

# Solar Powered Lantern for Flood Affected Areas

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## ***Abstract***

*Lighting is an essential element of human civilization. It is quite difficult to provide electricity to people living in all the parts of the country due to economic and technical reasons. The situation usually worsens at the aftermath of natural calamities like flood, cyclone, etc. A solar powered lantern as a lighting system has been proposed in this paper, in an effort to minimize the sufferings of flood-affected people living in isolated parts of the country. The design and construction principle of this lantern is presented in the paper. It investigates the performance characteristics of the proposed lantern. The paper also presents the comparison of the proposed lantern with the conventional lighting system, hurricane lantern and candle, in terms of cost and performance.*

## **INTRODUCTION**

Bangladesh being a low-lying country is a flood prone area. Due to incessant shower in the rainy season or due to the effect of En-Nino and Tsunami, the country often experiences deluge during the rainy season and many areas become inundated under floodwater. The power supply in the flood-affected areas is also disrupted. An alternative source of electricity, thus, may be used for an isolated rural home in such conditions. The operation of the alternative source should be less sophisticated so that rural people can easily operate it.

Photovoltaic (PV) cells may be an alternative source for an isolated home lighting since it does not require a complicated technical system for operation. Moreover, its input is available at every place, as long as sunlight reaches there. As the people are becoming more concerned about environmental pollution, the researchers are putting renewed emphasis on the use of PV cells. Over the last two decades, researchers have developed a large number of techniques (Bishop, 1989; Molenbrock et al., 1991; Pellegrini, 1991) to improve the performance of PV cells. The investigation on the use of PV cells for the isolated energy sector is also getting increasing importance (Chakma et al., 1997; Alam et al., 1998).

This paper presents an application of PV cells for an isolated home lighting. It proposes a solar powered lantern to meet the lighting system of a house. The basic components of this type of lantern are: (i) charging controller, (ii) one rechargeable battery, (iii) low voltage protection circuit, (iv) an inverter and (v) compact fluorescent lamp (CFL). The inverter circuit is properly designed so that its output *ac* voltage is maintained at an appropriate level. To control the charging of the battery the output of the solar panel is fed to the battery through a control circuit.

This paper investigates the real life performance of the proposed lantern. Accordingly, it estimates the number of lanterns required for a standard rural home. The paper also presents a comparison between the proposed lantern and other alternatives, conventional hurricane lantern and candle, in terms of performance and cost.

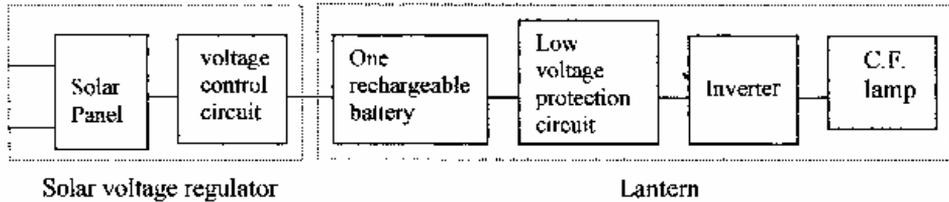
## **SOLAR POWERED LANTERN**

The source of energy of the proposed lantern is the electricity produced by a solar panel. The output illumination of this lantern is produced by its compact fluorescent lamp. The output of the solar panel is a *dc* voltage, while the required input for the lantern is *ac*. The energy from the panel is stored in a rechargeable battery. A voltage control circuit controls the charging of the battery. An inverter circuit is used to convert the *dc* voltage into *ac* and the *ac* voltage is fed as an input to the lantern. A low voltage protection circuit is incorporated to prevent the battery from deep discharging.

The rechargeable battery is placed inside the casing of the lantern such that it can be taken out of the casing for charging or can be placed inside the casing easily. The schematic of a solar powered lantern along with the solar voltage regulator is given in Fig. 1.

The locally available solar panels are mostly of two types: one having output voltage of 10V (6.5W) and the other 20V (10W and 43W). The commonly available rechargeable battery is of 6F and compact fluorescent lamp of 5W and

9W. Therefore, in a 10V panel a single battery may be charged while in a 20V panel two batteries may be charged simultaneously.



**Figure 1: Schematic of a solar powered lantern**

### **Construction**

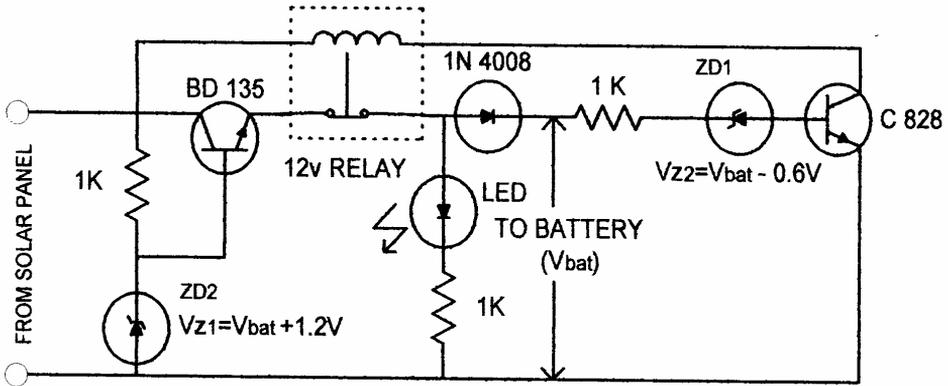
The principle that is followed in the construction of a solar powered lantern is that only those components are selected which are locally available. For the solar powered lantern only the voltage controller, low voltage protection circuit and inverter are designed and fabricated. In the following sections, the constructional details of voltage control circuit, low voltage protection circuit and inverter are presented.

