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Co-Relation of Light Intensity in Generation of Current, Voltage and Speed by Solar Panels

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Abstract:

India is the world's third largest producer and third largest consumer of electricity. The national electric grid in India has an installed capacity of 364.96 GW as of 30 November 2019. Renewable power plants, which also include large hydroelectric plants, constitute 34.86% of India's total installed capacity. During the 2018-19 fiscal year, the gross electricity generated by utilities in India was 1,372 TWh and the total electricity generation (utilities and non-utilities) in the country was 1,547 TWh. The gross electricity consumption in 2018-19 was 1,181 kWh per capita. In 2015-16, electric energy consumption in agriculture was recorded as being the highest (17.89%) worldwide.

Maharashtra state is the second largest producer of electricity in India which constitutes 13.91% of the total installed electricity generation capacity in India. The state has conventional electricity capacity of 24,105 MW. Renewable energy has 16% share in total electricity generation capacity of the state. Wind power potential in the country is about 49,130 MW, while in Maharashtra it is 5,439 MW. Objectives of study 1) To survey the solar photovoltaic water pumping system under parbhani district 2) To analyze the performance of solar water pumping system

Keywords: solar panel, width length, horse power, voltage in watt, speed.

1. Introduction

The energy consumption of India is now soaring and may face severe electricity shortage in the near future. India needs a sustained growth rate of 9 to 10% over the next 20 years to meet its growth objectives. The generation of power proves insufficient in comparison to its requirement. Thus the country is facing a persistent electricity shortage, since last few years. The quantity of available non-renewable energy resources such as coal, petroleum, natural gas etc. are decreasing and end result will be blackout for the world. There are many causes of power failures in an electricity network. Examples of these causes include faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, fuse or circuit breaker operation. Maharashtra facing shortage of electricity in agriculture sector due to long hours of load shedding.

The solution is by understanding the use and importance of the renewable energy resources. Non-renewable energy resources are only available finite in this earth surface but Renewable energy resources are infinite and inexhaustible. The most important form of energy is electricity. The production of this can be done by various means. It depends on the raw materials and economic background of each area. As a developing country like India, electricity can be developed by using water, nuclear, thermal and by using renewable energy resources. The most efficient and abundant renewable energy resource is solar energy.

The rural electrification program (2006) was the first step by Indian government in recognizing the importance of solar power. It gives guidelines for the implementation of off-grid solar applications however at this early stage, only 33.8 MW of capacity was installed through this policy. This primarily included solar lanterns, solar pumps, home lighting system, street lighting system and solar home systems.

In rural areas where adequate electrical power is not available for water pumping, in such places agriculture is fully depend on hand pumps or water from distant rivers. At that time the best solution for Water Pumping using solar energy and this pumping can also be done using the diesel powered motors. The differences between these two systems are, by considering the cost and efficiency the capital cost for diesel powered motors are low but the running cost and maintenance is high. For solar water pumping the capital cost is very high but the running cost and maintenance is low. For solar water pumping it requires high initial investment and the system requires proper maintenance. Because the panels should cleaned properly. The maintenance can be done by local workman and this system completely eco-friendly. For diesel motors the investment is low at initial stage but it becomes costlier on running and it requires proper lay man for maintenance and working. The diesel powered system is hazardousness to environment and there are chances for fire. By considering all these factors the best method for water pumping in isolated areas is solar water pumping.

Solar energy is radiant light and heat from the sun harnessed using a range of ever-evolving technologies such as solar heating, solar photovoltaic, solar thermal electricity, solar architecture and artificial photosynthesis. Solar technologies are broadly characterized either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the sun, selecting materials with favorable thermal mass or light dispersing properties, and designing that naturally circulate air.

In a solar powered water pumping system, a photovoltaic (PV) array, also known as solar modules or panels, convert solar energy directly into electricity to power water pump. When the conventional electricity supplies are not available at the remote location where the grid energy doesn't reach in the lands, the PV system plays an important role. Another important reason of using PV based pumping system is conventional electricity not supplies for sufficient time, the cost of conventional energy, government subsidy in solar pumping systems and it is difficult to extend the electricity grid to every location where it is needed for every farmer. One of the factors which affect the use of conventional fuel is increasing price and the operating cost of a diesel engine.

