

## **Sustainable Emergency Light for Scarcely Electrified Area of India**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors ST and MMS designed the study, performed the laboratory works, Authors NCG, SPM, and SRN wrote the protocol and wrote the first draft of the manuscript and managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

About 200 million people of India are deprived of grid based power supply, prominently in inaccessible hilly and rural hamlets of the country. Present research is an attempt to design, install, operate use, and maintain the hand on set of light source to address the unserved populations dwelling in electricity inaccessible areas in India. The approach is designing and developing a low cost sustainable or solar emergency light through, "Solar Home Lighting Systems" or "Sustainable Emergency Light" technology, which is one of the smart and innovative approaches of illuminating sources by harnessing solar energy to light the darkened places. The attractive daily usable gadget with surged luminous efficiency, durability, extended life, ecofriendly, compact, and efficient to work at both small values of current and voltages and they are growing acceptance. The safe and non-

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ignition start, is the uniqueness over conventional emergency light, and solar energy founded. The stand-alone device with mobile charging port with luminosity of 150 Lux can be used in lighting the escape routes, open areas and high risk areas. Under the crisis of pandemic of Covid-19 virus, the portable solar lights is safe and riskless light source for the economic backward classes, and can provide the children and students for online undisrupted study up to about 8 to 10 hours at low cost in remote areas.

*Keywords: Sustainable; sustainable emergency light; solar energy.*

## 1. INTRODUCTION

The unlimited supports of energy received from the nature which can be replenished within short span of time called renewable energy capitals such as water, Sunlight, current of air, geothermal, green hydrogen, and biomass, [1], [2]. The earth source of enormous energy can be harnessed two ways as heat or light through thermal route and photovoltaic route respectively, [3]. The country has targeted to reduce fossil fuel consumption by 40 till 2030, and invest \$701.5 billion to meet the sustainable development goal for universal access to electricity by 2030, (WL-1) The resourceful solar emergency light applications have increased in the ensuing decade and its users are increasing day by day.

The emergency portable light illuminates an area when the power supply is disrupted [4]. The standalone system is under fire safety legislation, ease of operation and maintenance under the Building Regulations 2000 (BS 5266 Pt 1 and 7: 1999 and EN 1838) and accomplishing agreement with legislations, [5].

Starting the journey from 18<sup>th</sup> century, researches carried to use electricity for light generation. The nonrenewable sources like coal, and fossil fuels were bump into global energy wants and they became a major donor to carbon footprint and discharge of GHG (greenhouse gas) emission till 20<sup>th</sup> century, [6]. As Solar, aeolian, geothermal, green hydrogen and biomass are the present renewable energy sources. Among the renewable sources, photo voltaics have claimed its ability for a cost effective, clean, quiet, replenishable, and reliable electricity generation matching the prerequisite, [7]. Smart movable solar emergency light is taken as a modified project taken from the standard circuit available at present.

The present research envisages planning, design and manufacture of photovoltaic knowledge integrated emergency light using LED lamp, battery and charging probes that is used for portable spotlight with low maintenance, [8]. The

product is safe, easy to design, cost effective, water proof, flexible, and efficient prepared to combat darkness, fire hazards and calamities.

### 1.1 Review of Literature

Electric arc lamp started from 1802 and invented by Humphry Davy and Thomas Elva Edison had achieved the patent for Centennial Light in 1806 (the then world's longest-lasting light bulb), [4]. The easily aligned set up; the solar emergency lights are the alternate energy saving arrangements are the friends of darkness, hazards, standby for emergency and electricity inaccessible areas for the economically backward people, [9], [10], [11].

The standalone emergency light, the friend in crisis and emergencies has the advantage of no external fuel sources, abundant cost free solar radiations, high longevity, zero temperature constraint, short ckt protected and safe under any load, pollution free, safe and greatly reliable with very high luminosity efficient, [12], [13], [14]. The LED built solar PV cell is cost effective in comparison to commercial voltaic solar lights for small stand-alone applications, [15], [16]. A modern Light Emitting Diode (LED) as lighting arrangement have extraordinary efficiency, long-lasting, energy-saving, high color luminosity, coast effective, and environmental friendly [16], [17].

