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EVALUATION AND PERFORMANCE ANALYSIS OF A 30KW SOLAR PV SYSTEM

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ABSTRACT

The basic and most common measure of almost all types of work is energy. Coal, natural gas, oil, and nuclear power are pure and major energy sources. The purpose of this work is to evaluate the performance of the 30KW solar power plant at the Alagappa Chettiyar Government College of Engineering and Technology in Karaikudi, Tamil Nadu. The system is monitored 3 days a week (July to September 2021) from Monday to Friday from 10:00 to 16:00. The real-time meter measurement values of the power and energy produced by the inverter are recorded at the input and output.

Key words : Solar Photovoltaic System, Solar Grid System

1. INTRODUCTION

The development of all countries requires energy demand. The scarce storage capacity of fossil fuels is limited. Fossil fuels emit harmful greenhouse gases and cause serious damage to the environment. The existing electricity in thermal power plants is also harmful to the environment. If we work hard to maintain the balance of the world's ecosystems, we can completely eliminate the problems of global warming and environmental damage. This can only be achieved by working together, recognizing and aware of the urgency of solving this problem. Due to its environmental protection, miniaturization and other advantages, the energy produced by solar energy has attracted more and more attention from human beings. Due to the rapid development of power generation technology and its advantages of pollution-free, low-maintenance, moving parts and grid distribution solar energy is an increasingly important renewable energy source. Compared with other existing power generation methods, the main advantage of solar energy is that smaller PV (solar) solar cells can be used to directly convert sunlight into solar energy. [1]

Photovoltaic solar cells convert solar energy into direct current through a photovoltaic process. Photovoltaic systems can be off-grid and grid-connected. Off-grid systems require batteries. In off-grid mode, the battery should be replaced every 3-5 years. The direct current generated by the photovoltaic panels (SPV) in the grid-connected rooftop photovoltaic system is converted into alternating current through the photovoltaic grid-connected inverter to form an 11KV or 440/230V line, three-phase line grid. If the single-phase and solar energy are insufficient, get it from the grid. [2]

2. SOLAR ENERGY

Our sun is a natural nuclear reactor. It radiates lesser packets of energy called photons and movements 93 million miles from the sun to the earth in about 8.5 minutes. Each and every hour, there are sufficient photons to move the earth and generate adequate solar energy to theoretically meet the world's energy demand for one year. Solar energy is produced by the fusion reaction inside the sun. The energy emitted from the sun is a mixture of ultraviolet, visible and infrared. The intensity of this radiation reaching the earth is 1361 W/m 2. When it passes and waits, some of the radiation is dispersed and some is absorbed. [3]

Solar cells and solar cells are manufactured according to the principle of photoelectric effect. They convert sunlight into direct current (DC). Solar cells are composed of two kinds of semiconductors, p-type and n-type silicon. P-type silicon is created by adding atoms such as boron or gallium, which have one fewer electron from an external energy level than silicon. Boron produces electron defects or holes because it requires one less electron than the surrounding silicon atom to form a bond. Therefore, N-type silicon generates more electrons in the outer layer than silicon. A person has five electrons instead of four electrons from an external energy level. It bonds with adjacent silicon atoms, but electrons do not participate in the bonding. In its place, it can travel easily within the silicon structure.

The solar cell consists of a p-type silicon layer next to the n-type silicon layer. The n-type layer has extra electrons, and the p-type layer has extra charged holes. The electrons on one side of the junction close to the two-layer junction move to the holes on the other side of the junction. This creates an area around the junction, called the depletion region, where electrons fill the holes. When all the holes in the depletion region are filled with electrons, the p-type side of the depletion region contains negatively charged ions, and the n-type side of the depletion region contains charged ions. The presence of these oppositely charged ions will generate an internal electric field, preventing electrons in the n-type layer from filling the holes in the p-type layer. When sunlight hits the solar cell silicon electrons are emitted forming holes left by the escaped electrons. Once it is created in an electric field, the electric field moves electrons to the n-type layer and holes to the p-type layer. When the n-type layer and the p-type layer are connected by a metal wire, the electrons in the n-type layer reach the p-type layer through the depletion region and then move again through the n-type outer wire generating flow of electricity. [4 - 5]