### **Charging Controller**

Figure 2 presents the connection diagram of a voltage control circuit. The main function of this unit is to charge the battery at an appropriate voltage and to ensure that the charging is stopped as soon as the battery attains the required voltage. In Fig.2, the relay operates when zener diode (ZD2) starts conduction in the reverse direction. This situation occurs when each battery is charged with a pre-defined voltage,  $V_{bat}$ . The operation of the relay causes the disconnection of the battery from the supply source, the solar panel. That is, the charging process is stopped. The LED is incorporated in the circuit only to indicate the on/off mode of the charging process. The battery and the parallel branch containing LED get disconnected from the source simultaneously. That means when the LED is “off” the battery is not in the charging mode.

### **Low Voltage Protection Circuit**

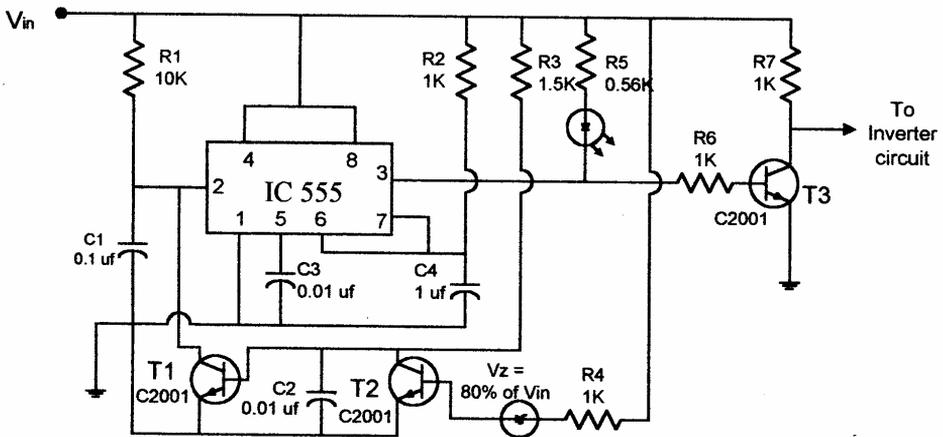
Figure 3 shows the connection diagram of a low voltage protection circuit. The main function of this unit is to monitor the battery voltage under loaded condition and to ensure that the discharging is stopped as soon as the battery voltage drops to a preset low voltage level and, thus, prevents the battery from deep discharging.



**Figure 2: Voltage control circuit**

The circuit shown in Fig. 3 consists of timer, switching device and low voltage sensor. IC 555 is an integrated circuit timer. Here IC 555 is connected in the monostable mode. When a negative pulse is applied to pin 2, the output goes high and terminal 7 removes a short circuit from capacitor C<sub>4</sub>. The output remains high for a time given by

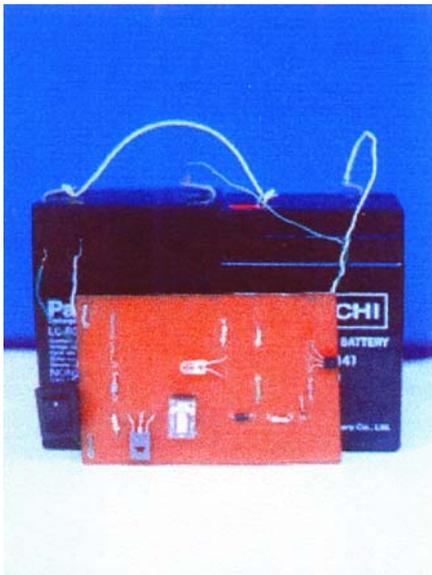
$$t_{\text{high}} = 1.1 R_2 C_4$$



**Figure 3: Low voltage protection circuit**

The high output in pin 3 is inverted by the transistor logic inverter comprising  $R_6$ ,  $R_7$  and  $T_3$ . The zener diode along with its series resistance forms the low voltage sensing part. The zener voltage is chosen in such a way that its zener breakdown voltage,  $V_z$  is equal to 80% of  $V_{in}$ , where  $V_{in}$  is the input voltage. If  $V_{in}$  is less than  $V_z$ , the transistor  $T_3$  remains off and  $T_1$  remains on; so trigger input pin 2 is shorted to ground. Thus total input voltage appears at terminal 3, which is logically inverted by transistor  $T_3$ . The corresponding low output at the collector terminal of transistor  $T_3$  isolates the externally connected inverter circuit from the battery and thus prevents battery from deep discharging.

The inverter circuit is a standard one. It converts 6.7-volt *dc* to 215-volt (Peak to peak) *ac*. The main components of an inverter are a transformer, a H1061 transistor and a capacitor. The transformer has a turns ratio of 18/ 300 (for 9W inverter) and 18/160 (for 5W inverter) with a 2:1 tapping in the primary. A view of control circuit, inverter circuit along with low voltage protection circuit and solar powered lantern used in experiments are given in Figs 4(a), 4(b) and 4(c), respectively.



**Figure 4(a): Control circuit**



**Figure 4(b): Inverter and low voltage protection circuit**

### **Performance Characteristic of a Solar Powered Lantern**

In this investigation, three different solar panels of rated output powers 43W, 10W and 6.5W have been considered. The particulars of these PV panels are

presented in Appendix (Table A1-A3). The daily output of the considered PV panels is measured. The output power, the open circuit voltage  $V_{oc}$  and the short circuit current  $I_{sc}$  of a typical sunny day for each of the panels are shown in Figs. 5(a), 5(b) and 5(c), respectively. In the region under study, the sky remains cloudy for a significant period of a year. To compare the output of a PV panel for a cloudy day the output parameters of a cloudy day are also shown in Fig. 5(a).