Solar torches are in contrast to outmoded on-grid solar lighting due to its cost-effectiveness. In increased radiance tropical areas these lights works in maximum with five day autonomy, (WL-2). India, the 3<sup>rd</sup> ranked energy consumer of the globe with possibility of wide range of alternate energy in future, the solar energy sector shall be in the cutting-edge of the solar power generation and consumption as per *India energy Outlook 2021*, [WL-3].

Present research is an attempt to design, install, operate use, and maintain the hand on set of light source to address the unserved populations dwelling in electricity inaccessible areas in India

due to its diverse topography, economy but housed in tropics.

## 1.2 Solar Home Lighting System

The solar energy amount received by the earth is about 3850KEJ (kilo exo-joules) in single year from the sun where the distance of the sun from the earth is about 149.6 Million km. It is about ten times of all the non-renewable sources (coal, oil, natural gas, and atomic *etc.*) used by human being on the earth. Solar radiation can be used in two ways. The 1<sup>st</sup> one is Photovoltaic (PV) technology: to convert light energy to electricity and 2<sup>nd</sup> way is thermal technology: to convert light/heat energy of solar radiation to heat/electricity [18-21].

Solar home lighting systems (SHLS) are off-grid system that offers a cost-effective approach for light and heat providing appliances to remote off-grid families. SHLS are also known as a pure direct current (DC) PV system. They are solar street lights, solar emergency lights, solar study lamps, garden lights *etc.* [21]]. A SHLS comprises of single or multiple PV modules enclosing solar cells, and charge controllers that allocates power, and guards the batteries, and annexed circuits from impairment. Minimum single battery is necessary and to be used for storing the generated energy for use without adequate solar irradiance. This system is powered by solar energy using solar photovoltaic (SPV) cells that converts solar energy (sunlight) directly to electricity, [22].

This technology is a smart effort to solve the problem by harnessing abundant solar energy of the country's housed in tropics of northern hemisphere. In the last two decades, solar home systems installations are surged up and gaining acceptance by Indians day by day. In rural inaccessible areas off grid supplies are common where the SHLS fulfills the energy demand of the household by satisfying their basic electric necessities. The traditional emergency lights use fluorescent lamp that requires dry batteries which has high energy requirement. They are of considerable size and have more weight. These light sources with extraordinary luminous efficiency functioning at low voltage level used, the battery size can be reduced and the system befits to be compact. The present objective of the research is to design and develops an emergency LED lighting system which can be assimilated to a compact and handy lamp, and

that can popularize the torch shaped emergency light for use in daily accomplishments,[22], [23].

Concern for climate change and environmental degradation are universal and conventional energy evolves noxious GHG's (greenhouse gases) with adverse concerns for human health and the ecosystem. Harnessing renewable power through growth of innovative know-hows is the significant strategic option in the present perspectives,. Rural communities in present Indian scenario, mainly in far remote and inaccessible areas, there is very little chance for supply of electricity through the conventional on-grid system. Consequent upon the present environment threats, the renewable energies can only contribute substantially to deliver alternative energy and relief to the users *etc.*. Adequate strategic planning and design of alternate energy generation systems are some of the key issues that can solve energy problems in the rural areas at low cost [24].

## 2. METHODS AND MATERIALS

There are in average 300 days are bright and sunny per year in India. The estimated solar energy incidence on India's land mass is  $\approx 5000$  trillion kilowatt-hours (T kWh)/ year. The available solar energy in a solitary year surpasses the probable energy output of all of the non-renewable energy reserves in India. Major areas in India receives high intensity of solar radiation @ 5 kWh/ m<sup>2</sup> per day in average as demonstrated in Fig. 1. The daily average solar panel power generation capacity in the country is  $\approx 0.20$  kWh/m<sup>2</sup> use of land [25].

In rural and in some remote India there less potential installations to indulge in the national electricity supply. Harnessing of solar energy and setting up of SPV systems or Solar Home Lighting Systems (SHLS) or Solar Emergency Light (SEL) are highly sustainable strategic option to overcome the lighting issues in the electricity deprived areas.

### 2.1 Block Diagram

The block diagram of Solar emergency light consists of four major blocks, these are; Solar module, Charge controller, Battery and LED light, demonstrated in Fig.2.

