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Analysis Report on 30Kw Solar PV Connected with Load in a Particular Site and its Impact on Grid

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Abstract – This paper deals with the technical and financial analysis of a 30 Kw Solar PV Connected with grid. In this work firstly a particular site has been identified and climatic analysis has been done to calculate the effects on the installed solar plant and for best extraction of power. A model has been designed in Matlab to analyze the outputs. The Residential or commercial building can be constructed in this selected location and as per the roof area, solar PV calculator gives the approximation of installed generation capacity of solar power plant. The Roof area, climate condition, direction of sun all these parameters will be analyzed before the installation and at the end the financial calculation will be done as per the roof area and capacity of plant, the installation cost and units saving and its impacts on the grid if installation will be done on net metering basis. A study will be completed to have a best understanding on the roof top capacity installation its benefits and cost analysis for the future observations and a needful impact on the green energy revolution and to reduce carbon emission.

Key Words: *Maximum Power Point Tracking (MPPT), Solar PV, Fuzzy control system, Pulse Width Modulation (PWM), non-linear loads, distribution transformer, linear-loads*

1. INTRODUCTION

Thermal power generation has a number of short-comings, Including consumption of coal, oil, and natural gas resources, serious environmental pollution, and low utilization rate. Solar energy is universal, nonpolluting, vast, noiseless, safe, and inexhaustible. So far, solar energy has experienced vigorous growth around the world and is one of the most prominent renewable energy sources. Therefore, more attention has been paid recently to solar PV power generation to reduce greenhouse gas emissions. The global cumulative installed capacity of solar PV power systems has increased rapidly over the past decade [1–3].

Now As per the financial terms electricity generation using renewable sources have higher price as compared to the non-renewable resources. But now a days the major challenge is to generate a good quality power with lesser incremental cost as much as possible and with lesser carbon emission. In that case we use renewable sources to generate power with good quality. So we should adopt the most convenient and cheapest way for generation transmission and distribution. In order to get an optimum power generation hybrid electricity is used so that increase in price may get compensated by the use of renewable assets. [4]

The level of international public financing available for energy projects supporting the realization of developing countries is still insufficient to mobilize the larger volumes of investment needed to reach the target. Enhancing international flows, leveraging public funds strategically, using concessional finance to de-risk investments and mobilize more private capital into climate solutions are key area for action.

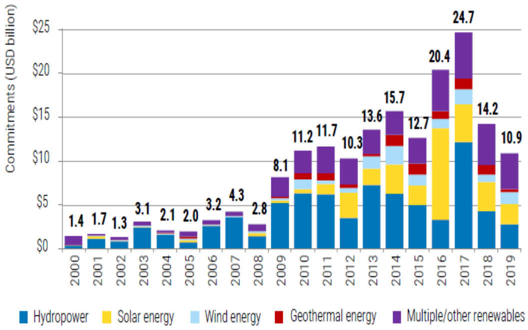


Fig -1: Financial commitments to developing countries 2000-2019

Although the private sector finances most renewable energy investments, the public sector remains a critical source of finance, particularly for many developing countries. International public financial flows to developing countries in support of clean energy decreased in 2019 for the second year in a row, falling to USD#10.9 billion. This level of support was 23 percent less than the USD#14.2 billion provided in 2018, 25 percent less than the 2010–19 average, and less than half of the peak of USD#24.7 billion in 2017. Except for large fluctuations in 2016 for solar energy and 2017 for hydropower, the flows remain within the range of USD#10–16 billion per year since 2010 (figure 1). A five-year moving average trend shows that average annual commitments decreased for the first time since 2008 by 5.5 percent from USD#17.5 billion in 2014–18 to USD#16.6 billion in 2015–19. The level of financing remains below what is needed to reach, in particular for the least-developed countries, landlocked developing countries, and small-island developing states.