It is observed from Figs. 5(a), 5(b) and 5(c) that  $V_{oc}$  and  $I_{sc}$  increase as the sun goes up (from 6:30 am) and  $I_{sc}$  starts to decrease from 12:30 pm. and  $V_{oc}$  from 3:00 pm with the declining sun. The variation of  $V_{oc}$  from 9:30 a.m. to 4:30 pm is insignificant. The maximum output power and  $I_{sc}$  for a cloudy day have been found to be slightly less compared to those of a sunny day, as expected.



**Figure 4(c) Solar powered lantern**

### **Charging Characteristics of a Battery**

While using 43W panel or 10W panel, two rechargeable batteries of 6.7 volts were connected in series to the output bus of the solar voltage regulator to study the charging characteristic of the battery. On the other hand, for 6.5W panel one single battery has been used. The increase in the battery voltages along with charging current and power with time for different panels is presented in Tables 1(a), 1(b) and 1(c). Table 1(a) presents the gain of the battery voltages for both cloudy and a sunny day. The power consumed by the two batteries, the corresponding short-circuit current  $I_{sc}$ , battery current and the pane output power with time are shown in Figs. 6(a) 6(b) and 6(c).

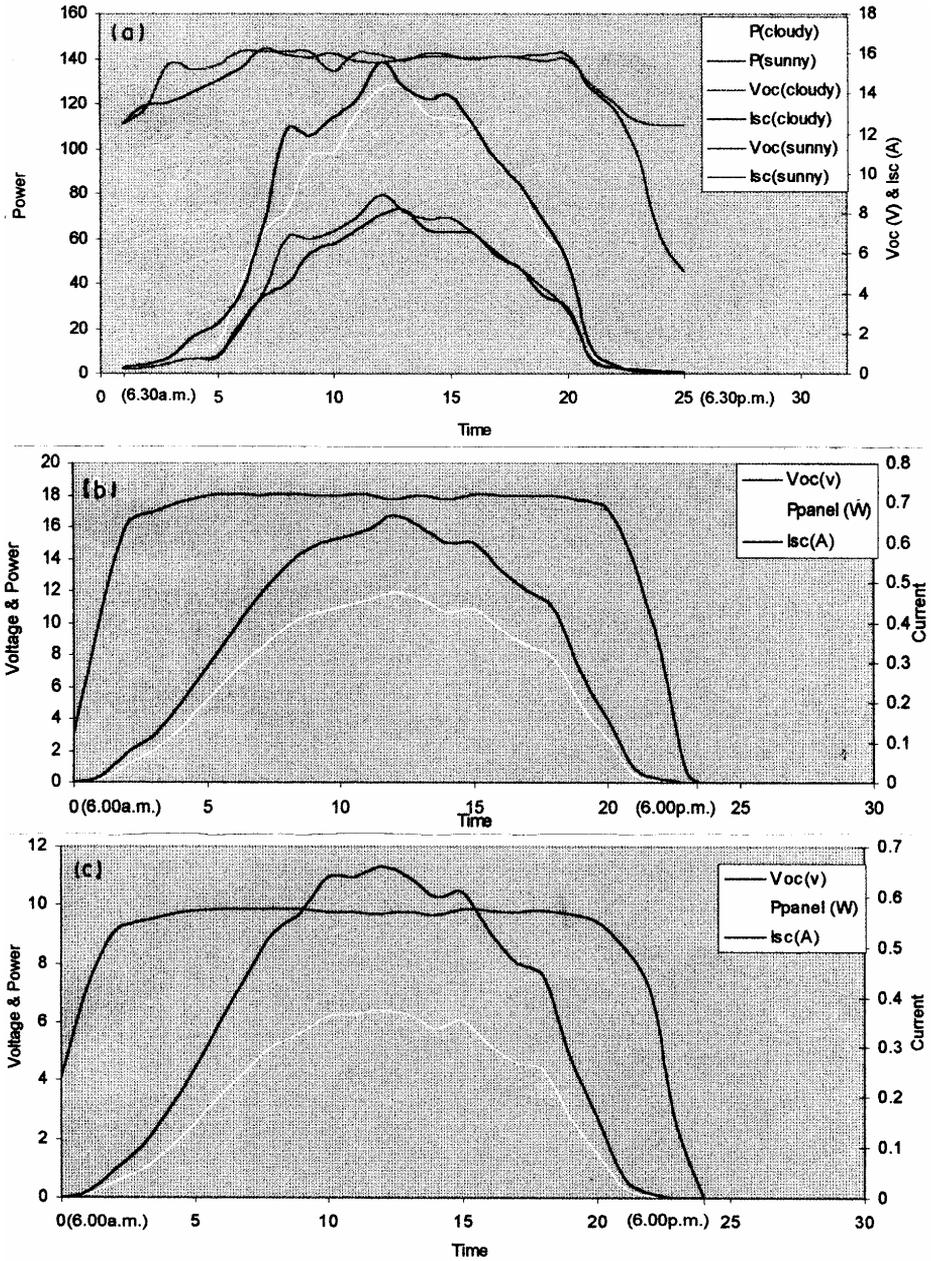
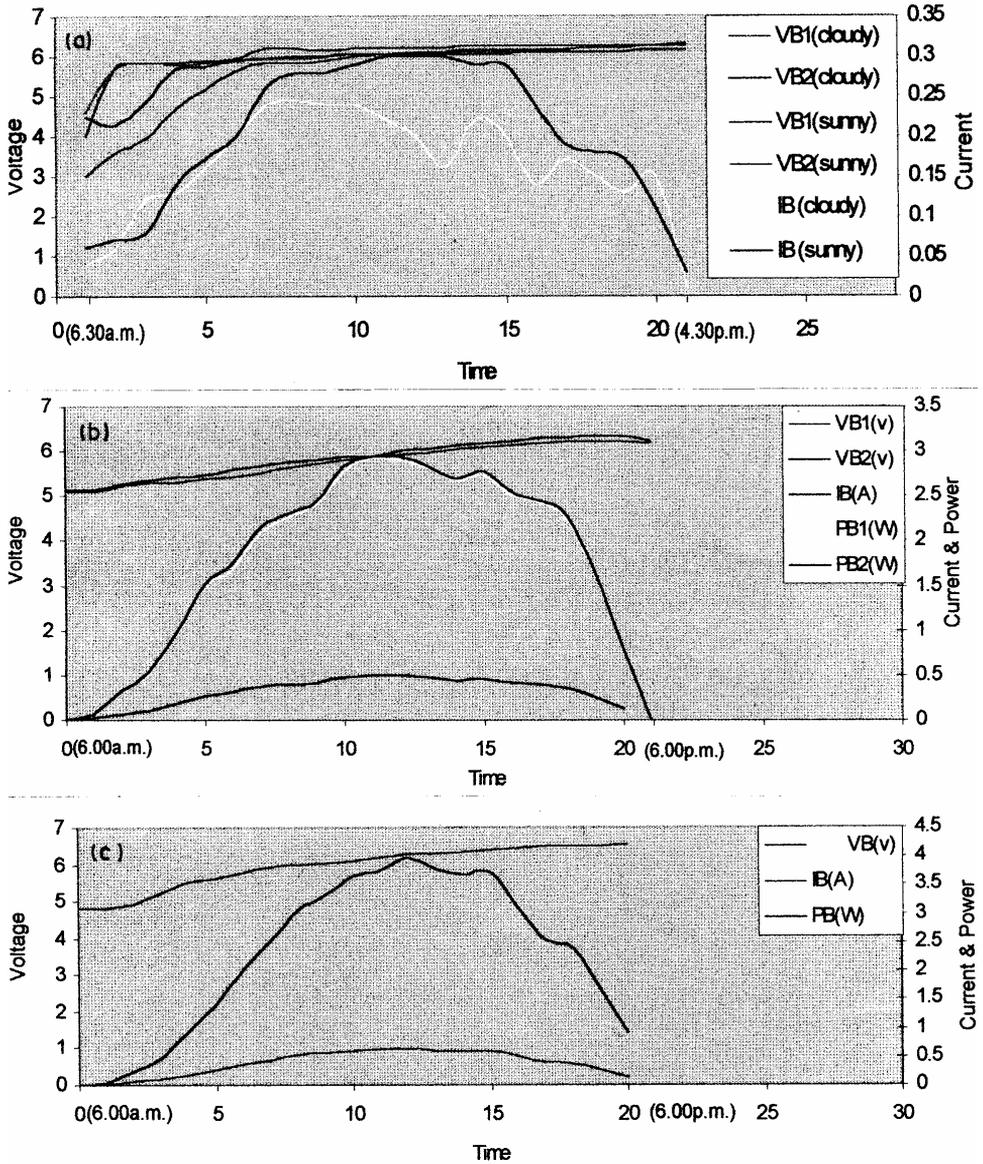


