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# Assessment of Temporal Solar Energy Potential for Selection of Photovoltaic Pumping and Agriculture System in a Hillock of Assam

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**Abstract—***Enhancing and sustaining the productivity of hill agriculture in hilly terrains is a major challenge as it is practiced under ecologically fragile environments which include altitudinal, climatic and topographical variations. Since, Assam has a large number of hilly terrains and still some areas are not connected with the grid connection. So, there is an urgent need for adoption of advanced irrigation technology to overcome those constrains for crop production. Addressing multitude of socio-economic and physical problems of the hilly region, the present study was carried out to envisage the potential of solar energy in a hilly. The observed solar radiation (August to December 2015) from a weather station installed within the experimental farm of the Department of Agricultural Engineering, Silchar was used for temporal (hourly, daily, weekly and monthly) analysis. The results revealed that the month of October has the highest average monthly per hour solar irradiance with 2.195 kW/$m^2$ followed by November, September, August and December with solar irradiance 2.112, 2.097, 1.868 and 1.297 kW/$m^2$, respectively. Also, monthly peak radiation was estimated and it is observed that month of September has the highest peak radiation with about 8.131 kW/$m^2$ followed by August, October, November and December with the peak radiation about 7.934, 7.850, 6.854 and 5.554 kW/$m^2$, respectively. The study revealed that there is tremendous amount of solar energy potential of 0.73 kW/$m^2$ in the hilly terrain of Assam. The assessments could take a step towards revealing the scope for selecting solar photovoltaic system in energy generation as well raising crops using solar photovoltaic pumping system in hilly terrains.*

## 1. INTRODUCTION

The North-Eastern region is a land of magnificent beauty, possessing undulating hills, rolling grasslands, cascading waterfalls, snaking rivers, terraced slopes and thrilling flora and fauna. This picturesque scenario is contrasted by widespread poverty, low per capita income, high unemployment and low agricultural productivity leading to food-insecurity. The region has several unique features: fertile land, abundant water resources, evergreen dense forests, high and dependable rainfall, mega biodiversity and agriculture-friendly climate. Yet it has failed to convert its strengths optimally into growth opportunities for the well-being of the people. The high vulnerability to natural calamities like floods, submergence, landslides, soil erosion, etc. has resulted in low and uncertain agricultural productivity. The low utilization of modern inputs in agriculture has further reduced the ability of the farm households to cope with high risks in production and income.

In India almost 70% population depends on agriculture either directly or indirectly. While 44% of the 140 million sown hectares depend on irrigation, the rest relies on the monsoons. In 2006–7, India's agricultural sector accounted for 22% of the total electricity consumption, up from 10% in the 1970s. There are about 21 million irrigation pump sets in India, of which about 9 million are run on diesel and the rest are grid-based [1]. In agricultural systems, significant amount of energy is consumed during irrigation periods. Nevertheless, the major technical obstacle for irrigating is the pumping unit and lack of access to electricity in the hilly terrain and remote land areas. Water pumping is an energy intensive activity and consumes a large amount diesel and electricity. Solar photovoltaic system is an efficient approach for using the solar energy.

Solar water pumping systems constitute a cost effective alternative to irrigation pump sets that run on grid electricity or diesel. Solar pumping technology has been continuously improved since the early 1980s.India's potential for solar photovoltaic (SPV) water pumping for irrigation to be 9-70 million, SPV pump sets, corresponding to at least 255 million L/year of diesel savings [5]. In 2010, solar water pumping became part of the off-grid and decentralized component of the Jawaharlal Nehru National Solar Mission [11]. The daily average solar energy incident over India varies from 4 - 7Whm$^{-2}$ which is equivalent to about 1,500–2,000 peak (rated) capacity operating hours in a year. It was reported that Assam has about 13.76 GWp of solar potential [9]. Thus, the present study focused on the assessment temporal solar energy potential and the scope for selection of photovoltaic system in energy generation and irrigation on a hillock of Assam.

## 2. MATERIALS AND METHODS

### 2.1 Study area

One of the hilly terrains situated in the Assam University, Silchar of Cachar district and in the southern part of the Assam, India was considered for the study area. The study area is one of the hillock of Assam University, Silchar covered total hill top area of about 10000m$^2$.

The study site is situated in the southern part of Assam state of India having latitude N 24$^0$ 43' 34.1'' and longitude E 93$^0$ 4' 21.7'' with altitude 31.40 m above mean sea level. The study area experiences a subtropical monsoonal climate with an annual rainfall ranging between 2500-3300 mm. The average rainfall of the area is over 3000mm and about 80-85% of this rainfall occurs during the month of April/May-September/October. December and January are normally the driest months. During summer average and minimum temperature is 35$^o$C and 20$^o$C, respectively. In winter average maximum and minimum temperature becomes 25$^o$ C and 11$^o$ C respectively.

