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Feasibility Study of Solar Power Plant for Pondicherry University

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Abstract: ***Globally energy demand is increasing day by day due to increase in population, urbanization and industrialization. The solar energy among other have the abundant capacity to support the increasing energy demand without intensifying the climate change impacts to the globe and its components. The isolated solar street lights installed in the outer circle of silver jubilee campus was a part of green incentive taken by the Pondicherry University to reduce the climate change issue during the establishment of the silver jubilee campus in 2010. With the time, the solar street lights faced new challenges that have significantly reduced the efficiency due to shading effects with the growing trees and some other social and security issues. The scope of work involves the study of the installed solar street lights and exploration of the opportunity for its better utilization by conducting of technical, economical and operational feasibility of uninstalling those panels utilized for street lightings and employing to construct the 7 KWp grid tie power plant in the terrace of administration block.***

Key word: Energy security, solar photovoltaic system, street lights, climate change

1. Background

The predominant source of energy until 1800 had been above the ground which means we had been burning wood for energy. With the industrial revolution, we started manufacturing things on large quantity which demand the use of buried carbon (oil, coal and natural gas) [1]. The carbon dioxide concentrations in the atmosphere have direct correlation with the global temperature. Atmospheric concentrations of the greenhouse gas, which drive global warming haven't been this high between 800,000 and 15 million years [2]. The 400 ppm carbon dioxide concentration in the atmosphere toady against 280 ppm earlier serves to show how much GHG has been added to the atmosphere since preindustrial times. The increase in this and other greenhouse gases in the atmosphere has warmed Earth's average temperature by 1.6^{o}F since the beginning of the 20th century[2]. Although scientists' figure on climate change differs slightly, many of them agree that some kind of inventions by academicians, politicians, government and individual is necessary.

Globally the energy generation is one of the important source of carbon emission with 32000 metric tons of carbon in 2014 [3]. The major share of energy comes from conventional source like underground carbon with more than 90 % emission. Although the renewable energy systems contribute to the emission during its manufacture and assembly, it is significantly very low.

On the other angle, energy plays a pivotal role in our daily activities. The degree of development of a country is measured / indicated by the amount of energy utilization by human beings. The energy planning study for the Uttar Kannada region in Karnataka state revealed that the energy demand can be met with the renewable energy sources [4]. The emissions of CO2, SOx, NOx for the Tamil Nadu state in the southern grid accounts to 46.657 million tons, 0.364 million tons and 0.130 million tons per year [5]. The world's fossil fuel supply viz. coal, petroleum and natural gas will thus be depleted in a few hundred years. Energy crises results due to increased energy consumption and decreased energy supply resulting in energy inflation and shortage. Hence alternative or renewable sources of energy have to be developed to meet future energy requirement. With the consistent growth of PV technology economically and technologically, the global installed capacity of Solar PV systems approached 23GW by the end of 2009, and rose to 69 GW by the end of 2011 which could produce over 85 Terra Watt-Hours of energy annually. The total installed capacity of Solar PV Grid connected systems in India by March, 2013 was 1686.44MW [6].

The climate change due to energy generation and consumption can be addressed through energy management which includes energy efficiency improvements and reviving of renewable energy like solar, wind, ocean, geothermal etc. Among all the solar energy has the highest potential to fulfill the energy demand for both present and future. The world energy assessment report, 2000 found the annual potential of solar energy was around 49,837 EJ which is several times larger than total world energy consumption, which was 559 EJ in 2012. Every hour enough sun light energy reaches the earth to meet the world's energy demand for whole year. The solar energy can be harvested using two different technologies namely solar thermal and solar photovoltaic systems. The present works focuses on conducting the feasibility study of solar power plant in the terrace of administrative block of Pondicherry University which is also an action towards the climate change mitigation although in

small scale.

