Application of Solar Energy Conversion in A Street Lighting System

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Abstract— A stand-alone solar-powered street lighting system model is designed and operated completely independent of the power grid. The paper focused and thus, a battery is charged during day time with the help of a simple charging circuit. During night, this stored energy is used to light. The device can be used for small-scale lighting applications in remote areas that are far away from the power grid. The system has a panel to collect the solar energy, a battery to store that energy and a light source to use the energy. The system operates like a bank account.on the viability of using solar energy to power the LEDs used as the lightning system. A model is constructed from equipment available on the market like LED, Solar panel, relay, lead acid battery and diodes for protection purpose. The system has the design capability to last for five hours of lightning. Here, solar energy is collected with the aid of a solar panel.

Index Terms— Inexhaustible, Multisim, Photovoltaic Cell, Renewable Energy.

1 INTRODUCTION

The Photovoltaic is the process of converting sunlight directly into electricity using solar cells. Today it is a rapidly growing and increasingly important renewable alternative to conventional fossil fuel electricity generation, but compared to other electricity generating technologies, it is a relative newcomer, with the first practical photovoltaic devices demonstrated in the 1950s. Research and development of photovoltaics received its first major boost from the space industry in the 1960s which required a power supply separate from "grid" power for satellite applications.

These space solar cells were several thousand times more expensive than they are today and the perceived need for an electricity generation method apart from grid power was still a decade away, but solar cells became an interesting scientific variation to the rapidly expanding silicon transistor development with several potentially specialized niche markets.

The increasing market for, and profile of photovoltaics means that more applications than ever before are "photovoltaically powered". These applications range from power stations of several megawatts to the ubiquitous solar calculators.

This paper focuses on using a renewable-energy-based stand-alone system to decrease the energy usage at times of low power consumption and promotes the use of an environmentally-friendly energy resource.

Solar panels produce electricity through individual photovoltaic cells connected in series. This form of energy collection is viable in regions of the world where the sun is plentiful, and can be used in isolated regions or on houses to supplement the rising cost of electricity from a power grid.

The direct conversion of solar energy into electrical energy by means of the photovoltaic effects that is the conversion of light into electricity.

The photovoltaic effect is defined as the generation of an electromotive force as the result of the absorption of radiation. Energy conversion devices which are used to convert sunlight to electricity by the use of the photovoltaic effect are called solar cells. A single converter cell is called a solar or, more generally, a photovoltaic cell, and combination of such cells; designed to increase the electric power output is called a solar module or solar array.

The photovoltaic cell offers an existing potential for capturing solar energy in a way that will provide clean, versatile, renewable energy. This simple device has no moving parts, negligible maintenance costs, produces no pollution and has a lifetime equal to that of a conventional fossil fuel.

The main objectives of this paper are-

i. To understand why renewable energy resources are gaining popularity.
ii. Applying solar power to the street light with its basic theory by software simulation on MULTISIM 12.0 and hardware model.

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Advantages of photovoltaic solar energy conversion are:

- Direct room temperature conversion of light to electricity through a simple solid state device.
- Absence of moving parts.
- Ability to function unattended for long periods as evidence in space programme.
- Modular nature in which desired currents, voltages and power levels can be achieved by mere integration.
- Maintenance cost is low as they are easy to operate.
- They do not create pollution and have a long effective life. They are highly reliable and consume no fuel to operate as the sun's energy is free.
- They have rapid response in output to input radiation changes; no long-time constant is involved, as on thermal systems, before steady state is reached.
- They are easy to fabricate, being one of the simplest of semi conductor devices.
- They can be used with or without sun tracking, making possible a wide range of application possibilities.

Disadvantages of photovoltaic solar energy conversion are:

- Their principal disadvantages are their high cost, and as a matter of fact, in many applications, energy storage is required because of no operations at night. Efforts are being made world-wide to reduce costs through various technological innovations.

2 SOLAR STREET LIGHTING SYSTEM

2.1 General Overview

A solar lamp is a portable light fixture composed of a LED lamp, photovoltaic solar panel, and a rechargeable battery. Solar lamps recharge during the day. At dusk, they turn on (usually automatically, although some of them include a switch for on, off and automatic) and remain illuminated overnight, depending on how much sunlight they receive during the day. Discharging time is generally 8 to 10 hours. Solar lights are easily installed and maintained, and provide a cheaper alternative to wired lamps.