The solar module is used to convert sun light to electricity and the output of solar module will be connected to the battery through controller for charging purposes. LED light will glow when it will be connected to the battery through connector.

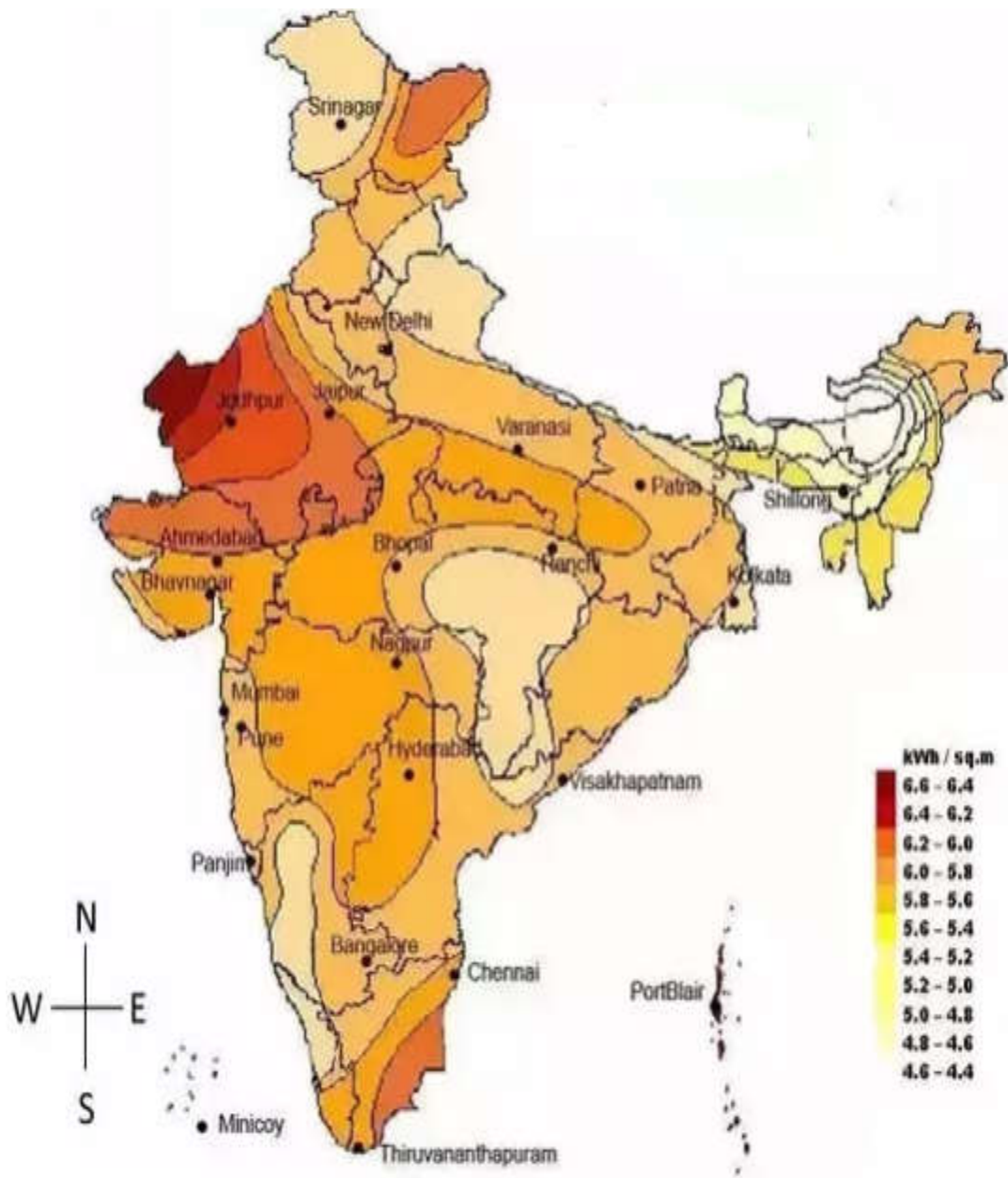


Fig. 1. Irradiance map of India [25]

