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Performance Enhancement of Solar Powered LED Street Light System

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ABSTRACT

Solar energy is a renewable energy which is used as a power source to charge the battery. As the main motive is to reduce cost and use of renewable energy which will help in development in Rural electrification. The issue with the existing design of solar LED street light was that the design is not application-oriented and other parameters such as boom angle, pole spacing, pole height etc. has not been considered. So in this project, we have investigated the effect of mounting angle of solar panel, panel sizing, battery capacity, pole spacing, boom angle, etc. Street lights need more energy in winter tha n on summer due to long winter nights therefore the effect of mounting angles of panel has a great impact on the cumulative energy output of the panels. Moreover, by installing sensors like motion sensor, Dusk and dawn sensor will allow operation of LED lights at different intensity levels thereby saving energy wastage. By Using correct pole spacing and optimum boom angle will help in reducing blind spot and increase the efficiency of the system. Basically Dialux-EVO and Relux software were used in lightning design to improve the system efficiency. Fabrication of pole was done according to the parameters with flexibility in the design.

KEYWORDS:*Solar Energy, Street light, Mounting angle. Panel size, Battery, Photo-voltaic Cells*

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I. INTRODUCTION

Scarcity of fossil fuels has led for man to look for an alternative source of energy. Solar energy is one such in-exhaustible source which provide large amount of energy which is available to us for free. Solar energy is the radiant light and heat from the Sun that has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar radiation along with secondary solar resources such as wind, wave power, hydroelectricity and biomass accounts for most of the available renewable energy on Earth. Only a minute fraction of the available solar energy is used.

The sun's heat and light provide an abundant source of energy that can be harnessed in many ways. There are a variety of technologies that have been developed to take advantage of solar energy. These include concentrating solar power systems, passive solar heating and day lighting, photovoltaic systems, solar hot water, and solar process heat and space heating and cooling. Solar power can be used in both large-scale applications and in smaller systems for the home. Businesses and industry can diversify their energy sources, improve efficiency, and save money by choosing solar technologies for heating and cooling, industrial processes, electricity and water heating. Solar power technologies, from individual home systems to large-scale concentrating solar power systems, have the potential to help meet growing energy needs and provide diversity and reliability in energy supplies.

The nature of solar energy is such that it requires two components to have a functional solar energy generator. These two components are a collector and a storage unit. The collector simply collects the radiation that falls on it and converts a fraction of it to other forms of energy. The storage unit is required because of the non-constant nature of solar energy; at certain times only a very small amount of radiation will be received. The amount of energy produced during cloudy conditions or at night by the collector will be quite small. The storage unit can hold the excess energy produced during the periods of maximum productivity, and release it when the productivity drops.

Solar energy also known as photovoltaic, are used to convert light energy into electric energy which is composed of photon particles. They use principle of solar cell. Solar cells absorb energy during the day, solar cell then convert solar energy into electric energy which is stored in battery. During the night time street light start automatically and consume the energy already stored in battery. During the day time battery recharged through the solar power and process keeps on repeating. Solar street light composed of LED light, they require very little current hence solar panels of smaller size required for solar street light.

Solar energy cuts down the electricity bill because electricity generated from sun is free. Using solar energy in our daily expenses can have significant saving. It is renewable energy source. Main motive to use solar energy is eco-friendly. Pollution is increasing day by day to save the earth renewable energy sources should be developed. Solar energy can be major source for the coming generations. The maintenance required for solar panels in minimum. When it is installed they can go at least twenty thirty years without maintenance needed. Once when it is installed you need to check the system only once in a year.

Why solar Photo-Voltaic (PV) systems?

Electric energy produced by solar cells is clean and noise free, because they do not use fossil fuels. PV systems do not release any harmful air or water pollution in environment, deplete natural resources, or endanger animal or human health. PV systems are quiet and visually unobtrusive. Small-scale solar plants can take advantage of unused space on rooftops of existing buildings. PV cells were originally developed for use in space, where repair is extremely expensive, if not impossible.PV still powers nearly every satellite circling the earth because it operates reliably for long periods of time with virtually no maintenance. Solar energy is a locally available renewable resource. It does not need to be imported from other regions of the country or across the world. This reduces environmental impacts associated with transportation and also reduces our dependence on imported oil. And, unlike fuels that are mined and harvested, when we use solar energy to produce electricity we do not deplete or alter the resource. A PV system can be constructed to any size based on energy requirements. Furthermore, the owner of a PV system can enlarge or move it if his or her energy needs change. For instance, homeowners can add modules every few years as their energy usage and financial resources grow. Ranchers can use mobile trailer-mounted pumping systems to water cattle as the cattle are rotated to different fields.