Figure 5: Output characteristics of (a) 43W panel, (b) 10W panel, and (c) 6.5W panel



**Figure 6: Charging characteristics of battery connected to (a) 43W panel, (b) 10W panel, and (c) 6.5W panel**

**Table 1(a): Development of charges in a battery connected to a 43W panel**

Time	In a Cloudy day			In a Sunny day		
	Battery voltage (volt)		Total battery current (amp)	Battery voltage (volt)		Total battery current (amp)
	No. 1	No. 2		No. 1	No. 2	
06:30 am	4.57	4.50	0.04	3.98	3.02	0.06
07:00 am	5.70	4.25	0.06	5.67	3.59	0.07
07:30 am	5.85	4.86	0.12	5.83	3.93	0.08
08:00 am	5.79	5.69	0.13	5.84	4.69	0.14
08:30 am	5.85	5.75	0.16	5.89	5.14	0.17
09:00 am	5.90	5.89	0.20	5.93	5.65	0.20
09:30 am	5.93	5.94	0.24	6.19	5.85	0.26
10:00 am	5.97	5.98	0.24	6.20	5.86	0.28
10:30 am	6.01	6.00	0.24	6.18	5.92	0.28
11:00 am	6.04	6.03	0.24	6.19	5.98	0.29
11:30 am	6.04	6.03	0.22	6.21	6.05	0.30
12:00 am	6.05	6.03	0.20	6.23	6.09	0.30
12:30 pm	6.06	6.04	0.16	6.23	6.12	0.30
01:00 pm	6.08	6.07	0.22	6.24	6.14	0.29
01:30 pm	6.09	6.07	0.20	6.25	6.15	0.29
02:00 pm	6.09	6.08	0.14	6.26	6.16	0.24
02:30 pm	6.11	6.10	0.17	6.27	6.18	0.19
03:00 pm	6.11	6.11	0.15	6.27	6.21	0.18
03:30 pm	6.13	6.13	0.13	6.27	6.23	0.17
04:00 pm	6.15	6.15	0.15	6.27	6.25	0.11
04:30 pm	6.15	6.15	0.01	6.34	6.25	0.03

Table 1(a) and Fig. 6(a) show that 43W solar panel requires about nine and a half-hour to charge a battery in a cloudy day. Table 1(c) and Fig. 6(c) show that 6.5W panel can successfully charge a single battery in a day, while 10W panel cannot charge two batteries in a day, which is evident from Table 1(b) and Fig. 6(b). Figure 6(a) shows that a battery attains the similar voltage in a sunny day in three to seven hours depending on the initial charge of the battery. It is observed from Fig.6 that the panel output power is much higher than the power consumed by the battery. This conclusion is further intensified by the following analysis based on energy consideration.

