PKL Backup LED Bulb—An Alternative Source of Electricity During Load Shading

K. A. Khan, Shahinul Islam, Salman Rahman Rasel, M. A. Saime, Syful Islam, and M. Hazrat Ali

1 Introduction

Energy sources are divided into two parts: Renewable energy sources and Non-renewable energy sources [1, 2]. Oil, gas and coal are the non-renewable energy sources [3, 4]. It is not an unlimited source. It will be finished within 2100. Then after that, what will happen, actually nobody knows. That is why it is very much necessary to conduct research on renewable energy sources [5, 6]. A renewable energy source is a type of source which is not limited. It can be used again and again and will never run out. Examples of renewable energy sources are solar energy, wind energy, biogas energy, biomass energy, geothermal energy, water energy, tidal energy, wave energy and OTEC [7, 8]. Now, we should increase the use of renewable energy resources for practical utilizations. To keep it in mind, research has been conducted on biomass energy [9]. The PKL power is part of biomass energy. We have conducted research on PKL electricity for many years through an extract base. But this research work is different from that process. In this research paper, living and fresh PKL backup LED bulb has been used. research has been conducted for power production from PKL

K. A. Khan (✉)
Department of Physics, Jagannath University, Dhaka 1100, Bangladesh

S. Islam
Department of Physics, Uttara University, Dhaka, Bangladesh

S. R. Rasel
Local Government Engineering Department (LGED), Fulbaria, Mymensing, Bangladesh

M. A. Saime
Dinajpur Polytechnic Institute, Dinajpur, Bangladesh

S. Islam
Government Louhajang University College, Louhajang, Munshigonj, Bangladesh

M. H. Ali
European University of Bangladesh (EUB), Dhaka, Bangladesh

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leaf directly in 3 different forms like PKL extract, living PKL and fresh PKL [10]. During load shading, this PKL backup LED bulb can help people both in urban and rural areas. Some similar research works have been done entitled "Development of cells for generation of potential difference from Aloe Vera" by Wajire and Gandole [11]. Similar works have also been done by the Massachusetts Institute of Technology (MIT) and University of Washington (UW), USA. They have found that it is possible to generate 250 mV when the electrodes are placed between two points in a tree. They have also found that if one electrode is placed in a living plant and other is placed into the soil, then electricity is produced [12]. Furthermore, previously we got 1.1 V for Zn/Cu single pair electrodes using PKL extract, whereas we got 1.00 V for Zn/Cu single pair electrodes using living PKL and 0.9 V for Zn/Cu single pair electrodes using fresh PKL. These are alternative sources of energy. Scientists are assuming that global climate change will not be controlled artificially. It needs to stop burning natural different renewable energy sources like biomass energy. If we start electricity generation from living trees or plants, then everyone wants to be plant in one's surroundings. Our Governments are motivated to the people such a process of plantation of trees and plants. As a result, a number of different trees are increasing in our countries [13]. This type of plantation will help to save our planet indirectly from the dangerous issue of global warming. This plant and tree energy is improbable to replace the power sources for most applications. Furthermore, After R&D, this type of energy could be of low cost, environmentally friendly, pollution-free and a natural option of the electricity or power source [14]. These research outputs may be the guid line for different practical utilizations in near future.

2 Materials and Method

2.1 Working Principle of PKL Backup LED Bulb

(i) **Electroluminescence:**

When electricity passes through the diode, the diode emits photons and finally creates light through the principle of electroluminescence. The mechanism of electroluminescence is the recombination of electron-hole pairs due to the flow of Electricity through the diode. The emission of light (in the form of photons) is the Output of the release of energy due to excited electrons. There is an adaptor in the Electronic circuit, and it converts alternating current (AC) to direct current (DC). The Diode gets DC by a bridge rectifier from the grid or from the PKL electricity produced by PKL extract-based source and emits photons and finally light is produced. In the unelectrified areas, an inverter is needed (DC to AC converter for proving AC Electricity to the PKL backup LED bulb). But during load shading, PKL backup LED bulb did not get grid electricity. Then the PKL extract-based electricity with an Inverter can be the alternative for grid electricity. At that moment to face the load shading, fresh PKL and living PKL can back up the LED bulb instantly.

(ii) **Chemiluminescence:**

As a chemical reaction, emission of light which is called Chemiluminescence occurs. Some emission of heat in a limited manner also occurs.