Rural electrification is the process of bringing electrical power to rural and remote areas. Electricity is used not only for lighting and household purposes, but it also allows for mechanization of many farming operations, such as well-pumping, threshing, milking, and silo filling. In areas facing labour shortages, this allows for greater productivity at reduced cost. Electrification began in cities and towns and gradually extended to rural areas. An inherent challenge of extending electrical grids into the countryside is that doing so is expensive, but amortizing its capital cost well enough to sufficiently reduce the unit cost of each hook-up is harder to do in lightly populated areas (yielding higher per capita share of the expense).

II. SOLAR LED STREET LIGHT SYSTEM

The solar street lights work on the principle of the photovoltaic cell or solar cell. The solar cell converts solar energy to the electrical energy which is stored in the battery. The solar lamp draws the current from this battery and it requires no other wiring.

Working of Solar Street Lights:

The solar street lights use solar energy, a form of the renewable energy. These days it is common to see the solar street lamps along the sides of roads. The solar street lights comprise of, which absorb the solar energy during daytime. The photovoltaic cells convert solar energy into electrical energy, which is stored in the battery. At the night time the lamp starts automatically and it consumes the electricity already stored in the battery. During the day time the battery gets recharged and the process keeps on repeating every day.

Types of lamp used in street light system:

[1]. Incandescent Lamps: It produces light when a thin wire called a tungsten filament is heated by electricity running through it making it so hot that it starts to glow brightly. This releases a lot of heat and the bulbs get hot to the touch, meaning this bulb is very inefficient. Many countries, including the United States, are currently passing legislation banning the sale of these light bulbs because they are so inefficient.

[2]. **High Intensity Discharge (HID) Lamps:** High-intensity discharge lamps (HID lamps) are a type of electrical gas-discharge lamp which produces light by means of an electric arc between tungsten electrodes housed inside a translucent or transparent fused quartz or fused alumina arc tube. This tube is filled with noble gas and often also contains suitable metal or metal salts. The noble gas enables the arc's initial strike. Once the arc is started, it heats and evaporates the metallic admixture. Its presence in the arc plasma greatly increases the intensity of visible light produced by the arc for a given power input, as the metals have many emission spectral lines in the visible part of the spectrum. High-intensity discharge lamps are a type of arc lamp.

[3]. **Mercury Vapor Lamps:** A mercury-Vapor lamp is a gas discharge lamp that uses an electric arc through vaporized mercury to produce light. The arc discharge is generally confined to a small fused quartz arc tube mounted within a larger borosilicate glass bulb. The outer bulb may be clear or coated with a phosphor; in either case, the outer bulb provides thermal insulation, protection from the ultraviolet radiation the light produces, and a convenient mounting for the fused quartz arc tube

[4]. **Metal Halide Lamps:** A metal-halide lamp is an electrical lamp that produces light by an electric arc through a gaseous mixture of vaporized mercury and metal halides(compounds of metals with bromine or iodine). It is a type of high-intensity discharge (HID) gas discharge lamp. Developed in the 1960s, they are similar to mercury Vapor lamps, but contain additional metal halide compounds in the quartz arc tube, which improve the efficiency and colour rendition of the light. The most common metal halide compound used is sodium iodide. Once the arc tube reaches its running temperature, the sodium dissociates from the iodine, adding orange and reds to the lamp's spectrum from the sodium D line as the metal ionizes. As a result, metal-halide lamps have high luminous efficacy of around 75–100 lumens per watt, which is about twice that of mercury Vapor lights and 3 to 5 times that of incandescent lights and produce an intense white light.

[5]. **High Pressure Sodium (HPS) Lamps:** The high pressure sodium lamp (HPS) is the mostcommonly used street light throughout the world. It produces light by running electricity through a mixture of gases, which produces light. The lamp itself is preferred because it requires little maintenance. These lamps are fairly efficient. They take a while to turn on completely and produce a yellow-orange glow.