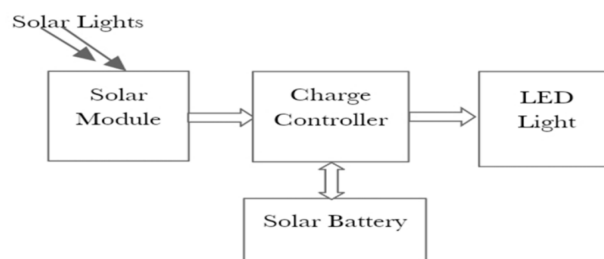


Fig. 2. Basic block diagram of a solar emergency light

## 2.2 Designing and Calculation

In this action research work, we have taken one 4 V 3 W LED light for 5 hours run. The total Energy consumption (E) = P\*t = 3x5 = 15 Wh/day (Watt hour/day).

So, battery amperes required are:

**Ampere of battery** = Total Load/Battery Voltage  
= 15 Wh/4 V = 3.75 Ah

We need a 4 V 3-4 Ah of battery for my project. To charge the battery Solar panel is required.

## 2.3 Panel Size

To charge 4 V battery at least 5-7 V voltage required from the solar pane output.

Average Sun hour in Odisha is around 5-7 hour/day.

Solar panel size = Total Load/Sunny hour = 15 Wh / 5 hour = 3 Watts

We need a 3 Watts of Polycrystalline solar panel for my project work.

A single core 2 meters electrical cable is also required for interconnection of all the equipment's.

Therefore, to design and implement a portable efficient sustainable emergency light it needed, one mini 3 W 6 V solar panel, one 4 V 3-4 Ah

Lithium ion battery, small controlling circuit, LED light, cover (wood or plastic) and electrical accessories, details demonstrated in Fig. 3 & Fig. 4.

## 2.4 Circuit Diagram

The circuit diagram of the research work is demonstrated in Fig. 3.

2C, 1 mm wire has been used for complete wiring process of my project. The positive and negative terminals of solar panel, Battery, Switch, Diode and resister are interconnected. The connection and testing of smaer solar emergency light is demonstrated in Fig. 4.

## 2.5 Working Principle

Solar panels are made up by more than one photovoltaic (PV) cell, convert light energy into electricity through the photovoltaic effect. When sunlight falls on the solar panel, it will produce electricity (DC). The output of solar panel will be connected to battery through control unit for passing of suitable current. Battery will discharge, when it will be connected to the load (LED light), demonstrated in Fig. 5.

The Controller make sure that lights remain alight throughout a power outage with a better allocation of the exit for evacuate the occupants from the building. The main aim of the solar light is to provide power/lights at night, so no doubt it contains a power storage device or attaching to a battery.