Principle of Chemiluminescence:

Due to a chemical reaction, electromagnetic radiation is generated as light by the release of energy. The light can be emitted into 3 parts: ultraviolet, infrared and visible light. Among them, visible light is most common. Let us consider the two reactants A and B, with an excited intermediate φ, then the chemical reaction of the Chemiluminescence is $[A] + [B] \rightarrow [\varphi] \rightarrow [\text{Products}] + \text{light}$.

(iii) **Principle of Bioluminescence:**

The production and emission of light by a living organism is called bioluminescence (Fig. 1). It is nothing but one of the forms of chemiluminescence. It occurs through a chemical reaction that produces light energy within an organism's body. For any reaction to happen, a species must contain a molecule named luciferin, which reacts with oxygen and produces light. Many organisms also produce luciferase which works as a catalyst to speed up the reaction.

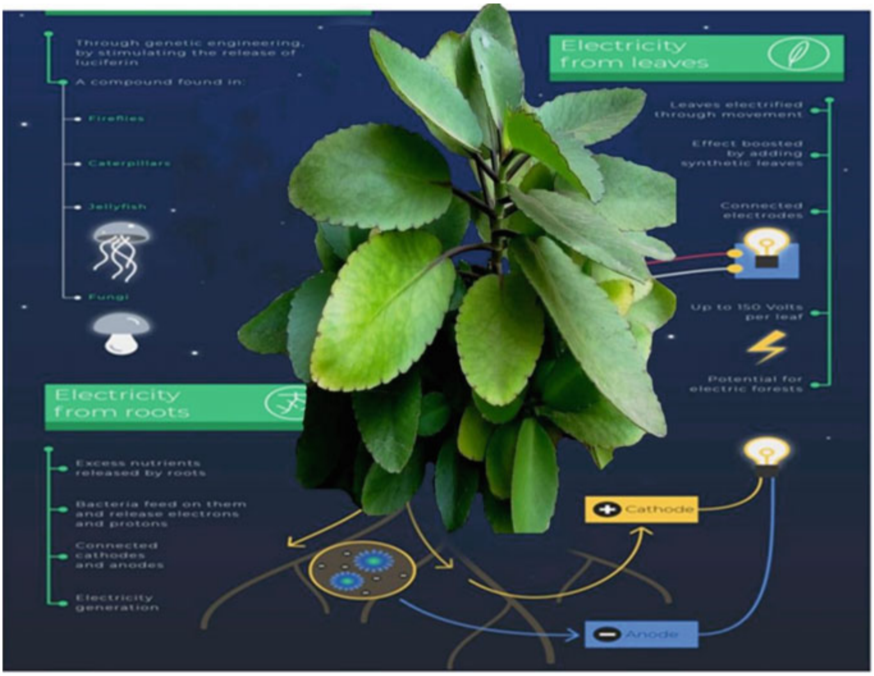


Fig.1 Methods of production and emission of light by a living organism

2.2 Types of Luminescence and Their Energy Sources

Luminescence is nothing but the emission of light by electromagnetic waves of a substance which does not arise from heating. Luminescence is divided into 7 parts:

(1) Photoluminescence (absorption of photons) → Fluorescence and Phosphorescence.
(2) Cathodoluminescence (bombardment by electrons).
(3) Chemiluminescence (initiated by chemical reactions) → Bioluminescence, Electroluminescence, Candoluminescence and Lyoluminescence.
(4) Electroluminescence (applied by electric field).
(5) Mechanoluminescence (through mechanical action) → Tryboluminescence, Fractoluminescence, Plazoluminescence and Sonoluminescence.
(6) Radioluminescence (bombardment by ionizing radiation).
(7) Thermoluminescence (activated by heating).

2.3 Materials for PKL Backup LED Bulb

The required materials are (i) Fresh PKL, (ii) Living PKL, (iii) PKL extract, (iv) An electronic circuit inside the LED bulb, (v) A small storage battery inside the LED bulb, (vi) A small charge controller inside the LED bulb, (vii) A small Printed Circuit Board (PCB) inside the LED bulb, (viii) Inverter, (ix) Bridge rectifier, (x) Transformer and (xi) Lux meter.

1st Step: An electronic circuit is designed and fabricated inside the LED bulb where there is a small storage battery, a small charge controller, and a small Printed Circuit Board (PCB).

2nd Step: A PKL battery and an inverter are taken to light a 20 W LED bulb. Then the LED bulb is used for 1 h.

3rd Step: Then the LED bulb is set up under short-circuit condition by a fresh and living PKL. The time duration is collected by a stopwatch.