A photovoltaic array is a combination of series and parallel solar modules. The combination of solar cell modules in series and parallel is called a solar cell array. Solar cells are placed in glass materials to protect them from the environment. A single crystal of the semiconductor material of the photovoltaic cell is placed on the solar panel. The photon beam that makes the light fall on the earth produces a small amount of energy. Such solar panels are arranged in large numbers to generate large amounts of energy. Photon absorption is mainly based on the band gap energy present in photons and solar cell semiconductor materials. This can be expressed in electron volts (eV). Photons are mainly produced by the sun falling in front of the solar panel toward the semiconductor material solar cell. A single photovoltaic cell can generate a very small amount of electricity, about 0.5V. The solar cell is connected in series with the cathode terminal on the side of the terminal on the opposite side of the anode terminal from the developing terminal. [6]

3. SOLAR – GRID SYSTEM

Grid-connected solar energy is a technology that allows large-scale solar energy generated by photovoltaic systems to penetrate the existing grid. This technology also requires careful consideration and attention in the manufacturing, installation and operation of photovoltaic modules. The level of solar penetration needs to be effectively interconnected with the grid. In many ways, these interconnections require an in-depth understanding of their impact on the network. A photovoltaic system that uses solar modules to power the grid is essentially composed of different components. In essence, the inverter is the most important integrated component. Other components include photovoltaic generators (solar modules), generator junction boxes (GJB), meters, grid connections, DC and AC wiring. Inverters play an important role in all solar systems and are usually considered the brains of the project.

The basic function of the inverter is to "reverse" the output direct current (DC) into alternating current (AC), which is a standard used in all commercial equipment. Regardless of the load conditions, the inverter needs to provide a constant voltage and frequency, and must supply power or drive when a negative load occurs. In addition to inverters, inverters will coordinate systems with each other to deliver solar energy to the grid as efficiently as possible. Therefore, the yield rate of the photovoltaic system depends only on the orientation, interconnection and quality of the photovoltaic modules, as well as the reliability and efficiency of the inverter. [7]

4. REAL TIME SYSTEM DESIGN

The main aim is to design and install 30KW solar rooftop solar power plant.

A. Key facts of solar rooftop power plant Plant capacity in KWp : 30KWp
   Rooftop Solar power plant PV Technology/Module: Polycrystalline modules
   Power evacuation: 440/230V, three/single-phase, 50HZ
   Real on-site 30KW Solar Roof Top Power Plant of Alagappa Chettiyar Government College of Engieering andTechnology , Karaikudi, Tamilnadu is shown in below

Fig.1. 30KW solar plant at Alagappa Chettiyar Government College of Engieering and Technology , Karaikudi

B. System capability based on rooftop area

Total Power output = Total area x Solar irradiance x Conversion efficiency

30000 = Total area x 1000 Watts/m2 x 0.15

Total area required for 30KWp = 200 Sq.m = 2152.78 sq.feet

The rooftop area required to install 30KWp is around 2200 sq.feet.

C. Number of PV panels for the system

Divide the total watt-hours per day needed from PV panels by the rated output watt-peak of PV modules.

Capacity of each module: 220 Wp

Number of PV panels or modules required = 30000Wp / 220 WP = 136.3

The maximum power of this module is 220Wp; hence it requires nearly 136 modules to design 30KW PV system.

Fig.2. Solar array junction box

D. Solar Grid Inverter rating the solar array PV capacity is 30KW. In solar grid connected plant, input rating of inverter should be same as PV array rating.

Fig.3. Solar grid inverter

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Fig.4. Parameter measurement

5. REAL TIME TEST RESULTS & DISCUSSIONS

The solar cell module absorbs solar radiation and converts it into useful electrical energy. Data will be collected manually at 10:00, 12:00, 14:00, and 16:00 on July 26, 2021. During peak hours (12:00), solar radiation is the largest on the panel and is now very high, just like under the conversion of DC and AC power generated by solar panels (Table 1). The bar graph shows a graph (Fig.4) that shows the change in power over time and daily results.

