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Performance of solar power fencing system for agriculture

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Solar power fence system provides controlling for all type of animal. Its applications suits remote areas provide an economical and practical solution to achieve maximum protection of field or particular areas. The preset solar power fencing system works on the solar energy The daily observations like solar radiation, panel voltage, panel current, battery voltage, fence voltage and current were note and graphs were plotted among these parameters. The average input-output energy from solar panel were found 172 and 23 watts respectively. Voltage in the fence live wire ranges from 2 to 11 kV. The range of pulsating current through fence wire was 0.005 to 0.008 Amp. Each pulse in fence wire is for 0.0003 of a second and pulses are spaced about 1.0 seconds apart. One panel of 35 kW and 12 V battery was found effective for 3.5 km fence line. As sunshine hours of day decreases and battery get discharged. As results fence wire voltage decreases and gives poor performance to control animals.

Key words: Solar photovoltaic, Energy, Battery, Voltage, Current, Sunshine hours

Intrduction

The sun generates power in the form of radiant energy at the rate of 3.8 x 10^{23} kW. An extremely small fraction of this is intercepted by the earth, but even this small fraction amounts to the huge quantity of 1.8 x 1024 kW, intercepted by the sun side of earth every 24 hours (Anonymous, 2000). India has about 95 percent clear sunny days with average daily incidence of solar radiation at 5000 kcal/m2/day for 8 to 10 hours a day over most calendar year (Gupta *et. al.,* 1989).

It is observed that on a typical land area of earth, approximately 1000W/m^2 of energy from photons is available for conversion into electrical power at solar noon. Although about 85% of villages are electrified through the electricity, it is available only for limited durations. Therefore, in the larger

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national interest, there is an urgent need to explore alternatives, renewable substitutes for these conventional sources of energy, solar energy is potential option since it is free of cost and pollution (Anonymous, 2002).

The solar photovoltaic system has certain disadvantages as relatively high initial investment, requires storage devices, solar energy available at a place is not a constant, local weather conditions affect on its reception, it is not in concentrated form hence collection and concentrating surfaces are required. The Concentrating and storage equipments are expensive (Anonymous, 2002).

The solar photovoltaic (SPV) system converts the sunlight directly *into* DC current. The SPV technology is now a days being efficiently used for electric fencing purpose. Man- animal conflicts have reached alarming proportions today. Much of these conflicts can be alleviated with proper management of areas set aside both for wild animals and man. The solar power fencing system provides both an economical and a practical solution to achieve maximum protection through effective control of animal trespass and browsing (Anonymous, 2002). Solar-powered fencing-system enables the control of animals by giving them a short, sharp but safe shock which is sufficiently memorable that they never forget it. The present study was taken for the study and performance of solar photovoltaic fencing system.

Material and methods

This experiment was carried out at research farm, Marathwada Agricultural University, Parbhani. Specifications of the solar panel are given in Table 1. The panels were adjusted along the N-S direction of earth i.e. face the South Pole in order to get maximum exposure. The angle made by the panel with horizontal is kept (latitude $\pm 15)^0$.

Table 1. Specification of solar panels (large and small).

Sr. No.	Specifications		Dimensions	
			Small arrays	Large arrays
1	Size of arrays		45×23.5 cm	100×40 cm
2	Peak power		7.5W	27W
3	Open circuit voltage		15 V	18V
4	Short circuit current		0.5 A	1.5 A
5	Cell C. E.		10%	10%
6	No. of Cell		32	36
7	One all generates		0.46 V	0.5 V
8	Total area of cell		560 cm^2	2826 cm^2
9	Solar arrays frame	Length of arrays	46 cm	102 cm
		Width of arrays	24.5 cm	12 cm
10	Solar arrays	Length	45 cm	100 cm
		Width	23.5 cm	40 cm

Components of solar power fencing system

Solar panel: Solar panel acts simply as a battery charger. It converts the sunlight directly in to DC current. A panel of 12 V/35 W capacity was used to change the 12 V/100 AH (Plate 1). The size of the solar panel depends upon the energizer size, power setting, geographical locations, level of usage, full year, and summer or spring autumn.

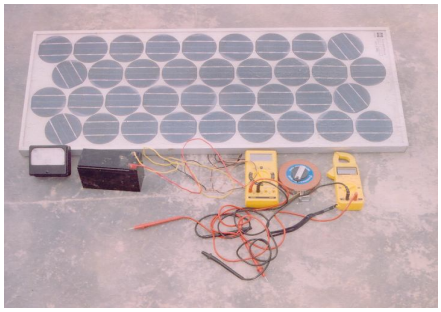

Plate 1. Solar photovoltaic panel, thermometer, solarimeter, digital voltmeter, digital ammeter

Battery: Battery acts as energy storage device (12 V/100AH). It stores the electricity generated by the solar panel, which allows the energizer to operate at night or during cloudy day. While selecting battery points should be considered, 1) It must be sufficient capacity to reliably power the energizer during winter and cloudy day, 2) designed for regular charge and discharge cycles without permanent damage by deep cycle, marine and leisure batteries.