LED Street lighting is a fresh new alternative to traditional street lamps such as LPS, HPS, or MH street lights. LED lighting provides a multitude of advantages over conventional incandescent light. LED street lights are environment friendly, energy efficient, and cost-effective. This smart, "green" option for outdoor lighting has emerged on the green scene due to the recent technological advancements of LED illumination.

But more "greener" option is Solar street lighting by recycled green energy lighting system. They are of energy saving and environmental friendly, which can be used for residential, road, park and so on. High quality solar panel absorbs sunlight and convert into electric energy, this charges maintenance-free battery and finally LED street lights switches on automatically when day off, auto-off when day break.

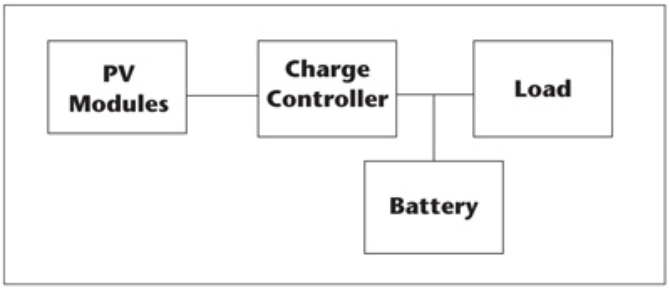
The working method of solar street lights is: solar panel absorbs sunlight and converts it to electricity to drive 12W/36W LED Street light.

The whole system is mainly composed by:
12W/36W LED street lighting, solar panel, lead acid battery and solar street lighting controller, pole (suggest 6-8m height).

There have some **advantages** of LED solar street lighting projects like lower power consumption, higher intensity, save all electricity cost, electric transformer and cable cost, free maintenance and environmental impact - Eliminate Hazardous Disposal apart from these the most important part is longer lifetime: Lifespan of solar panel is 20-25 years. Lifespan of LED street lights is 6-8 years. Lifespan of battery is 4-6 years.

Some **disadvantages of solar street lighting system** are:
1. The conversion efficiency of solar cells is limited to 10 percent. Large areas of solar cell modular are required to generate sufficient useful power.
2. The present costs of solar cells are comparatively high, making them economically uncompetitive with other conventional power generation methods for terrestrial applications, particularly where the demand of power is very large.
3. Solar energy is intermittent and solar cells produce electricity when sun shines and in proportion to solar intensity. Hence, some kind of electric storage is required making the whole system more costly. However, in large installations, the electricity generated by solar cells can be fed directly into the electric grid system.
4.Battery charge level maintenance and discharge limit and life shortened.

2.2 Block diagram of solar lighting system



2.3 Components

Solar street lighting system uses the photovoltaic technology to convert the sunlight into DC electricity through solar cells. The generated electricity can either be used directly during the day or may be stored in the batteries for use during night hours.

The solar street lighting system comprises of

i) Solar photovoltaic module
ii) Battery box
iii) Lamp with charge controller
iv) Lamp post

Solar street lighting system is ideal for street lighting in remote villages. The system is provided with battery storage

backup sufficient to operate the light for 10-11 hours daily. The system is provided with automatic ON/OFF time switch for dusk to dawn operation and overcharge / deep discharge prevention cut-off with LED indicators. The SPV modules are reported to have a service life of 15-20 years. Tubular Batteries provided with the solar street lighting system require lower maintenance; have longer life and give better performance.

2.4 Additional benefits

2.4.1 Improved Safety – The solar powered street light does not require connection to an electrical grid. It is safer and easier to install. In the event of a power outage, the light remains on. This reduces the chance of car accidents and the constant light deters theft/vandalism from nearby businesses.

2.4.2 Lower Operating Cost – It is less expensive to operate a solar powered street light than a traditional street light.

2.4.3 Reduced Damage/Theft – By locating the solar technology directly on the lightfixture and placing the battery within the light fixture, the risk of damage, theft ortampering is greatly reduced. There are no wires in the street pole, which meansthat the wire itself (which exists in regular street lights) can't be stolen and soldfor scrap.

