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Assessment of Solar Power Generation Potential for Agriculture Production and Processing in Andhra Pradesh

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ABSTRACT

Traditional agriculture is mostly dependent on non-commercial energy sources, whereas the modern agriculture largely depends upon commercial energy sources. Conservation of commercial energies in production, processing, handling and storage of agricultural products by supplementing and substituting with renewable energy sources both for process heat and shaft power is very much in need. Solar radiation can be effectively and strategically used if the locations of high potential solar energy generation is identified, hence the study was carried out to identify locations of high solar energy potential. The seasonal variability of different climatic parameters varies from north to south parts of coastal Andhra Pradesh and Rayalasema region and shown the considerable variation among all the months of the year for all locations. The Andhra Pradesh state has received an average global solar radiation on 5.14 kWh/m^2, air temperature of 27.28 $^{\circ}$C, 63.75% of relative humidity and 3.4 m/s wind speed. Ananthapur and Hindupur areas recorded maximum and Srikakulam recorded minimum global solar insolation. The annual average air temperature varies in the range of 25.1-29.6°C. Vishakhapatnam recorded maximum relative humidity i.e 72.5% whereas minimum 57.4% at Ananthapur.

Key words*: Andhra Pradesh, Average relative humidity, Average temperature,Solar radiation.*

The structure of energy consumption in the Indian agriculture has changed substantially, with a significant shift from animal and human labour towards tractor for different farming operations and electricity and diesel for irrigation. Quantitative assessment has indicated that in 1970-71, agricultural workers and draught animals contributed considerably to the total energy-use in agriculture (15% and 45%, respectively), while electricity and fossil energy together provided 40 percent energy. In a span of three and a half decades, the contribution of electricity and fossil energy together has gone up to 86 per cent and of agricultural workers and draught animals has come down to 6 per cent and8 per cent, respectively (Girish *et al*., 2012). There is room for conservation of commercial energies in processing, handling and storage of agricultural products by supplementing and substituting with renewable energy sources both for process heat and shaft power.

India has high solar insolation and an ideal place for generating electricity from solar energy. Because of its location between the tropic of cancer and the equator, India has an average daily global radiation is around 5 kWh per square meter per day with sunshine ranging between 2300 and 3200 h per year in most parts of India (Harinarayana and Kashyap, 2014). Though the energy density is low and the availability is not continuous, it has now become possible to harness this abundantly available energy very reliably for many purposes by converting it to usable heat or through direct generation of electricity (Vikas *et al*., 2013). Most part of Andhra Pradesh are endowed with vast solar potential with about 300 sunny days a year. The daily solar incidence is 5.5 to 6 kWh/m^2 in different parts of the state (Harinarayana and Kashyap, 2014). Photovoltaic (PV) system always offer economic and maintenance advantages over grid power, diesel generators and wind turbines in rural and remote areas where there is little or no grid power supply. The PV system has the potential to produce up to 80% and 25% of its total energy capacity on partly cloudy and extremely overcast days, respectively (Sivaraman and Keoleian, 2010).The solar radiance is strongly dependent on location and local weather. Solar radiation can be effectively and strategically used if the locations of high potential solar energy generation is identified (Das, 2014). Hence the present work is taken up

to identify the potential areas for production of thermal as well as shaft power to use in various agricultural operations.

MATERIAL AND METHODS

Collection of solar radiation data

The average annual solar radiation information and average annual climatic parameters of different parts of Andhra Pradesh state were compiled from the NASA-SSE satellite data (NASA, 2015). The volume of data generated by satellite images will be reduced to average daily, monthly or yearly radiation data. Andhra Pradesh state has been geographically divided into Coastal Andhra region and Rayalasema region. Therefore eight identical locations which cover the entire Andhra region and six locations from Rayalasema region were selected. The coordinates such as latitude and longitude are given in the table1.Twenty two years average global solar insolation, air temperature, relative humidity and wind speed data was obtained and used for assessing the solar energy potential.