[6]. **Fluorescent Lamps:** A fluorescent lamp, or fluorescent tube, is a low-pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light. An electric current in the gas excites mercury vapor, which produces short-wave ultraviolet light that then causes a phosphor coating on the inside of the lamp to glow. A fluorescent lamp converts electrical energy into useful light much more efficiently than incandescent lamps. The typical luminous efficacy of fluorescent lighting systems is 50–100 lumens per watt, several times the efficacy of incandescent bulbs with comparable light o

[7]. **Compact Fluorescent Light Bulb:** These spiraled light bulbs are far more efficient than the standard incandescent bulb. Compact Fluorescent Light bulbs (CFLs) work by running electricity through gas inside the coils, exciting that gas, and producing light. There is a coating on the spirals, which makes this light white. These bulbs do not get nearly as hot as the incandescent bulbs.

[8]. **Induction lights:** The internal electrode less lamp or induction lamp is a gas discharge lamp in which an electric or magnetic field transfers the power required to generate light from outside the lamp envelope to the gas inside. This is in contrast to a typical gas discharge lamp that uses internal electrodes connected to the power supply by conductors that pass through the lamp envelope. Eliminating the internal electrodes provides two advantages:-

- Extended lamp life (internal electrodes are the most limiting factor in lamp life).
- Ability to use higher-efficiency light-generating substances that would react with internal metal electrodes in conventional fluorescent lamps.

[9]. **LED Lights:** LED technologies have developed rapidly in recent years and these bulbs are now being integrated into outdoor lighting solutions. While the energy savings are significant, LEDs produce a lot of blue light, too much of which can have negative effects on human health and wildlife.

[10]. **Solar Charge Controller:** A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. The terms "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack, battery-powered device, or battery charger.

Types of Charge Controller:

[1]. **PWM regulators** are similar to series regulators, but they use a transistor instead of a relay to open the array. By switching the transistor at high frequency with various modulated widths, a constant voltage can be maintained. The PWM regulator self-adjusts by varying the widths (lengths) and speed of the pulses sent to the battery. Unlike the on/off charge controllers which instantaneously cut off the power transfer to minimize battery overcharging, PWM regulators act like a rapid on/off controller constantly. When the width is at 100%, the transistor is at full ON, allowing the solar array to bulk charge the battery. When the width is at 0% the transistor is OFF, open circuiting the array preventing any current from flowing to the battery when the battery is fully charged. Like the series regulator, the transistor can be placed in either the positive or negative line, allowing the regulator to be used in positive and negative ground systems. The difference between the series regulator and the PWM regulator is the PWM of the transistor. When the modulation width is at 100% or 0%, the regulator is essentially a series regulator, it is that modulation width variation that allows the PWM regulator to create a constant voltage to the battery as opposed to the on/off of the series regulator.

Some PWM regulators have provisions for converting to a series (on/off) regulator. This could be needed for sensitive loads that have an issue with the noise created by the frequency of the PWM. Some PWM regulators have provisions for converting to a series (on/off) regulator. This could be needed for sensitive loads that have an issue with the noise created by the frequency of the PWM. Because PWM charge controllers require transistors, they are always solid-state; this means heat dissipation can become a problem, especially in larger solar arrays. As with series regulators, because the PWM regulator regulates by opening the array during regulation (at high frequency), if you were to measure the array voltage during this time, the array voltage can be anywhere between battery voltage and open circuit voltage depending on the regulator's charging stage. If an array voltage value less than the battery voltage was ever measured during normal operation, this would indicate a problem.

[2]. **MPPT Charge Controller:**The Maximum Power Point Tracking (MPPT) charge controller takes the PWM to the next level, by allowing the array voltage to vary from the battery voltage. By varying the array input, the charge controller can find the point at which the solar array produces the maximum power. The MPPT process works like this. Imagine having a battery that is low, at 12 V. A MPPT takes a voltage of 17.6 volts at 7.4 amps and converts it down, so that what the battery gets is now 10.8 amps at 12 volts. MPPT controllers takes the DC input from the solar panels, convert it to high frequency AC, and then change it once again to a different DC voltage and current. The point is the voltage will exactly adhere to the requirements of the battery. As the MPPT charge controller uses the negative line as a reference and then switches the positive line, they can be used in negative ground systems only. It is crucial to understand that voltage is a potential difference; the 'difference' refers to the difference between ground potential and some potential. This means that the starting point is below zero, but this is only used as a reference point.