In order to evaluate the performance of installed system the study on performance evaluation of solar powered water pumping system under Parbhani district has been undertaken during 2019-20 at Department of Irrigation And Drainage Engineering, College of Agricultural engineering And technology, V.N.M.K.V., Parbhani.

2. Review of Literature

A comprehensive review of concept and past relevant literature of solar photovoltaic pump are presented in this chapter. The work of various researches related to the present study has been reviewed and their findings are reported briefly as under following sections.

2.1 Solar Photovoltaic Pumps Based Pumping System

Dyk Meyer et al., (2000) evaluated the performance parameters of PV modules deployed outdoor studied on the current voltage characteristics and started that as the temperature increases, voltage would decrease while current typically increase as at the rate defined by the temperature coefficient of the module voltage, however, was more greatly affected, and thus there was an overall decrease in power output and panels actual efficiency. This had been shown for various module technologies including crystalline silicon, polycrystalline silicon, copper indium dieseline module type, which had strong, negative temperature dependence. However, the temperature dependency of the power output was not as straight forward for a silicon panels and found that silicon model showed less temperature dependence. This means that the module efficiency increase with increase in temperature within the operating cell temperature range of approximately 15˚C to 35˚C.

Fiaschi et al, (2005) Investigate effectiveness of solar pumping system by using modular centrifugal pump with variable system at south Sinai, Egypt with the possibility of improving the performance of deep well solar pumping system by using centrifugal pumps with variable rotational speed and modular number of working stages and the values compared to with traditional system equipped with pumps having a fixed number of stages. In the study, a 30 m^2 system with the capacity of approximately 3KW peak power and to a well depth of 100m were taken into account and regarding a commercial 46-stage submersible pump, it was determined that a breakpoint at the 30" impeller produced an increase close to 9% of the yearly pumped water yield with respect to a conventional, non- modular pump.

King et al, (2010) Analyzed the factor influencing the annualenergy production of photovoltaic system.He studied the effect of insolation incident on the solar panels orientation of the module relative to the sun. It was because the reflection of the direct beam component of solar radiation, on the panel surface, greatly increases when the angle of incidence, the angel between the beam incidents on the surface, was found greater than 60˚ tracking of panels followed the movement of the sun which decreased the angle of incident and therefore, the amount of solar radiation.

Bakeli et al, (2011) recommended optimal sizing of photovoltaic pumping system with water tank storage using LPSP concept design. The photovoltaic pumping project was designed to supply drinking water in remote and scattered small villages. It recommended an optimal sizing model to optimize the capacity sizes of different components of photovoltaic water pumping system using water tank storage.

Ozturk et al, (2016) Presenting research on water pumping through solar energy and studied on water pumping through solar energy. DC voltage was measured as46.16 V at the input of the inverter, AC voltage values was measured as 341.6 V at the output of the inverter in the PV system. And the average electrical power that was produced by the PV system was calculated to 2982.72 Watt.

2.2 Performance Evaluation of SPV Pumping System

Hamaza and Taha (1995) analyzed the performance of submersible PV solar pumping system under the condition of Sudan(average solar radiation is6KW/day). These SP4-8 submersible pumps used for the study were run by M-51 and M-53 PV system and found 10-25% less efficient than manufacture claim. Meike et al, (1998) investigated the hot climate performance comparison between poly crystalline and amorphous silicon cell connected to a utility mini grid and also investigated the effect of irradiance level on performance of solar array rated parameters. One such parameter is the maximum power voltage, (Vmp) which indicated the modules behavior or performance in low light conditions. This was an important variable to consider when the solar array would be situated in a typically cloudy location, where the level of irradiance would be considerably less than the standard test conditions (STC). The Vmp or the voltage at the maximum power point, increased as the irradiance level decreased, allowing the silicon model to maintain a similar or higher voltage output at lower level of irradiance, as compared to the operating voltage at STC.

