Solar Energy Utilization in Raj Bhawan and Bijulee Bhawan, Guwahati: A Case Study

Anubhav Goswami[1], Anamitra Phukan[2], Akkhiraj Borah[3], Manjuri Hazarika[4]

[1,2,3,4] Assam Engineering College
Jalukbari, Guwahati – 781013, Assam. INDIA.
[1]*goswamianubhav@gmail.com*
[2]*ritomanamitraphukan@gmail.com*
[3]*akkhiraj.glt@gmail.com*
[4]*manjurih@gmail.com* *

Abstract: ***In this paper, a case study regarding utilization of solar energy in Raj Bhawan and Bijulee Bhawan in Guwahati is presented. Solar photovoltaic (PV) system is used to harness solar energy in both the sites. A comparative analysis of the reduced energy consumption after commissioning the grid-interactive solar plant in Raj Bhawan is presented along with an overview of the off-grid solar plant in Bijulee Bhawan.***

Keywords: Solar energy, Photovoltaic (PV), Renewable Energy.

(Article History: Received 18 September 2017 and accepted 10 December2017)

1. Introduction

The global demand for energy in all spheres of human civilization has increased manifold in the last few decades. The alarming rate of energy consumption leading to energy crisis is an important issue in need of immediate attention. Moreover, government has formed new industrial regulations to go green to ensure environmental protection. In the present scenario, exploring renewable and alternative energy sources is gaining prime importance. Harnessing sustainable energy is a promising research area that deals with the issues of the environment and global warming. Efforts are on for extracting clean, green and renewable energy from the sun, wind, water, and biomass across the globe. Another key issue is energy efficiency, i.e. extracting the maximum benefits from the existing energy sources. UN Secretary General Ben Ki Moon is urging the investors to at least double their clean energy investments by 2020 to ensure a safer and prosperous future for the ensuing generations [1]. This work focuses on solar energy and its utilization involving a case study in Guwahati city.

The sun is the eternal source of abundant energy and the earth receives only one billionth of energy emitted by the sun. However, only 0.01 % of the incident solar radiation is sufficient to meet the entire global energy requirements. Efforts are on for a long time to tap the inexhaustible source of solar energy for the benefit of mankind. Although there are a number of evolving technologies to harness solar energy, the most viable option for offices, homes, educational institutions, and commercial establishments is the solar photovoltaic (PV) technology Solar PV is basically an electrical power generation technology where solar radiation/sunlight is converted to direct current (DC) by using semiconductors that exhibits photovoltaic (PV) effect. Figure 1 shows the basic components of a solar PV system. An array of PV modules produces DC electricity when exposed to sunlight. DC is converted to alternating current (AC) using the inverter. Power conditioning units like charger, charge controller, inverter are used according to need. Battery is used as a storage device and power may be supplied to both DC and AC electrical loads. Other power sources like electric grid, fuel cells, and electrical generators may be coupled with a solar PV system.

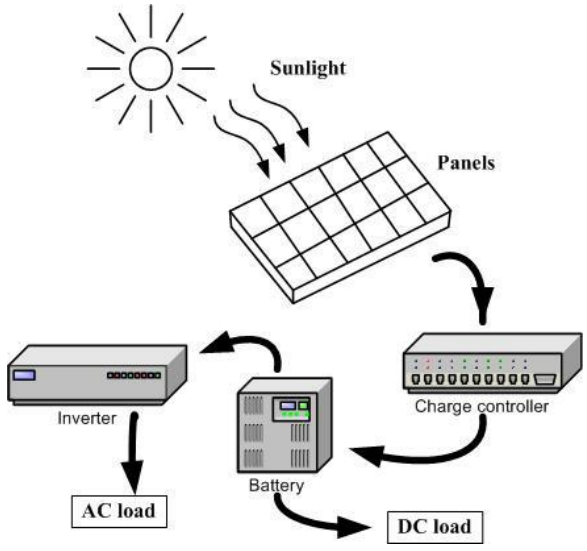


Figure 1: A solar PV system

All solar PV systems may be broadly classified into two categories: stand-alone solar PV systems and interactive solar PV systems. Stand-alone solar PV system operates independently and the source of power may be the PV modules or a combination of PV and wind turbine. Battery is used for energy storage. Interactive solar PV system is interconnected with an electric grid of local distribution network and operates in parallel. The AC power produced by interactive solar PV system is supplied to the connected loads and excess power (if any) is fed back to the electric grid. Similarly, power is supplemented from the grid in case load demand is more than the solar PV output.