Table 1. Unit Generation and consumption per day [26.07.2021]

Date	Time	Pdc	Pac	Etod
26.07.2021	10am	17.43	16.96	31.87
	12pm	21.02	19.98	68.74
	2pm	15.54	14.82	107.63
	4pm	1.84	1.8	128.3

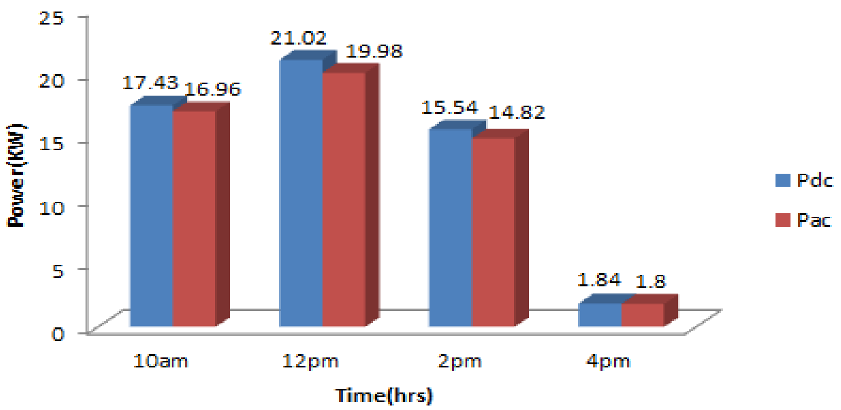

Fig.4.DC power output and converted AC power Per Day

The bar graph (Fig.5) displays the graph showing the total energy change according to the time when the daily results are provided.

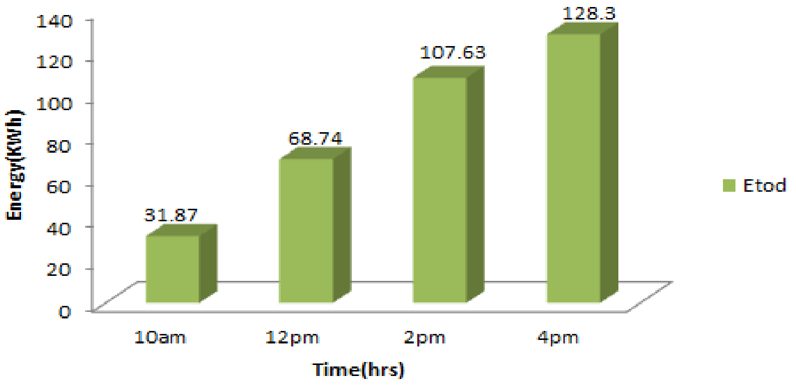

Fig.5.Total energy created per day

Collect weekly average data on July month (Monday, Wednesday, and Friday) at different times of the day to obtain weekly average results on different days of the week. On July 30, it will generate higher direct current and higher alternating current. The bar graph shows (Fig.6) the weekly average results extracted from the DC and AC power sources, and the bar graph shows the total energy generated in three days.

Table 2. Average Unit Generation and consumption per week

S.No	Date	Pdc	Pac	Etod
1	26.07.2021	13.95	13.39	84.13
2	28.07.2021	12.46	12.19	41.44
3	30.07.2021	15.93	15.08	86.58

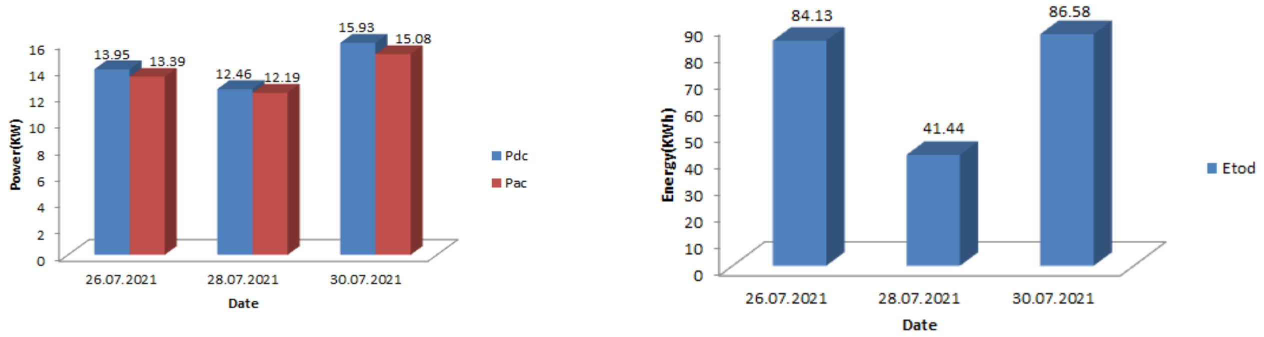

Fig.6.Weekly average power and energy results

The data is collected manually at 10.00 am 12.00 pm 02.00 pm and 04.00 pm in the month of 16^{th} August 2021. The solar radiation is maximum at the panel at Peak time (12.00 pm) and dc power output from solar panel and converted ac power are very high at this time as shown in (table 3) below. A graphical plot showing (Fig.7) the variation of power with respect to time giving the daily results is shown in the bar graph.