2.4.4 No Insect Swarming – The solar powered street light uses LED street lightingwhich does not produce Infrared light, and therefore will not attract insects. (No more moths and other flying insects swarming around the light.)

2.4.5 Fast Installation – Since you don't need to trench power lines to the pole, runwires up the pole, connect wires to an electrical grid, or hard wire the street light, the installation is significantly faster. In fact, it is so easy, that it can be installed on the pole before it's erected, and thereby reducing a step completely from the process.

3 Design Considerations

This project required examining the concepts of how a solar lightning system worked and how to connect the panel, the batteries, and the load together. Investigating commercially-available systems assisted in determining what equipment is required to build a complete solar lightning structure. The next stage was to establish the equipment necessary to operating the system so it would be durable and cost effective. The design of the system began with the making of the circuit taking in consideration of the value of the components. Then we have done the simulation of the circuit on MULTISIM 12.0 software and also made a model of the circuit.

4. Working Procedure

A **12 volt solar panel** is used to charge the battery during day time. The battery is connected to the input line through the NO and Common contacts of the relay. Diodes D1 and D2 drops 1.4 volts and charge indicator LED uses 1.8 volts. Relay also drops some voltage so that around 8 volts will be available for charging the battery. The high value (4700uF) Capacitor C1 act as a **"buffer"** for the clean switching of the relay and also prevents **"relay clicking"** when the input voltage reduces momentarily.

During day time, the solar panel generates 12 volt DC which makes the relay active and the **NO** (Normally Open) contact makes connection with the **common contact**. This completes the current path to the battery. Two 1 Watt power LEDs are connected to the NC (Normally Connected) contacts of the relay. When the relay energize, the NC contact breaks and LEDs do not get power. In the evening, current from the solar panel stops and relay de-energize. At the same time, the NC contact of the relay gets power from the battery through the common contact and LEDs turn on. Theoretically, the battery can power 12 hours with 350 mA current, but the battery voltage and current reduces drastically. So it is better to turn off the lamp after 5 or 6 hours using the switch S1.

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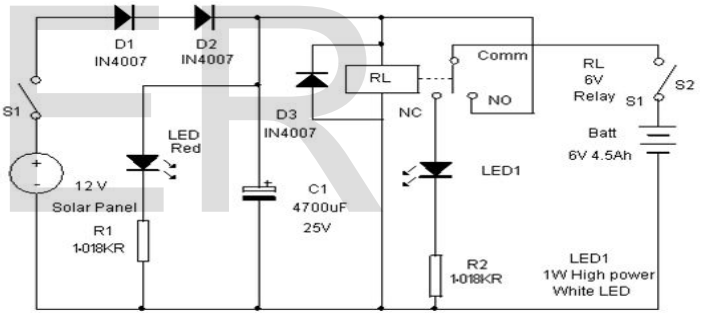
5 Lay out Diagram



6 Software Simulation On Multisim 12.0

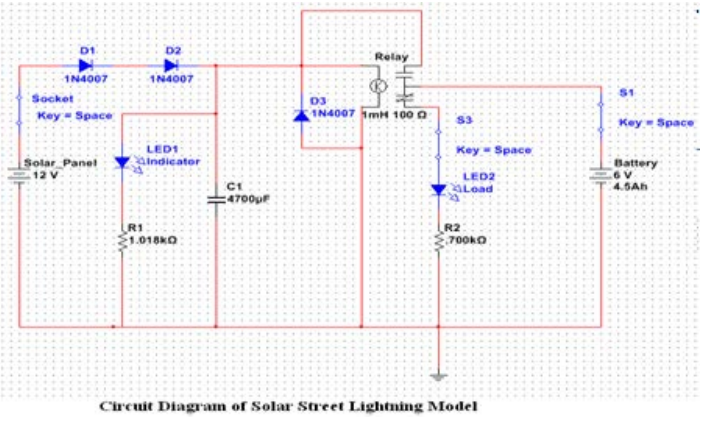


Fig 6.1 Simulating circuit in Multisim software

This is a simple circuit simulated on MULTISIM 12.0 to represent solar street lightning. Diode D1 and D2 drops the dc volt-

age to bring it to a tolerance limit for avoiding overcharging the battery. Voltage drop also occurs through LED 1, R1, C1, and relay coil.