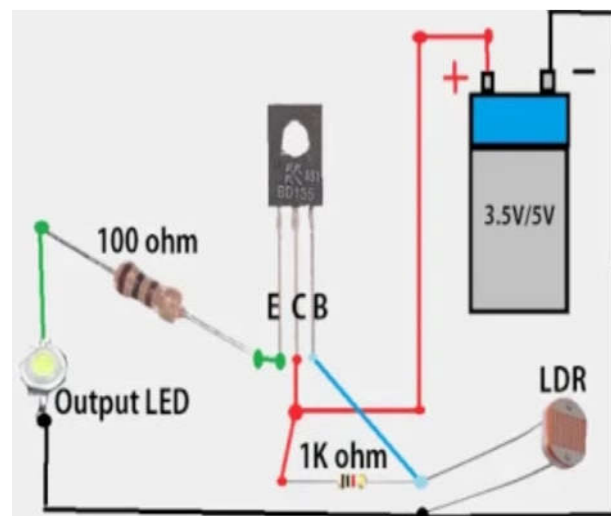
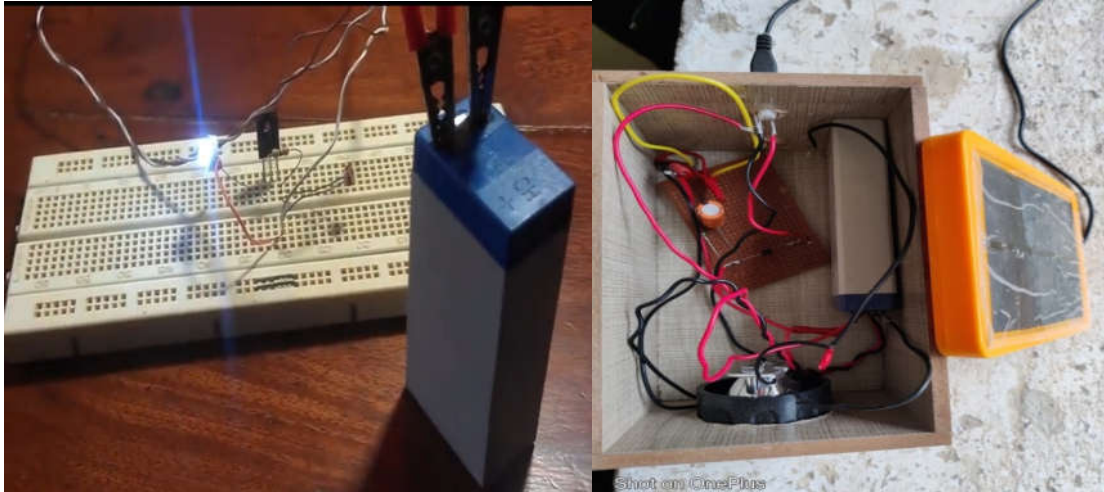
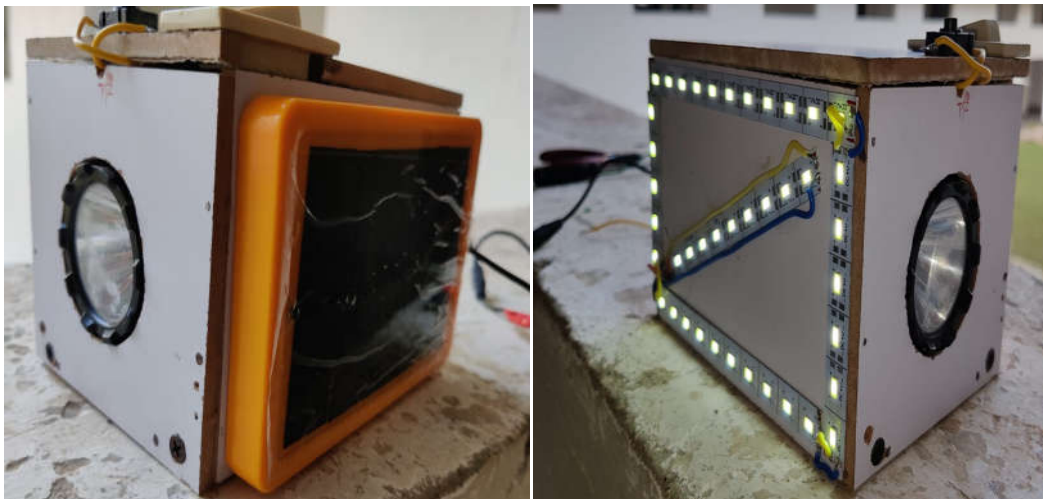


Fig. 3. Circuit Diagrams of the proposed Solar Emergency Light



**Fig. 4. Wiring connection and testing of sustainable emergency light**



**Fig. 5. Operation of Sustainable Emergency Light**

The cost analysis of our research project work is demonstrated in Table-1.

### 3. RESULTS AND FINDINGS

After successfully completion of my project work, it is observed that-

- Completed solar emergency light is a portable and reliable to use.
- Used in both indoor and outdoor.
- Lower operating cost (Rs. 200) than kerosene lamps as it uses solar energy from the sun is free, unlike fuel.
- Runs up to 6.5 hours in a day.
- Charging and discharging time of battery is measured by digital Multi-meter (Model:

2703C BK PRECISION), demonstrated in Table-2.

- Easy to maintain in anytime and anywhere.