Carr et al, (2003) compared of performance of different PV module type in the temperature climates and investigated the performance of five different types of photovoltaic modules which have been measured for five different types of photovoltaic modules which have been measured for more than year in the temperature climate of Perth, Western Australia. Perth averages over 5.4 peak sun hours each day, from less than 3 in the winter months to over eight at the height of summer. The average sun-up temperatures range between 16.5˚C and 28˚C. The types of module examined in the study are crystalline silicon, laser grooved buried contacts, polycrystalline silicon, triple junction amorphous silicon and copper indium dieseline using a purpose built outdoor monitoring facility the energy production under actual operating conditions has been measured for each module.

Ghoeneim (2006) investigated the possibility of improving the performance of a photovoltaic powered water pumping system by using modular centrifugal pumps with variable rotational speed. The direct coupled photovoltaic water pumping system was examined. The pump water was aimed to satisfy the domestic needs of 300 people. 40lit./person/day for water consumption volume of 12 m^3 needs to be pumped daily from a deep well throughout the year.

Gad (2009) studied the performance prediction of a direct coupled PV water pumping system. The system is found to be capable of pumping 24.06lit./day, 21.47 lit. /day and 12.12 lit/day. The calculated PV array efficiency ranges from 13.86% in winter to 13.91%.

Hegazi a (2010) studied relation between pumping system delivery and solar radiation values hourly based average measurements for 10 years (1995 to 2005) of solar radiation values were lined to PVC discharge to estimate the whole year water output of the system. Pump discharge was 7.33 m^3/h at 4m head with 1016 Watt/m^2 solar intensity and pumping efficiency was less than 40%.

Aligah et al, (2011) studied design of PV water pumping system and compared it with diesel powered pump from the comparative study of SPV pumps and fuel operated engine pump it was found that as the cost of conventional fuel increasing day by day, the operating cost of diesel engine would be increased due the high fuel cost, operating the PV system above 7.2 KW was feasible and less operating cost than diesel engine.The decentralized system was found feasible where the population lived at a small bunch in far the distance.

Oko (2012) Analyzed the unit electrical cost per KWH of the designed system and it was found to be 18.2% less than the value (0.74US$/KWH) low UES is attributed to the more favorable economic index in Egypt, inflation rate of 3% and interest rate of 10%, as against 9.40% and 9.25% respectively.

Lal et al, (2013) studied performance analysis of PV based submersible water pump. The coal consumption of 10.93 tons during the year 2012 for production of 14194.45 KWH electricity toaccomodate the annual discharge of SPV based water pumping system. The annual CO_2 emission is reduced by 14977.57 kg/year or 6051 tons per year. These other pollutants or evaluated per KWH and total annual pollutant can be saved by SO_2 = 11707.53 kg/year and NO=39.52 kg/year. The NPV and PP for different are CNG 124787.79,3.787,PV313860.63, 1.814,diesel370155.60, 1.354.

Baskar (2014) investigated the performance of a 936watt PV water pumping system with water spray over the PV cell. The spraying wear over the cells increases the mean PV cell efficiency, sub system efficiency and total efficiency 3.26%, 1.40% and 1.35% respectively. A 16 m maximum PV cell efficiency at standard conditions was 13.5%. The PV water pumping system with water spray over the cells archives 12.57% mean PV cell efficiency during the test day .the water spray improved the optical performance by 1.8%.

Bhattacharya et al., (2015) studied the statical analysis of solar PV module with influence of different metrological parameter in Tripura India. Efficiency measured (η_1) is 301.2924; efficiency calculated (η_2) is 299.4600 .

Kalbande et al., (2016) studied the performance evaluation of 3, 5 and 7hp solar operated submersible pump and the experimental data on head discharge, input power, solar insolation etc. were recorded in order to access the overall efficiency of system. The overall efficiency of 3, 5 and 7hp pump was found in the range of 5 to 10%. The discharge was found to be directly proportional to solar intensity.

3. Material And Methods

This chapter deals with the performance evaluation of SPV pumping system installed at farmers field in Parbhani district. The aspects in respect of location, the technical specification, site observations and discharge variation with respect to solar intensity was collected and presented in following sections.

3.1 Location of Study

To study the performance evaluation of photovoltaic pumping systems the field work was conducted by students of Department of Irrigation And Drainage Engineering, College of Agricultural Engineering And Technology, V.N.M.K.V., Parbhani during 2019-20 on the selected farmers field of Parbhani district.