The distribution of flows by technology in 2019 is similar to those in 2018 (figure 2). Hydropower attracted the bulk of flows (26 percent), followed by solar energy (21 percent) and wind energy (12 percent). Geothermal energy received a little over 3 percent of commitments in 2019. Compared with 2018, the share of wind energy commitments increased by 6 percentage points, while the share of commitments to the other technologies saw a decrease, as commitments increasingly fall into the "multiple/other renewables" category reflecting growing interest in energy funds, green bonds, and other government-led programs to support renewables, energy efficiency and electricity access. [5]

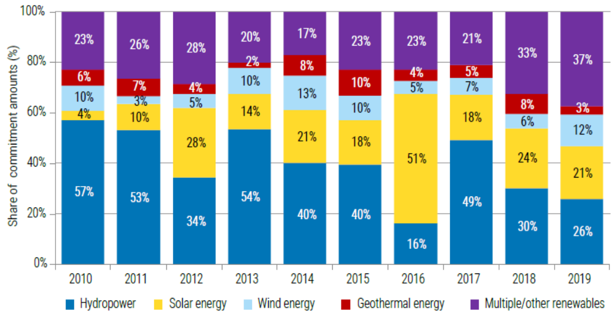


Fig -2: Share of annual commitments by technology 2000-2019

2. CLIMATE ANALYSIS

The climate in Dehradun, Uttarakhand is identified as Composite, from the Climate Zone map of India. The Energy plus weather data of Dehradun, Uttarakhand (IND_Dehradun.421110_ISHRAE.epw).

The monthly temperature variations indicate that the summer season (March to July) in Dehradun, is pleasant with maximum temperature reaching up to 35°C. Relative Humidity varies from 45–98%. Monsoon season prevails from June to September with the highest relative humidity; maximum precipitation is in August (851 mm avg.).

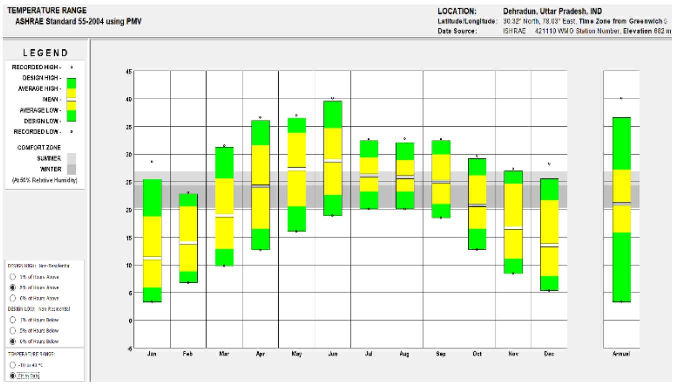


Fig -3: Monthly temperature variation

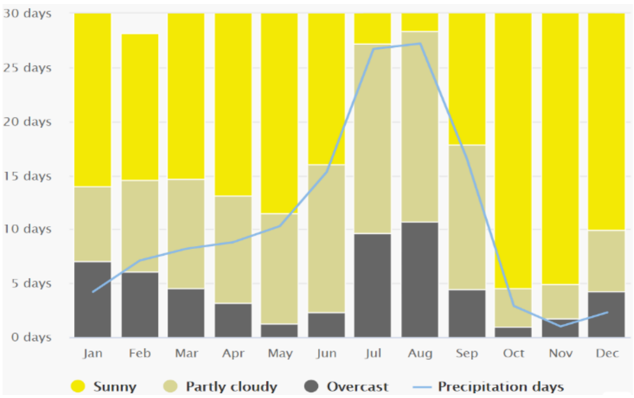
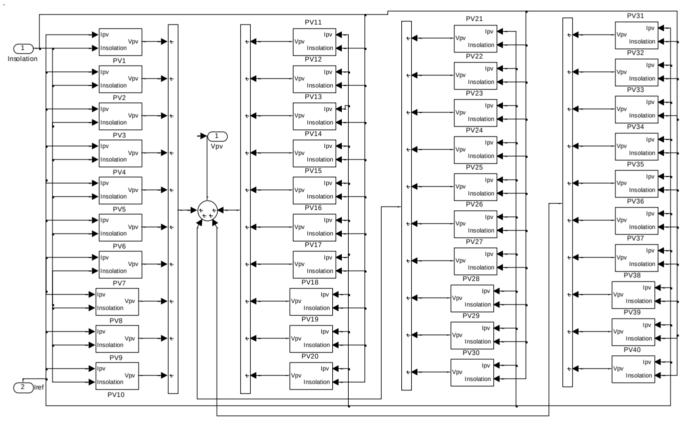


Fig -4: Cloudy, Sunny, Precipitation days

The graph shows the monthly number of sunny, partly cloudy, overcast and precipitation days. Days with less than 20% cloud cover are considered as sunny, with 20-80% cloud cover as partly cloudy and with more than 80% as overcast.