### 4. DISCUSSION

There is more electrical power crisis in our country, people are moves to continue power like emergency light for lighting in important place. Solar emergency lighting functions in the event of a complete mains power failure, to avoid fright and let safe passage out of sealed off areas in the event of an emergency condition such as fire. Like all other forms of non-natural lighting, emergency lighting is provided by luminaires. The option for emergency light is either decentralized luminosity source or discrete

**Table 1. Cost structure and specifications of the research project work**

#	Name of Item	Specifications	Cost (in Rs.)
1	Solar Panel	3 Watts 6 Volts	100
2	Battery	4 Volts 2.5-4 Ampere hour	40
3	LED Streeep Light	3 Watts 4 Volts	20
4	Electrical Appliances	2 Meters	10
5	Miscellaneous	Soldering & Wood Cover	30
Total Cost (in Rs.)			200/-

**Table 2. Effective running time observation**

#	Month/Date	Day time (Charging of Battery)	Night time (Lighting)
1	January-21/24 <sup>th</sup>	6 hours	6 hours
2	February-21/1 <sup>st</sup>	5.5 hours	6 hours
3	February-21/27 <sup>th</sup>	5.5 hours	6.5 hours
4	March-21/16 <sup>th</sup>	5 hours	6.5 hours
5	March-21/25 <sup>th</sup>	4.5 hours	6.5 hours
6	April-21/14 <sup>th</sup>	4 hours	6.5 hours
7	April-21/30 <sup>th</sup>	4 hours	6.5 hours

battery keys or that solves the present crisis for the children, students and the patients in the hospitals. . The future of such lights can be extended as lightening of areas such as secondary, safety, anti-panic, Exit routes, and high risk work places, and interrupted electric supply areas.

This research is based on a practical design and implementation of a simple and low cost multi-tasking solar emergency light to resolve the lighting problem in both urban and rural areas of India. This is not only a simple solar emergency light; it has an additional feature of charging mobile through connector. This will fulfil the minimum requirement in both indoor and outdoor work, such as cooking, studying, walking at night and lighting the room. This emergency light consists of mini solar panel, controller, battery, and electrical accessories. The preference for SHLS and/or SEL depends on a range of factors such as: safe, cost effective, enhanced light quality, and duration; facility to brighten the entire house; minimal destruction to the PV apparatus; and long life operation. The designed solar emergency light can provide continuous light of 150 Lux for around 5 to 7 hours.

There are plenty of scopes for improvements in near future which can make it more efficient with more light weight, adding more features like mobile charging, as a power bank and with more beautiful design. The research indicates that, efficient design with low cost of portable emergency light where a low cost can be the best option in near future. Provision of electricity

in the hospitals can be extended for emergency health services using PV standalone system shall be valuable and economical, in view of its decreasing prices and the surging luminosity efficiencies and reliability in addition to helping the economic backwards classes and inaccessible areas.

## 5. CONCLUSION

The designed smart emergency light based on PV power generation system and can be used for stand-alone systems without any grid or complex electronic mechanism. The emergency light which will illumines the surrounding can help the economically backward students for their study; remove patient's dizziness and home lighting and a friend in the dark road in inaccessible and non-electrified tropical areas.