1. Introduction

Pondicherry University is a central government University established in Kalapet, Puducherry, India. It is located at 12.01°N and 79.85°E with elevation of around 8.5 meters above the sea level. The university extends for 780 acres facing Bay of Bengal. The university has the electricity maximum demand of 3000 kVA with the local utility in Puducherry and maximum energy consumption is 970 MWh evident from the record of 2015. The power network inside the university consisted of 22 KV high tension line extending 10.2 kilometers, 5 transformers with capacity of 500 kVA transforming 22 KV to 430 V, 5 diesel generator ranging 125 to 320 kVA for backup. The energy related monthly peak emission accounts 523 tons. The silver jubilee campus is the new establishment of Pondicherry University in 2010 with the capacity to accommodate 2500 students. The campus is powered from the thermal plant (99%) around Pondicherry and the green energy source (solar) with less than 1%. The energy consumption of the campus contributes 2446 tons of carbon equivalent emissions into the atmosphere annually. The outer and inner ring of the campus is powered using the pole mounted 74 solar street lights. Each of the solar light is powered using two 80Wp solar photovoltaic modules, inverter and the battery. The isolated solar street light around the outer ring of the campus have several technical, economic and social related limitations that includes the efficiency drop of the system due to new shades (trees have become taller) to the panels with time, efficiency of the insolated system is comparatively lower, excess cost and time for maintenance and services arising from diversified located of the system assemblies, demand of battery backup and expensive replacement and servicing, increasing security issues in-terms of loss of batteries and accessories, delay response for complaints on time with the limited maintenance team. With this limitation in mind, this work focus on studying the possibility for the relocation of solar collectors to the administration block to come up with grid tie solar power plant.

2. Objective and Method

The present work is focused on exploring the feasibility of uninstalling the isolated street light system and employing these system components in coming up with small scale grid tie solar power plant to address the above operational, technical and economic issues. The initial phase of the work covers the study of geographical and weather parameter that includes insolation, temperature, wind, dust accumulation, tilt angles of the targeted site. The study of geographical and weather related parameters are obtained utilizing the measuring tools (magnetic compass, measuring tape, and AC-Clamp meter, camera and site survey form) and followed by confirmation with the satellite data from NASA database. The solar radiation has been recorded for a week during the winter month and the recorded values over the time of the day are plotted in the following figures. The selected site has been measured manually for the accommodation of arrays and the shadowing effect has been considered by calculating the angle and height of the structures located nearby. The shadow can be observed in the layout diagram in the following section. The figures below shows the irradiation variation over the time of the day and it is evident that the peak radiation nears 900 watts. The intensity of the solar radiation for the site is sufficient for solar photovoltaic units to generate electron hole pairs and trigger current flow powering the various loads.

