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Solar Energy Based Lighting and Ventilation System for Rural Poultry House in Bangladesh

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Abstract

Due to the shortage of electricity in Bangladesh, there should be an alternative energy sources for providing continuous lighting and ventilation in the poultry house. In the study, solar energy based system is proposed for the mentioned purposes. Solar panel using in the experiment produced a power of 26.73 W/m^2 when solar irradiance was 848 W/m^2 in study area. Maximum solar power was received from solar panel during 12~13 pm when panel was placed in south face at 30° angle. A total of 9 m^2 area was considered to conduct the experiment. According to the experiment, 31.5 W power was required for lighting and ventilation purposes for 108 chicks in 9 m^2 area. In cloudy day, a 12V 100 Ah battery is able to provide 38 hrs back up time for 9 m^2 area. Rural farmers may use the solar based energy for dual purposes in their living and poultry houses. So, solar energy based system may be considered for rural farmers in Bangladesh.

Key words: Poultry house, Chicks, Lighting, Ventilation, Environment, Solar energy.

1. Introduction

Bangladesh is an agricultural country. Poultry plays a significant role in the subsistence economy through 1.6% contribution to GDP (Alam *et al*., 2014). Depending on the farm size, poultry farming can be main source of family income or can provide subsidiary income and gainful employment to farmers throughout the year. Poultry manure has high fertilizer value which can be used for increasing yield of all crops.

Where majority of the people are landless, malnourished, uneducated and poor, family poultry could play a pivotal role in income generation, poverty eradication, women empowerment, nutrition, and food security. Poultry industry is an emerging agribusiness started practically during 1980s in Bangladesh (Haque *et al*., 2005). Environment friendly poultry house is a prerequisite for sustainable commercial broiler industry. An appropriate indoor environment of poultry house is essential for healthy and safe poultry production. Therefore, it is necessary to provide proper lighting and ventilation system for sustainable environment friendly poultry house.

Poultry farming in rural area faces difficulties to maintain temperature of poultry house in summer and winter seasons. Newly hatched chicks have a poor ability to control body temperature, and require some form of supplementary heating in winter season. Light is also important for feeding, as poultry identify food by sight. A combination of high temperature and high humidity is a problem (Fanatico, 2007). Lighting and ventilation are continuously necessary in any poultry house to ensure an adequate supply of oxygen, feeding and removing waste gases (Glatz and Bolla, 2004). It is also necessary to maintain desirable temperature for poultry house through continuous ventilation. As the frequent load shedding or lack of accessibility to electricity in rural areas, there should be an alternative energy source for providing continuous lighting and ventilation.

Bangladesh is located between 20°30' and 26°45' north latitude and has a total area of 1.4 (1011 m^2). An average of 5 kWh/m^2 solar radiation falls on this land over 300 days per annum. The fluctuation of solar radiation throughout year in Bangladesh is shown in Fig. 1. The abundant solar energy has a

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large potential to be used in various sector in Bangladesh for reducing the demand of traditional fossil fuel based power consumption and ensuring a green environment for the future generation (Deb *et al*., 2013). Environment friendly solar based energy can be used in poultry house for lighting and ventilation purposes. There is no available practices of solar energy in poultry house in Bangladesh. It will be more considerable in rural areas experiencing frequent load shedding or lacking accessibility to electricity. Rural farmers may use the energy for both poultry house and their living house simultaneously. Solar power system may serve about 20-25 years without any additional cost (Hirok *et al*., 2011). Therefore, the present study was conducted to develop a lighting and ventilation system using solar energy for rural poultry house in Bangladesh.