### 2.2 Solar data monitoring

The solar radiation data were monitoring from the NOVALYNX weather station and also solar energy sensor model number 110-WS-16SRD installed within the Department of Agricultural Engineering, Assam University. This sensor measures global radiation within 10 seconds interval. The sensors transducer, which converts incident radiation to electrical current, is a silicon photo diode with wide spectral response.

### 2.3 Temporal solar energy potential analysis

In order to find out the temporal variation of solar energy on a Hillock of Silchar, Assam for selection of solar photovoltaic system during dry season, the solar radiation data were collected and analyzed for five months, i.e., August to December, 2015. Due to the unavailability of nearby solar radiation monitoring station, an automatic weather station was installed within the department on July, 2015. The station provides solar radiation data at 10 seconds interval which was collected and analyzed for hourly, daily and monthly basis (Aug to Dec).

## 3. RESULTS AND DISCUSSION

The variation of average daily, hourly, monthly, maximum and minimum variations of solar energy were analyzed for each five months. The observed peak radiations for each month were also estimated. The details of the results are presented in the following sections.

### 3.1 Daily variations of solar energy potential

The daily average solar energy variations for the five months (August to December) observed on a hillock of Silchar, Assam are presented in Fig. 1-5. Among the months, it was noticed that the daily variations were found different due to the effect of temperature and clouds.

During the month of august, the highest solar energy potential was found on 11$^{th}$ August i.e., 3330.72 W/m$^2$ and lowest potential on 31$^{st}$ August i.e., 491.81 W/m$^{2.}$ Similarly, for the September month the highest and lowest solar energy potential were found to be 3205.54 W/m$^2$on 13$^{th}$ and 583.30 W/m$^2$on 22$^{nd}$, respectively. While, for October the highest was found to be 2733.53 W/m$^2$and lowest to be 689.93 W/m$^2$on 1$^{st}$ and 31$^{st}$ of the month, respectively.

During the month of November the highest solar energy potential was found 2436.74 W/m$^2$ on 21$^{st}$ November and lowest 663.22 W/m$^2$ on 18$^{th}$ November. While, for the month of December the highest solar energy potential was found to be 1774.36 W/m$^2$ on 22$^{nd}$ and lowest was found 431.30 W/m$^2$ on 13$^{th}$ November, 2015.