A. Measurement result from Pyranometer

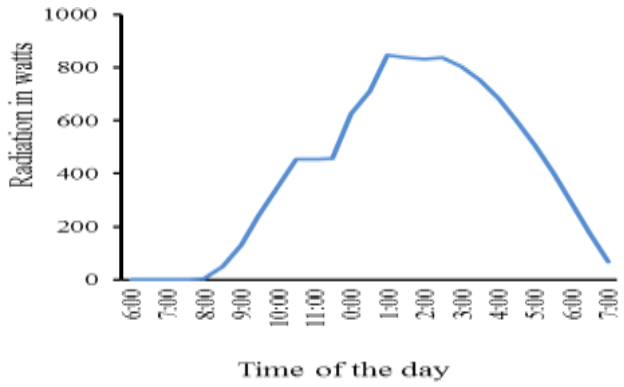

Figure 1: Solar radiation for 8th January 2016

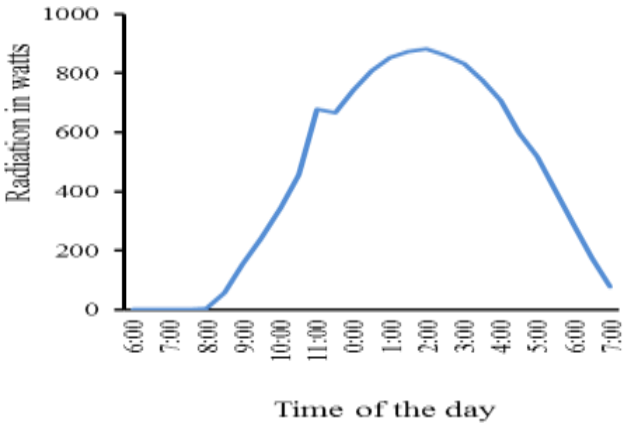

Figure 2: Solar radiation for 9th January 2016

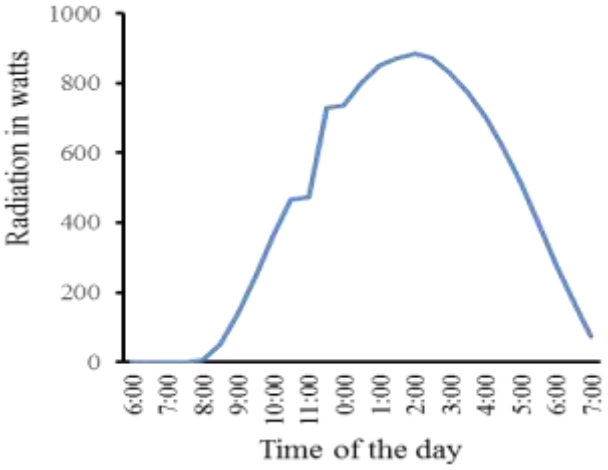

Figure 3: Solar radiation for 11th January 2016

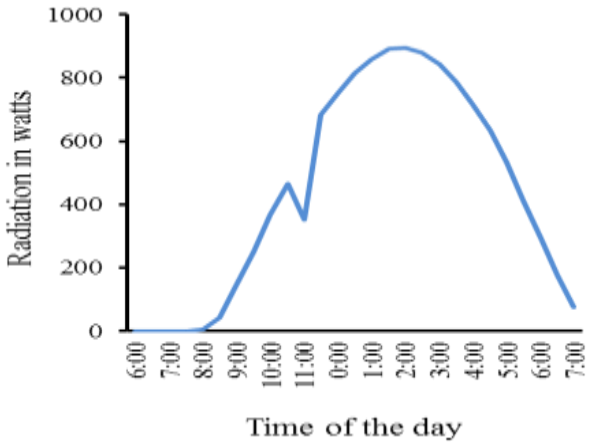

Figure 4: Solar radiation for 12th January 2016

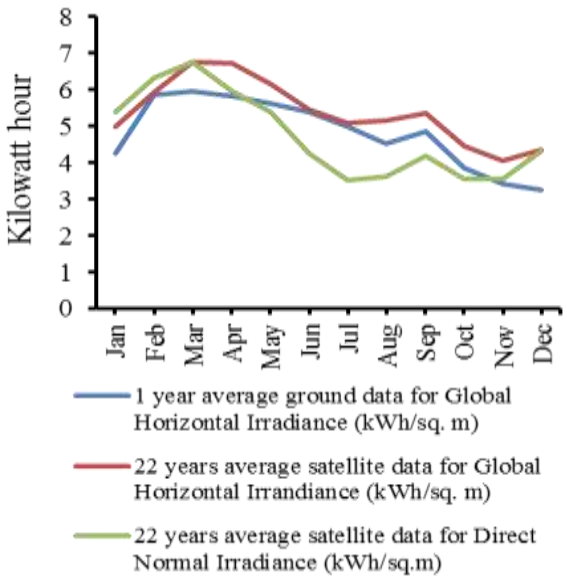

Figure 5: Solar radiation vs. months of the year

B. Solar Resource

Pondicherry (79.81° E and 12.01° N) receives good amount of solar radiation with an annual average of 5.36kWh/m2/day. Solar Radiation data for the site has been derived from NASA [7]. From the recorded insolation values, it is of worth to mention that the site have excellent solar resource that can be utilized in generating heat and electricity.

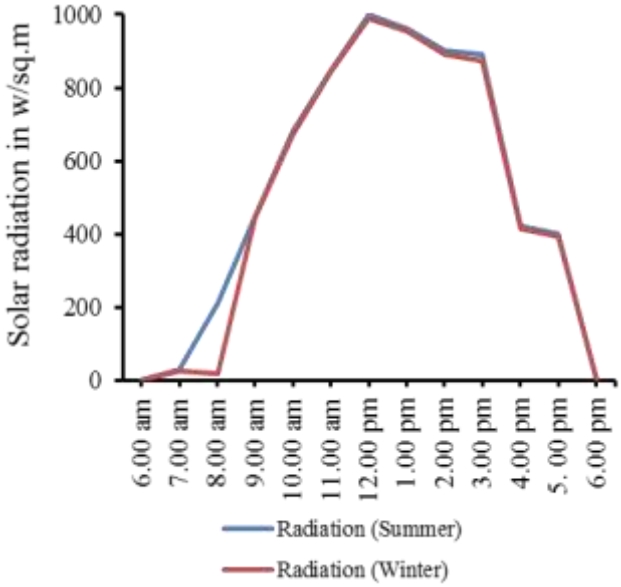

Figure 6: Irradiation vs. time of the day

C. Temperature

Monthly average, minimum and maximum ambient temperature profile for the site at 10m-height is shown in the figure below. Average temp is 30 degree and the coefficient of temp is -0.3 % per degree from the standard temperature. The need of the artificial cooling arrangement is not required for the system.