It is shown from Fig. 2 that the LED bulb lights up with short-circuit condition by a single fresh Pathor Kuchi Leaf (PKL). The LED bulb is connected with one single fresh leaf only. The intensity is measured by a lux meter.

It is shown from Fig. 3 that the LED bulb lights up with short-circuit condition by a single garden living Pathor Kuchi Leaf (PKL). The LED bulb is attached with

(a) (b)

Fig. 2 Experimental setup for 20 W PKL backup LED bulb with a single fresh Pathor Kuchi Leaf

(a) (b) (c) (d)

Fig. 3 PKL backup LED bulb lights with short-circuit condition by a garden living Pathor Kuchi Leaf (PKL)

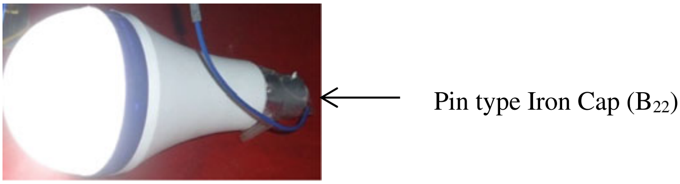


Fig. 4 LED bulb lights with self-short-circuit condition

only one single living leaf from a living PKL tree. The intensity was measured by a Lux meter.

It is shown from Fig. 4 that the battery LED bulb lights up with a self-short-circuit condition without any fresh or living Pathor Kuchi Leaf (PKL). The intensity was measured by a Lux meter.

The data of the intensity of light was collected by a Lux meter (shown in Fig. 11) with time duration. With the help of this data a curve for the variation of Intensity has been drawn with time duration without the 20 W PKL backup LED bulb.

Ag Nanoparticles (NPs) have been synthesized and characterized for monitoring of power production. Figure 5 shows that firstly the voltage was collected from living PKL using Zn/Cu electrodes without Ag NPs and secondly the voltage was collected from living PKL using Zn/Cu electrodes with Ag NPs. The Ag NPs were in liquid form.

Figure 12 shows the data for voltage collection using the living PKL tree and the effect of Ag NPs. The voltages were measured by a calibrated multimeter. The time duration for data collection was 100 min.

2.4 Block Diagram for Charging and Discharging of the Experimental Setup of the PKL Backup LED Bulb

The block diagram for charging and discharging is given below.

Figure 6 shows that the PKL electricity which is generated from the leaf extract is DC and is converted to AC by an inverter. By using AC, the LED bulb has to be

Fig. 5 Experimental setup for voltage measurement with and without NPs

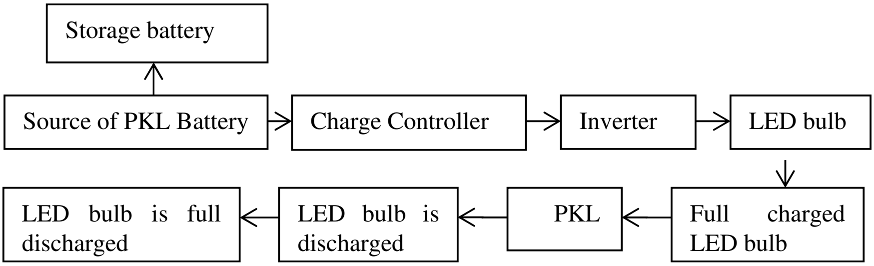


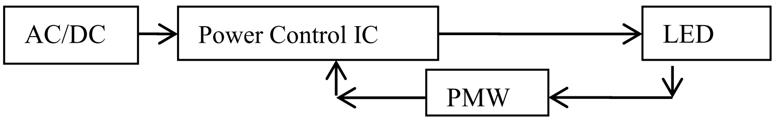
Fig. 6 Block diagram of the experimental setup of the PKL backup LED bulb during charging and discharging

fully charged with the help of an adaptor. A living or fresh PKL has been set up with the two ends of a designed and fabricated lead bulb. The time duration (measured by stopwatch) and intensity (measured by Lux meter) of the LED bulb have been recorded.