**Table 1(b): Development of charges in a battery connected to a 10W panel**

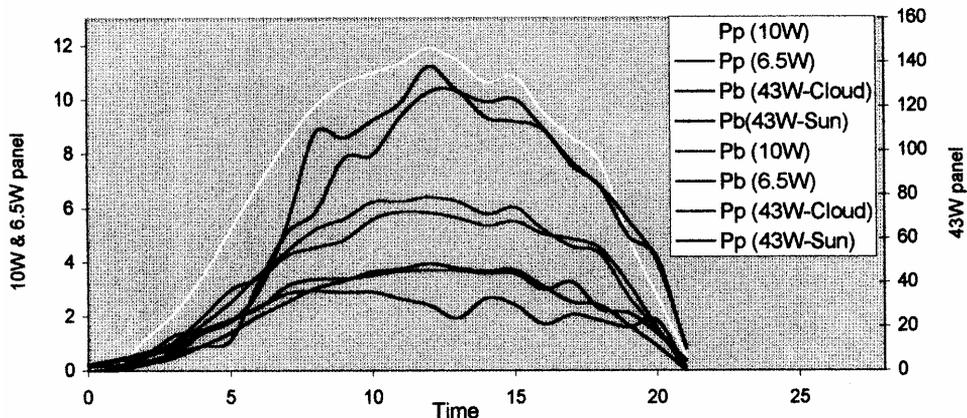
Time	$V_{B1}(V)$	$V_{B2}(V)$	$I_B(A)$	$P_{B1}(W)$	$P_{B2}(W)$
06:00 am	5.1	5.14	0.000	0.0000	0.0000
06:30 am	5.1	5.14	0.012	0.0612	0.0617
07:00 am	5.2	5.25	0.063	0.3276	0.3308
07:30 am	5.29	5.36	0.099	0.5237	0.5306
08:00 am	5.32	5.41	0.183	0.9740	0.9900
08:30 am	5.39	5.48	0.275	1.4823	1.5070
09:00 am	5.43	5.60	0.310	1.6833	1.7360
09:30 am	5.51	5.69	0.380	2.0938	2.1622
10:00 am	5.63	5.76	0.400	2.2520	2.3040
10:30 am	5.71	5.80	0.420	2.3982	2.4360
11:00 am	5.78	5.89	0.480	2.7744	2.8272
11:30 am	5.84	5.90	0.500	2.9200	2.9500
12:00 am	5.91	5.99	0.490	2.8959	2.9351
12:30 pm	5.98	6.05	0.470	2.8106	2.8435
01:00 pm	6.06	6.12	0.440	2.6660	2.6928
01:30 pm	6.09	6.16	0.450	2.7405	2.7720
02:00 pm	6.13	6.21	0.410	2.5133	2.5461
02:30 pm	6.19	6.28	0.390	2.4141	2.4492
03:00 pm	6.22	6.31	0.360	2.2392	2.2716
03:30 pm	6.22	6.32	0.255	1.5861	1.6116
04:00 pm	6.23	6.33	0.125	0.7788	0.7913
04:30 pm	6.16	6.20	0	0	0

**Table 1(c): Development of charges in a battery connected to a 6.5W panel**

Time	$V_B(V)$	$I_B(A)$	$P_B(W)$	Time	$V_B(V)$	$I_B(A)$	$P_B(W)$
06:00 am	4.80	0.000	0.0000	11:30 am	6.16	0.610	3.7576
06:30 am	4.80	0.004	0.0192	12:00 am	6.29	0.630	3.9627
07:00 am	4.90	0.050	0.2450	12:30 pm	6.30	0.600	3.7800
07:30 am	5.20	0.0910	0.4732	01:00 pm	6.36	0.580	3.6900
08:00 am	5.50	0.169	0.9295	01:30 pm	6.41	0.580	3.7178
08:30 am	5.62	0.249	1.3993	02:00 pm	6.44	0.480	3.0912
09:00 am	5.79	0.350	2.0265	02:30 pm	6.48	0.390	2.5272
09:30 am	5.91	0.430	2.5413	03:00 pm	6.51	0.370	2.4087
10:00 am	5.98	0.510	3.0498	03:30 pm	6.51	0.2550	1.6600
10:30 am	6.03	0.550	3.3165	04:00 pm	6.52	0.140	0.9128
11:00 am	6.08	0.600	3.6480	04:30 pm	--	--	--

### Comparison of Panel Output Power and Charging Performance

For crucial comparison of the panels, the output power and charging performance of the panels have been considered. The schematic view of the comparison is shown in Fig.7. The area under each curve i.e., the total energy delivered by solar panels or consumed by batteries, as found by trapezoidal rule, is tabulated in Table 2.