The technology to harness solar energy has improved over time gaining higher efficiency compared to the earliest 6% efficiency of a solar cell to the current efficiency of approximately 25% to 40% [2]. Exploring means to harness solar energy has been an active research area in the recent times and it is widely investigated by various researchers. Harinarayana and Kashyap [3] carried out a study to identify the potential of solar energy generation across India. They were of the opinion that, in addition to solar radiation, other influential parameters for solar energy generation are ambient temperature, wind velocity, weather and topographic conditions. T. Buragohain [4] provided an assessment of the social significance of rural electrification with solar energy in villages of Assam, Meghalaya, Jharkhand, Odisha, Madhya Pradesh, and Chhattisgarh. In a similar study Verma et al. [5] discussed the pros and cons of rural electrification programs of the government using solar energy and suggested some methods of improving its functionality. Narnaware et al. [6] presents a review of the availability, current status and future potentials of renewable energy options in India considering solar, wind and biomass energy. This work presents a case study on utilization of solar energy using grid-interactive solar PV in the Raj Bhawan, Guwahati and off-grid solar PV in the Bijulee Bhawan, Paltan Bazar, Guwahati. A comparative analysis of use of electrical energy before and after installation of solar PV system and the resulting savings in energy is presented.

2. Case Study: Solar PV Power Plant in Raj Bhawan, Guwahati

Installation of a 30 kW_p grid-interactive solar PV power plant in Raj Bhawan's premises is an effective way to harness clean and green energy with proven technology. This project is sanctioned by the Ministry of New and Renewable Energy (MNRE). MNRE's objective is to make renewable energy generation self-sustainable, profitable and thereby contribute to saving in energy in the country. It provides financial support to government and NGOs for promotion of solar power. Assam Energy Development Agency (AEDA), being a State Nodal Agency, has implemented the solar power project in Raj Bhawan as part of special area demonstration project of MNRE. Raj Bhawan accommodates the house and office of the honourable governor of Assam and the requirement of power in Raj Bhawan is high throughout the year. The connected load of the building in Raj Bhawan (where solar power is fed) is 184 kW as per electricity bill issued by APDCL. The following sub-sections present the details of the solar PV power plant in Raj Bhawan.

2.1 Components of the Solar PV Plant

The location for installation of solar modules plays a vital role in extracting the maximum amount of solar energy. Generally, roof tops are preferred for receiving the most amount of sunlight. Sometimes roof-mountings are not practical due to limitations of space and unexpected shading throughout the day. In Raj Bhawan, the solar modules are ground mounted using limited space and there are no big obstructions nearby. These modules are capable of producing 30 kW_p power at standard test condition (STC). Figure 2 shows the solar modules in Raj Bhawan.

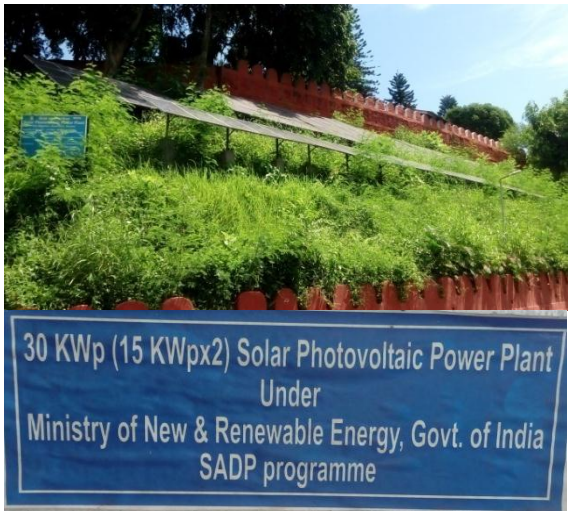


Figure2: Solar PV modules in Raj Bhawan

Since the state of Assam falls in the northern hemisphere, the solar modules are installed to face the true south/geometric south direction to receive the maximum solar radiation throughout the day. The basic electrical circuit of the grid-interactive solar PV system in Raj Bhawan consists of solar modules, junction boxes, inverters, combiner box, solar meter,

