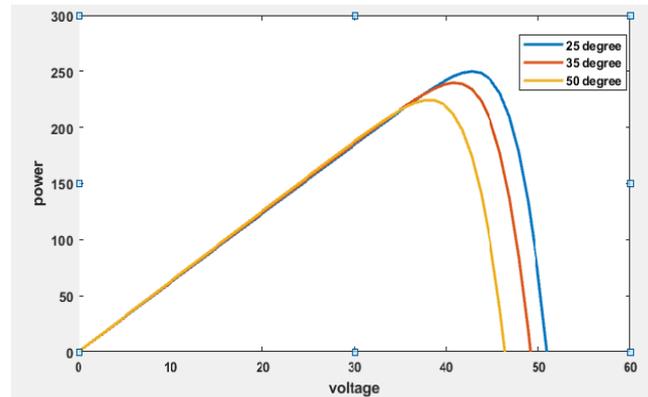


Fig. 14. PV characteristics of solar PV model with various temperature.

Temperature is one of the critical parameters which affects the PV module's performance. It has an inverse relationship with efficiency and maximum power. As above literature, we study that the temperature of the earth become rise day by day because increasing the concentration of greenhouse gas .so my aim of doing this literature review to know how the concentration of greenhouse gas will effect on solar PV performance.

### VI. CONCLUSION

India has been pursuing its agenda on renewable quite aggressively which is evident from the ambitious target of 175 GW of installed capacity by 2022 .and demand of solar PV system is increasing day by day than other renewable sources. The solar PV module is susceptible to temperature .so it is necessary to maintain the temperature of the PV system on standard condition using different mechanism .now a days water spray is using to decrease the temperature of PV panel.

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