Design of Stand-Alone Solar Street Lighting System with LED

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Abstract: There are several ways in which can extraction energy from surroundings. This includes energy extraction from sunlight, wind, biomass, sea levels, etc. All these ways are renewable in nature, i.e. the energy source itself renews, which can provide us energy forever. The solar energy is transformed to the electricity. The solar energy has high initial cost but no maintenance cost at late. The propose development and optimization of a new generation of photovoltaic powered street lighting systems which integrate LEDs devices. The combination of high efficiency photovoltaic panels with whites LEDs of last generation allows the release of an autonomous and performing solar lighting system. The solar street light is used to the nature solar electric. The lighting system is composed to the battery, solar charger controller, lighting sensor control and PV solar panel (necessary size). The essential features of solar energy system. Moreover, it is carried out the design and specifications of solar street light.

Keywords: Photovoltaic Cell Technology, Solar Street Lighting, Battery Storage System, Luminous Design And LED Lamp Distance.

I. INTRODUCTION

Today, Energy-efficient lighting is an important factor for sustainable development and energy strategies. Indeed, Lighting consumes about 20 percent of the electricity for a nation. Also, renewable energy utilization development permits the reduction of CO_2 emission and contributes to the decrease of fossil energy dependency. In the past few years, developing energy-efficient street-lighting with light-emitting diodes (LEDs) has gained an enormous interest. LED luminaires also have the potential of increasing illumination uniformity and glare reduction, which improves both the eye comfort and the visual discrimination ability of car drivers. Traditional street lighting technologies, such as high-pressure sodium or mercury, emit light in all directions, and consequently the light distribution is difficult to control. This is why a common street luminaire usually has defects such as glare, non-uniform light pattern, upward reflected light, light pollution, and waste of energy. The association of a solar energy to High efficiency lighting technology as LEDs (Light Emitting Diodes) is the focus of this article and contributes to the development of a clean energy (Solar) and green lighting technology (LEDs). In comparing LEDs to other lamps technologies, we can say that LEDs are the Greenest lighting choice.

Indeed, high power LEDs (Light Emitting Diode) devices permit the design and fabrication of street lighting units in order to replace existing luminaries which are using sodium or metal halide or CFL (Compact Fluorescent Lamp) lamps. A simple LED light bulb that can fits standard E40 bulb holders can be applied for solar powered street light system which is totally independent of power mains. The high power LEDs of last generation and technology offer a considerable alternative to a conventional street lighting with energy savings of up to 75 % and an important reduction in carbon emissions. The photometric properties of high power LED street lights adding to their bright, natural light color, give a uniform rectangular beam pattern that is 50% brighter and 50% larger than the oval beam pattern produced by a conventional lamp. This highly focused beam pattern allows LED lights to be spaced at much wider intervals than sodium and CFL lights. Competitors to conventional lead-acid batteries include nickel-cadmium, nickel-metal hydride, and lithium-ion, lithium-polymer, and nickel-zinc technologies.

II. ENERGY TECHNOLOGY FOR PHOTOVOLTAIC SYSTEM

A. Photovoltaic Energy

Photovoltaic offer consumers the ability to generate electricity in a clean, quiet and reliable way. Photovoltaic systems are comprised of photovoltaic cells, devices that energy directly into electricity. Because the source of light is usually the sun, they are often called solar cells. The word photovoltaic comes from photo, meaning light, and voltaic, which refers to producing electricity. Therefore, the photovoltaic process is producing electricity directly from

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sunlight. Photovoltaic are often referred to as PV. New technological approaches are always necessary to make low cost and high energy conversion efficiency cells so that photovoltaic energy from now until 2020 can cross the competitiveness threshold in comparison with other sources of electricity production.

B. Photovoltaic Conversion

After obtaining the professional applications market for remote sites, being in a good position for electrifying rural populations in developing countries, solar electricity has asserted itself in industrialized countries as a complementary source to classic electric energy sources. The photovoltaic effect is obtained by the absorption of photons in a material possessing at least a possible transition between two levels of energy (semiconductors). To obtain a current, separate the electron and the hole by creating an electric field in a semiconductor, a p-n diode. Zone p has an excess of holes, giving rise to an electric field separating the charges created by the photovoltaic effect. A difference in potential is established at the terminals of the photovoltaic cell as shown in Fig.1. For silicon, we obtain a p zone by doping it with boron and an n zone by doping it with phosphorus.