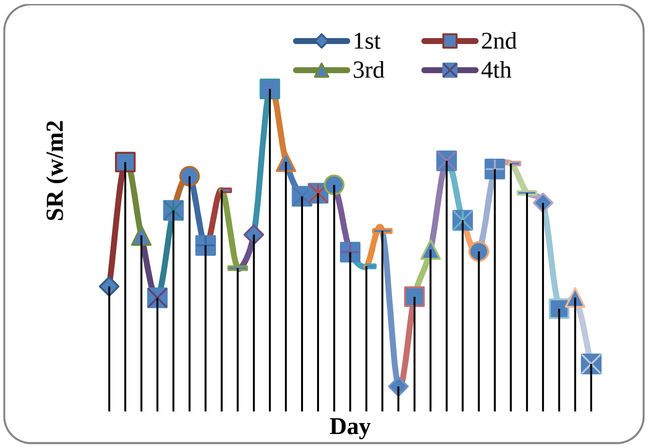


**Fig. 1: Average daily variations of solar energy observed in August, 2015.**

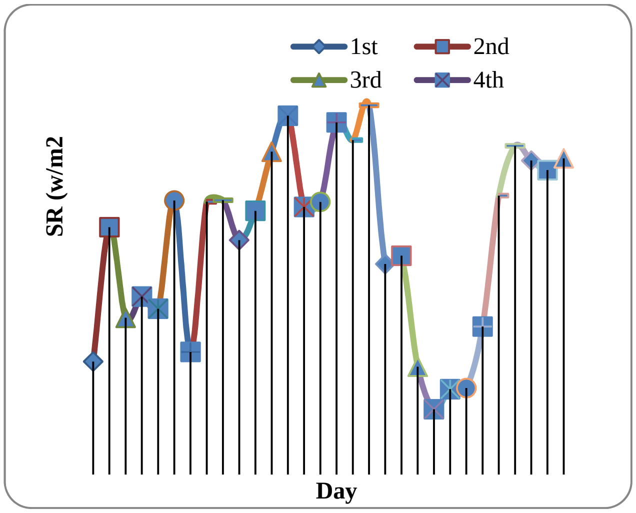


**Fig. 2: Average daily variations of solar energy observed in September, 2015.**

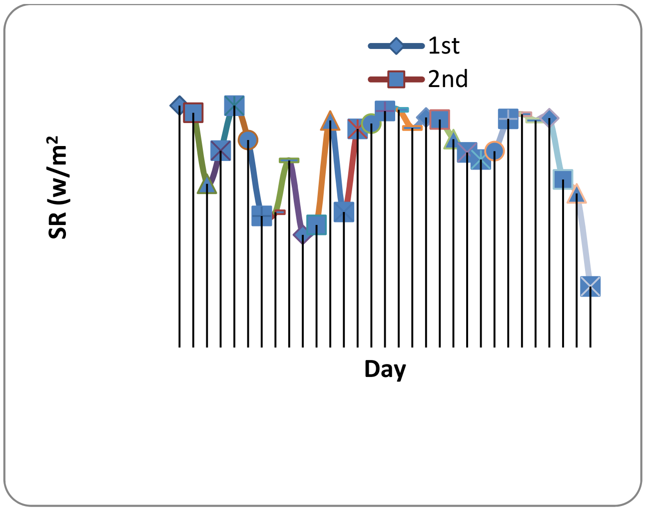


**Fig. 3: Average daily variations of solar energy observed in October, 2015.**

It was observed that the average daily solar energy potential gradually decreasing from the August to December.

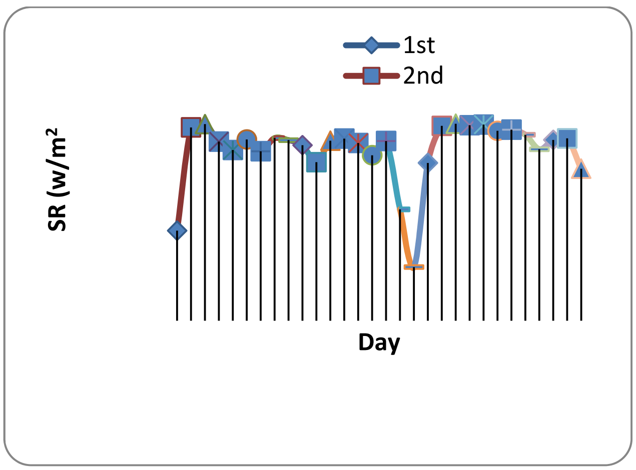


**Fig. 4. Average daily variations of solar energy observed in November, 2015.**

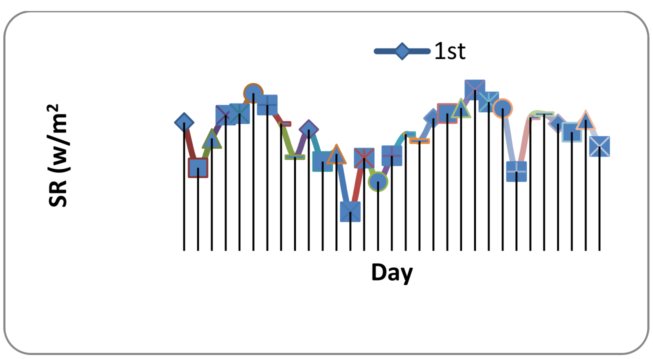


**Fig. 5: Average daily variations of solar energy observed in December, 2015.**

### 3.2 Monthly variations of solar energy potential

The month wise hourly variation of average solar energy were estimated to know the peak hour for each month for find out the availability of wattage for a solar photovoltaic system to be installed hillock of Silchar, Assam and presented in the Table 1.

The "Table 1" indicates the month wise daily hourly variation from 5 AM to 5 PM. During the study period, it was observed that intensity of solar energy gradually increases from 5 AM to 11 AM and gradually decreases from 12 PM to 5 PM. The maximum solar intensity for the whole five months was found at 11 AM and lowest at time 5 PM. Among the five months, at 11 AM in the month of October received the highest solar radiation i.e., 4489.801W/m$^2$ and followed by November, September, August and December, respectively. During the study period, the average daily solar radiation intensity was found 1901.505 W/m$^2$. The peak hour in energy generation and average solar radiation intensity could be used for selecting a solar photovoltaic system for a hillock of Silchar, Assam.