3.2 Selection of Farmers

In order to select the farmers for performance evaluation of photovoltaic pumping system in Parbhani district. The information was collected from MSEDCL (MAHAVITARAN) office located at Parbhani and presented in following table.

Table: 1

Sr. No.	Name of Farmer	Address	Mobile No.	Date of Purchace	Capacity of Pump
1	Mr.Prashantrao Lad	At- Jamb Tq. Dist.-Parbhani	9822969896	20.04.19	5HP
2	Mr.Ashroba Nile	At-Hatkarwadi Tq. Dist.-Parbhani	8637864213	10.04.19	5HP
3	Mr.Pranav Simargavkar	At-Simargaon Tq.-Selu Dist.-Parbhani	9404192415	06.02.19	5HP
4	Mr.Prasnna Simargavkar	At-Simargaon Tq.-Selu Dist.-Parbhani	7588791292	06.02.19	5HP
5	Mr.Anil Nakhate	At-wadi Tq.-Pathri Dist.-Parbhani	9822731555	20.04.19	5HP
6	Mr.Umesh Kulkarni	At-Pathri Tq.-Pathri Dist.-Prbhani	9011122412	23.04.19	5HP
7	Mr.Eknath Shinde	At-Devnanda Tq.-Pathri Dist.-Parbhani	9860495219	24.04.19	5HP
8	Mr.Santra	At- Jamb	9657201	05.09.	3HP

	m Renge	Tq. Dist.-Parbhani	160	19	
9	Mr.Prakashrao Lad	At- Jamb Tq. Dist.-Parbhani	9822969896	10.07.19	3HP
10	Mr.Sahebrao Lad	At-Parava Tq. Dist.-Parbhani	9970340472	05.08.19	3HP
11	Mr.Sudamrao Kolhe	AT-Kasapur Tq.-Pathri Dist.Parbhani	9552636701	25.10.19	3HP

From above stated list of farmers the five farmers near to Parbhani was selected for performance evaluation of SPV pumping system.

Table: 2

Code No. of SPV System	Farmer Name	Name of Village	Longitude	Latitude	Elevation	Survey No.	Date of Survey
SPV PJ-I	Mr.Renge S.N.	Jamb	76.70	19.27	399.24m	242	27.11.19
SPV PJ-II	Mr.Lad P.B.	Jamb	76.66	19.26	432.64m	376	29.11.19
SPV PJ-III	Mr.Lad P.P.	Jamb	76.67	19.25	430.66m	309	29.11.19
SPV PP-IV	Mr.Lad S.B.	parava	76.81	19.29	420.11m	427	30.11.19
SPV PK-V	Mr.Kolhe S.B.	kasapur	76.45	19.25	423.23m	436	04.12.19

From above five farmer's SPV system, three farmers are selected from Jamb, one from Parava and one from Kasapuri and evaluated for performance. The farmers in order to simplify the SPV pumping system site the code number/nomenclature for farmer's SPV system is given and presented in Table: 2

3.3 Specifications of SPV Pumping System

The technical specifications of SPV system was recorded at five SPV pumping location as discuss in following table.

Table: 3

Sr. No	Technical Description	SPV PJ-I	SPVPJ-II	SPV PJ-III	SPVPP-IV	SPV PK-V
1	Make	TATA Power Pvt. Ltd.	Renewsys Ind. Pvt. Ltd.	Jain Pvt. Ltd.	Renewsys Ind. Pvt. Ltd.	TATA Power Pvt. Ltd.
2	Model Number	TP310LBZ	DESERV3M6-320	JJ-M672	DESERV3M6-315	TP308LBZ
3	Maximum Power	310WP	320WP	315 WP	320WP	310WP
4	Rated Current	8.41A	8.62A	8.61 A	8.62A	8.41A
5	Rated Voltage	36.9V	37.20V	36.59V	37.20V	36.9V
6	Short Circuit Current	8.88A	9.07A	9.10 A	9.07A	8.88A
7	Open Circuit Voltage	44.9V	46.18V	45.35A	46.18V	44.9V
8	Maximum System Voltage	1000 VDC	1000V DC	1000 VDC	1000V DC	1000 VDC
9	Series Fuse Rating	20A	15A	15A	15A	20A
10	Power Tolerance	0 to +5W	0 to +5W	+3%	0 to +5W	0 to +5W