2.5 Circuit Diagram of the Experimental Setup of the PKL Backup LED Bulb

Figure 7 shows the experimental circuit diagram of the PKL backup LED bulb. There is a digital Printed Circuit Board (PCB). There are total 47 diodes (36 AC diodes and 11 DC diodes), 2 Integrated Circuits (ICs) and 1PWM (Pulse Width Modulation)

IC which controls drop voltage and drop current and then power. Finally, the PWM IC-1 acts as a power control IC and IC-2 works for battery charging and discharging. The 5 resistors, Resistors R_3 acts as a shunt resistor which converts drop voltage to current, Diode (D_1) is the Silicon Carbide Diode which is the series of ES1J or, ES2J high speed switch (kHz to MHz range), 1 Socket which is a SSD (Solid State Device). Here, Power IC controls the power of the circuit. There is a Bridge rectifier which converts from 220 AC to 310 DC and this is also called high-speed diode. The surface mounted device (SMD) LED converts electrical energy into optical energy. The socket is used to control the different connections. The 5 resistors is used for current sensing. Here, N indicates negative and L indicates positive terminals. The resistors R3 is used for feedback voltage but PWM IC converts current. There is a charge controller on the PCB also. There is a small transformer on the PCB. There is a small rechargeable battery under the PCB. It can be charged by the alternating current (AC) with the connection of a transformer, rectifier, charge controller, storage battery, inverter and then LED light. The LED light and the storage battery are connected with the charge controller. The block diagram can be summarized by the following.



A DC-to-DC buck converter needs high voltage into low voltage. A DC-to-DC boost converter needs low voltage into high voltage. AcBuck-Boost Converter can also be used. The Iron cap can be pass type (E_{27}) and Pin type (B_{22}). The Pin type (B_{22}) has been used in our research work. The array mismatch factor has been considered here.

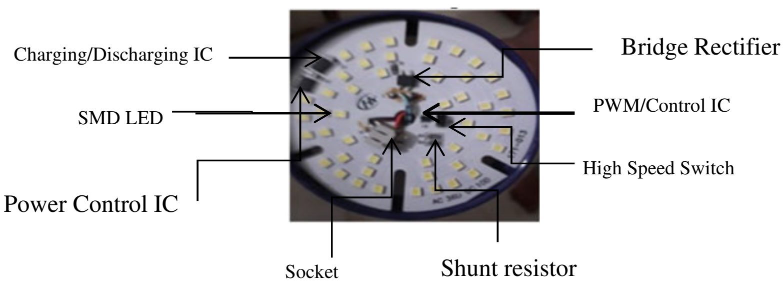


Fig. 7 Experimental setup of different electronic components of the experimental setup of the PKL backup LED bulb

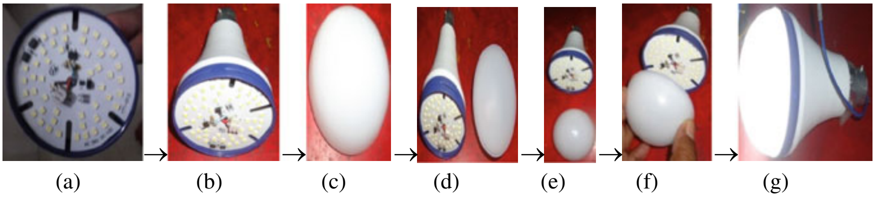


Fig. 8 Different steps of the Experimental setup of the PKL backup LED bulb

2.6 Experimental Setup of the PKL Backup LED Bulb

Figure 8a shows the circuit with PCB for LED bulb; Fig. 8b shows that covered by a back cover where there is a small storage mobile phone battery. Figure 8c shows the outer cover of the bulb and Fig. 8d shows the LED bulb and outer cover side by side together. Figure 8e shows the LED bulb and outer front cover made of plastic face to face together. Figure 8f shows the LED bulb and outer cover face to face moving along each other for finish product and Fig. 8g shows the final and fresh product of the LED bulb.

2.7 Peukert's Law for PKL Backup LED Bulb

In 1897, the German scientist W. Peukert expressed the capacity of a lead–acid battery with respect to the rate of discharging the battery. As the rate increases, the battery's available capacity decreases. Peukert's law can be written as

$$t = H(C/IH)^k \tag{1}$$

where H = the rated discharge time (h), C = the rated capacity at that discharge rate (Ah), I = the actual discharge current (A) and k = Peukert's constant (dimensionless). The value of k lies between 1.1 and 1.3 and t = the actual time to discharge the battery or cell (h) through the fresh or living PKL or self-discharge.

3 Results and Discussion

Figure 9 shows the variation of Intensity with time duration for 20 W PKL backup LED bulb with a single fresh Pathor Kuchi Leaf. The total time duration was 1200 min. The 20 W PKL backup LED bulb was charged by a PKL module with the help of an inverter. Then, it was discharged with the help of a single fresh Pathor Kuchi Leaf (PKL). It is shown that the intensity decreases slowly up to 185 min.