Since MPPT charge controllers can vary the charge current to the battery, the regulator can be a multi-stage charger with bulk, absorption, and float settings. They are always solid state; this means heat dissipation can become a problem, especially in larger solar arrays. MPPT controllers are typically step-down converters, so the array voltage always needs to be higher than the battery voltage. Therefore, an array voltage value less than the battery voltage during normal operation would indicate a problem.

[3]. **Solar LED Lights:** LED stands for light emitting diode. LED comprises of the chemical compound that gives of the light when direct current (DC) from the battery passes through it. Solar LEDs are available from number of companies in different sizes, shapes and styles. The life of LED is usually very high extending up to 50,000 hours. The LEDs require very little current hence the solar panels of smaller sizes are required for the solar lights with LED lamps.

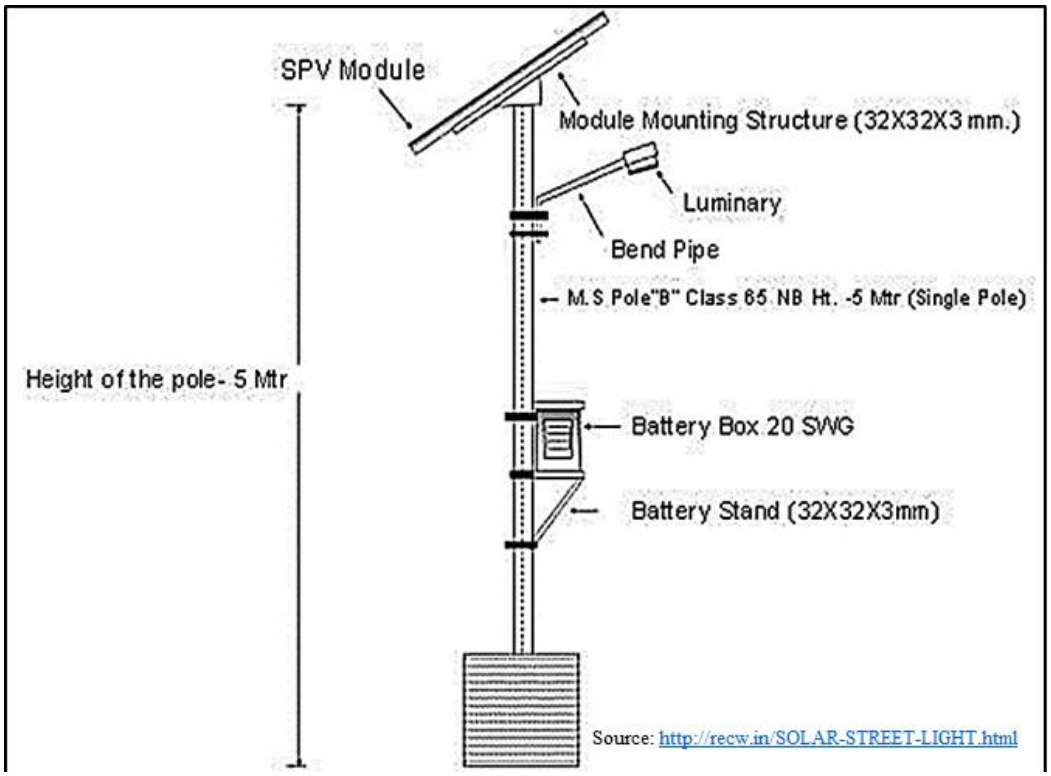

Fig. Solar LED Street Light

Types of Solar LEDStreet Light System

1. Conventional Solar LED Street Light System
2. Integrated Solar LED Street Light System

Conventional Solar Street Lights	Integrated Solar Street Lights
1. Bulky	1. Compact
2. Uses any type of battery	2. Usually uses Lithium-ion battery
3. More autonomy due to larger Ah battery (24-36 hrs)	3. Less autonomy due to smaller Ah battery (12 hrs)
4. Flexible use- direction of PV panel LED lamp can be different	4. Restricted use- same direction of PV panel and LED lamp
5. More ergonomic	5. More aesthetic
6. Relatively expensive	6. Relatively cheaper
7. Source: www.nexcelbahrain.com	7. Source: www.indiamart.com

Table: Difference between Conventional and Integrated Street Light

III. ABOUT DIALUX-EVO AND RELUX

What is Dialux EVO and Relux?