Energizing device: It is the heart of solar power fencing system. It referred as unit controller, charger of fencer (Plate 2). It produces a short, high voltage pulse at a regular rate of one pulse per second. Each pulse was provided for 0.0003 second pulses are spaced about one second apart. Selection of the energizing device based upon type of animal, length of multi-wire fence, vegetation load on fence line, number of standards, and type of power source.

Plate 2. Energizing device (right side in box) and solar panel

Earthing system: The earthing system must be well adjusted in order to complete the pulse circuit and give an effective shock to animals. The earth (ground) system of the energizing device is similar to the radio antenna or aerial as shown in plate 3. As a large radio requires a large antenna to effectively collect sound waves and high powered energizer requires large earth (ground) system to collect the large number of electrons from the soil earth (ground) system must be perfect of that the pulse can complete its circuit and give an effective shock to animal.

Plate 3. Earthing system

Fence system: The fence system consist of following components

Fence wire: It is used to apply the pulsating power through it. It is smooth one and made up of galvanized iron (G. I.) metal. A 2.5 mm (12.5 gauge) high tensile (H.T.) wire is recommended for electric fence systems because of its advantages .There are total eight wires, in present system. The upper (top) one is live and lower one is earth wire. The live and earth wires are alternately placed.

Main post: It is a large diameter (Approximately 3-4 cm) and height 2.6 m galvanized iron pipe. After every 150 m distance it give great support to fence wire. The total numbers of main post in present systems are 24. It supports the 8 fence wires which run horizontally. It is also called corner or strainer post. The grouting is done at 60 to 75 cm depth with the help of cement concrete.

Supporting post: It is galvanized iron pipe having diameter 1 to 2 cm, used to support the main post from both sides.

T-post: The T-post is galvanized iron (G.I.) post of T cross section. It is used in between the two main posts to support or to mount the fence wire on it. It has height 2.6 m including 60-75 cm grouting. The distance between main

post and T-post is six meter and the spacing between two T-post is also six meter.

Lightning diverter (lightning strikes) and choke kit: Lightning strikes can damage energizers. The damage can be minimized by disconnecting the energizer from the fence line and unplugging it from the power supply during electrical storms. An IG684K lightning diverter kit is recommended to minimize energizer damage. Lightning always finds the easiest way to earth (Plate 4). Therefore earth (ground) system of the lightning diverters must better than the energizer earth (ground).

Plate 4: Lightning diverter

Super earth kit: It consists of earthing rods of stainless steel (122 cm length) along with the earthing material bag. There are seven earthing rods at central farm for two units.

Super strain insulator: They are high insulators used to join the fence wire to the main post, while running along its lengths. The strain insulator is specially designed plastic insulator. Its main function is to avoid direct contact between live fence wire and main post.

PP real insulators: It is specially designed insulator, used to mount the fence wires (live and earth both) on the support post and T- post. Its main function is to avoid the direct electrical contact between the live fence wire and t-posts also between live fence wire and support post.

Permanent wire tightener and chain wire strainer: Wires can be tensioned by using a chain wire strainer with a built-in tension indicator or by using a permanent wire tightener. Tension in all wires 90 kg (200lbs). This is adequate tension for 2.5 mm (12.5 gauge) high tensile wire. For wild animal control the tension should be increased to 180 kg (400lbs), especially at the bottom wires. On long strains, it is recommended to place IG 643 permanent wire tightener in the centre of the fence so that the wire pulls in from both sides.

Tension springs: It is used in fence line to release the tension on fence line and protect them the breaking down. When animals are forced through electric fences bush fire or by dogs, in such situation the springs gets released which releases load or pressure on fence line and thus avoid the breaking down of fence line.

Double insulted lead out cable: This is one of the insulated cable used to give connections from battery to energizer, energizer to fence live line, energizer to earthing system; where, there is a gateways and in such similar conditions. G627 double insulated lead-out cable should be used in building, under gateways and where soil could corrode exposed galvanized wire.

Joint clamps: It is specially designed iron clamps used join one fence wire to another fence wire. In this fencing system, it is used to join the four live wire and four-earth wire.

Gateway and gates: The position of gateways is on flat, firm areas, away from sleep banks where erosion occurs. There should not use electric gates to get power across gateways.

Cutout switches: It is used to help find faults by isolating sections of the fencing system. Use two screws to attach a cut out switch to the inside a post from loop in tails from second wire and fasten securely to base of cut out switch. Attach incoming power cable to top of cut out switch using IG627 lead out cable.