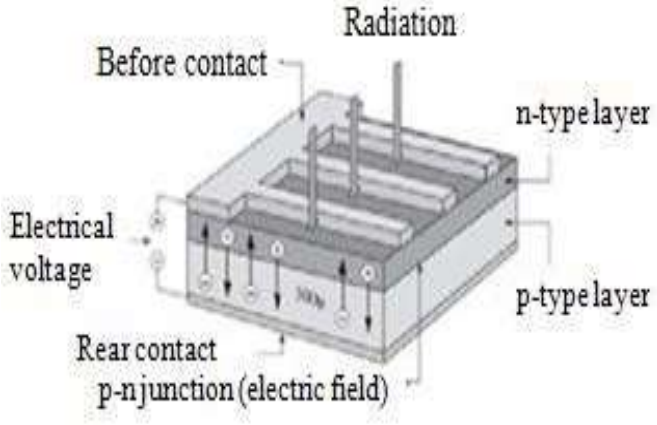

Fig.1. Solar Photovoltaic Cells.

C. Cells with Centralized Silicon Base

Silicon, the basis of the entire modern electronic industry, is obtained by reduction of silica in an electric oven, furnishing the metallurgic material, whose purity is about 98 percent. This is in turn purified in the form of trichlorosilane or silane gas. After paralysis of the latter, the material obtained serves as the starting point for growth.

- Mono-crystalline Silicon
- Multi-crystalline Silicon

III. SOLAR STREET LIGHTING

Solar lights are the most advanced electrical light sources in the world.With10000 hour rated life and the energy efficiency and color rendition of the best florescent lamps, there is no other light source that provides so many benefits while also minimizing heat and CO_2 output. To maintain the highest level of international manufacturing and testing standards so that our products are durable and safe for the environment. Whatever aspect of lighting that it prioritizes, solar lights are superior in many categories. Energy efficiency, life, color rendition, lumen depreciation, waste/heat output, glare etc. Solar lights are truly the next generation of electric lights that is set to displace several existing forms of electric lighting.

A. Lamp Types

A lamp is a device that transforms electrical energy or gas into light. The amount of light produced by a lamp depends of the device's efficacy. Visible light output is usually measured in lumens. The main lamp types identified are: incandescent lamps, tungsten halogen lamps, fluorescent lamps, compact fluorescent lamps (CFL), high intensity discharge lamps (High Pressure), mercury lamps, metal halide lamps, high pressure sodium lamps, electrode less lamps, induction lamp. A different category is solid-state lighting represented by light-emitting diodes (LED), organic light-emitting diodes (OLED) and light-emitting polymers (LEP).

B. Sodium Low Pressure Vapor Light

Solar Low pressure Sodium Light can be used for public lighting on roads, residential areas, parks and shopping malls. The main system of solar Low Pressure Sodium Lights is the Solar generation system, the Solar module which collects sunlight and converts into Electricity which in turn charges the maintenance free sealed battery during the day time .At night the light turns on automatically ,using the electricity which is stored in the batteries during the day. No wiring, no utility bills to be paid, with lighting option from 4 to 12 hours. The pole for solar street light is made of high quality steel with painting or lacquering after hot galvanization. It is strong, durable and easy to install. The main components of the solar street lights System includes the Solar Modules, Charge Controller, maintenance free Lead Acid Battery.

C. Led Street Lighting

LEDs components are made of Gallium Nitride (GaNi) semiconductor material which is doped by phosphorous chemicals. The electronic structure of LED is a diodes or tandem structures [5]. After processing of this electronic device the produced LEDs chips are connected by micro-wiring or flip-chip technology and then packaged in a transparent epoxy material of specific composition which is different from one manufacturer to another. The Fig. 2 and 3 show respectively a picture view of a single LED device and the LEDs light Unit. The table 1 gives some Illumination Data for a LED light unit. Saving 50 percent Cost of Solar Panel with LED Lights & special time control circuit. Special timer control design conserves the solar energy, after 6-8 hrs full lighting it automatically switches to lighting with half power consumption at midnight. Efficiency LED lighting uses advanced and very power full LEDs to match the solar energy supply. Efficiency control Circuit with the lowest static current consumption to conserve the solar energy, over charge Protection and over Discharge Protection. Install solar LED Street lights mixed with city power street lights to avoid emergency. LED module lamp with lamp housing, built in solar controller and, accessories included (optional), solar panel.

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Fig.2. Schematic view of LED device.

Fig.3. Schematic view of a LED light unit.