The year 2020 and till date in 2021 the human livelihood has been challenged through the pandemic and many solar institutions are drowned and lagged the rapid progress of previous years. The stop gap created to the digital evolution must be up-surged to remain in the gallop which is confronted as stark reality. The design of the present smart, portable and small emergency light can advance the progress a little ahead, and shall prove as friend to all.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Nada KH, Alrikabi MA. Renewable energy types. *Journal of Clean Energy Tech.* 2014;2(1):61-64.
2. Kumar JCR, Majid MA. Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities. *Energ Sustain Soc* 2020;10(2).
3. Jäger K, Isabella O, Smets AHM, R. van Swaaij ACMM, Zeman M. *Solar Energy Fundamentals, Technology, and Systems*, Delft Univ. of Tech. 2014;1-401.
4. Prabhat R, Shubham Ku, Sujit Ku, Naregalkar PR. Smart solar emergency lamp with motion detector. *International Research Journal of Engineering and Technology (IRJET)*. 2016;03(05):2246-2252.
5. Cat04\_technical. *Emergency lighting design guide. The building regulations.* 2000;1-11.
6. Bruckner T, Bashmakov IA, Mulugetta Y, Chum H, et al. *Energy systems. in: climate change 2014: mitigation of climate change. Contribution of working group III 5<sup>th</sup> AR of IPCC*, [Edenhofer O, Pichs-Madruga R, et al.]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA;2014.
7. Burke MJ, Stephens JC. *Political power and renewable energy futures: A critical review.* Elsevier, *Energy Research & Social Science.* 2018;35:78-93.
8. Budisusila EN, Hapsari JP. *An analysis of intelligent LED emergency lamp with voltage and resistance activated sensor.* IOP Conf. Ser. Mater. Sci. Eng. 2018;403:012030.
9. Bastian A, Devara K, Ramadhant S, Abuzairi T. *Design of portable emergency lamp utilizing thin film solar cell and inflatable case.* E3S Web of Conferences 2018;67:1-5:01019.
10. Ashok S, Srikanth B. *Design and construction of smart solar led light bulb with remote control.* IJRET. 2017;6(8):1-3.
11. Ghalley MR, Singye P, Choden K, Dorji R. *Standby automatic LED light on power failure.* Research J. of Recent Sc. 2018;7(6):12-15.
12. Pinto RA, Cosetin MR, Cervi M, Campos A, Dalla Costa MA, do Prado PN. *Compact emergency lighting system using high-brightness LED lamp.* Conf.: Industry Applications (INDUSCON), 9th IEEE/IAS International Conference. 2010;1-6.
13. Vieira JAB, Mota AM. *A high-performance stand-alone solar pv power system for led lighting.* Int.I Scholarly Res. Notices; 2013.
14. Shah, Vatsal, *Automatic LED Emergency Light, Project report, Indus Institute of Technology and Engineering, Indus University.* 2014;1-21.
15. Pal N, Das N, Sadhu PK. *Studies on Low Cost LED Based Solar Cell for Emergency Lighting.* Int. J. of Eng. Sc. & research tech. 2013;2(2):858-865.
16. Hao Ma, Tenti P. *The solar LED street light, thesis, Universita Degli Studi DI Padova.* 2013;1-39.
17. Chen L, Wang W, Huo J, Chen J. *Research of a LED lighting system based on solar energy.* 2013 25th Chinese Control and Decision Conference (CCDC). 2013;2249-2252.
18. Vasavada S, Sen-Gupta N. *Solar home lighting system; learning from Practice. Removing the Darkness and Improving Livelihoods.* 2010;1-44.
19. Karmakar R, Maitra SK, Biswas S, Chatterjee S, Biswas DP, et al. *Solar home and street light design.* Indo-Iranian J. of Scientific Res. (IJSR). 2017;1(1):38-40.
20. Islam T, Awal MA. *Efficient load and charging method for solar powered home lighting system.* IEEE, 3rd Int. Conf. on the Dev. in Renewable energy Tech. (ICDRET). 2014;1-3.
21. Jain, A, Tharani K, Dhall H, Singh NK, Bhatia S. *Solar home lighting system with AC and DC Loads.* IOSR J. of El. & Electro. Eng. (IOSR-JEEE). 2017;12(3):07-13.
22. Abu-Zarif A. *System design of photovoltaic-solar home lighting for household in Gaza strip.* 2014, 3rd Int. Conf. on Geol. and Env. Sc. IPCBEE. 2014;73(14).
23. RDSO Specification No. RDSO/PE/SPEC/PS/0093-2008 (RW.0) amendment 3 standalone solar photovoltaic LED based street lighting system.
24. Boraha RR, Palit D, Mahapatra S. *Comparative analysis of solar photovoltaic*



- lighting systems in india. energy procedia. 2014;54:680-689.
25. Giri NC, Siiba Prasad Mishra RC. Mohanty. Performance parameters, optimization, and recommendation in large scale on-grid SPV power plant, Odisha, India, Int. Jr. of Modern Agriculture, 2020;9(4):159-167.
- Web-Links (WL)**
- WL-1: <https://av.sc.com/corp-en/content/docs/Standard-Chartered-Opportunity-2030.pdf>.  
WL-2: <https://www.streetlights-solar.com/solar-lighting-guide.html>.  
WL-3: <https://iea.blob.core.windows.net/assets/>.

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