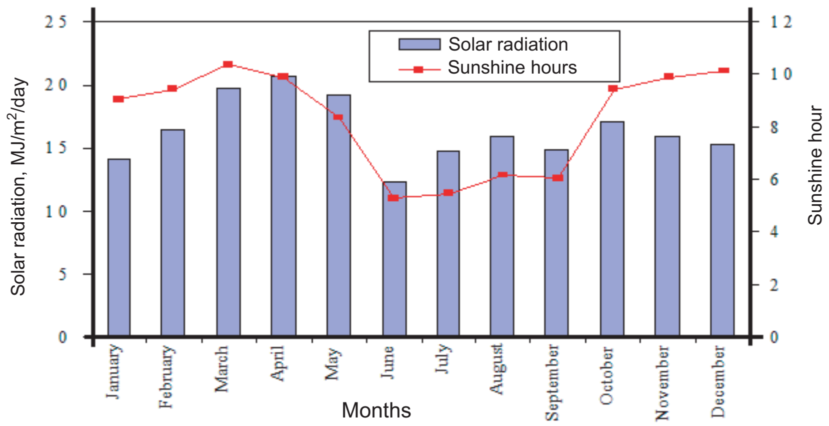


Fig. 1: Monthly solar radiation fluctuation in Bangladesh (Hossain *et al*., 2011)

2. Materials and Methods

Solar energy based system is designed for knowing the feasibility of the solar powered lighting and ventilation of poultry house in rural areas of Bangladesh. Solar energy is an inexhaustible source of energy. The full potential of the energy cannot be utilized unless suitable way is developed.

2.1. Experimental design

2.1.1. Considerations for solar energy based poultry house

Total power requirement of particular poutry house for lighting and ventilation purposes depends on number of chicks and also on housing materials, size and orientatiion. For requirement of lighting and ventilation, a total 9 m^2 area was considered to conduct the experiment. Power requirements per chick is also need to be determined. Number of bulbs and ventilation fan with its position should also be considered for a solar based poultry house. The experiment was carried out in the workshop, Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh, from January to June, 2014.

2.1.2. Installation of solar panel on roof

A well-designed solar electric system should be placed in clear and unobstructed place for continuous access to the sun in most of the day throughout the year. Setting a solar panel with a system precisely is a critical and important issue in order to achieve maximum power production. Optimal orientation for solar panels is true south. If move away from true south, a system will suffer production losses up to as much as 15–25% for panels oriented east or west. Solar panels produce the maximum power annually when mounted at a tilt of roughly 30° angle (SCL, 2013). According to instruction, solar panel was sat up on the roof of workshop laboratory.

2.1.3. Experimental set up

The solar panel converts solar energy to electrical energy. Electricity conveys from solar panel to charge controller by high quality electrical cable. Charge controller is used to protect the battery from over charge. In this experiment, LED bulbs were used for lighting and DC fan was used for ventilation.

Load such as bulb and fan were connected to the battery in parallel. A DC ventilation fan with 0.15 m dia. was connected with solar panel via battery for circulating and flowing fresh air in the poultry house. The fan and four bulbs were connected in parallel way in the circuit. The amount of current for operating the fan at different times in a day was measured. The voltage drop across the fan was same as that of the LED bulb due to the parallel connection. The circuit diagram of the whole system is shown in Fig. 2. In the experiment several accessories were used to measure various parameters and to conduct experiment for lighting and ventialtion purposes. All required accessories and measuring instrument for the experiment are shown Fig. 3.