**Figure 7: Comparison of panel output power and charging characteristics**

**Table 2: Power delivered by panels and power consumed by batteries**

Energy delivered by panels (Watt-hr)				Energy consumed by battery (Watt-hr)			
43 W Panel		10W Panel	6.5 W Panel	43 W Panel		10W Panel	6.5 W Panel
Cloudy	Sunny			Cloudy	Sunny		
1412	1531	149	80	41	52	77	47

From Table 2 it can be estimated that a 43W panel can charge a thirty sets of two batteries simultaneously. However, from realistic point of view a conservative calculation may be adopted which allows twenty sets of batteries to be charged by a 43W panel. That is, in a day a 43W solar panel may be used to charge 40 batteries on an average and these 40 batteries can energize 40 solar powered lanterns, one battery for a lantern. It has been found that one 10W panel cannot charge one set of two batteries simultaneously in a day, but one 6.5W panel can charge a single battery in a day.

### Illumination Produced by a Solar Powered Lantern

One single rechargeable battery is the design requirement of the proposed lantern for both 9W lamp and 5W lamp. The battery is placed inside the lantern. The illumination produced by the lantern is measured at different distances from the lantern. The performance of both the lamps has been investigated in order to find out the efficient output voltage of the inverter circuit for each lamp. The variation of illumination level with different battery voltage at different distance from the lantern is presented in Tables 3 and 4. The graphical presentations are shown in Figs. 8 and 9. To determine the duration of acceptable light intensity the variation of lux with time and at a distance of 3 feet is tabulated in Table 5.

**Table 3: Illumination produced by a 9W solar powered lantern at different distances**

Voltage →	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5
Distance (ft) ↓	v	v	v	v	v	v	v	v	v	v	v	v
1	230	320	280	260	260	240	220	200	180	150	110	80
2	60	100	90	90	90	80	80	50	40	35	26	19
3	45	58	55	50	48	43	40	30	22	18	13	10
4	32	40	41	38	36	30	28	25	18	15	11	8
5	24	28	26	25	24	22	20	18	17	14	8	7
6	19	20	20	18	19	18	17	16	15	12	7	6
7	13	13	12	13	13	12	11	10	10	8	6	5
8	11	12	12	12	12	11	9	8	8	7	5	5
9	8	9	8	8	9	8	8	6	7	6	5	5
10	7	7	7	6	7	6	7	5	5	5	5	5
11	6	6	5	5	5	6	6	5	5	5	5	5

It is observed from Tables 3, 4 and 5 and Figs.8 and 9 that near the lantern it is possible to conduct all activities of the house for up to four and half-hours. The standard illumination required for different places of a residential house is presented in Appendix (Table A4). All activities including reading of a hand written material is possible up to 3 hours after switching the lantern at a distance of 5ft from the lantern. It has been observed that clear visibility exists for up to four and half hours in all places of a room of 5.4 x 5.4 meters if the lantern is placed at the center of the room.

### Estimation of Number of Lanterns

The study considers that a typical rural home usually consists of two bedrooms, one kitchen, one courtyard and a bathroom, located a little away from the house.

The activities of the rural people continue up to three to four hours after the sunset. The study period of the children is usually two to three hours in the evening. Therefore, two lanterns may be required for two bedrooms, one for the courtyard and one for the kitchen/bathroom. That is, a maximum of four lanterns may be required simultaneously in a house. However, a conservative plan may reduce the requirement to one lantern during flood.

**Table 4: Illumination produced by a 5W solar powered lantern at different distances**

<b>Voltage →</b>	<b>6.0</b>	<b>5.5</b>	<b>5.0</b>	<b>4.5</b>	<b>4.3</b>	<b>4.0</b>	<b>3.5</b>	<b>3.0</b>	<b>2.5</b>	<b>2.0</b>	<b>1.5</b>	<b>1.0</b>
<b>Distance (ft) ↓</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>	<b>v</b>
1	Light turns on but not stable	80	80	88	170	150	150	148	130	111	82	50
2		28	25	28	55	54	53	54	48	37	30	20
3		17	18	18	28	24	25	23	19	19	17	12
4		11	12	13	18	16	16	17	15	14	12	9
5		11	11	11	14	11	12	12	10	11	11	8
6		10	10	9	11	10	9	10	8	9	10	6
7		8	7	6	8	9	8	8	7	8	9	6
8		6	5	4	7	7	7	7	6	6	8	5
9		4	4	4	6	6	6	6	5	6	6	4
10		4	4	4	6	5	5	6	5	5	6	4
11		4	4	4	4	4	4	4	5	4	4	4

**Table 5: Variation of lux with time and distance**

<b>Time</b>	<b>Solar powered lantern (9W)</b>		<b>Solar powered lantern (5W)</b>	
	<b>Battery voltage (v)</b>	<b>Lux</b>	<b>Battery voltage (v)</b>	<b>Lux</b>
0.00	7.00	45	7.00	18
0.30	6.80	49	6.85	18
1.00	6.45	57	6.60	28
1.30	6.20	56	6.40	24
2.00	5.85	52	6.01	25
2.30	5.55	50	5.75	23
3.00	5.09	48	5.43	19
3.30	4.43	42	5.07	19
4.00	4.21	41	4.78	17
4.30	4.16	40	4.53	12