Electrified flood gates: In heavy rainfall areas when the water level rises, an electric fence that is partly or entirely submerged may lose most of its pulse energy. The flood gate and IG604 flood gate controller will overcome this problem.

Live light: It help us in a flash if our power fence in effectively operating condition. It is nothing but flashing light to alert you. It is mounted on pipe post at top. It is visible from approximately 1000m at night. At 3KV or above, it flashes every pulse; at 2-3KV it flashes every second pulse; at less than 2 KV it does not flash.

Fence voltage alarm: Alarm on earth output and fence voltage alert you if any animal control is at risk. When voltage in live fence wire drops 3.6 KV due to any unusual fault, the fence voltage alarm get ON and siren gives a high frequency sound which alert you.

Performance efficiency of solar panel

From the data recorded, Input, output array and conversion efficiency calculated with following formulae given below.

Array output (AO), Watts = $Voltage(V) \times Current(A)$

II). Input to arrays (IA), Watt = $G(W/m^2) \times A(m^2)$

Where, G - Incident solar radiation (W/m^2)
A - Panel Area (m^2)

Conversion efficiency, % $= \frac{AO(Watts)}{AI(Watts)} \times 100$

Working of solar power fencing system

The energizer has to be set up with its earth (ground) terminal coupled to an adequate earthing (grounding) system. The terminal is coupled to the live insulated wires of the fence. A correctly installed energizer sends an electric current along an insulted steel wire. As animal touches this live wire creates a path for the electric current through its body to the ground and back to the energizer via the earth (ground) system, thus complete the circuit. The greater the shock the animal receives more lasting the memory will be and more the fence will be avoided in the future. The shock felt is a combination of fence voltage and pulse time (energy). The higher the joule rating of the energizer the greater the shock and the greater the fence performance provided the installation is correct.

Evaluation of the solar power fencing system

The solar energy (light) is converted into D.C. electricity by using the solar panel, which is further stored in the rechargeable battery dug time. This stored energy is then utilized for electrifying the fencing line at the night time and during cloudy weather.

The voltage and current in fence line is measured by using the digital voltmeter and ammeter respectively. While measurement of voltage in fence wire with Digital Volt Meter (DVM) the one terminal or knob of DVM is connected to live wire and another terminal (earth terminal) is connected to earth fence wire or any post or touch to ground. The current in the fence line, it is always connected in series with fence live wire.

It is observed that the voltage in fence line drops, when battery is not fully charged or discharge due to cloudy weather condition. The observations of fence voltage are recorded when battery is ¼ discharged, ½ discharged, ¾ discharged and fully discharged.

The voltage in fence line also drops below 3.5 KV, when there is an unusual fault. After detection of fault by walking along fence wire line and inspecting fence line, it is removed by making power OFF in fence line with the

help of cut-out switch. After removing the fault the fence voltage remains constant. The observations of fence voltage are recorded after every 500 m distance, with help of DVM (starting from energizer and ending to fence end, total 3.5 km) (Plate 5).

Plate 5. Animal control and measuring voltage in fence live wire with DVM

Results and discussion

Collected data of the solar radiation and temperatures from 08.00 hrs to 18.00 were analyzed and shown in the Fig 1.

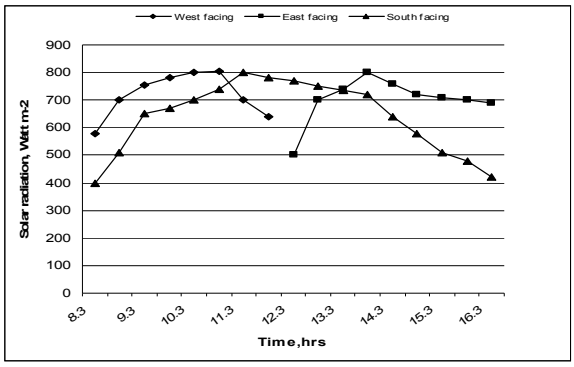

Fig. 1. Effect of tracking on solar radiation on panel

It also observed that solar radiation received by south facing panel was for maximum time during the day as compared to east and west facing panel. Energy input and output of solar array: It was noted that solar insolation from 12:00 hrs to 15:00 hrs were in the range of 75mW/cm^2 and input and output of panel varies and found maximum for same period. The total input energy to large panel varied between 96.06 W to 226.08 W from that output energy was obtained between 6.23 W to 34.53 W (Fig 2). For small panel total input energy

to unit varied between 25.2W to 47.04 W and output energy were obtained between 6.39W to 2.84 W (Fig.3).