Table 3. Unit Generation and consumption per day [16.08.2021]

Date	Time	Pdc	Pac	Etod
16.08.2021	10am	17.52	17.1	28.6
	12pm	20.72	20.34	78.98
	2pm	19.64	19.1	108.59
	4pm	5.45	5.32	138.29

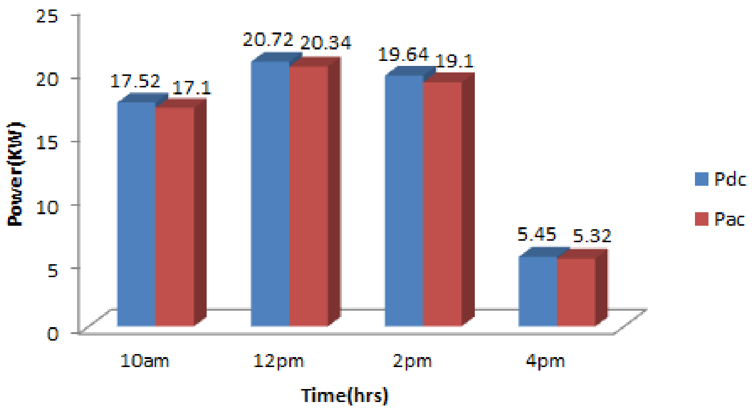

Fig.7.DC power output and converted AC power Per Day

A graphical plot showing (Fig.8) the variation of total energy generated with respect to time giving the daily results is shown in the bar graph

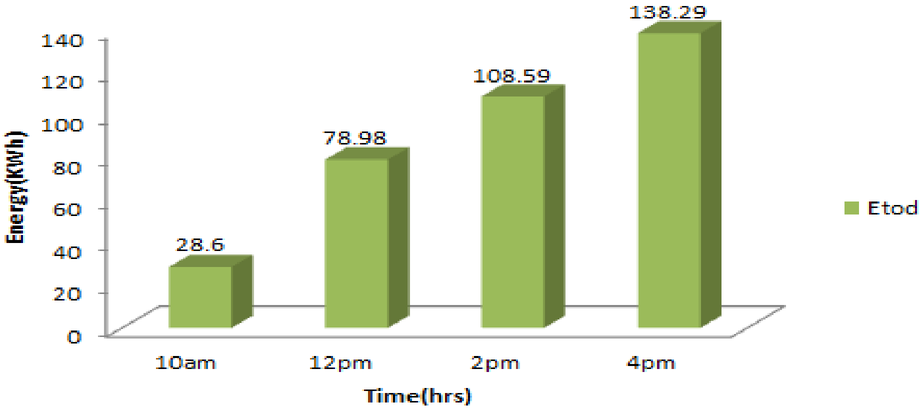

Fig.8.Total energy created per day

The average weekly data is taken for three days in the month of August (Monday, Wednesday and Friday) at different times of the day to obtain the average weekly results on various days. Higher dc power generation and ac power output on 30th July .From the bar graph is shown average weekly results drawn for dc power, ac power and total energy generated for three days is represented in bar graphs.

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Table 4. Average Unit Generation and consumption per week

S.No	Date	Pdc	Pac	Etod
1	16.08.2021	15.83	15.46	88.61
2	18.08.2021	13.23	12.54	84.09
3	20.08.2021	13.54	13.25	77.89