manual isolating device, grid-solar interface, utility export-import meter, load distribution module, etc. The network of all the components of the circuit is as follows: The solar modules are first connected to the inverter via a junction box. The inverter converts the DC power generated by solar modules to AC power. In this case two inverters each of 18 kW are installed and to each inverter, 60 numbers of 250W_p solar modules are connected. The two inverters are further connected to the combiner box where the AC power from the inverters is combined. The combiner box is connected to the solar meter which gives the information regarding the amount of solar energy the unit has been generating. The inverter is connected to the manual isolating device, which provides safety to the workers and technicians during any repair or maintenance work on the line. The manual isolating device is further connected to the grid-solar interfacing device at LT side of a 500 kVA transformer through a utility export-import (net) meter. Finally the grid-solar interface is connected to the load distribution module, which supplies the required electrical power to the various appliances. Figure 3 shows the circuit diagram and Figure 4 shows some of the components of the grid-interactive solar PV plant in Raj Bhawan.

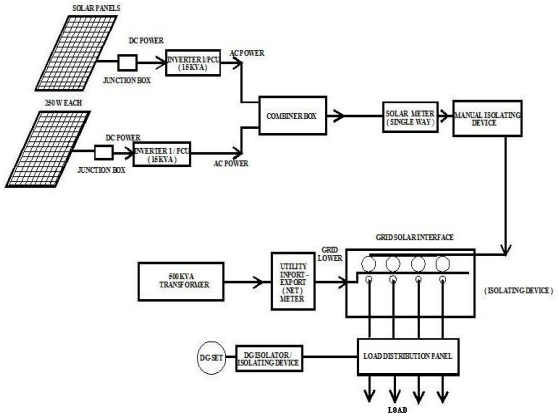


Figure 3: Circuit diagram of the solar plant in Raj Bhawan

Inverter Combiner panel Solar meter

Load breaker Interfacing unit Transformer

Figure 4: Components of the Solar Plant in Raj Bhawan

2.2 Energy Generated by the Solar PV Plant

The grid-interactive solar PV plant was commissioned in Raj Bhawan on 8th February in 2017 (8/2/2017). Beforehand the entire power requirement of Raj Bhawan was met by the electricity supplied by Assam Power Distribution Company Limited (APDCL). Table 1 shows monthly energy consumption from the grid in Raj Bhawan from January 2017 to June 2017.

TABLE 1: Monthly energy consumption in Raj Bhawan after commissioning of the solar PV plant (Source: APDCL, IRCA-I, Guwahati)

Period	Energymeter Reading (a)	Multiplying Factor (b)	Energy consumed from the grid(kWh) (a)x(b)
1/1/17–31/1/17	27.33	500	13665
Solar Plant of 30 kW_p commissioned on 8/2/17			
1/2/17–28/2/17	15.60	500	7800
1/3/17–31/3/17	16.85	500	8425
1/4/17–30/4/17	18.46	500	9230
1/5/17–31/5/17	24.03	500	12015
1/6/17–30/6/17	28.93	500	14465

It can be observed from Table 1 that after the installation of the solar PV plant in February'2017, energy consumed from the grid is reduced significantly during the months of February, March and April' 2017 compared to the month of January'2017. A part of the energy requirement is met with the solar energy generated by the PV plant and the rest is taken from the grid. However, this reduced energy consumption cannot be entirely credited to the solar PV energy. Another reason for lower consumption may be reduced load. It is difficult to precisely measure the shares of the solar energy and grid energy in the total energy consumption. Higher energy consumption during May and June'2017 may be attributed to more loads like air-conditioner, air-cooler, etc.

Table 2 shows energy consumption pattern from grid over six months from Jan–June for two successive years 2016 and 2017. It is evident from Table 2 that after commissioning the solar PV plant in February 2017, considerable saving in energy is obtained compared to 2016 for the same months. Percentage saving in energy on an average is approximately 30% which is quite significant. Figure 5 shows this same comparison between the amount of energy drawn from the grid in 2016 and 2017 in graphical form.