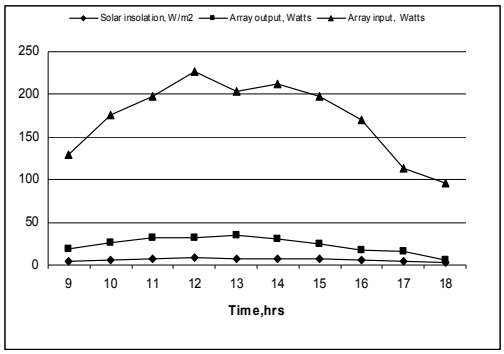

Fig. 2. Daily variation of energy input & output w.r.t insolation for large panel

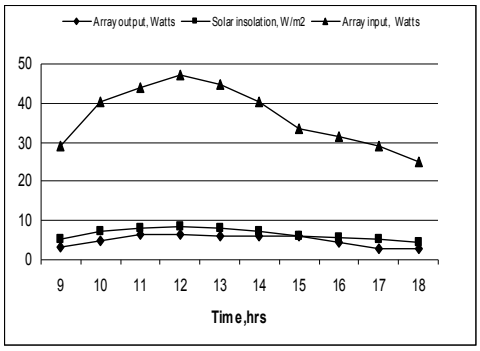

Fig 3. Daily variation of energy input & output w.r.t insolation for small panel

Conversion Efficiency: The conversion efficiency decides the capacity of the solar cell to covert incoming solar insolation into electrical energy. Average value of conversion efficiencies of large panel and small panel varies between 16.97% to 10.48% and 18.24% to 10.30% respectively (Fig.4 & Fig.5).

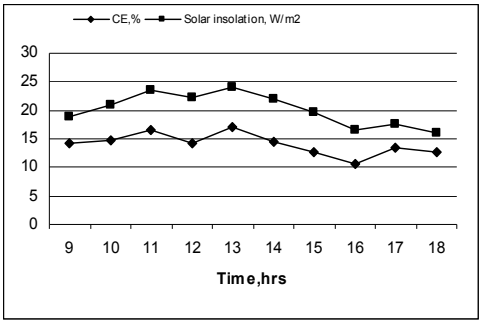

Fig 4. Daily variation of conversion efficiency w.r.t. solar insolation on large panel

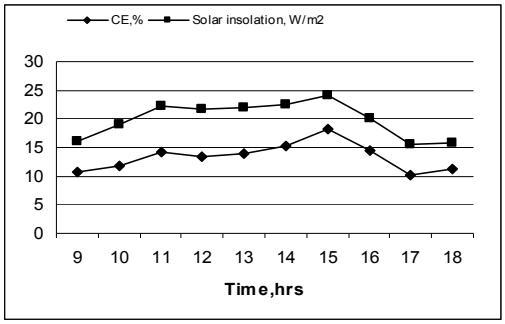

Fig 5. Daily variation of conversion efficiency w.r.t. solar insolation on small panel

Performance of solar power fencing system

The voltage on fence wire measured after every 500 m distance by using Digital volt meter. The recorded observations were shown in Table 2.

Table 2. Solar power fence voltage at the interval of 500 m distance.

Distance from energizer unit (Metre)	Corresponding fence voltage (KV)
0	11.0
500	10.4
1000	9.3
1500	8.6
200	8.1
2500	7.6
3000	7.0
3500	6.6

It is found that the fence voltage remain constant throughout the system, it is not affected by vegetation or any unusual faults. Fence voltage varies from 6.6 kV t0 11.0 kV along its length. When affected by vegetation or any other fault and in normal condition it shows the value 6.6 kV to 7.6 kV. Observations of fence voltage corresponding to the battery voltage shown in Table 3. It gives 11 kV when battery was fully charged, as battery discharge its corresponding fence voltage also showed decreased in voltage.

Table 3. Solar power fence voltage in discharged condition of battery.

Sr. No	Battery voltage in discharged condition (Volts)	Corresponding fence voltage in discharged condition of battery (KV)
1	12.00	11.0
2	10.00	9.00
3	8.00	7.00
4	6.00	5.00
5	4.00	3.00
6	2.00	1.00
7	0.00	0.00

Sun is free, clean and cheap source of energy. Solar photovoltaic cell abosorb the solar energy and directly converted into electrical energy. This electrical energy can be used for giving safe electrical shock to animal. Solar fencing system can provide the safe, durable and economical way to protect the crop from animals (domestic and wild).

Electric fences are psychological barriers so they don't rely on excessive physical contact for effectiveness. Large panel received input and output energy, 172 watts and 23 watts where as for small panel input and output energy was 39 watts and 4.9 watts respectively. In normal operating condition the fence voltage remains between 6.6 kV to 7.6 kV, however 3.5 kV to 11 kV is satisfactory; below 3.5 kW it is not so effective. When sunshine hours of day

are decreased, battery gets discharged slowly and fence voltage also decreases. One panel of 35 kW and 12 V battery is found effective for 3.5 km fence line. The cost of solar power fence $ 3300 per kilometer of length.

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