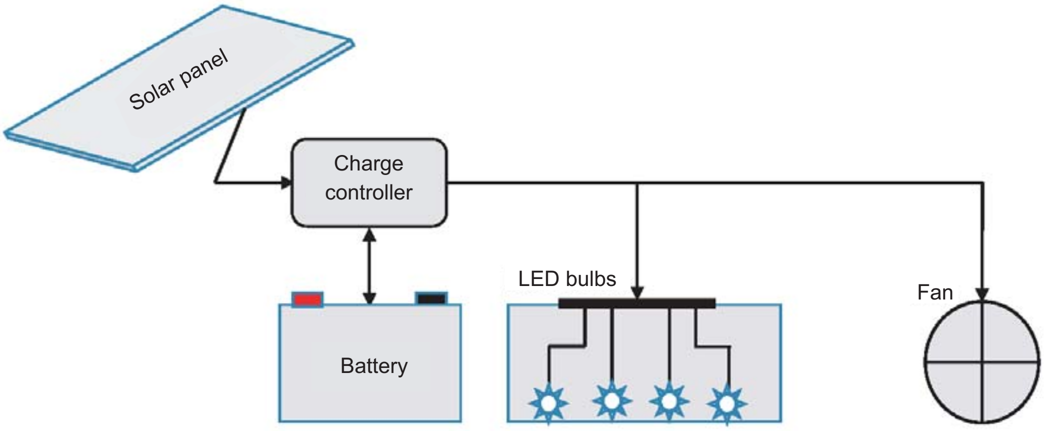
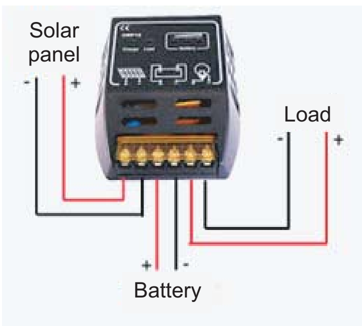


Fig. 2: Circuit diagram for solar powered system



Charge controller

DC ventilation fan

12V DC storage battery

LED bulb

Fig. 3: Accessories and measuring instrument required for conducting experiment

2.2. Calculation of electrical energy requirement for lighting and ventilation system

For knowing relationship between capacity of solar panel and electrical appliances used for poultry house, it is necessary to determine the total power requirement. Power requirement of lighting and ventilation through LED bulb and DC ventilation fan, respectively, was calculated using following Eqs.

Power required for lighting,

$$P_L = V \times I_L \tag{1}$$

where, P_L = power required for lighting (W), V = voltage (V) measured by voltmeter and I_L = amount of current across the LED bulb measured by ammeter (A).

Similarly power required for ventilation fan,

$$P_V = V \times I_V \tag{2}$$

where, P_V = power required for ventilation fan (W), V = voltage (V) measured by voltmeter and I_V = amount of current across the ventilation fan measured by ammeter (A).

Finally, total power required was calculated from (1) and (2)

$$P = V \times I \tag{3}$$

where, P = total power requirement (W), and$I$= (I_L+I_V) = total current measured by ammeter (A).

2.3. Measurement of air flow rate, irradiance and global irradiance

Air flow rate is important for properly removing waste and warm air from poultry house. In the experiment air velocity was measured using an anemometer and after that air flow rate was determined using Eq. 4 (Xin, 2009).

Air flow rate, $Q = R \times A$ (4)

where, Q = air flow rate (m^3/s), R = anemometer reading (m/s), and A = area of fan (m^2).

Irradiance is a measurement of solar power and is defined as the rate at which solar energy falls onto a surface. Solar irradiance is a term to measure the power per unit area, so irradiance is typically quoted as W/m² (Chowdhury *et al.*, 2012). Global irradiation or radiant exposure is the product of irradiance by the duration of irradiation. The phenomenon of irradiance and global irradiance is shown in Fig. 4 (Quaschning, 2011). Global irradiation is typically quoted by Wh/m^2 and is sum of the direct solar irradiance and diffuse solar irradiance. Total power loss due to reflection is equivalent to $(I_r - P_0)$, where Ir is solar irradiation and P_0 is power available from solar panel. Technical specifications of solarimeter and photosensor are presented in Table 1.