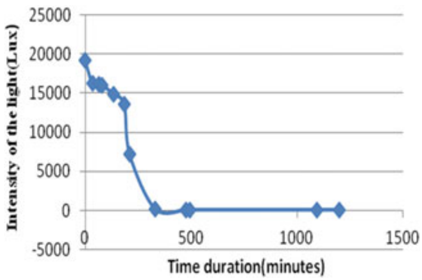


Fig. 9 Variation of Intensity with time duration for 20 W PKL backup LED bulb with a single fresh Pathor Kuchi Leaf (PKL)

Then it decreases rapidly up to 1200 min. It is concluded that the discharge through the fresh PKL follows Peukert's law, $t = H(C/IH)^k$.

Figure 10 shows the variation of Intensity with time duration for 20 W PKL backup LED bulb with a single living Pathor Kuchi Leaf. The total time duration was 1200 min. Firstly, the 20 W PKL backup LED bulb was charged by a PKL module with the help of an inverter. Then, it was discharged with the help of a single Pathor Kuchi Leaf (PKL). It is shown that the intensity decreases slowly up to 185 min. Then it decreases rapidly up to 1200 min. It is concluded that the discharge through the fresh PKL follws Peukert's law, $t = H(C/IH)^k$.

Figure 11 shows the variation of Intensity with time duration without 20 W PKL backup LED bulb. The total time duration was 1200 min. Firstly, the 20 W PKL backup LED bulb was charged by a PKL module with the help of an inverter. Then, it was discharged without the help of a single living or fresh Pathor Kuchi Leaf (PKL). It is shown that the intensity decreases rapidly up to 185 min. Then it decreases very

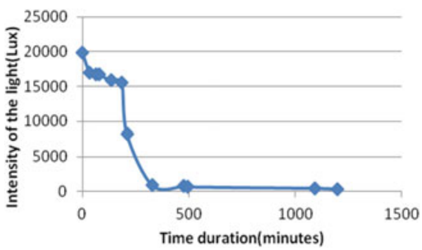


Fig. 10 Variation of Intensity with time duration for 20 W PKL backup LED bulb with a single living Pathor Kuchi Leaf (PKL)

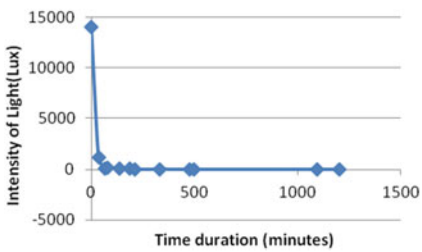


Fig. 11 Variation of Intensity with time duration for a LED bulb with short-circuit condition

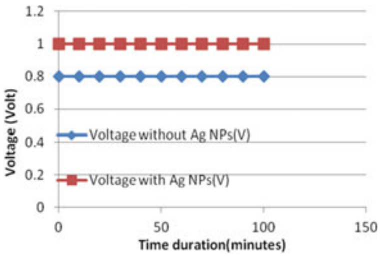


Fig. 12 Variation of voltage with the time duration for using with and without Ag NPs

rapidly up to 1200 min. It is concluded that the discharge through the fresh PKL follows Peukert's law, $t = H(C/IH)^k$.

Figure 12 shows the variation of voltage with the variation of time duration with and without Ag NPs. Firstly, the voltage was collected without Ag NPs. The collected voltage was 0.8 V. It is also shown that the voltage was constant for 100 min. Zinc and Copper plates were used between two sides of a single living PKL leaf. Then the liquid Ag NPs were used between the Zinc and single living PKL & Copper and single living PKL. It is also shown that the collected voltage for using Ag NPs was 1.00 V. This voltage was also totally constant for 100 min.

4 Conclusions

This type of research work has not been done yet. The output of this research work can be used both in rural and urban areas during load shading. For R&D, work should be continued to get better performance. Double or triple living and fresh leaves should be used instead of single living or fresh leaf. The effect of different NPs should be used to get better performance. Ultra-low-cost electrodes should be used for further works to get better performance. Using single or double PKL, anybody can face the load shading problem both in urban and rural areas. If the researchers start conducting research on living trees and fresh leaves, then our dependence on conventional sources (oil, gas and coal) may be reduced to a great extent. If we start to use the living PKL trees and PKL fresh leaves surrounded by us for lighting our PKL backup LED bulb, then our imagination can cross the boundaries.

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