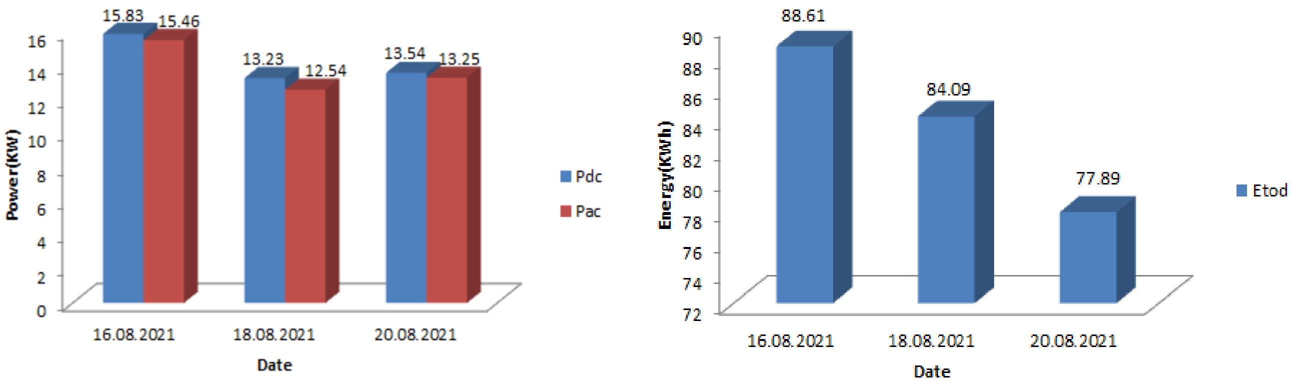

Fig.9. Average Unit Generation and consumption per week

The data is collected manually at 10.00 am 12.00 pm 02.00 pm and 04.00 pm in the month of 6th September 2021. The solar radiation is maximum at the panel at Peak time (12.00 pm) and dc power output from solar panel and converted ac power are very high at this time as shown in (table 5) below. A graphical plot showing the variation of power with respect to time giving the daily results is shown (Fig.10) in the bar graph

Table 5. Unit Generation and consumption per day [06.09.2021]

Date	Time	Pdc	Pac	Etod
06.09.2021	10am	12.42	12.29	25.64
	12pm	18.47	18.21	64.79
	2pm	19.6	19.01	94.65
	4pm	5.41	5.34	117.33

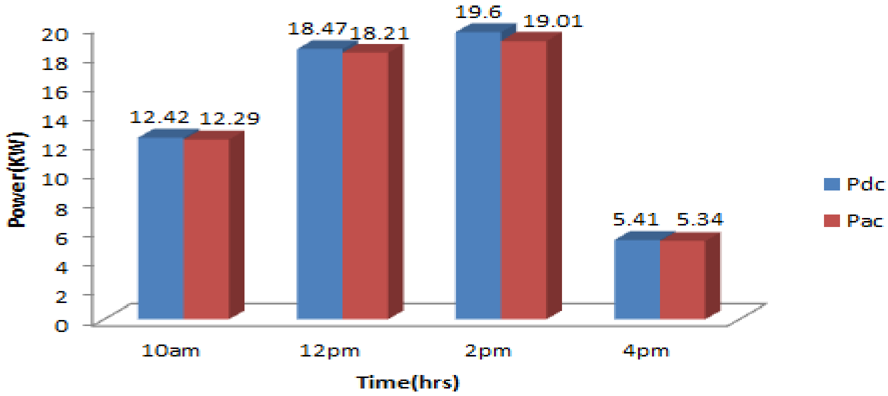

Fig.10.DC power output and converted AC power Per Day

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A graphical plot showing the variation of total energy generated with respect to time giving the daily results is shown in the bar graph

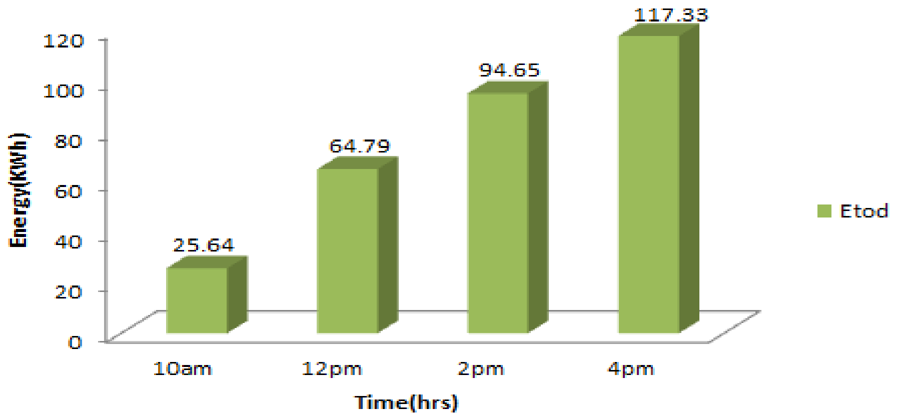

Fig.11.Total energy created per day

The average weekly data is taken for three days in the month of September (Monday, Wednesday and Friday) at different times of the day to obtain the average weekly results on various days. Higher dc power generation and ac power output on 30^{th} July .From the bar graph is shown (Fig.12) average weekly results drawn for dc power, ac power and total energy generated for three days is represented in bar graphs.