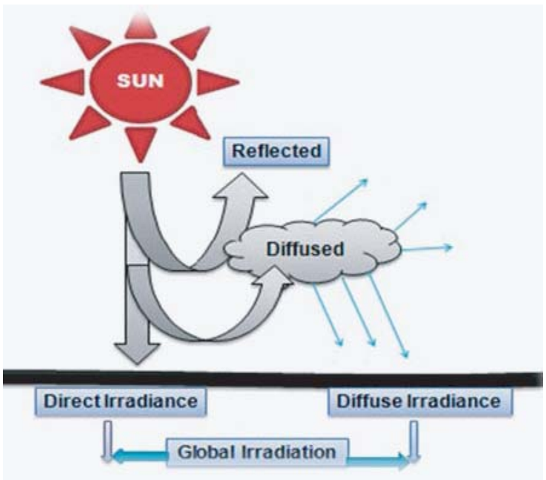


Fig. 4: Phenomenon of irradiance and global solar irradiance

2.4. Calculation of PV cell size and battery capacity

Solar panel should be selected on the basis of power requirement for operating LED bulb and ventilation fan. Solar panel with different capacities are available in the local market. Based on the power requirement farmers may select and collect it. Battery should be selected on the basis of backup time and load requirement. Generally battery capacity can be defined as amp-hr (Ah). Battery level 12V-100 Ah means that backup time 100 hrs when it is connected with 12V load and current across the load is 1 A (Hirok *et al.*, 2011). Battery capacity can be determined using Eq. 5.

Battery capacity, $BC = I \times T$ (5)

where, I = amount of current across the load (A) and T = backup time (hr).

Table 1: Technical specifications of solarimeter and photosensor

Instrument	Items	Specified range
Solarimeter Made in Japan Model: KC50	Solar irridiance measuring range Energetic exposure measuring range Operating temperature Power supply	1 W/m^2 to 1300 W/m^2 1 Wh/m^2 to 500 kWh/m^2 -10°C to +50°C 3 LR3-AAA batteries
Photosensor Made in France Model: KIMO	Nominal sensitivity Effective area Mode	100 mv for 1000W/m^2 1 cm^2 Photovoltaic
Solar panel Made in Japan Model: KC50	Capacity	30 W (1.5 m^2)
Battery	Capacity	12V-100 Ah

3. Results and Discussion

Poultry housing is most important factor for chicken farming. When planning poultry housing, it is necessary to keep in mind about proper ventilation and controlling indoor temperature. The chicken house should be made based on the local climate to control indoor environment.

The voltage drop and amount of current for operating the LED bulbs at different times in a day were measured. The required average power was also calculated. Average values of voltage drop and current of the measured data are presented in Table 2. Solar power supplied to LED bulbs increases from 10:00 am to 12:00 noon and then decreases and minimum power across the LED bulbs was found 0.18 W at 16:00 pm.

Proper flow and circulation of fresh air and removing waste gases and warm air are essential elements in any poultry house. A ventilation system should provide fresh oxygen-rich air for chicks, which maintain friendly environment for chicken. Improper ventilation will increase humidity and build up carbon dioxide and odor.

Average values of voltage drop and current of the measured data for ventilation fan are presented in Table 2. Maximum solar power was generated during 12~13 pm. Solar power supplied to DC fan increases from 10:00 am to 12:00 noon and then decreases and minimum power across the DC fan was found 2.97 W at 16:00 pm.

Depending on volume of space in a poultry house and climate conditions, air flow rate is another key factor for proper ventilation. Air flow rate of DC ventilation fan on the basis of power consumption with time in a day is presented in Table 2. Air flow rate increases from 10:00 am to 12:00 noon and then decreases and minimum was found 2.97 W at 16:00 pm.

Enegry produced by a solar panel depends on many factors like climate, geographical conditions, and local weather. Solar panel converts only a small percentage of the energy that strikes it into usable energy. One of the key characteristics of a solar cell is an ability to capture incident photons (Fan, 2014). The energy scenario in relation to irridiance and global irridiance at the experimental area is presented in Table 3. It is not possible to harvest available solar irradiation due to the reflection of radiation.

