IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

COMPARATIVE ASSESSMENT OF THE CONSUMPTION OF ELECTRICITY OF 100KW ROOFTOP SOLAR PHOTOVOLTAIC POWER STATION CONNECTED TO THE ON-GRID AND OFF-FRID IN NGF COLLEGE

[1]Dr.Vinod Kumar, [2]Sweety, [3]Akansha, [4]Sapna Chauhan

[1] Professor, [2] Assistant Professor, [3]Assistant Professor, [4] Assistant Professor
[1]Electrical Engineering,
[1]NGF College of Engineering & Technology, Palwal, India.

Abstract: The objective of this paper is to analyze the comparative evaluation of the electricity consumption of a 100kw solar PV plant with or without a grid-connected system. The work is divided into different phases. The first phase involves comparing the electricity bill with and without grid-connected solar PV and plotting various graphs such as: (1) Energy consumption (kWh) vs. month, (2) Energy consumption costs vs. Moon. The second phase involves comparing the fuel consumption of the generator before and after the installation of the solar panel. The third phase includes a study on the direct and indirect benefits of installing a solar panel in this institution, e.g. saving on bills and supplying energy back to the grid, etc.

Index Terms **- Charge Controller, Grid Connected Inverter, Grid Tied Inverter, Net Metering, On-Grid.**

I. INTRODUCTION

Solar energy is a readily available non-conventional type of energy. Energy from the Sun is in the form of radiation. The intensity of solar radiation falling on the earth's surface is around 1369 watts per square meter. A solar power system typically consists of solar panels, an inverter, a charge controller, wiring, and support structures. The three most common types of solar electric systems are grid-connected, grid-connected with battery back up, and off-grid (standalone).Sunlight is always changing and this different form Solar energy is used to power solar panels using the photovoltaic (PV) effect. The PV effect causes an electric current to flow through a solar cell when it is exposed to sunlight. Several solar panels together form a solar array. There is four types of panels depending upon the material composition and design. They are

1. Mono-crystalline silicon
2. Polycrystalline-silicon
3. Thin film
4. Multi-junction

II. MAIN COMPONENTS

- SOLARPANEL
- SOLARCHARGECONTROLLER
- GRIDCONNECTEDINVERTER
- GRIDINTERACTIVEINVERTER
- NETENERGY METERING (NEM)

Site Information

Site of NGF College of Engineering & Technology, is located in Palwal, Haryana, India. It has following coordinates

I. Latitude 29.0588N
II. Longitude 76o0856E

III. BLOCK DIAGRAM REPRESENTATION OF 100 KW SOLAR POWER PLANT

.

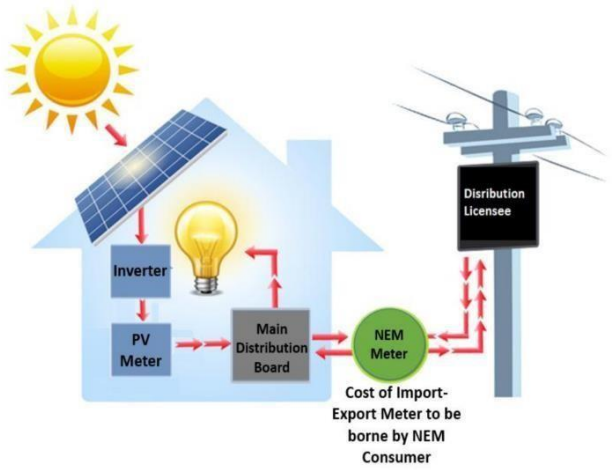

Figure 3.1: Block diagram representation of 100KW solar power plant.

The above mentioned solar power plant is of 100kw and is basically composed of three sub-parts i.e. 50kw, 30kw and 20kw. Theirs coupled by two power conditioning units i.e., inverter of capacity 100KW is used.

Our 100 kw solar PV system consists of 315 solar modules each module as capacity of 315 watt.

The total peak power will be 99.25kw or approx.100kw. There are 15 to 20 modules placed in series and the output is taken to the array junction box with the help of 4mm, 2 dc cable All the modules are placed on the roof top of NGF College at a tilt an angle of 26 degree.