RESULTS AND DISCUSSION

An average solar radiation and other climatic parameters were compiled and shown in Table 1.The Andhra Pradesh state received an average global solar insolation 5.14 kWh/m^2, air temperature of 27.28 ˚C, 63.75% of relative humidity and 3.4 m/s wind speed. There was significant variation among the two regions, the global solar insolation was high in Rayalasema region when compared with coastal Andhra region of Andhra Pradesh. The total global solar radiation varies in the range of 4.82-5.35 kWh/m^2. Bapatla and Ongole areas recorded maximum and Srikakulam recorded minimum global solar insolation in coastal Andhra region. Ananthapur and Hindupur areas of Rayalaseema region recorded maximum and Rajampeta area recorded minimum global solar radiation.

The annual average air temperature varies in the range of 25.1-29.6 ˚C, the average air temperature was found slightly high i.e 27.71˚C in Andhra region compared to Rayalasema region i.e 26.85 ˚C. The annual average air temperature increased from north coast to south coast of Andhra region. Ongole and Narasaraopeta areas of Andhra Pradesh reported maximum (29.6 ˚C) and Srikakulam reported minimum (25.7 ˚C) temperature. In Coastal Andhra Region the annual average temperature varied relatively in wide range viz. 25.7- 29.6 ˚C whereas in Rayalasema region annual average temperature varied in narrow range i.e. 25.1- 27.7 ˚C.

The annual average relative humidity is high in north coastal regions viz. Srikakulam, Vishakhapatnam and Rajahmundry compared to remaining coastal districts of Andhra Pradesh. Vishakhapatnam recorded maximum relative humidity i.e. 72.5% whereas Nellore recorded minimum (62.4%) relative humidity in Coastal Andhra region. Areas in off-coast and Rayalaseema region recorded less relative humidity. Rayalaseema region recorded maximum relative humidity 64.5% at Tirupati and minimum 57.4% at Ananthapur.

The wind speed is high in Vishakapatnam comparatively, followed by Srikakulam and Rajahmundry. Coastal Andhra recorded relatively more wind speed. Wind speed varied in the rage of 3.2 to 4.6 m/s in Coastal Andhra region compared to less variation in Rayalaseema region i.e 2.9 to 3.4 m/s.

Average monthly distribution of global solar Insolation

The average monthly distribution of global solar insolation at different parts of Andhra Pradesh has obtained, compiled and reported in Table1 and the locations which has obtained maximum and minimum annual average Insolation has been shown Fig.1.The average annual global solar insolation has shown the considerable variation among the months of the year for all locations. The seasonal variability varies from north to south parts of coastal Andhra Pradesh and Rayalassema region. From the Figure 2 it was observed that the global solar radiation increases from January to April then starts decreasing, crossed the Andhra Pradesh mean line during June and reached bottom during July and August. The radiation values rose from the lower bottom and formed the lower top nearer to A.P mean line during the month of September. Further the radiation intensity values decreased slightly from September to October then maintained almost flat till the December. Average monthly global solar radiation curve of Srikakulam

Table 1. Average annual solar radiation and climatic parameters for Andhra Pradesh.

S.No	Place	Latitude	Longitude	Global solar radiation	PV Power output	Air Temp	Relative Humidity	Wind speed
		(^{0}N)	(^{0}E)	kWh/m^2/day	kWh/m^2/day	^{0}C	%	m/s
Andhra Region								
1	Srikakulam	18.3	83.9	4.82	68.93	25.7	69.5	4.0
2	Vishakhapatnam	17.688	83.219	5.07	72.50	26.6	72.5	4.6
3	Rajahmundry	16.98	81.78	4.95	70.79	27.2	69.7	3.9
4	Vijayawada	16.508	80.642	5.02	71.79	27.5	64.7	3.2
5	Bapatla	15.889	80.47	5.21	74.50	27.8	66.5	3.5
6	Nellore	14.43	79.97	5.10	72.93	27.7	62.4	3.4
7	NarasaRaopet	16.25	80.07	5.02	71.79	29.6	64.7	3.2
8	Ongole	15.5	80.05	5.21	74.50	29.6	66.5	3.5
	Region Mean			5.05	72.22	27.71	67.06	3.66
Rayalaseema Region								
9	Kadapa	14.47	78.92	5.29	75.65	27.1	59.2	3.2
10	Karnul	15.83	78.05	5.18	74.07	27.4	57.7	3.0
11	Ananthapur	14.68	77.6	5.35	76.51	26.5	57.4	3.1
12	Thirupati	13.65	79.42	5.13	73.36	27.3	64.5	3.2
13	Rajampeta	14.183	79.167	5.10	72.93	27.7	62.4	3.4
14	Hindupur	13.83	77.49	5.32	76.08	25.1	61.4	2.9
	Region Mean			5.23	74.77	26.85	60.43	3.13
	A.P Mean			5.14	73.49	27.28	63.75	3.40