3.2. Energy requirements for particular poultry house

For sustainable commercial and environment friendly poultry house, one square meter floor space is required to live 12~14 chicks and it is possible to keep 4~5 weeks in the space (Xin, 2009). Air flow rate for ventilation should be 0.07 m^3/hr/chick, 0.32 m^3/hr/chick and 0.68 m^3/hr/chick for cold, mild and hot seasons, respectively (Xin, 2009). According to the above basis and floor space considered in the experiment, it would be possible to keep at least 108 [12 × 9] chicks in 9 m^2 floor area. According to

Table 2, average air flow rate of the ventilation fan was 5.45 m^3/min (327 m^3/hr). The ventilation fan with mentioned specification would be able to circulate fresh air in a 40 m^2 [(9 × 480)/108] poultry house for 480 [327/0.68] chicks during hot season. Based on the average power [5.59 W] required for the fan, 1.3 W [(5.59 × 9)/40] power would be required to ventilate fresh air for 9 m^2 poultry house. According to experimental conditions, total 10 bulbs with 30.2 W [3.02 W/bulb] power would be required for 108 chicks in 9 m^2 poultry house. It means that total 31.5 W [1.3 + 30.2] power will be required for both lighting and ventilation purposes of 9 m^2 poultry house. Power required for a 9 m^2 area with 108 chicks is shown in Table 4.

3.3. Selection of PV cell size and storage battery

Based on the power required for a 9 m^2 area with 108 chicks, a solar panel with 31.5 W capacity should be selected. For selecting battery, it is necessary to determine backup time of the battery. Considering a battery with 12V, 100 Ah specifications, the backup time of the battery will be approximately 38 hrs [100 ÷ (31.5/12)] for a 9 m^2 area with 108 chicks. During night and cloudy environment, the mentioned battery may provide 31.5 W power for 38 hrs approximately as a backup time.

Table 2: Average measured data of different parameters

Parameters	Day time						
	10	11	12	13	14	15	16
Average voltage drop across LED bulb (V)	10.50	10.75	11.10	10.80	10.50	9.57	7.59
Average amount of current across LED bulb (amp)	0.33	0.33	0.38	0.36	0.33	0.24	0.02
Average power across per LED bulb (W)	3.47	3.59	4.20	3.91	3.47	2.32	0.18
Average voltage drop across DC fan (V)	10.5	10.75	11.10	10.80	10.50	9.57	7.59
Average amount of current across DC fan (amp)	0.57	0.58	0.61	0.58	0.57	0.51	0.39
Average power across DC fan (W)	5.97	6.22	6.77	6.26	6.07	4.86	2.97
Total power from solar panel (W)	9.44	9.81	10.97	10.17	9.54	7.18	3.15
Air flow rate (m^3/min)	5.58	5.62	6.07	5.62	5.59	5.10	4.56

Table 3: Energy scenario at the experimental area

Data measured using solarimeter and photosensor			Calculated value
Average power available from solar panel/m^2, P_0 (W/m^2)	Average solar irradiation in study area, Ir (W/m^2)	Global irradiation in study area (Wh/m^2/min)	Power lost due to reflection, ($Ir – P_0$) (W/m^2)
26.73	848	14.2	821.27

Table 4. Power requirement for a 9 m^2 area with 108 chicks

No. of chicks	Area required (m^2)	Power required for lighting (W)	Power required for ventilation (W)	Total power (W)
108	9	30.2	1.3	31.5

4. Conclusions

Solar energy based system becomes popular day by day in the rural areas of Bangladesh. Electricity generation using solar energy is very simple. Sun ray is available everywhere in Bangladesh and it has high potentiality. It is possible to generate electricity using solar energy in everywhere. The maximum power was received from the solar panel from 12:00 to 13:00 pm every day. When solar irradiance was 848 W/m^2, output power of the solar panel was 26.73 W/m^2. For a 9 m^2 area with 108 chicks, 30.2 W and 1.3 W power would be required for lighting and ventilation, respectively. A 12 V, 100 Ah battery might be able to provide backup power for lighting and ventilation of a 9 m^2 area with108 chicks.

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