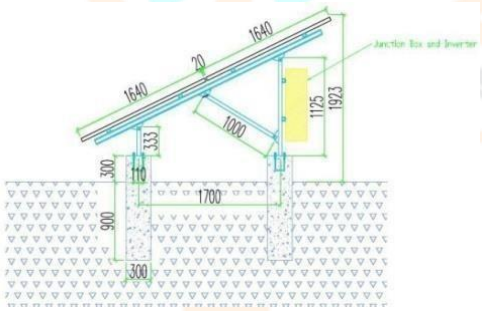

Figure 3.2: Structure of PV module.

- Most important aspect of the installation is in formative energy monitoring and display system, which can be monitored by 24×7 on website.

During day time if the solar module energy is less compared to energy required by load then excess energy required by the load will be taken by the utility grid.

When excess energy is generated after meeting our load demands it is then feedback to the grid.

IV. DETAILS OF 100KW SPV POWER PLANT

Table 4.1: Details of 100kw Spv Power Plant

Installed Capacity	100KWp
Date of Installation	30thMarch,2017
System Cost	Rs.6000000/-
Type of SPV Power Plant	GRID Connected with NET Metering facility without Battery Bank
Make of Modules	Tata Power Solar System Ltd.
Capacity of each PV Modules	315Wp
Numbers of PV Module	315
Solar Cell Technology	Polycrystalline
Make of Inverter	Delta

Capacity of each Inverter	50Wp,30Wp,20Wp
Details of Metering	NET Metering
Make of Meter	Applied
Monitoring Mechanism	Online Monitoring
Grid connected Level Voltage	Connectedat11KVLevel
Daily Power Generation	400-450 Units (On Sunny Days)
Annual Power Generation	1,50,000Units(Approx)

V. TECHNICAL SPECIFICATION OF 100KW SPV POWER PLANT

5.1 Specification of External Grid

Table 5.1: Specification of External Grid

Number of Phases	Three phases
Voltage-rating	400-Volts output AC
Frequency of supply	50Hz.

5.2 Specification of 100kw solar roof top PV Plant

Capacity of system	100 Kw
Output-Voltage	400 Volts dc
Output-Current	36 Adc
Number of Modules	315 nos.
Required Area	1150 m²

5.3 Specification of Delta Connected Inverter

Table 5.2: Specification of Delta Connected Inverter

KVA Rating	100-110KVA
Input DC volts	240 Volts DC
Input Dc current	36A
Output AC voltage	186.96VAC
No. of Phases	3-φ
Inverter type	PWM (for reduction of harmonics)
Inverter Efficiency	Almost 90-93%
THD	<5%

5.4 Specification of Solar PV Module

Table 5.4: Specification of Solar PV Module

Power rating	315W
Voltage rating	24V
Current rating	5A
Material used	Poly-crystalline
System Efficiency	15.2%
Temperature	26°c
System Dimensions in (mm)	1593×790×50 Surface Area of 1panel =1258470 (mm)
Tilt angle	30.7
Mounting	Fixed Type

Table 5.5: Specification of Trans former

Rating in V	110KVA
Number of phases	3-φ
Frequency rating	50 Hz
Pri. side voltage	186.96 V
Sec. side voltage	400V
Pri. Side current	64.18Aandadditionof(10-15%extra)
Sec. side current	27.27Aalsoadditionof(10-15%extra)
Type of Connections	Primary-delta
Efficiency	Almost95%
Other features	Air cooled

VI. DESIGNANALYSIS ANDCALCULATION

Total no. of modules = 315
For 30kW solar module system:
Open Ckt Voltage rating of 30kW inverter used = 550V
Panel open ckt voltage (Voc)= 37.5V
No. of panels connected in series are = 13
Panel working voltage=30.5V
Series Panel Working Voltage=13×30.6 = 397.8V
Total power= (V×I) = 30kW
Total power= (V×I) = 30kW..... (1)
From equation(1)
Working current is calculated as = 75.414A
From the panel details we get Isc = 8.18A
No: of panels connected in parallel=10

For10kWsolarmodulesystem:
Obtained Voltage ratings is given = 240V
No. of panels connected in series=10 (Inverter Voltage) / (Panel voltage) = 7.8 ≈7
Panel Working Voltage = 30.6V
Series Panel Working Voltage = 7×30.6 = 214.2V
Total Power=(V×I)=10kW
Working Current= 46.68A
No of panels connected in parallel = 5.70≈6