TABLE I: Example of Illumination Data for a Led Light Unit

Suspension Distance (m)	Lighting Area (m × m)	Illumination (Lux) at maximum lumens based on the illuminated area and the LED street light			
		LED 15W	LED 30W	LED 50W	LED 65W
6	8 × 20	10Lux	19Lux	30Lux	39Lux
8	10× 25	6Lux	12Lux	18Lux	23Lux
10	13×30	4Lux	8Lux	12Lux	15Lux
12	16×35	2Lux	5Lux	8Lux	11lux

D. LED Equivalent to High Pressure Sodium/Mercury Lights

TABLE II: Comparison of LED Street Lighting and High Pressure Sodium/Mercury Light

LED Street Light	High Pressure Sodium/Mercury Light
30W	80W
60W	170W
100W	250W
140W	400W

TABLE III: Comparison the Design of Road Lighting (recommended) and Ground Luminance

	Pole high	LED high Power	Distance between pole (meter)	Max (Lux)	Average (Lux)
Solar street light	4m	15m	12-18m	25	18
	5m	18m	14-20m	30	18
	6m	30m	18-24m	32	20
	7m	50m	21-28m	32	20
Common street light	8m	100m	24-32m	40	22
	9m	110m	27-35m	34	20
	10m	140m	30-40m	35	22
	12m	180m	30-40m	33	23
	14m	200m	30-40m	30	21

E. Comparison to Conventional Lighting Source

The investment required for LED light sources over their entire product life is competitive with conventional lamps. The initial cost for an LED lamp is much higher than that of a HPS lamp. However, due to the high maintenance costs and system efficiency of the HPS lamp, the total cost for HPS lamp is assumed to be higher than that for the LED lamp over its lifetime, while product lifetimes are expected to be nearly the same. With the continuous improvement of LED performance and cost reduction of LED products, this crossover point can be expected to occur even earlier in the future.

TABLE IV: Comparison of Various Lighting Sources

Lamp Type	Power Consumption (W)	Luminous Flux (x1000 lm)	Efficacy (lm/w)	CRI (Colour Reproduction Index)	Lifetime (x 1000hr)
High Pressure Sodium	35-400	1.3-55	39-140	20-40	24
Metal Halide	35-400	3.4-32	70-90	60-90	6
High Pressure Mercury	50-400	1.8-22	35-90	40-60	8-12
Low Pressure Sodium	18-90	1.8-15	100-160	<20	16-30
Compact Fluorescent	5-55	0.25-4.8	50-88	40 to>90	9
LED (Lm4)	112	7	55	80	10-50 (50% light decrease)

F. Illumination Distribution at Different Heights

The beam pattern of distribution curve also can be changed by different section's demand. Rationally control the distribution to be a rectangular beam pattern as shown in Fig.4. The edge of the beam pattern is very clear and side, no glare out of the effective radiation region, will not cause any light pollution. Satisfy the requirements of the road lighting or other special lighting, which can be using in the special requirements such as street lighting, advertising lighting, etc.

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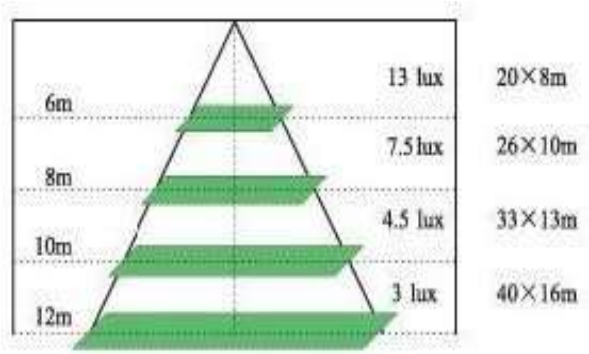

Fig.4. Area of illumination distribution.

G. Structure of Solar Powered Leds System

Solar Street Lights system includes: solar panel, battery, solar controller, LED lighting unit and pole. The solar LED street light system converts the sun energy into electricity and stores it to provide green illumination. Luminaries utilize High Power white LED with superior thermal management design as shown in Fig.5. These extremely durable fixtures are waterproof and designed for multiple applications including indoor and outdoor. LEDs lamps have a lifetime of more than 50 000 hours.

Fig.5. Schematic representations for the structural composition of a PV LED lighting system.

- 1-Tilted solar modules placed on a mounting structure facing the sun path.
- 2- LED lighting unit suspended on a pole short arm.
- 3- Vented steel enclosure, (contains the battery/ies and the solar charge controller).
- 4- Structural anticorrosion parts consists of the pole, the affixing base, the short arm and the modules mounting structure.

H. Types of Solar Panel

There are three main types of photovoltaic solar panels for both commercial and residential use. They are:

- Monocrystalline ,
- Polycrystalline Silicon (Multi crystalline) and
- Amorphous Silicon (Thin film).