3. MODELLING OF PV ARRAY

Total 30 array system is connected to achieve 30 KW of power with suitable series and parallel combination. In a single module 30 cells are connected in series to get 22 v open circuit voltage. The mathematical model of PV cell is represented by a current source with a diode connected in parallel as shown in figure 2. The intrinsic series resistance whose value is very small. The equivalent shunt resistance whose value is very high, applying Kirchhoff's law to the node where Iph, diode, Rp and Rs meet. [6]



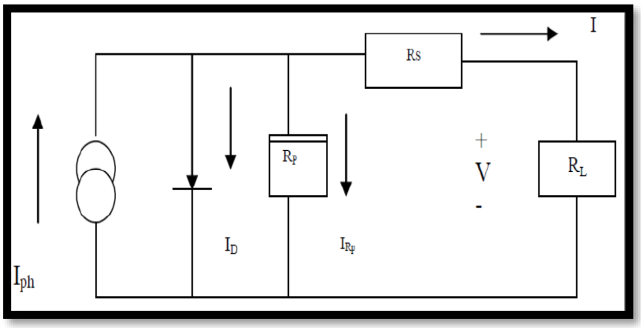


Fig -5: Electrical model of solar PV system

$$I = I_{D} - I_{RP} - I_{ph} \quad \ldots (1)$$

$$I = I_{ph} - I_0 - \left[exp\left(\frac{V+IRs}{V_T}\right) - 1\right] - \left[\left(\frac{V+IRs}{R_p}\right)\right] \ldots (2)$$

$$I = n_p I_{ph} - n_p I_{rs} - \left[exp\left(\frac{q}{KTA} * \frac{V}{n_s}\right) - 1\right] \ldots (3)$$

$$I_{rs} = I_{rr}\left[\frac{T}{T_R}\right]^3 exp\left(\frac{qE_G}{KA}\left[\frac{1}{T_r} - \frac{1}{T}\right]\right) \ldots (4)$$

$$E_G = E_G(0)\frac{\alpha T^2}{T+\beta} \ldots (5)$$

$$I_{ph} = [I_{scr} + K_i(T - T_r)]\frac{s}{1000} \ldots (6)$$

Iph is the Insolation current, I is the Cell current, I0 is the Reverse saturation current, V is the Cell voltage, Rs is the Series resistance, Rp is the Parallel resistance, VT is the Thermal voltage (KT/q), K is the Boltzmann constant, T is the Temperature in Kelvin, q is the Charge of an electron.

4. BOOST CONVERTER

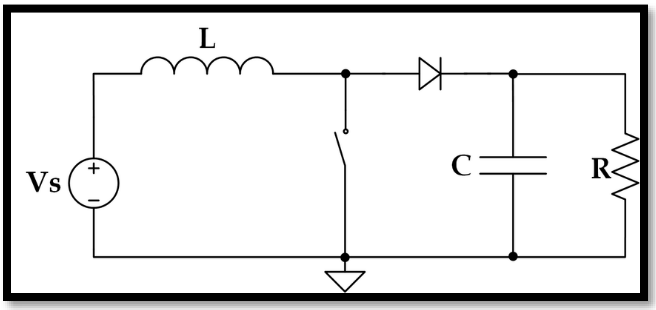


Fig -6: Boost Converter

We can use DC-DC converters as switching mode regulators. The unregulated dc voltage can be converted to regulated dc output voltage. The PWM at a fixed frequency is the main key to get regulated supply. Commonly used switching devices are BJT, MOSFET or IGBT.The minimum oscillator frequency should be about 100 times longer than the transistor switching time to maximize efficiency [3].