Table: 4 Technical specifications of SPV pump

Sr. No.	Description	Model I	Model II
1	Solar PV array	3000WP	4800WP
2	motor pump set	Submersible	Submersible

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	type	pump	pump
3	Motor capacity	3HP	5HP
4	Max. TDH	120m	160m
5	Required shadow free area	120 sq.m	200 sq.m
6	Water output (discharge)	51,000 lit./day	82,000 lit./day

3.4 Other Instruments/Equipments Used For Installation

In order to record the various observations for performance evaluation the already installed instruments and few other additional instruments/equipments were installed and used for proposed study.

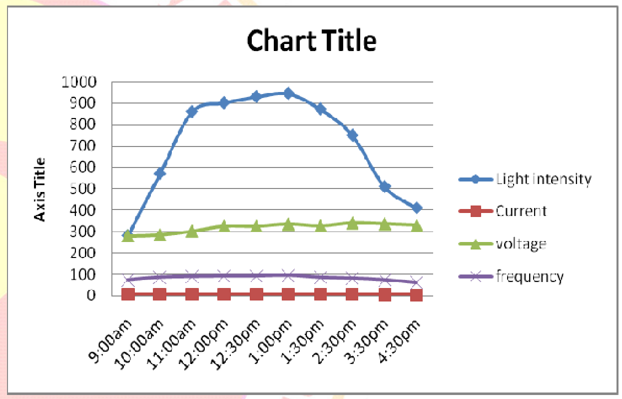
Table: 4

Sr. No.	Name Of Instrument	Technical Specifications	Purpose
1	Pyranometer	Make: CEL Range: 0 to 1000 W/m^2	To measure the Solar radiation
2	Pressure gauge	Make: TIPCO	To measure the Water pressure
3	Tape	30m measurement tape	To measure the Shadow free area and area occupied by panels
4	Water Tank	Material: PVC Capacity: 200 lit.	To measure Water discharge
5	Stopwatch	Timing capacity: 23 hrs,59m and 59 seconds Accuracy: ±3 sec/day	To measure the water discharge time

Effect of light intensity on the generation of current, voltage and speed by solar panels at SPVPJ-I

Table:4.1

Sr. No.	Time	Light intensity	Current	voltage	frequency
1	9:00am	280.16	5.6	280	75
2	10:00am	570.16	5.6	285	87
3	11:00am	860.11	5.9	302	90
4	12:00pm	902.16	6.3	325	92
5	12:30pm	930.19	6.3	325	92
6	1:00pm	945.25	6.1	335	95
7	1:30pm	872.15	5.6	327	86
8	2:30pm	750.05	5.2	340	82
9	3:30pm	510.12	4.4	336	75
10	4:30pm	410.16	3.1	330	62



Effect of light intensity on the generation of current, voltage and speed by solar panels at SPVPJ-II

Table:4.2

Sr. No.	time	Light intensity(w/m^2)	Current (Amp)	Voltage (V)	frequency
1	9:00am	370.26	4.9	297	75
2	10:00 am	585.15	5.2	334	88
3	11:00 am	740.09	5.5	321	90
4	12:00 pm	870.10	5.9	339	95
5	12:30 pm	890.27	6.1	327	96
6	1:00pm	890.11	6.0	335	96
7	1:30p	720.12	5.5	329	85