- Dialux-EVO is professional light designing software where we can design, calculate and visualize light professionally – single rooms, whole floors, buildings, street lightning and outdoor scenes.
- Relux is a high-performance, intuitively-operated application for simulating artificial light and daylight. This powerful visualization tool allows for simulation of lighting and sensors in real time for detailed renderings, and an extensive results section to provide a comprehensive report on lighting designs. It can calculate absolute values, national and international standards, and is compatible with CAD and BIM systems, plus a great deal more.

IMPORTANT TERMS IN DIALUX-EVO AND RELUX

- Illuminance: Illuminance is the quantity of light or luminous flux falling on an area of unit surface. It is designated by symbol "E". Unit is LUX. One lux equals lumens per square metre. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface.
- Illuminance is measured as amount of light striking a surface whereas Luminance, is what we measure off of the surface that has light hitting it.

- L-Luminance, IL, I = Incident Light. Illuminance is measuring the incident light. Luminance is what's leaving the surface – L = leaving. Illuminance is measuring incident, luminance is measuring what's leaving.
- Em - maintained illuminance:-Maintained illuminance is 'Illuminance at the time when maintenance is expected to take place.
- SR - surround ratio:-Average illuminance on strip just outside the edges of the carriageway in proportion to the average illuminance on strips just inside the edges.
- Uniformity. Lighting uniformity (which translates to the human perception of how evenly illumination is distributed throughout the parking lot) is expressed as the ratio of maximum-to-minimum illumination levels.
- Uo - overall uniformity:-ratio between minimum luminance level to average luminance level.

IV. LIGHTING CLASS

- **M-Class:**The M classes are intended for drivers of motorized vehicles for use on traffic routes, and in some countries also residential roads, allowing medium to high driving speeds.
- **C-Class:**The C classes are also intended for drivers of motorized vehicles, but for use on conflict areas such as shopping streets, road intersections of some complexity, roundabouts and queuing areas.
- **P-Class:**The P classes or the HS classes are intended for pedestrians and pedal cyclists on footways, cycle ways, emergency lanes and other road areas lying separately or along the carriageway of a traffic route, and for residential roads, pedestrian streets, parking places, schoolyards, etc.
- The **SC classes** are intended as an additional class in situations where public lighting is necessary for the identification of persons and objects and in road areas with a higher than normal crime risk.
- The **EV classes** are intended as an additional class in situations where vertical surfaces need to be seen in such road areas as toll stations, interchange areas.

Parameters affecting solar LED street lights are:-

- **Boom angle:** It is the angle that overhang makes with the pole.
- **Overhang length:** It is the length of extruded part of pole on which LED light is attached.
- **Light intensity:** In photometry, luminous intensity is a measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle, based on the luminosity function.
- **Pole spacing:** It is the distance between two poles for getting proper luminous intensity.
- **Panel orientation:** Solar Panel Orientation refers to our azimuth setting. Most of the energy coming from the sun arrives in straight line. A solar panel or solar array will capture more energy if it is facing directly at the sun, perpendicular to the straight line between the position of the panels installation and the sun.

V. ISSUES WITH EXISTING SOLAR LED STREET LIGHT SYSTEM

Common Problems In Street Light System:

Although at different places different street lighting systems are used and have a different approach to their management, there is a range of problems that is common for all of them.

- The first, without any doubt, is the high consumption. Each year, in the world, several trillion kWh are expended on street lighting. A high consumption means a high amount of generated energy, which in turn translates into a high level of noxious emissions.
- Secondly, there are difficulties related to the maintenance of the system. How does the lighting network operator find out that a certain lamp or a component of a street-light came out of action and needs to be repaired or replaced?

Of course, there are solutions for almost all these issues. For example, new, LED-based lamps consume twice less energy and last twice as long as the ordinary HPS or HID lamps and this really solves the high consumption problem.

- The photoelectric sensors will make the lamps light only during the night time. However, now and then, these photo-sensors go out of order or get dusty and then the lamp either won't turn on, or will work throughout the day.
- As to the maintenance problem, people are reporting idle lights. Almost every municipality or street lighting network owner has a web page, which assists people to communicate about broken lamps, using a special form or through the telephone.
- However, it is unlikely the information will reach the dispatcher immediately after the lamp goes out of order and the delay between the time the lamp is broken and it is repaired can be quite long. In addition all these solutions also have a significant disadvantage – they are isolated and fragmented, and treat each problem separately and not the system as a whole.