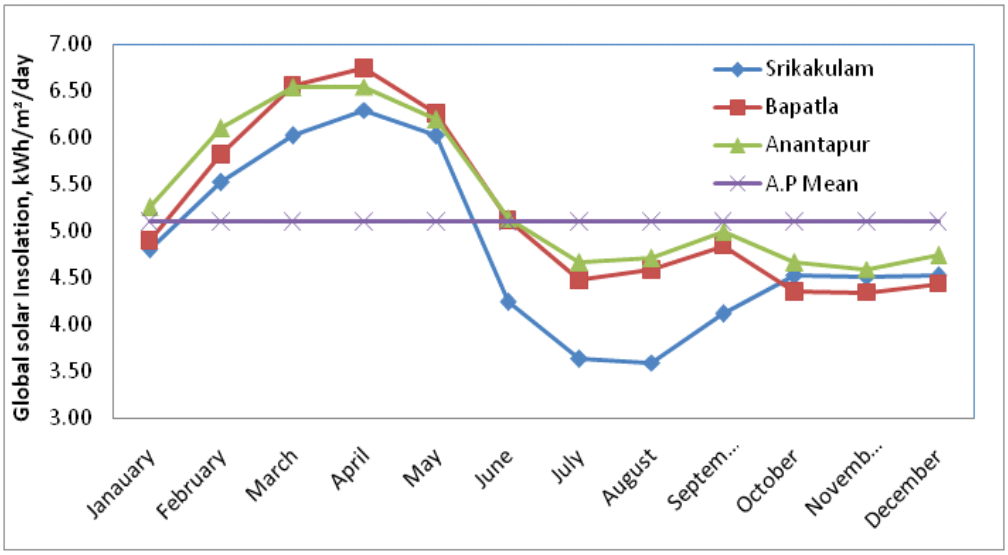

Fig.1. Monthly Averaged solar Insolation Incident on A Horizontal Surface at different places of Andhra Pradesh.

followed lower band and Ananthapur covered the upper band. Bapatla has recorded highest average monthly solar insolation during April with 6.75 kWh/m^2/day and Srikakulam recorded lowest value during August with 3.60 kWh/m^2/day.

The average monthly global solar insolation distribution pattern is required for assessing solar power potential and for selecting the suitable areas for inception of photovoltaic powered agricultural production and processing machinery. The monthly trends in global solar radiation and PV power output was calculated for all the months by taking 14.3% as PV panel efficiency (Ganguli and Jasvir, 2010) and shown in Fig. 2. Solar PV energy can be tapped throughout the year in almost all the places, however maximum energy can be tapped during January to June months with the peak in the April, during July to December less amount of energy can be tapped. In the north coastal areas (Srikakulam, Vijayanagaram and Vishakhapatnam) the output will be low during July and August due to cloudy weather due to monsoon season. The monthly averages of PV output less than yearly average in winter and more than yearly average during summer.

Monthly average temperature distribution pattern

Monthly average temperatures of Andhra Pradesh state has been studied and presented in the Fig 3. It was observed that monthly averaged air temperature varied in the range of 22- 31 °C. Lowest monthly average air temperature was observed during the months of January and December and highest was observed in Kurnool during the month of April. Relatively low temperatures were observed during the months of December and January whereas high temperatures were observed during the months of May and June. Monthly average temperatures of locations which has obtained the height and lowest monthly average temperature has shown in Fig. 3. The curves followed a same trend i.e. parabolic shape. Monthly average temperature curve of Ongole moved in upper portion whereas the average temperature curve Srikakulam moved below Ongole, almost with same gap throughout the year. Monthly average air temperatures provide the information about the places which are more suitable for tapping the thermal power. Those places which have obtained more temperature can be used effectively for various agricultural processing operations like drying, dehydration, cooking, water heating, desalination of water etc.