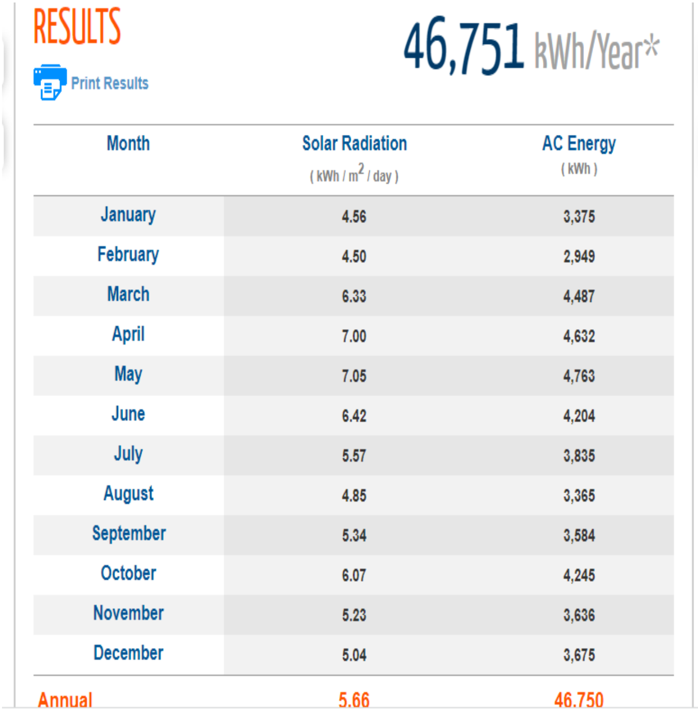
$$V_{out} = \frac{1}{1-D} V_{in} \quad \text{.....................................} (7)$$

$$R_{pv} = (1-D)^2 R_{out} \quad \text{...........................} (8)$$

Table 1 Technical Assessment

Roof Area in m²	**1000**	**m²**
Area available in m²(25 % of Available Roof Area)	**250**	m²
Area reqd per kW in m²	**8**	m²
Total kWp potential	**30**	
Direct Normal Irradiance in kWh/m².day		kWh/m².day
Solar PV Panel Efficiency	**16%**	
Annual Energy Generation	**46,751**	kWh/year
Cost per kWp	**68000**	INR
Total capital cost for proposed Solar PV plant	**20,40,000**	INR
Electricity cost per kWh	**7.0**	INR
Payback period	**6.2**	Years

As we can see from the technical assessment that firstly we should decide the quantity of solar roof top capacity and it depends upon the available roof space and the needful criteria of load connected or the contract demand of the client or consumer. In some building bye laws and codes the 25 % of the roof area can be taken as the space for the solar PV. Accordingly we can calculate from the roof area that how much capacity will be needed for the simple calculation to understand we have taken roof area of 1000 square meters and as per the calculation the Kw potential is 30KW. Panel Efficiency is 16 % and from the solar PV calculator we can calculate the other parameters by entering the capacity of 30KW, the annual energy generation will be estimated by calculator is about 46,751 kWh/Year and other parameters also described accordingly with the help of PV calculator.


RESULTS
Print Results
46,751 kWh/Year*

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	4.56	3,375
February	4.50	2,949
March	6.33	4,487
April	7.00	4,632
May	7.05	4,763
June	6.42	4,204
July	5.57	3,835
August	4.85	3,365
September	5.34	3,584
October	6.07	4,245
November	5.23	3,636
December	5.04	3,675
Annual	5.66	46,750

Fig -7: PV Calculator

The location once specified in the calculator we can see the approximate solar radiations kWh/m2/day month wise and the approximate generation of units every month in a year as shown in fig 7.

In fig 8 system technical specifications described like type, system losses, inverter efficiency, weather data source, latitude and longitude of the location. All these calculations required in the financial analysis also to give the estimation of payback period. In this case if the units generated per year will be near about 46,751 units then as per the current average unit rate that is 7 Rs per unit we can see that the installation cost can be recovered in about 6 years even if we calculate as per the same unit rate, if the unit rates will increase in future then this payback period will be lesser then 6 years.

Location and Station Identification	
Requested Location	dehtradun
Weather Data Source	Lat, Lng: 30.29, 78.06 1.5 mi
Latitude	30.29° N
Longitude	78.06° E
PV System Specifications	
DC System Size	30 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	20°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*