Therefore, for 30kW inverter, we connect the panels as 13×10 (i.e. 13 panels are connected in series and 10 in parallel respectively)

VII. VARIOUS PERFORMANCE LIST AND VARIOUS CURVES ARE DRAWN ON THE BASES OF ABOVE CALCULATION

To analyze the performance of the solar power plant installed in the college, the electricity bills of our college before and after installation of the solar plant were analyzed and graphs were plotted.
Electricity Consumption Pattern-Supply from DHBVN before the Installation of Solar PV Plant (from May-2017 to April-2018)

Table 7.1: Electricity Consumption Pattern-Supply from DHBVN before the Installation of Solar PV Plant (from May-2017 to April-2018)

Months	Energy Drawn from DHBVN (KWH)	Energy Charges Paid to DHBVN (Rs.)
1-05-17	62289	524664.00
1-06-17	67605	883092.00
1-07-17	32994	598364.00
1-08-17	23301	245691.00
1-09-17	45150	660220.00
1-10-17	33006	275500.00
1-11-17	39393	349811.00
1-12-17	30198	284799.00

1-01-18	27081	256655.00
1-02-18	20397	208329.00
1-03-18	25764	245714.00
1-04-18	56730	505656.00
Total(Annually)	463908	5038495.00

Before installation of solar plant

It was found that during the years 2017-2018 from January - March the demands were almost same. There was a peak during May & June 2017 due to construction works in college and also due to the high temperatures during summer. During August 2017 and February 2018 the demand decreased due to summer vacation & rainy season and winter vacation respectively for the students. Energy consumption increased during the September 2017 due to the admission of more number of students to the college for the new academic year.

From Table no-7.1,it observed that Electricity Consumption Pattern-Supply from DHBVN before the Installation of Solar PV Plant (from May-2017 toApril-2018**)**

The average Energy drawn from the DHBVN from May-2017 to April-2018 is 463908 units and amount which is to be paid to DHBNL is Rs.5038495/- (Annually)

Electricity Consumption Pattern-Supply from DHBVN after the Installation of Solar PV Plant (from May-2021to April-2022)

Table 7.2: Electricity Consumption Pattern-Supply from DHBVN after the Installation of Solar PV Plant (from May-2021to April-2022)

Months	**Energy Drawn from DHBVN (KWH)**	**Energy Charges Paid to DHBVN (Rs.)**
1-05-21	32530	292770.00
1-06-21	41560	393866.00
1-07-21	28642	266370.00
1-08-21	37500	356739.00
1-09-21	36600	336102.00
1-10-21	34400	326800.00
1-11-21	29500	280024.00
1-12-21	25100	233782.00
1-01-22	15200	151836.00
1-02-22	20500	170471.00
1-03-22	28400	269683.00
1-04-22	39500	355102.00
Total(Annually)	**369432**	**3433545.00**

After installation of solar plant

In April 2018, the 100kw Solar PV plants has installed in the roof of the NGF College and after checking all the parameters and safety devices and it start to generate electricity w,e.f 1st May-2018

It was found that the energy consumption was stabilized. The demand from DHBVN was reduced considerably.

It was observed from Table-2 that during the years2021-2022 .There was a peak during June 2021due to construction works in college and also due to the high temperatures during summer. All ACs are in working condition.

During July 2021 and January 2022 the demand decreased due to rainy season and winter vacation respectively for the students.

Electricity Consumption Pattern-Supply from DHBVN after the Installation of Solar PV Plant (fromMay-2021toApril-2022). The average Energy drawn from the DHBVN from May-2021 to April-2022 is 369432 units and amount which is to be paid to DHBVN is Rs.3433545/- (Annually). From table 1&2 it observed that the benefits of **Rs.1604950**/- (Annually).

It is clearly seen that the energy charges were reduced considerably after the installation ofthe100KWrooftopsolarPVplant.