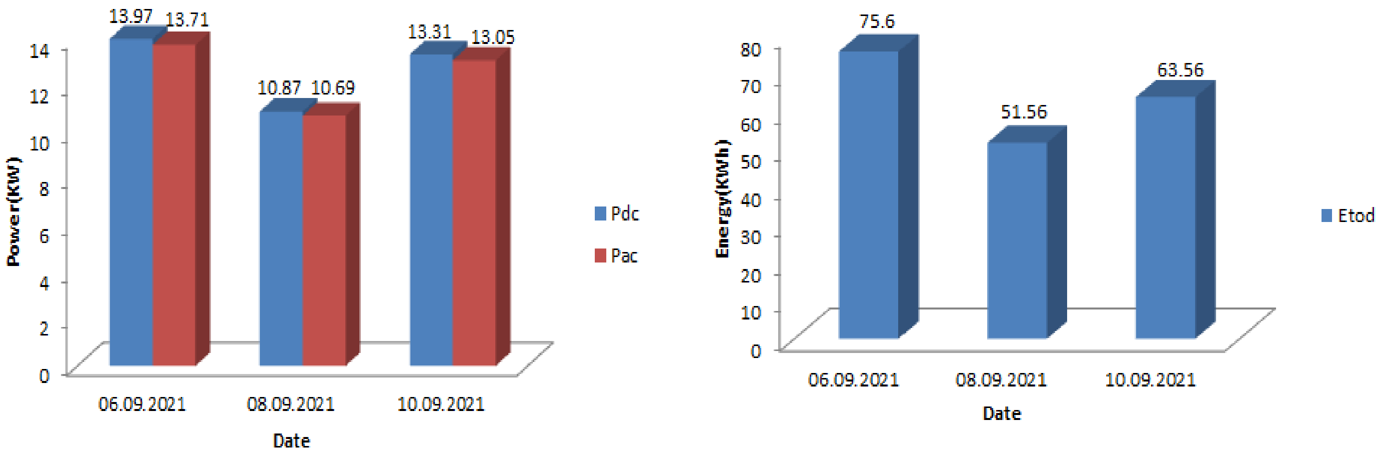

Fig.12.Weekly average power and energy results

The different irradiance conditions of the sun various with respect to time. This will cause the generation of DC and AC power sources to change over time, depending on your requirements. The results of DC average power, AC power, and total energy produced are shown in the table (table 6). You can observe the power changes at other times of the day.

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Table 6. Average Unit Generation and consumption for three months

S.No	Month	Pdc	Pac	Etod
1	July (4th Week)	14.11	13.55	70.72
2	August (3rd Week)	14.2	13.75	83.53
3	September(1st Week)	12.72	12.48	63.57

In August, 83.53kWh (average) power generation equipment will be provided. The figure below shows the result of the average DC power generation in three months, and the average AC power is displayed as a bar graph.(Fig.13)

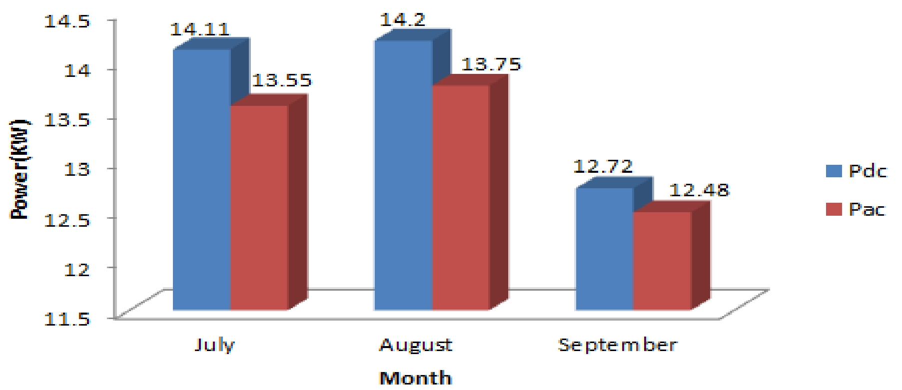

Fig.13.Average DC power output and converted AC power for three months

The Fig.14 below is a bar graph showing the results of the average total power generation over 3 months.