TABLE 2: Comparative energy consumption (from grid) from Jan–June for 2016 and 2017
(Source: APDCL, IRCA-I, Guwahati)

Month	Energy used in 2016 (kWh)	Energy used in 2017 (kWh)	Saving in energy (kWh)	% saving in energy
January	13300	13665		
Solar Plant of 30 kW_p commissioned on 8/2/17				
February	11200	7800	3400	30.35
March	12230	8425	3805	31.11
April	13695	9230	4465	32.60
May	16925	12015	4910	29.01
June	18498	14465	4033	21.80

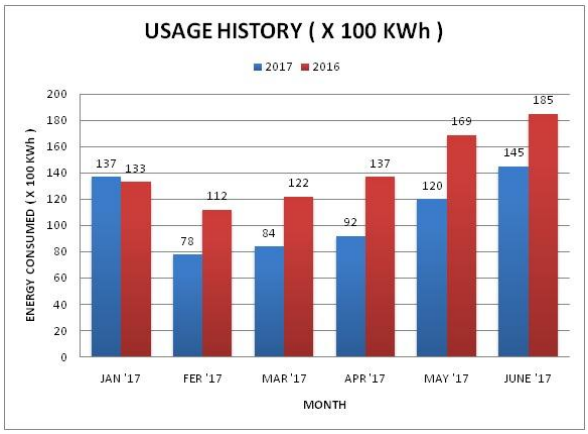


Figure 5: Energy consumption pattern (from grid) for 2016 and 2017
(Source: APDCL, IRCA-I, Guwahati)

After analysing data from Table 1, Table 2 and Figure 5, it is observed that installation of solar power plant in Raj Bhawan has indeed made some difference in total energy consumption leading to saving in energy from grid. It can be concluded that use of generated solar power is a major cause for these energy savings.

3. Solar PV Power Plant in Bijulee Bhawan, Paltan Bazar

An off-grid 100 kW rooftop solar PV power plant was installed in Bijulee Bhawan, Guwahati in 31.7.2012. APDCL, being a State Nodal Agency for renewable power in Assam, has implemented the project that was sanctioned by the Ministry of New and Renewable Energy (MNRE). Figure 6 shows the circuit diagram of the solar plant in Bijulee Bhawan and Table 3 gives the technical specifications of its various components.

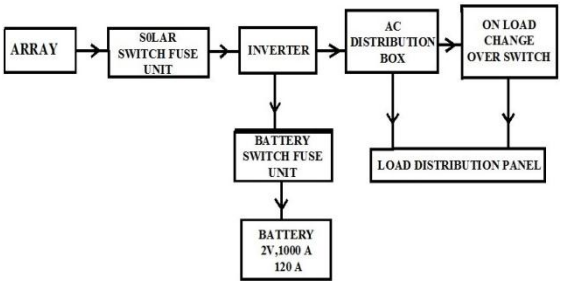


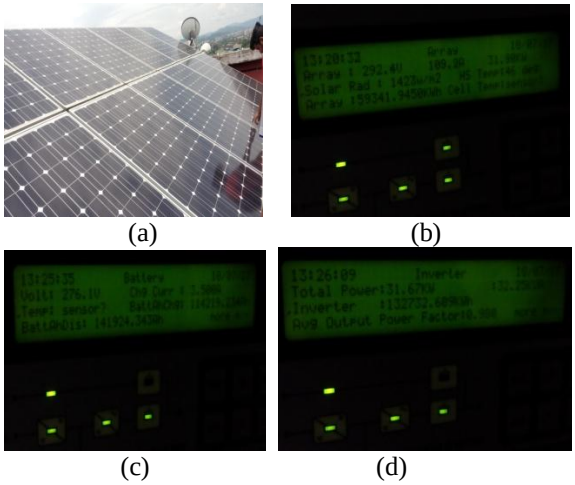
Figure 6: Circuit diagram of the solar plant in Bijulee Bhawan

Table 3: Details of Technical Specification of the Solar Power Plant in Bijulee Bhawan

Specification of Solar Modules	
Make of Solar Module	Alpex Exports Pvt. Ltd.
Wattage of each solar module	250 Wp
Type of Solar Module	Mono Crystalline
Total nos. of Modules Installed	400 Nos.
Nos. of Series and Parallel Combination	Series: 10 Modules Parallel: 40 Modules
Details specification of batteries	
Make	HBL
Battery System Voltage and Ampere hours	Battery System Voltage: 240 Volt Ampere hours: 1000 Ah
Nos. of Batteries	120 Nos.
Type of Battery	VRLA Gel Type
Details of Inverter	
Make	Emerson
Rating	100 kW
Type of Charge controller	MPPT Type
Earthing and Protection	Provided
Structure(Tracking or Non Tracking)	Non Tracking