Table 7.3: Electricity Consumption Pattern-In-house Solar Panel

Duration	Unit Generatedby DHBVNL	Unit Generatedby Solar	Total Consumption(DHBVNL+ Solar)
1-05-21	37530	12160	44690
1-06-21	41560	11560	53120
1-07-21	23642	4832	28474
1-08-21	32500	5551	38521
1-09-21	36600	9850	46450
1-10-21	34400	9454	43854
1-11-21	29500	6830	36330
1-12-21	25100	7550	32650
1-01-22	15200	6515	21715
1-02-22	20500	9036	29536
1-03-22	33400	10620	44020
1-04-22	39500	11195	50695
Total	**369432**	**115206**	**465061**

Energy generation annually from the solar roof top photo voltaic system has been calculated on the basis of data available on roof top solar PV plant at NGF College at district Palwal.

Average power consumption unit's of 369432 annually from the DHBV Nandaverageun it generated by 100kw solar plant is 115206 kwh annually while average maximum demand is 92.90KVA.Actual number of units consumed shows as pike in various months like May and June which are the peak summer months in Palwal region and air conditioning requirements are very high. It can be seen that during Jan, Feb and July there is dip in energy consumption, as during this period college is Non-functional and rainy season

The total power drawn from the grid is reduced since April18 as in house solar plant was commissioned. On the basis of analysis, design and capacity of 100kw solar roof top PV power plant at NGF College we put fan, lighting and many small loads on it such that the system can run maximum devices at a time without any overload on the system. NGF engineering college is planning to build a second phase of roof top solar power plant with a capacity of 100kw. As we know that the power obtained from solar system is not continuous but due to grid interaction the regulation of supply is quit improved. Installation cost of solar power plant is high but its running cost is low also line losses are very less as compared to other power system.

Hence, by the installation of 100kw solar power plant NGF College become a pro-consumer due to net-metering system.

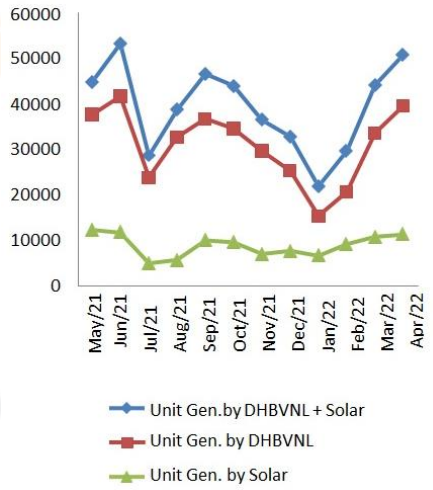

Figure 7.1: Shows the graph between months and units (kwh)generated by the solar plant and DHBVN.

Table 7.4: Unit Generated by DHBVN with &Without Solar Installation.

Duration	Unit Consumption from DHBVN with Solar Installation (KWH)	Unit Consumption from DHBVN Without Solar Installation (KWH)
1-05-21	32530	44690
1-06-21	41560	53120
1-07-21	28642	28474
1-08-21	37500	38527
1-09-21	36600	46450
1-10-21	34400	43854
1-11-21	29500	36330
1-12-21	25100	32650
1-01-22	15200	21715
1-02-22	20500	29536
1-03-22	28400	39020
1-04-22	39500	50695
Total	**369432**	**465061**

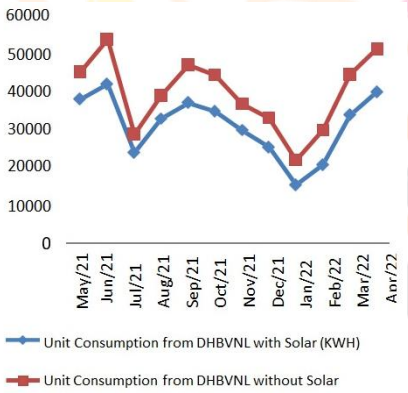

Figure 7.2: shows the graph between months and units (kwh) generated by DHBVN with and without solar plant.