Fig -8: PV System specification calculator

5. RESULTS

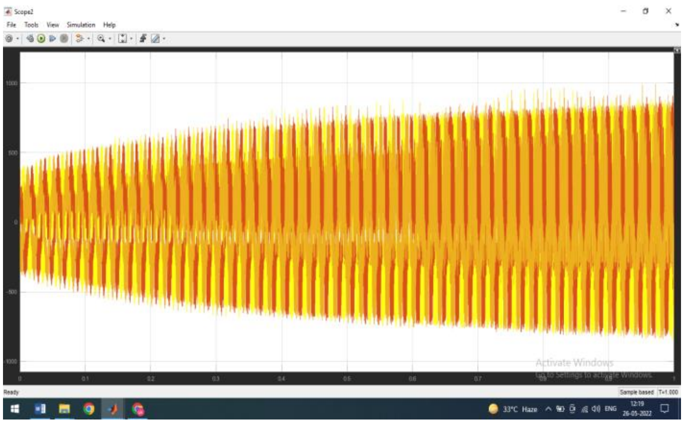


Fig -9: Three Phase Voltage

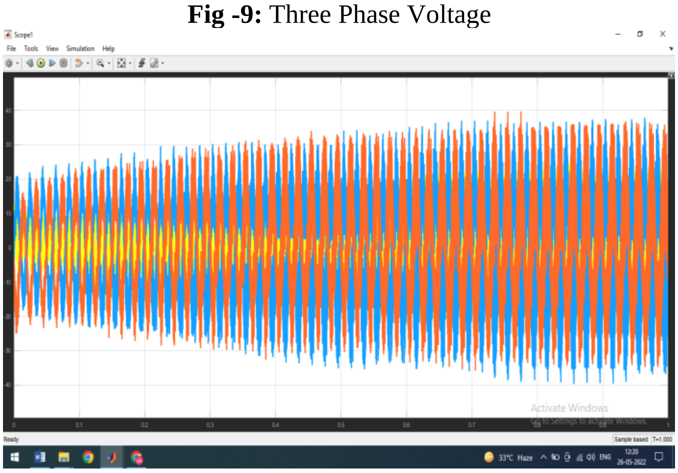


Fig -10: Three Phase Current

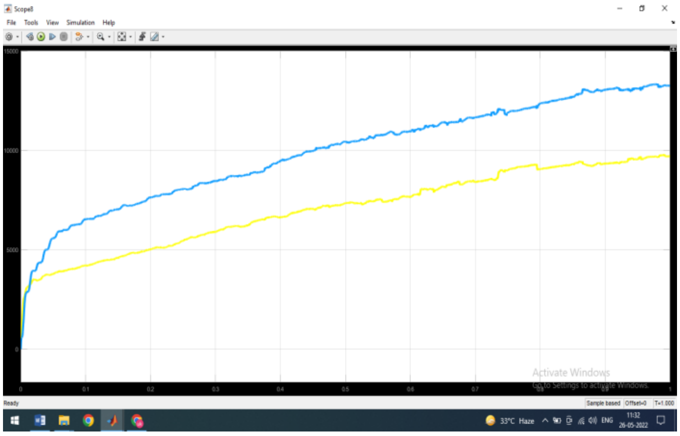


Fig -11: Active and reactive power

A 30 KW solar PV system has been modelled and analyzed the outputs by connecting it with the load by using the same kind of capacity of equipment's and try to get the desired outputs and the nature of the output.

The output voltage from the solar PV array ids near about 700 V and after the boost converter voltage boosted up to 800 volts and then after conversion into AC with the help of inverter we can see that the simulation is done for 60 seconds and the voltage gets increasing at the starting and become near about 1500 V and then gets steady state condition and remains constant. Active power increasing continuously up to 12000W.

The specified location has been taken in our analysis for getting the practical results of a site and solar PV generation and outputs for the captive load by using net metering process and we can for storage kind of facility also. The main aim is to have an analysis as per the climate and the location that may be building commercial or institutional or industrial also and try to find out the installation cost and payback period which is almost 6 years in the present case and current unit rate taken.

6. CONCLUSION

As per the reports the energy consumption is very high in percentage as per the building sector that may be commercial or industrial and will be increased by 3 folds in the next 20 years upcoming so that will be a great challenge for us to reduce the consumption by the conventional generation system and solar based generation is one of the best idea we can say to reduce the demand by the building consumers and that's why a great research and a better understanding needed for the installation. In this paper we connected the site location, its climatic condition with the solar power generation capacity and its technical and financial assessment will be done by using various calculators and software's like Matlab and financial analysis has been done as per the current average unit rate, the units of generation by solar plant and its payback period for the installation cost. This step will be a great help to reduce carbon footprints.

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