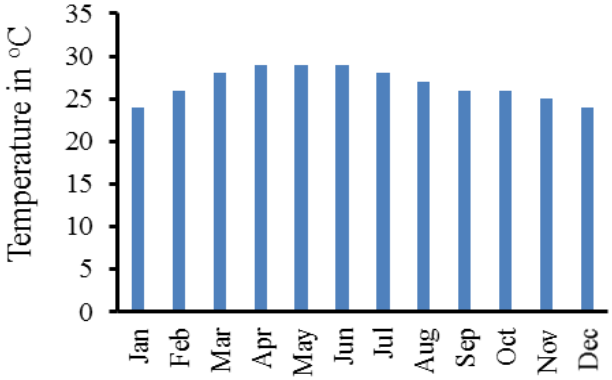

Figure 7: Temperature over months of the year

D. Wind Resource

Centre for Wind Energy Technology (C-WET) has installed four wind monitoring stations in the union territory of Pondicherry out of which two stations were located in Puducherry. The table below shows means annual wind power density measured in the two wind monitoring stations located at Puducherry. The average wind speed is 4.4 m/s at the height of our proposed site. The wind speed has positive coefficient of wind speed. Further the sharp change in wind profile is not observed on daily basis/monthly basis/yearly basis. The wind profile of the Pondicherry University is shown in the above figure. Thus the wind speed of the site does not have the effects on the system efficiency.

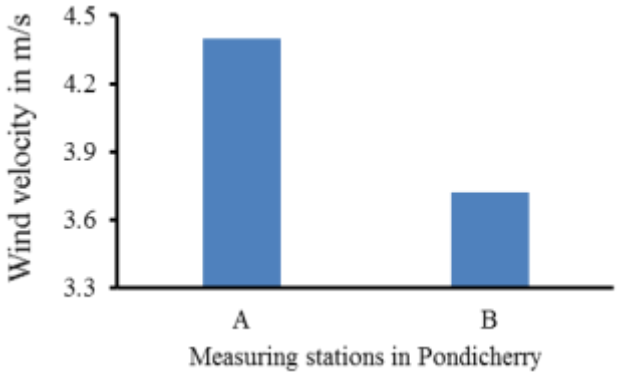

Figure 8: Wind velocity from two measuring stations

E. Dust Effect and Accumulation

The environmental dust has a significant effect on the performance of the solar photovoltaic. The dust reduces by power by 92 percent and efficiency by 89 % [8]. The inclination of the panels will reduce the dust accumulation to some extent and this is only the step that can be done during the design and installation to avoid significant efficiency loss. To get the maximum efficiency and prevent the dust effect, the operation and maintenance department has to ensure the periodic cleaning to avoid the dust accumulation on the panel.

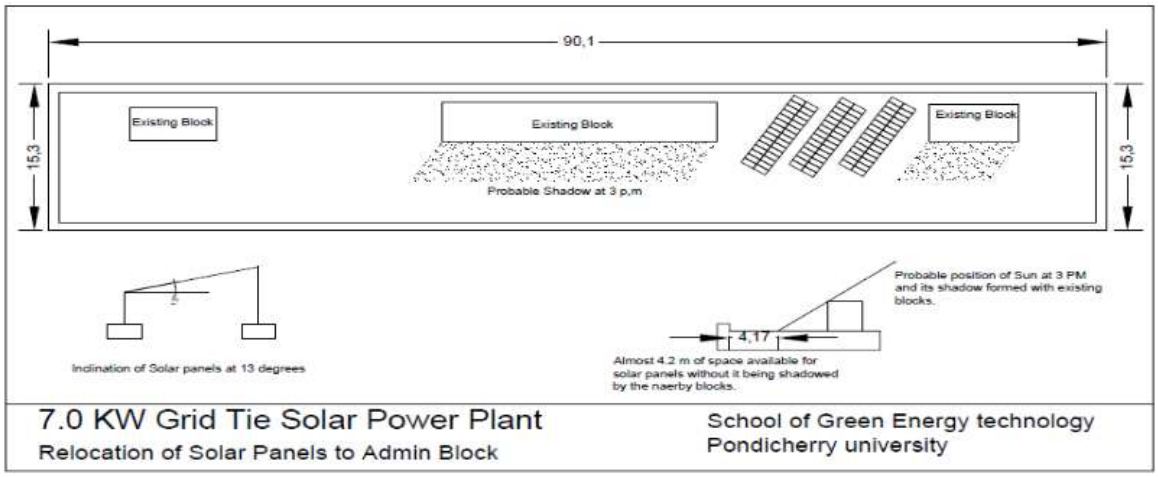

Figure 9: Layout of the small scale solar power plant in terrace of admin block

Figure 10: Google map for the administrative block

4. Result

With the study of climatic and geographical parameters of the site and the present scenario of the solar street lights, it is feasible to construct grid tie solar power plant in the terrace of administrative building of Pondicherry University. The panels used in the solar lighting can utilized for construction of grid tie solar power plant without batteries in the terrace of administration block.