TABLE V: Comparison Three Basic Types of Modules

Solar module	Efficiency	Lifetime	Price	Power/Area
Monocrystalline Silicon	10-13%	25 years 90% rated power, 30 years 80% rated power	High	High
PolycryStalline Silicon	9-13%	10 years 90% rated power, 25 years 80% rated power	Moderate	Moderate
Amorphous Silicon	6-8%	10 years	Low	Low

IV. BATTERY STORAGE SYSTEM FOR PHOTOVOLTAIC CELL

The batteries are the main components in the solar LED street lights system as shown in Fig.6, they can store energy which are generated by the solar cell during day time, and meet the power consumption of lighting at night and lighting needs in consecutive rainy days. It is not possible to meet the needs of night lighting if the battery capacity is too small. Inversely if the battery capacity is too large, we need large solar panels to ensure the battery is fully charged in a limited time during the day. The over-large panels and battery will cause increasing of cost and also the waste. If the solar panel is not large enough, the battery cannot be fully charged in limited period of time during the day, it will always be in a state of power deficit, this is a bad effect of the battery life. The most common batteries used in stand-alone photovoltaic systems are lead-acid batteries. The lead-acid batteries are made up of cells. Each cell produces about 2volts. A 12 volts battery has six 2 volts cells. They are rechargeable, easily maintained, relativity inexpensive, available in a variety of sizes and most will withstand daily discharges of up to 80 percent of their rated capacity.

Some advantages of NiCd bateries include their long-life expectancy, low maintenance requirement and their ability to withstand extreme conditions. Also, the NiCd battery is more tolerant to complete discharge. It is important to choose a quality battery rated at a minimum of 100 amp-hour storage capacity. Firstly, calculate the current 12V battery system, 1pcs lamp, 30W

Total for = 30×1= 30W
I= 30W ÷ 12V= 2.5A

Secondly, battery capacity needs street lighting for total full load = 10 hours
Cloudy day (3days or 4 days
Battery capacity = 2.5×10×(3+1) = 100Ah

Calculation of illumination

$$E = \frac{I}{d^2} \quad (1)$$

If E=32lux, d =6m

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$I = Ed^2$
$= 32lux \times 6^2$
$= 32 \times 36$
$= 1152$ lumens
~ 1200 lumens

That is a single pole design, in which is defined the battery storage backup and solar module system. The sample design composes to the one pole of solar street lighting. In the research is found ten poles of solar street lighting.

Each pole design, LED power consumption = 30W
Solar module power supply = 100W
LED Lamp high = 6 m
LED luminous area = 20×8 m^2

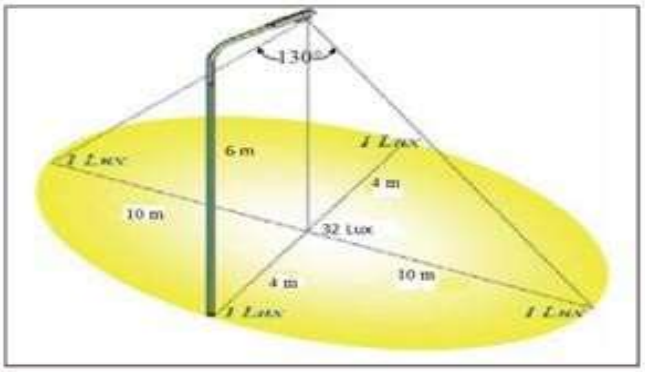

Fig.6. Specified LED street lamp distance.

For ten pole, LED power consumption= 30×10 poles
Solar Module power supply= 100×10 poles
Lamp pole space= 20 m
Street distance = 200 m

The power consumption of appliances is given in Watts. LED 30W light fitting, on for 10 hours, will take 30×10=300Wh from the battery for a 100Ah, 12V battery Watt Hours is 100×12= 1200Wh.

To calculate the energy it can supply to the battery, multiply Watts by the hours exposed to sunshine, then multiply the result by 0.85 for the solar 100W panel in 4.5 hours of sunshine, 100×4.5×0.85=382.5Wh. This is the amount of energy the solar panel can supply to the battery.

TABLE VI: 30 Solar Powered Led Street Lighting System 10 Hrs 100AH/12V 1PC

Model No	KT-SSL-30W
Total power consumption	33W
Daily working hours	10 hrs
Peak sunshine duration	4.5 hrs
Continuously rainy days	4 days
Interval between rainy days	20 days
Solar panel	100W/17.5V 1PC
Battery	100AH/12V 1PC
Solar Controller	5A/12V

VI. CONCLUSION

Solar energy is transmitted from the sun light by electromagnetic radiation. The solar energy transforms to the electric with necessary device (Photovoltaic Devices). The use of PV power system becomes attractive because of high reliability, low maintenance requirement as they don't have moving parts of generating electricity, low running costs, suited to most location and long life expectancy for main components. The solar LED street lighting is performed the solar electric to the battery storage and solar light controller. At the summary of this paper, the size of solar panel is expressed the capacity of LED Lamp as design and specifications, features and benefits of solar LED street lighting.

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