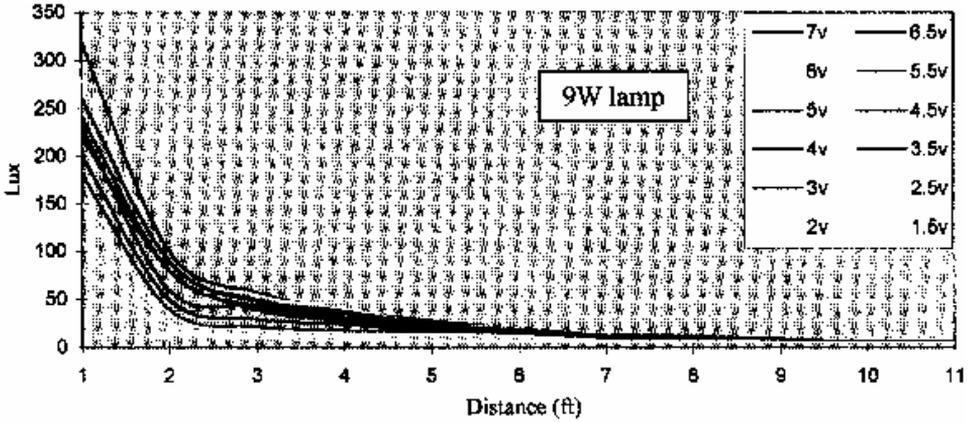


Figure 8: Variation of illumination level for different battery voltage at different distances (9W lamp)

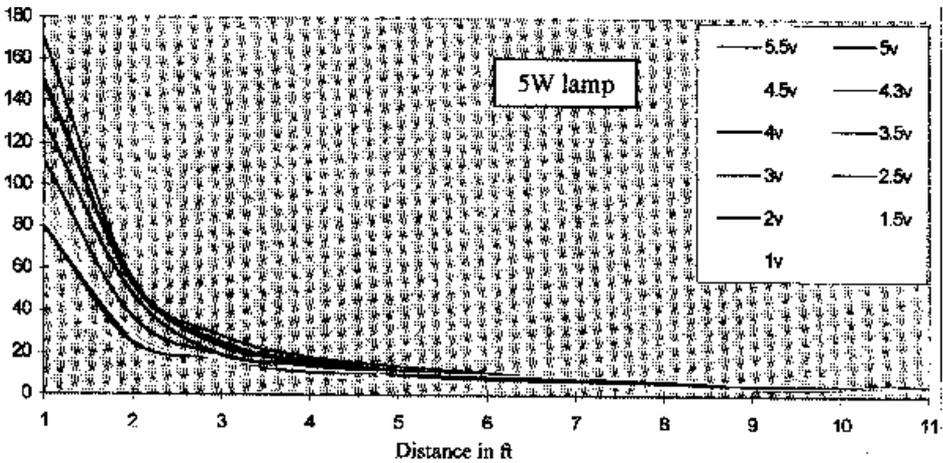


Figure 9: Variation of illumination level for different battery voltage at different distances (5W lamp)

**Estimation of Number of Lanterns**

The study considers that a typical rural home usually consists of two bedrooms, one kitchen, one courtyard and a bathroom, located a little away from the house. The activities of the rural people continue up to three to four hours after the sunset. The study period of the children is usually two to three hours in the

evening. Therefore, two lanterns may be required for two bedrooms, one for the courtyard and one for the kitchen/bathroom. That is, a maximum of four lanterns may be required simultaneously in a house. However, a conservative plan may reduce the requirement to one lantern during flood.

**Cost of a Solar Powered Lantern**

The cost and life of each unit of a solar powered lantern along with the solar voltage regulator are presented in Table 6. The cost of a solar powered lantern is evaluated by considering a 10% interest. In this evaluation, it is also considered that a 43W solar panel is capable of charging forty batteries in a day, 10W panel charges two batteries and 6.5W panel charges one battery in a day. Considering the appropriate present worth factor, the annual repayment cost of each unit of a solar powered lantern is evaluated and is presented in Table 7.

**Table 6: Price and life of different units of a solar powered lantern scheme**

Description of Unit	Total cost in Taka	Life in years
PV Panel	1,700.00 (6.5W Panel) 7,800.00 (10W Panel) 18,700.00 (43W Panel)	20
Voltage Control Unit	135.00	20
Low Voltage Protection Circuit	51.00	20
Inverter	58.00	20
Casing	100.00	20
Rechargeable Battery	310.00	2
Compact Fluorescent Lamp	120.00	10

**Table 7: Annual repayment cost of each unit of a solar powered lantern**

Unit	Annual Repayment Cost in Tk.		
	43W Panel	10W Panel	6.5W Panel
Solar Panel	54.91	458.00	199.68
Battery	178.62	178.62	178.62
Lamp	19.53	19.53	19.53
Voltage Control Circuit and Low Voltage Protection Circuit	21.58	21.58	21.58
Inverter and Casing	18.56	18.56	18.56
<b>Total</b>	293.20	696.29	437.97

## CONVENTIONAL SOURCES OF LIGHTING IN A RURAL HOME

The conventional sources of lighting in a rural home are usually two types: (i) Hurricane lantern and (ii) Candle. The photographic view of Hurricane lantern and Candle used in our experiment are shown in Figs. 10 and 11, respectively. The hurricane lantern is made of steel. It has a reservoir/tank for fuel. The usual fuel is kerosene. The flame is produced by firing a cotton feather, which absorbs kerosene from the fuel tank. A tubular glass covers the flame.

A candle is made of wax. It comes in different sizes. For this study a candle of 24.5 cm height and 4.8 cm diameter is considered. It provides light for 20 hours for its complete burn. The illumination produced by a hurricane lantern with low and high flame and a candle has been compared with that of the solar powered lantern in Table 8. This table gives the illumination level at different distances from the source.



**Figure 10: Hurricane-lantern**



**Figure 11: Candle**

In evaluating the cost of a hurricane lantern, it is considered that its life is 5 years and price is Tk. 100. The consumption of kerosene by a hurricane per hour is 41 ml and the price of kerosene per liter is Tk 18.00. It is also considered that hurricane lantern is used for 4 hours per day for illumination. Therefore, the annual repayment cost of a hurricane lantern including the fuel is Tk. 1121.38. The cost of a candle is also evaluated. Considering 4 hours of illumination in each day the annual expenditure becomes Tk.2190.00.