The recommendation involves shifting of 87 panels out of 148 panels each of 80Wp installed around the outer ring presently. The individual power devices are not required as in the above case thus increasing the overall efficiency of the system. The solar module name plate specification is TATA BP SOLAR, TBP1275M, 80 Wp, 0.56*1.21 m, mono crystalline and the inverter is with input capacity of 8.3 kW, 350-900 V and 29 A. The comparative analysis is done for the existing system and the proposed system technically and economically in the following sections.

The cost analysis for the recommended system has been carried out and the summary of the system is being presented in tabular form. The implementation of the recommendation is feasible with minimum financial requirement with improved system efficiency and eliminating all the above discussed issues.

1) Cost savings and investment recovery period

The project costs 187,000 INR including the labor and the accessories purchase. The cost for installing the existing panels comes around 30,000 INR which not included in the total cost of the system. The energy generation per year will be 8205.5 kWh and considering the electricity rate of Rs. 5 per unit, the cost savings will be 41,027 INR. The payback period for the invested capital will be in 5 years. The cost can be reduced significantly if the inverter quality and features are compromised. The other monetary benefits from this system is that it will save 264,000 in three years as the battery service is completely eliminated in this design. The existing design needs the periodic service of batteries and have to invest periodically, the cost of inverter and its service is eliminated thus saving huge amount of money. The maintenance cost will be reduced. Including all these the approximate payback period will be 1 year and 6 months.

Table 1: Comparison of the systems

Description	Existing system	Proposed
Energy production	6351.1 kWh	8205.5 kWh
Cost of batteries	Expensive	N/A
Service of batteries	Expensive	Not required
Maintenance	Expensive and time consuming	Cheap and less time
Security issues	Theft issues	Safe
Shading effects	Yes with the tall growing trees	No
Dust accumulation	Yes	Very low
Design and installation cost	Minimum 500,000 INR	187,000 INR

Table 2: Costing of the proposed solar power plant

S/N	Description	Amount
1	PV module	N/A
2	Inverter	135,000
3	Cables	10,000
4	Junction box	4,000
5	Terminal holding stripe	100
6	Breakers and Fuses	4,500
7	Mounting and labor cost	30,000
8	Energy Meter (Optional)	4000
Total		**187,600 INR**

2) Carbon emission analysis with the proposed system

The system will produce 8205.5 kWh which also means the same amount of energy import will be reduced on implementing this system. With the reduction of 8205.5 kWh of conventional energy import, the carbon emission will be reduced by 5500 kg.

5. Conclusion

It is clear that the Grid Connected SPV system can provide some relief towards future energy demands. The analysis in the above sections has indicated that there is energy saving of 8205.5 kWh of energy annually, saves the cost on batteries and its periodic servicing. It is evident that the payback period is just one and half year. The various limitations of the existing solar street lights like security, social, technical and economic issues can be overcome with this proposed system. With the above study, it is worth to mention that the 7 kWp grid tie solar power plant is more attractive than the isolated solar street light and the same has been evident from the technical and economical perspectives. The proposed system design demands synchronization for greater reliability, which has to be connected in between solar photovoltaic system and utility grid.

6. Acknowledgement

We wish to place on record our thanks to Mr. V. Mourougavelou and D. Shigaravelou, electrical wing of Pondicherry University for their closer cooperation and dedicated support during our study. We also gratefully acknowledge the unstinted cooperation offered by the staff of electrical and civil wing of Pondicherry University. The excellent rapport and understanding shown by them are of great help to us in carrying out this study. We also thank the Pondicherry University administration for providing us with the necessary facilities. Any missing of names is purely unintentional.

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Author Profile

Deepak Acharya holds Master of Technology from Centre for Green Energy Technology, Pondicherry University, Puducherry and Bachelor of Engineering from Anna University, Chennai. He also have PG diploma in statistical and research methods,

PG diploma in Rural Development from Pondicherry University. Further he had taken up the courses on Climate change & Cities, Climate change & health and Green Economy & Trade offered by UNITAR, UN-CC, UN-HABITAT and WHO. Presently he is working as Researcher with Royal Society for Protection of Nature for Green Public Procurement Project Bhutan, European Union funded project (Under Switch Asia Program).

Khina Gautam holds B.Com from North Bengal University and currently she is handling accounts for a NGO in Bhutan. Her exposure with NGO equipped her with the environmental and climate change finances and economics.

Arun Prasath received his PhD and M.Phil. in Polymer/Materials from Anna University, Tamil Nadu, B.Sc and M.Sc in Chemistry from Bharathiar University, Tamilnadu. Currently he is serving as Assistant Professor with Pondicherry University.