**Table 1: Month wise hourly average solar energy potential**

| TIME | Average Solar Radiation (W/m$^2$) | | | | |
|---|---|---|---|---|---|
| | Aug | Sep | Oct | Nov | Dec |
| 05:00 | 155.33 | 143.49 | 102.99 | 50.77 | 0.82 |
| 06:00 | 591.22 | 756.27 | 639.88 | 624.51 | 157.76 |
| 07:00 | 1229.75 | 1628.63 | 1772.38 | 1666.49 | 610.37 |
| 08:00 | 1803.57 | 2645.10 | 3208.24 | 2961.60 | 1316.56 |
| 09:00 | 2676.93 | 3317.95 | 4100.98 | 3853.72 | 2020.18 |
| 10:00 | 3212.01 | 3967.47 | 4354.42 | 4594.72 | 2751.93 |
| 11:00 | 3525.62 | 4026.27 | 4489.80 | 4413.92 | 2885.74 |
| 12:00 | 3401.30 | 3816.95 | 3976.90 | 3813.37 | 2606.59 |
| 13:00 | 3032.73 | 3355.43 | 3238.09 | 3048.38 | 2046.73 |
| 14:00 | 2452.35 | 2300.22 | 2000.59 | 1877.21 | 1205.58 |
| 15:00 | 1506.68 | 1021.74 | 553.70 | 531.64 | 395.24 |
| 16:00 | 633.88 | 279.68 | 95.41 | 21.21 | 16.43 |
| 17:00 | 72.78 | 12.54 | 2.16 | 24.88 | 0.06 |

### 3.3 Comparative analysis of solar energy potential

In order to attain a comparative picture of solar energy potential in the hilly terrain, the average, maximum and minimum of solar radiation were estimated for the month of August to December, 2015, and shown in Fig. 2.

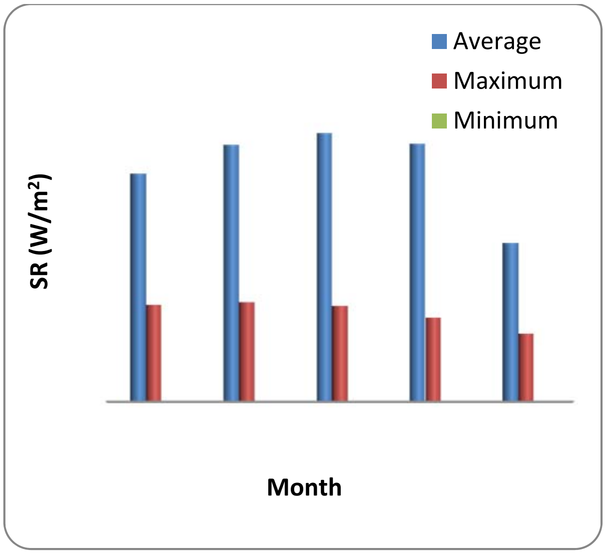


**Fig. 2: Month wise variations of average, maximum and minimum solar energy potential of the study site.**

It was observed that the average monthly solar radiation gradually increases from August to October and decreases from November to December. The more solar radiation was noticed in the month of September, October and November than the December. However, among the five months it was observed that the month of October has the highest average monthly per hour solar irradiance with 2195.04 W/$m^2$ followed by November, September, August and December with solar irradiance 2112.13, 2097.82, 1868.77 and 1297.25 W/$m^{2,}$ respectively. And the average maximum value of solar radiation was observed in the month of September i.e., 813.143 W/m followed by August, October, November and December such as, 793.46, 785.06, 685.48 and 555.42 W/$m^2$, respectively. Also, the average minimum solar radiation i.e., 0.278 W/$m^2$ observed in the month of November followed by September, December, October and August such as, 0.428, 0.473, 0.56 and 0.64 W/$m^2$, respectively.

### 3.4 Peak variation and selection of SPV system

Among the many applications of photovoltaic energy, pumping is one of the most promising. In PV pump storage system, solar energy is stored, when sunlight is available as potential energy in a water reservoir and is consumed according to the demand. There are advantages in avoiding the use of large banks of lead acid batteries, which are heavy and expensive and have one fifth of the lifetime of PV panel. Since, Solar Photo voltaic (SPV) systems are also increasingly being used for agricultural applications. Solar water pumps are the one the best examples. These pump systems are gaining popularity all over the world, especially remote and rural areas where still no grid connections or frequent power cut is being a major and regular problem and high fossil fuel cost is also a one of the barrier for their socio-economic development of the community. Solar water pumping systems constitute a cost effective alternative to irrigation pump sets that run on grid electricity or diesel.

The Ministry of New and Renewable Energy (MNRE) has been promoting solar PV water pumping systems for irrigation as well as drinking water. The detail of the MNRE indicative technical specifications for surface and submersible pumps are given in Table2.