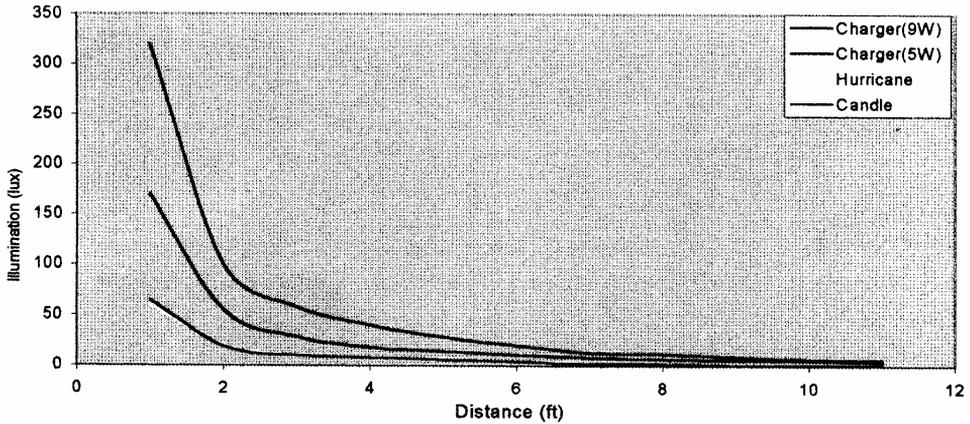
**Table 8: Illumination produced by a hurricane lantern and a candle at different distances**

Distance (ft.)	Light Intensity (Lux)				
	Hurricane Lantern (Low flame)	Hurricane Lantern (High flame)	Candle	Solar Powered Lantern	
				9W	5W
1	55	60	65	320	170
2	17	20	19	100	55
3	9	11	10	58	28
4	8	9	8	40	18
5	5	7	6	28	14
6	3	5	4	20	11
7	2	3	2	13	8
8	2	2	2	12	7
9	1	2	1	9	6
10	1	1	1	7	6
11	1	1	1	6	4

**COMPARISON OF SOLAR POWERED LANTERN WITH THE CONVENTIONAL SOURCES**

The variation of illumination with distance of a solar powered lantern is compared with those of conventional sources in Fig. 12. It is clearly observed that the solar powered lantern produces higher illumination level at all distances.

From Table 8 the average illumination level of each source may be evaluated. The average illumination of solar powered lantern (9W and 5W), hurricane lantern and a candle are 55.73, 29.73, 11 and 10.82 lux, respectively. Note that the average illumination of a hurricane lantern with the low flame is 9.45 lux. Therefore, a 9W solar powered lantern is equivalent to two 5W solar-powered lanterns, 5 hurricane lanterns and 5 candles, as far as brightness is concerned. Considering this illumination equivalence the annual cost of the illumination of an isolated rural home by a solar powered lantern is compared with those by the conventional sources in Table 9. It is clearly observed from Table 9 that a solar powered lantern is much cheaper than the conventional sources. Moreover, it produces a higher illumination than a conventional source. Also it is hazard free from the operational point of view.



**Figure 12: Comparison of the illumination level of solar powered lantern, hurricane lantern and candle**

**Table 9: Comparison of illumination cost of a rural home with different types of sources**

Sources		Annual Expenditure (Tk.)
9W Solar Powdered Lantern	With 43W Panel	879.60
	With 10W Panel	2088.87
	With 6.5W Panel	1313.91
5W Solar Powdered Lantern	With 43W Panel	1759.20
	With 10W Panel	4177.74
	With 6.5W Panel	2627.82
Hurricane lantern		16820.71
Candle		32850.00

## CONCLUSIONS

This paper proposes the use of solar powered lantern for the lighting system of an isolated flood affected home. It presents the design, construction and the performance characteristics of a solar powered lantern. The lantern is much cheaper than the conventional sources of illumination. Moreover, it produces higher illumination without any operational hazard.

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## APPENDIX

**Table A1: Description of 43W PV panel**

Manufacturing company: Arco Solar Inc. Model: M65 Solar Irradiants and Cell Temperature as indicated Made in USA Rated Power at 20°C = 43W Maximum amp at 47°C(sc) = 3.68 A Maximum volts at 0°C = 20 V dc Size: 48 x 42 sq. in.
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**Table A2: Description of 10W PV panel**

Manufacturing company: Webel Solar Model: SQR49L Solar Irradiants and Cell Temperature as indicated Made in India Rated Power at 20°C = 10W Maximum amp at 47°C(sc) = 1.23 A Maximum volts at 0°C = 20 V dc Size: 15 x 14.75 sq. in.
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**Table A3: Description of 6.5W PV panel**

Manufacturing company: Siemens Model: GL418TF Solar Irradiants and Cell Temperature as indicated Made in Japan Rated Power at 20°C = 6.5W Maximum amp at 47°C(sc) = 1.5 A Maximum volts at 0°C = 10 V dc Size: 12 x 9 sq. in.
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**Table A4: Standard Illumination (Kaufman and Haynes, 1981)**

Sites	Standard Illumination (Lumen/m <sup>2</sup> )
Living room/dining room/hall	2.0
Kitchen/laundry	3.0
Bathroom/toilet	3.0
Corridors	1.0 – 1.5
Working sites	5.0
Hand writing places	7.5