During a visit to study the rooftop power plant in Bijulee Bhawan on 18.7.2017, The following data were recorded at 1.20 pm during noon: array cumulative energy generated 59341.94 kWh for 1423 W/m^2 solar radiation (Figure 7, (b)), battery ampere-hour 141924.34 Ah (Figure 7, (c)), and inverter instantaneous total power 31.67 kW and inverter

cumulative power 132732.09 kWh (Figure 7, (d)). However, the authority in APDCL informed that the solar power plant was having some technical fault and past data was not available for analysis. The solar power generated by the plant supplements some part of the total energy requirement of Bijulee Bhawan, thus saving in energy generated from other sources.



(a) (b) (c) (d)

Figure 7: (a) Rooftop solar array (b) Array readings (c) Battery readings (d) Inverter readings on 18.7.17 at 1.20 pm in Bijulee Bhawan

Assam has a solar energy potential of 14 GW_p and MNRE, APDCL, APGCL and AEDA are taking initiatives to tap this abundant source of energy [7]. Some of the completed and ongoing projects are: Solar Park, grid-interactive and off-grid solar plants for residential, social, institutional sectors, solar street lights, lantern charging stations, solar pumping systems, micro/mini grid plant, etc.

4. Conclusions

In this work, a case study on the use of solar PV power plants in Raj Bhawan and Bijulee Bhawan in Guwahati is presented. The energy consumption data for a specific period obtained from Raj Bhawan are analyzed. It is observed that the solar energy produced from the plant is making significant impact in reducing the total energy consumption from the grid. Percentage saving in energy is on an average 30% for the same months in two successive years 2016 and 2017. Although a detail analysis could not be presented in case of Bijulee Bhawan due to unavailability of past data, it can be concluded that solar energy from the plant is contributing towards saving in energy.

Harnessing solar energy is the call of the day as it has the advantages of being renewable, sustainable, portable, green and clean. Moreover, it can be used for remote and bulk energy uses and replacement for conventional grid power. However, certain disadvantages of solar PV systems are lack of national and international Standards, higher initial cost, and inconsistent energy source as it is dependent on weather. Efforts are on to overcome these difficulties and it is hoped that by 2020, PV systems will be economical and much more efficient with the use of superior technology. Sunlight concentrator PV, tracking modules are already in use for enhancing efficiency. Research is going on to capture the infrared portion of the sun's light spectrum and convert to useful energy. Hybrid of solar and wind is another promising application of renewable energy in favourable locations.

It can be predicted that harnessing green, clean and renewable energy will attain the maximum importance in the near future to deal with energy crisis and environmental protection. It is the responsibility of all concerned to develop technology that ensures a cleaner, safer and sustainable global environment for decades to come.

References

[1] http://www.se4all.org/content/un-secretary-general-urges-doubling-clean-energy-investment-2020. [Accessed: August 14, 2017].

[2] "Timeline of Solar Cell," Wikipedia, Wikimedia Foundation. http://www.wikipedia.com. [Accessed: August 14, 2017].

[3] T. Harinarayana and K.J. Kashyap, "Solar Energy Generation Potential Estimation in India and Gujarat, Andhra, Telangana States," Smart Grid and Renewable Energy, pp. 275-289, 2014.

[4] T. Buragohain, "Impact of Solar Energy in Rural Development in India," International Journal of Environmental Science and Development, pp. 334-338, 2012.

[5] N. Verma, I. Dua, N. Kumari, "Scenario of Rural Electrification in India-Challenges and Impact, Int. Journal of Engineering Research and Applications, pp.39-43, 2014.

[6] P.H. Narnaware, R.G. Surose, S.V. Gaikwad, "Current Status And The Future Potentials Of Renewable Energy In India-A Review," International Journal of Advances in Science Engineering and Technology, Special Issue-1, pp. 33-38, 2015.

[7] http://mnre.gov.in/file-manager/annual report/2016-2017/EN/pdf/13.pdf. [Accessed: August 22, 2017].