Monthly average Relative Humidity

The relative humidity data of all 14 locations were obtained, the places those has obtained maximum and minimum relative humidity has been shown in Fig. 4. Monthly average relative humidity of Vishakapatnam and Ananthapur of Andhra Pradesh which has recorded highest and lowest has shown in Fig. 4. The average RH showed a great variation among the location and months. It was varied in the rage of 35.8% to 80.5%. The Rayalaseema region shown less relative humidity with regional average of 60.44% compared to 65.63% of coastal Andhra regional average. North coastal region of Andhra Pradesh observed minimum RH values during the month of December, and peak during September. The remaining parts of Andhra Pradesh observed the minimum monthly average relative humidity's during March. The Maximum Relative humidity values were observed in North coastal region during July to September, remaining parts of Andhra Pradesh were seen during October.

Average daily distribution of global solar Irradiation

Variation in daily average global radiation at Bapatla has been studied and presented in Fig. 5. The two months i.e. April 2015 and November 2015 were taken for comparative study as these days represents the higher and lower radiation months. The average daily radiation obtained during April month was uniform throughout all the days with higher values. During November month solar insolation obtained has shown more variability. Most of the days recorded yearly minimum values during this month, this is due to seasonal monsoonal rains and cloudy weather condition.

CONCLUSION

The assessment of solar radiation and other climatic parameters for different locations are useful for selecting the appropriate solar gadgets for agricultural commodity production, processing, and preservation, irrigation and water supply systems,

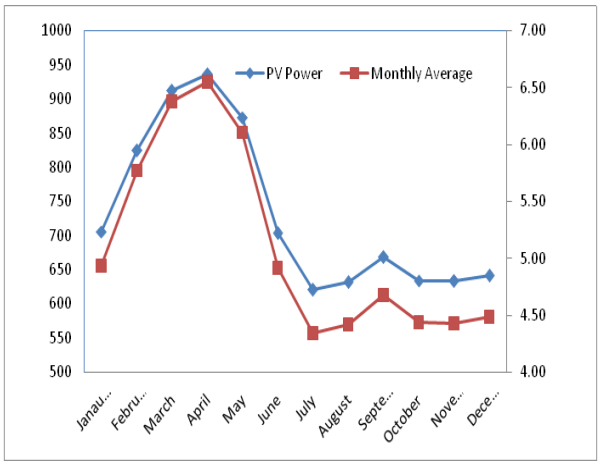

Fig. 2 Monthly average Insolation and photovoltaic power output in the different months of the year.

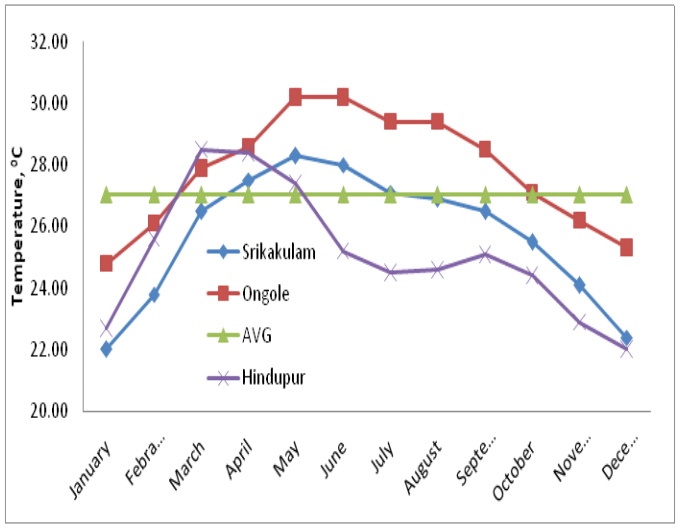

Fig. 3 Monthly average temperature distribution pattern in Andhra Pradesh.