Table 7.5: Cost of Unit Generated by DHBVN with & Without Solar Installation

Duration	Cost of Unit Generated by DHBVN with Solar Installation (Rs.)	Cost of Unit Generated by DHBVN without Solar Installation (Rs.)
1-05-21	292770.00	432210.00
1-06-21	393866.00	520016.00
1-07-21	266370.00	299503.00
1-08-21	356739.00	384448.00
1-09-21	336102.00	414825.00
1-10-21	326800.00	412686.00
1-11-21	280024.00	356970.00
1-12-21	233782.00	315600.00
1-01-22	151836.00	226292.00
1-02-22	170471.00	290916.00
1-03-22	269683.00	377180.00

1-04-22	355102.00	500602.00
Total (Annually)	**3433545.00**	**4531248.00**

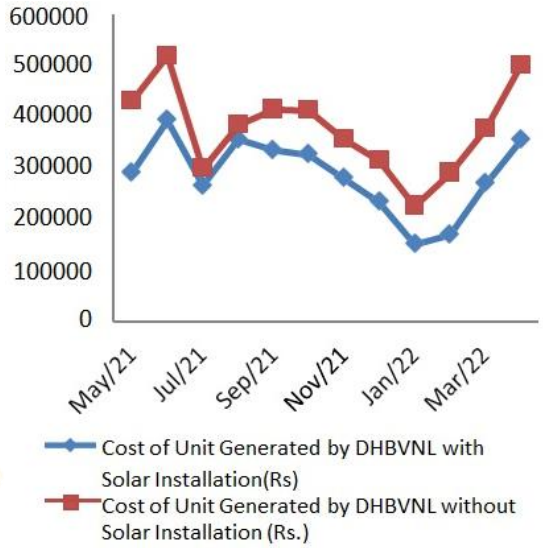

Figure 7.3: shows the graph between months and cost of units (kwh) generated by DHBVN with and without solar plant.

For the evaluation purpose, a period from May 2021to April 2022 was considered. The energy consumed from DHBVN with and without the solar plant was considered. The energy consumed from DHBVN with solar plant installed was obtained from the electricity bill. The energy from solar was obtained from the server.
Therefore the energy consumed from DHBVN if the solar plant was not installed was calculated by adding the above two energy consumption. The energy charges paid to DHBVN with and without the installation were also calculated and the savings were calculated

1. *Economic Analysis*

If money invested is in a bank
Total initial investment = Rs. 60, 00,000/-Subsidy =30% (Rs.1800000/-)
(a) Initial investment.= Rs.6000000-Rs.1800000= **Rs.42,00,000/- (With Subsidy)**
(b) Initial investment.= **Rs.60,00,000/-(without loan & without subsidy)**

If rate of interest chosen to be 8% Then yearly interest= Rs.4, 80000 /-
Total Interest for 6 years (4,80,000 x 6= Rs.2880000/- Total Initial investment.= Rs.60,00,000
+Rs 2880000 = Rs.88, 80,000 /-

(c) Initial investment = **Rs 88, 80,000/- (with loan & without subsidy)**

In direct Saving

Calculation on tariff

The average Energy drawn from the DHBVN from May-2021 to April-2022 is 369432 units and amount which is to be paid to DHBVN is **Rs.3433545**/-(Annually) with solar PV system

The average Energy drawn from the DHBVNL from May-2021 to April-2022 is **465061** units and amount which is to be paid to DHBVN is **Rs.4531248**/- (Annually) without solar PV system

From table 5, it observed that indirectly get a Average saving per year = Bill before installation –Bill after installation of solar plant

Average saving per year = **4531248 – 3433545 Rs. 1097703/-**

Diesel Savings (Annually)
Average diesel consumption be for installation of solar plant = 5000 liters
Average diesel consumption after installation of solar plant = 1000liters
Therefore, savings in diesel consumption = 5000-1000 = 4000 liters and cost of diesel Rs.90/- per liter so that total cost of diesel is 4000x90 = **Rs.360000/-** (Annually) in 2021-22

Table 8.1: The Annual Savings Due To Installation of Solar Plant.

S.NO	Parameters	Without SolarPV	With Solar PV	Annually Net Saving (Rs.)
1	Amount paid to DHBVN (Rs)	4531248	3433545	1097703
2	Cost of Diesel (Rs.)	450000	90000	360000
	Total Net Savings (Rs.)			**1457703**

We can see that on adding, indirect savings and generator fuel consumption savings we get almost a total savings,
Indirect savings= **Rs.1097703**/- (Annually)
Saving on diesel consumption = **Rs.360000/-** (Annually).
Hence, overall we have total net saving of **Rs.1457703/-** (Annually) after installation of 100kw solar power system.