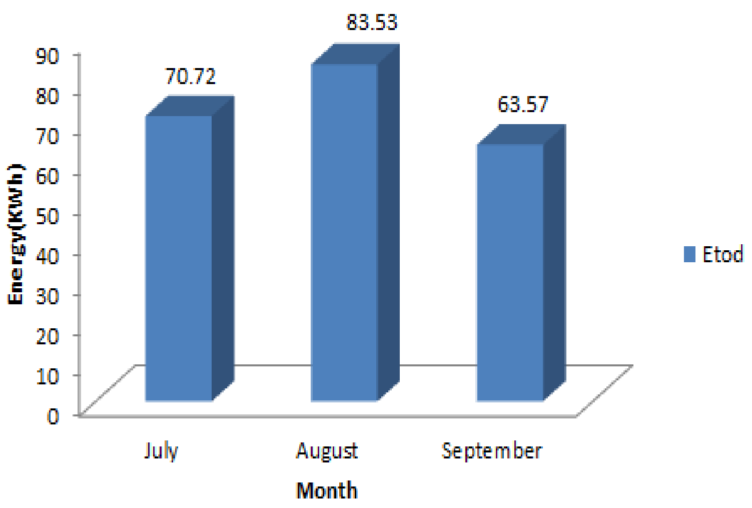

Fig.14. Average total energy created for three months

6. CONCLUSION

In this study, the performance of a 30KW photovoltaic power generation system and analyse the daily and monthly output during the period. The power plant's monthly output varies from 70.72 kWh in July, 83.53 kWh in August and 63.57 kWh in September. We will evaluate the performance of the 30KW photovoltaic power generation system and analyse the performance changes during the three days of the month. In future, there is scope to calculate the performance ratio and Capacity utilization factor of 30 KW on-grid solar photovoltaic systems for six days and yearly data will be obtained from 10.00AM to 4.00PM and also savings of plant may be analysed. Elsewhere, comparing the results of this study is to improve plant performance.

REFERENCES

[1] Bhuvaneswari C , Vijay B and Natarajan P, " Estimation and Performance analysis of a 15kW Off-Grid Solar PV System", International Journal of Engineering & Technology, 7 (2.25) (2018) 143-147

[2] Jayanna Kanchikere , Dr.A.K.Ghosh and Dr.KalyanKumar, "Online Monitoring And Simulation Of 30KW Grid Connected Rooftop Solar Power Plant At St.Peter's International School, Hyderabad using PV Syst", IJARIIE-ISSN(O)-2395-4396, Vol-4 Issue-3 2018.

[3] S. V. Kiseleva, Yu. G. Kolomiets, and O. S. Popel, "Assessment of Solar Energy Resources in Central Asia", ISSN 0003 701X, Applied Solar Energy, 2015, Vol. 51, No. 3, pp. 214–218. © Allerton Press, Inc., 2015.

[4] Rokeya Jahan Mukti and Ariful Islam, "Modeling and Performance Analysis of PV Module with Maximum Power Point Tracking in Matlab/Simulink", ISSN 0003 701X, Applied Solar Energy, 2015, Vol. 51, No. 4, pp. 245–252. © Allerton Press, Inc., 2015.

[5] B. Shiva Kumar, K. Sudhakar, "Performance evaluation of 10 MW grid connected solar photovoltaic power plant in India", Elsevier , Energy Reports, Volume 1, November 2015, Pages 184-192

[6] C H B Apribowo , M Nizam , S Pramono1, H Maghfiroh and K Hakim," Design and Analysis Performance Solar Power Plant 15 kW By Maximizing Final Yield and Performance Ratio In Small-Medium Office", IOP Conf. Series: Materials Science and Engineering 1096 (2021) 012082.

[7] K.N. Nwaigwe ⇑ , P. Mutabilwa and E. Dintwa," An overview of solar power (PV systems) integration into electricity grids", Materials Science for Energy Technologies 2 (2019) 629–633.