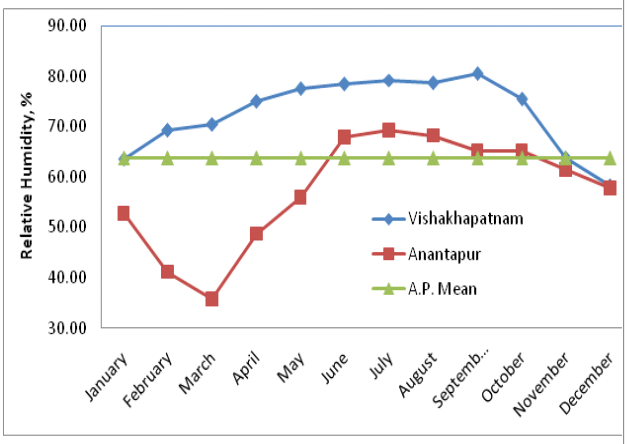

Fig 4. Monthly average Relative Humidity for different parts of Andhra Pradesh.

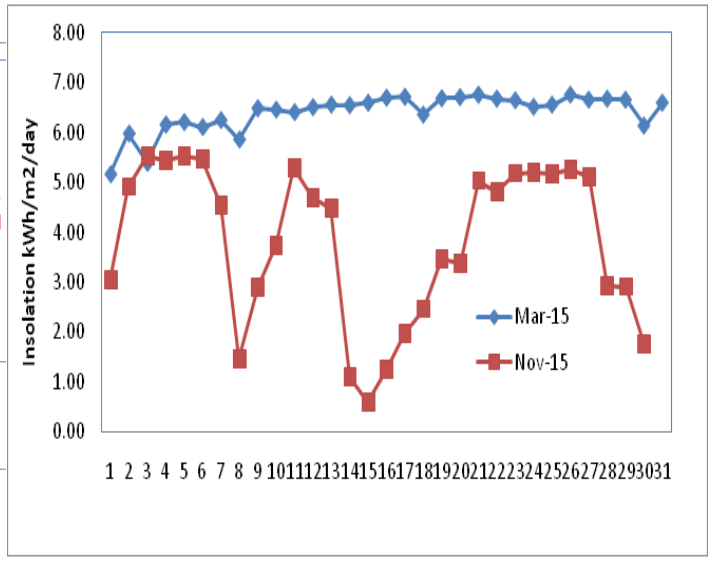

Fig 5. Average daily distribution of global solar radiation at Bapatla.

and livestock production.The global solar insolation was high in Rayalasema region when compared with coastal Andhra region of Andhra Pradesh. The average air temperature was found slightly high i.e 27.71ºC in Andhra region compared to Rayalasema region i.e 26.85 ºC. The annual average relative humidity is high in north coastal regions when compared to areas in off-coast and Rayalasema region.

LITERATURE CITED

Das B 2014 Solar powered lighting and ventilation of poultry house. M.S. thesis. Mymensingh: Bangladesh Agricultural University, Department of Farm Power and Machinery.

Ganguli and Jasvir S 2010 Estimation of solar photovoltaic generation potential and possible plant capacity in Patiala. *International Journal of Applied Engineering Research,* 1(2): 253-259.

Girish K J. Suresh P and Singh A 2012 Changing Energy-use pattern and the Demand Projection for Indian Agriculture. *Agricultural Economics Research Review,* 25(1): 61-68.

Harinarayana T and Kashyap K J 2014 Solar Energy Generation Potential Estimation in India and Gujarat, Andhra, Telangana States. *Smart Grid and Renewable Energy*, L(5): 275-289.

Nasa 2015. https://eosweb.larc.nasa.gov/cgi-bin/sse/sse.cgi?skip@larc.nasa.gov.

Sivaraman D and Keoleian, G A 2010 Photovoltaic (PV) electricity: Comparative analyses of CO_2 abatement at different fuel mix scales in the US. *Energy Policy,* 38: 5708-5718.

Vikas K, Savita N and Prashant B 2013 Status of solar wind renewable energy in India. *Renewable and Sustainable Energy Reviews*, 27:1-10.

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