Capacitor C1 of high capacitance value is used for clean switching of the relay coils.

Diode D3 is used as a freewheeling diode during the changing of the NO and NC contacts

LED1 is used as charging indicator and LED2 as load having resistances R1 and R2 in series with them respectively.

CaseI: During daylight when there is adequate solar energy available to generate on average a dc voltage of 12V,the load circuit through switch S3 is to be kept open and battery connection is closed by closing switch S1.

There is a voltage drop through the diodes (D1, D2), capacitance (C1), LED1,R1 and through the relay circuit such that around 8volt is available to charge the battery which is connected with the solar panel through Normally-open (NO) contacts of the relay.

Until and unless battery gets fully charged LED1 glows as to indicate charging.

CaseII: During evening when there is no adequate solar energy available to generate on average a dc voltage of 12V, the load circuit through switch S3 is to be kept closed and battery connection is closed by closing switch S1.

(As a representation of darkness in the simulation solar panel is made connectionless by opening the socket.)

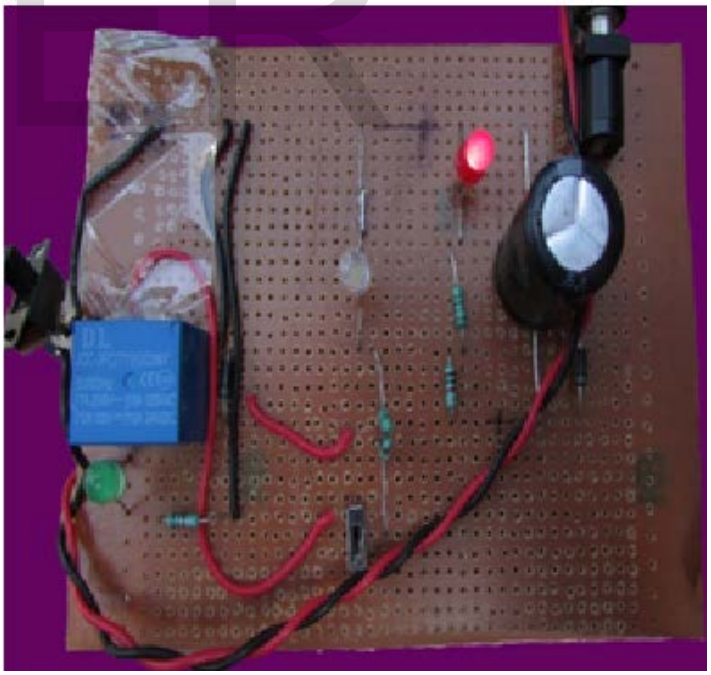
Load is connected through the Normally-closed (NC) of the relay with the battery. The LED2 glows which represents the street lightning phenomenon.

7 HARD WARE

7.1 Overview

CaseI: *Battery is getting charged from Solar energy and load is disconnected.*

CaseII: *Load is connected with the battery when solar energy is unavailable.*



8 CONCLUSION

Due to the ongoing energy crisis all over the world renewable resources are gaining popularity. For a better and secure future we need a gradual change to shift from the depleting conventional energy resources to the replenishing non-conventional energy resources. Solar energy is one of the

choices to be taken into consideration.
Solar street lightning is one of the applications of solar energy. By the conversion of sun's energy to electrical energy by the solar cell we can use it to light up our street. It is not only cost effective but also low maintenance cost and high productivity has discarded to give a second thought on using it. Independence of grid system is also a factor for using this system.
The other side of the coin is that on a cloudy or windy day when sun light is less available efficiency of solar lightning decreases so much that we may have to use an ac source as an alternative. During adequate sunlight using solar lightning system is definitely a good option.
From this project we have learnt many unknown facts about the solar energy and its application by extensive research work on the facts available from various sources apart from daily chores. The interdependence of grid system which is the stand alone system has been an interesting fact for us. The making of the model have been the most interesting of all which has given us a complete idea of stand-alone solar street lightning system

FUTURE SCOPE

To compare the efficiency of conventional energy resources with solar energy.
To execute speed control of d.c. machine with buck-boost converter.
To run a.c. load like fan, a.c. light with help of an inverter.

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"Excellence is not a destination; it is a continuous journey that never ends"

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