VIII. CONCLUSION

The installation of 100 kW solar power generation plant at NGF College of Engineering and Technology not only provides a self-sustaining way of producing power from renewable energy source (i.e. sun) but also provides economic benefits. From the bill assessment it was found that the energy demand as well as the energy charges decreased after the installation of solar panel.

From the economic assessment it was found that a considerable amount of savings were made and the pay back period was to be found

(a) With subsidy is about 3-4 years.

(b) Without loan or without subsidy is about 4-5 years.

(c) With loan without subsidy is about 6-7 years.

By using Net Energy Metering (NEM) the system becomes more economically. Net metering enables the user to sell the excess energy back to the utility grid. Thus the installation of such a renewable power generation plant not only helps in achieving economic benefits but also reduces impact on the environment by reducing pollution, global warming and other implications. When solar plant is connected to grid it becomes the source of income because under no load or light load conditions the electrical power supply is fed back to the grid.

REFERENCES

1. N.Jabalameli, S.Deilami, M.A.S.Masoumand M.Abshar "Roof top PV with battery storage solar smoother" 2014 IEEEPES General Meeting Conference & Exposition, National Harbor ,MD, 2014, pp. 1-5.
2. M.Thula, M.N.Kumar and V.S.Reddy, "Simulation and performance analysis of 100kWp solar roof top using Solar Pro software" *2017 Innovationsin Power and Advanced Computing Technologies (i-PACT)*, Vellore, 2017, pp. 1-5.
3. B. Ravindra, "Are Indian electricity consumers ready to become solar prosumer" *2017 International Conference on Technological Advancements in Power and Energy (TAP Energy)*, Kollam,2017, pp. 1-6.
4. F.Giraudand Z.M.Salameh, " Steady – state performance of a grid-connected roof top hybrid wind-photovoltaic power system with battery storage," in *IEEE Transactions on Energy Conversion*, vol. 16, no. 1, pp. 1-7, March 2001.
5. Zou, F. Jiang and H. Liu, "Performance analysis of a rooftop PV plant and a desert PV plant," *2016 Chinese Control and Decision Conference (CCDC)*, Yinchuan, 2016, pp. 6173-6176
6. Y.Kim, J.Zhao, S.Kim and R.J.Harrington, "Power management strategy for residential housing connected to the roof top solar PV," *2017 IEEE Conference on Technologies for Sustainability (SusTech)*, Phoenix, AZ, 2017, pp. 1-7.
7. F. R. Pazheri, S. Aramco, T. Baby and O. K. Safoora "Rooftop solar projects enhance the environmental friendly power dispatch in Kerala," *2014 International Conference on Advances in Energy Conversion Technologies(ICAECT)*, Manipal, 2014, pp. 233-236
8. R. P. Mandi "Grid interactive rooftop solar PV power plant for educational institute ,"*2017 International Conference On Smart Technologies For Smart Nation(Smart Tech Con)*, Bangalore, 2017, pp. 1473-1478.
9. ZaitsevR.V., KirichenkoM.V., KhrypunovG.S., Prokopenko D.S., Zaitseva L.V" Development Of Hybrid Solar Generating Module For High-Efficiency Solar Energy Station", , *2017 IEEE First Ukraine Conference on Electrical and Computer Engineering (UKRCON) India*, Sep14-15, 2018
10. Pradhan Arjyadhara, Ali S.M, Jena Chitralekha ,"Analysis of Solar PV cell Performance with Changing Irradiance and Temperature", International Journal Of Engineering And Computer Science ISSN:2319-7242, Volume2 Issue 1 Jan 2013 Page No. 214-220.

11. HanifM., M.Ramzan, M.Rahman, M.Khan, M. Amin, and M. Aamir, " Studying Power Out put of PV Solar Panels at Different Temperatures and Tilt Angles", ISESCO JOURNAL of Science and Technology, volume 8, November 14 2008.
12. E M Natsheh and A Albarbar, "Solar power plant performance evaluation: simulation and experimental validation", 25th International Congress on Condition Monitoring and Diagnostic Engineering, Journal of Physics : Conference Series 364 (2012) P (1-13).
13. YousifI. Al-Mashhadany, Mouhanad F.Al-Thalej, "Design and Analysis of High Performance Home Solar Energy System", Anbar Journal for Engineering Sciences, 2011.