In order to select the desired solar PV water pumping systems for irrigation as well as drinking water, the peak variations for the different months were estimated and presented in Table 3. Based on the solar energy potential, one can select the capacity of the SPV array, motor capacity and also the total dynamic head of the pumping system.

**Table 3: MNRE Indicative Technical Specifications for Surface Pumps and Submersible Pumps.**

| Pump Description | | Model | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| Centrifugal DC monoblock | Solar PV Array | 900 Wp | 1,800Wp | 2,700Wp | n/a |
| | Motor Capacity | 1 HP | 2 HP | 3 HP | n/a |
| | Max. TDH | 10 mtrs. | 15 mtrs. | 25 mtrs. | n/a |
| Submersible motor with electronic controller | Solar PV Array | 1,200 Wp | 1,800Wp | 3,000 Wp | 4,800 Wp |
| | Motor Capacity | 1 HP | 1HP/2HP | 3 HP | 4.6 HP |
| | Max. TDH | 70m. | 70m. | 120m. | 160 m |

**Table 2: Peak variation and possible plant rating**

| **Months** | **Peak Output W/ m2** | **Average Peak Output W/ m2** | **Plant Capacity kW /100m2** |
|---|---|---|---|
| August | 793.46 | | |
| September | 813.143 | 726.515 | 72.65 |
| October | 785.062 | | |
| November | 685.483 | | |
| December | 555.421 | | |

On the basis of monthly peak radiation, the average peak radiation was determined from where the possible plant rating is made. The study revealed that the hilly terrain of Silchar, Assam can achieve average 73KW plant capacity with considering the 100$m^2$ area and the plant can be utilized for crop planning.

## 4. CONCLUSIONS

The temporal variability of solar energy potential study revealed that among the five months analysis, at 11 AM in the month of October received the highest solar radiation i.e., 4489.801W/$m^2$ and followed by November, September, August and December, respectively. During the study period, the average daily solar radiation intensity was found 1901.505 $W/m^2$. That indicates that energy influx from solar radiation is widely regarded as sufficient to meet the present primary energy needs of the study site. Useable solar influx is limited by diurnal variation, geographic variation and weather conditions. The peak hour in energy generation and average solar radiation intensity could be used for selecting a solar photovoltaic system for crop planning on a hillock of Silchar, Assam.

The reliable solar photovoltaic (SPV) water pumping system could be the only reliable alternative for lifting water from the ground/rainwater harvesting structure as compared traditional pump run by diesel, gasoline, and kerosene. The SPV system powered by solar energy sources could be especially useful in remote locations like a hillock of Silchar, Assam where a steady fuel and electricity supply is problematic and skilled maintenance personnel are scarce.

## 5. ACKNOWLEDGEMENTS

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## REFERENCES

[1] A report on Solar PV Applications in India, published by Center for Study of Science, Technology and Policy (2006-07).

[2] EPIA (2011b), Global Market Outlook for Photovoltaics until 2015, EPIA, Brussels.

[3] European Photovoltaic Industry Association (EPIA) (2011a), Solar Generation 6: Solar Photovoltaic Energy Empowering the World, EPIA, Brussels.

[4] GCEP Technical Assessment report, “An Assessment of Solar Energy Conversion Technologies and Research Opportunities”, issued by the Global Climate and Energy Project, 2006. http://gcep.stanford.edu.

[5] Hahn, A., Technical information of Photovoltaic Water Pumps,13.European Photovoltaic Energy Conference, Nice (1995) page 1783.

[6] HWWI, (2005). “CDM potentials for SPV pumps in India” Hamburgisches Welt Wirtschafts Institute (HWWI), Research Paper No 4.

[7] IEA, “World Energy Outlook 2004”, International Energy Agency, Paris, IEA/OECD, 2004.

[8]

[9] Jayakumar, P., Solar Energy Resource Assessment Handbook, ‘‘Economic and Social Commission for Asia and the Pacific (ESCAP) ’’ September 2009.

[10] NREL, 2003; National Renewable Energy Laboratory, Argaw, N., Foster, R., Ellis, A.; Renewable Energy for Water Pumping Applications in Rural Villages; Las Cruces, New Mexico.

[11] Photovoltaic Water Pumps Andreas Hahn GTZ - OE 4429 (May 2000).

[12] Physical Progress (Achievement). Ministry of New and Renewable Energy, Govt. of India. 31 January 2014.

[13] Tewari, N.P., Solar irrigation pumps: the Rajasthan [India] experience. IWMI-Tata Water Policy Research Highlight, 35. 7p.

[14] Yalla, S.P., Ramesh B, and Ramesh A. Autonomous Solar Powered Irrigation System. *growth* 3.1 (2013): 060-065.