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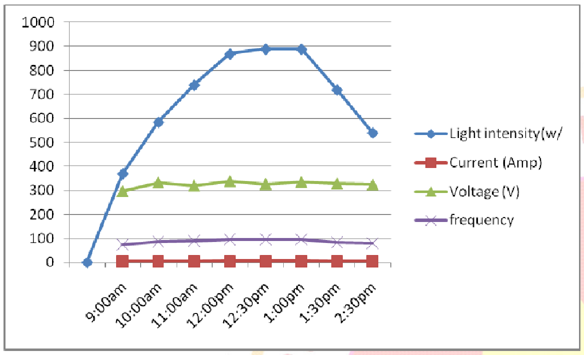
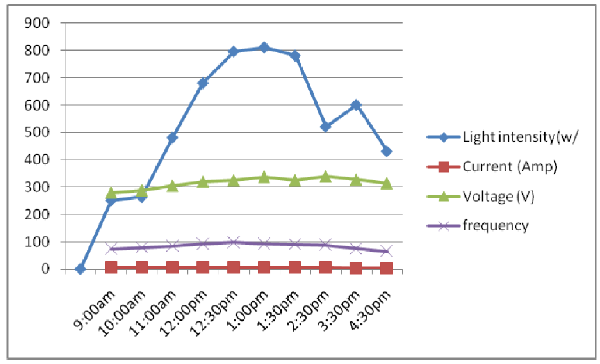
	m				
8	2:30pm	540.72	5.2	325	82
9	3:30pm	340.17	3.1	327	62
10	4:30pm	334.71	3.1	325	65



Effect of light intensity on the generation of current, voltage and speed by solar panels at SPVPP-IV

Table:4.3

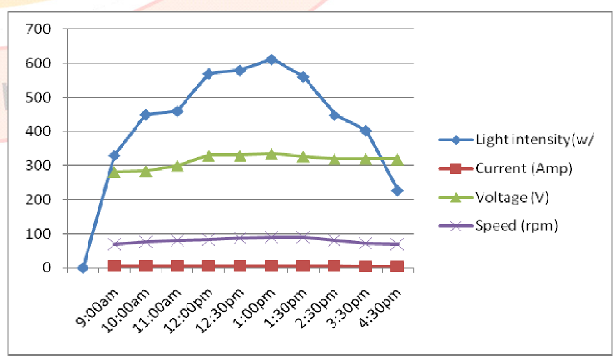
Sr. No.	time	Light intensity(w/ m^2)	Current (Amp)	Voltage (V)	frequency
1	9:00am	251	5.5	280	74
2	10:00am	263	5.6	289	78
3	11:00am	480	5.7	305	85
4	12:00pm	680	5.9	320	92
5	12:30pm	795	6.1	325	98
6	1:00pm	810	6.2	337	92
7	1:30pm	780	6.0	325	90
8	2:30pm	520	5.8	339	88
9	3:30pm	600	4.8	327	75
10	4:30pm	430	3.7	315	65



Effect of light intensity on the generation of current, voltage and speed by solar panels at SPVPK-V

Table:4.4

Sr. No.	time	Light intensity(w/ m^2)	Current (Amp)	Voltage (V)	Speed (rpm)
1	9:00am	330	5.5	282	71
2	10:00am	450	5.5	284	76
3	11:00am	460	5.6	300	81
4	12:00pm	570	5.8	330	83
5	12:30pm	580	5.9	330	88
6	1:00pm	612	6.1	335	90
7	1:30pm	561	6.1	327	89
8	2:30pm	448	5.8	320	82
9	3:30pm	403	4.1	320	72
10	4:30pm	227	3.7	319	70



4.Results And Discussion

This chapter deals with the results obtained from the study in respect of performance evaluation of solar water pumping system. The SPV pump was installed at the selected villages of Parbhani District. The data was generated for various parameters e.g

Solar intensity, current, voltage, speed and discharge of water and water pressure.

4.1 Performance Evaluation of 3HP SPV Pump

The performance evaluation of 3HP SPV pumping system were conducted at farm location of Mr. Santram Renge At.post-Jamb, Tq.Dist.-Parbhani on dated 27.11.2019. The observations in respect of light intensity, current and voltage generated by SPV panels and frequency of pump was recorded using pyranometer, ammeter, voltmeter and frequency meter respectively at different time from 9.00am to 4.30pm with an interval of one hour. The similar observations were recorded at another locations at Jamb, Parava and Kasapuri villages namely on the farm of Mr.Prakashrao Lad, Mr.Sahebrao Lad and Mr.Sudamrao Kolhe on dated 29.11.2019 , 30.11.2019 and 04.12.2019 respectively.

The observations recorded at SPVPJ-I, SPVPJ-II, SPVPP-IV and SPVPK-V are presented in Table 4.1 to 4.4

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