Now we will talk about what are the issues with existing design of solar street light.

1. The design is not application-oriented:-Lightning classes are not taken into consideration means whether the user has to install it at park, roadways, accident-prone areas etc. There is a single design of pole which is used for every application without considering what type of luminous intensity and how much luminous area will the light cover.
2. When the manufacturer of street light is asked to install and his only question is what is the LED wattage required and based on that they give the street light system without any calculations how much pole length is required?
3. As the pole height is taken by assumption this results in either luminous intensity is very high due to low height or luminous intensity is very low due to high height. Luminous area is also affected by pole height.
4. As the manufacturer only asks about LED wattage and does not take into consideration the spacing between poles. As the spacing between poles are not considered this results in following disadvantages:
    - Due to improper spacing there are various blind spots created (where intensity of light is low or there is no light).
    - Over the same area if no of poles required are 4 by calculation but as calculation is not done no of poles can be more or less which will affect the luminous intensity
    - As the no of poles required are not proper it may unnecessarily increase the cost of the system.
5. Boom angle is a very important factor while considering the design of Street light. No manufacturer gives proper attention to this parameter thereby affecting the intensity of light.
6. Solar panel size and orientation is not proper which results in less charging of battery and due to this battery runs dry after working for some hours and not fulfilling the purpose.
7. Proper solar declination angle is not taken into consideration which greatly affects the efficiency of solar panel.

VI. PERFORMANCE ENHANCEMENT DONE USING DIALUX-EVO AND RELUX

What is Dialux-Evo and Relux?

In the software there are various governing parameters so here is the glimpse of the software which we have used while doing the calculation and designing part of the project.

1) Relux
2) Dialux-Evo

Procedure on how to use Relux-Software:

- It is an open-ware software which can be directly downloaded from the internet.
- In Relux we have to select Road lightning module.
- After selecting road lightning module, a new window will appear where it will be showing a 2-D representation of road.
- We have to input parameters such as road width, walkways, emergency lane etc.
- After giving road width and other parameters we have to now go for adding lightning module.
- After clicking on lightning module you will be ask to choose the light from various available luminaire catalogues available online.
- After selecting luminaire catalogues we have to input parameters such as Boom angle, pole spacing, Overhang length, height of pole etc.
- After these step we have to select lightning class as per our required applications.
- After selecting the results table will appear which will show whether our input parameters were right or wrong.
- We can manually input values or run simulation which will give us the results.
- After the results are given we have to go for a LDC function which will tell us how the intensity of light will fall on surface.

The Procedure of using Dialux-Evo software is same as using Relux software.

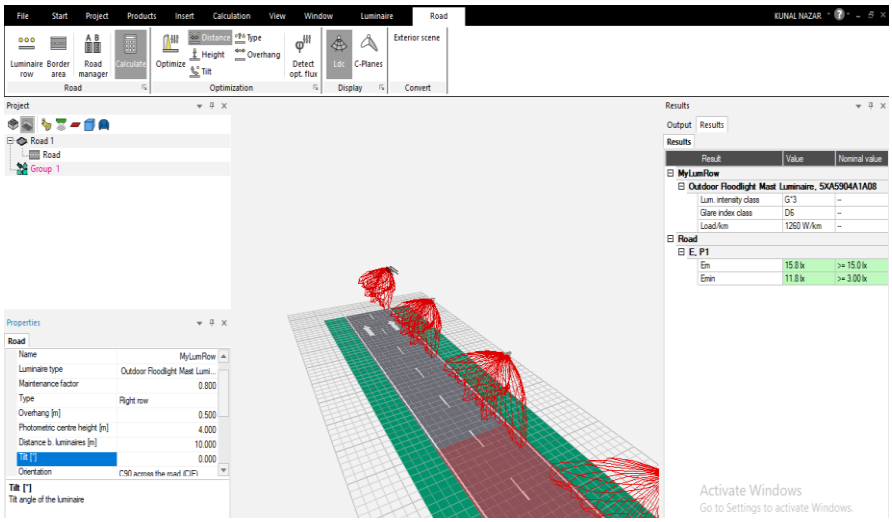

Fig. Use of LDC function in software

This Figure shows on how the Light distribution curve works. Curves in red shows that how the light intensity will fall on ground.

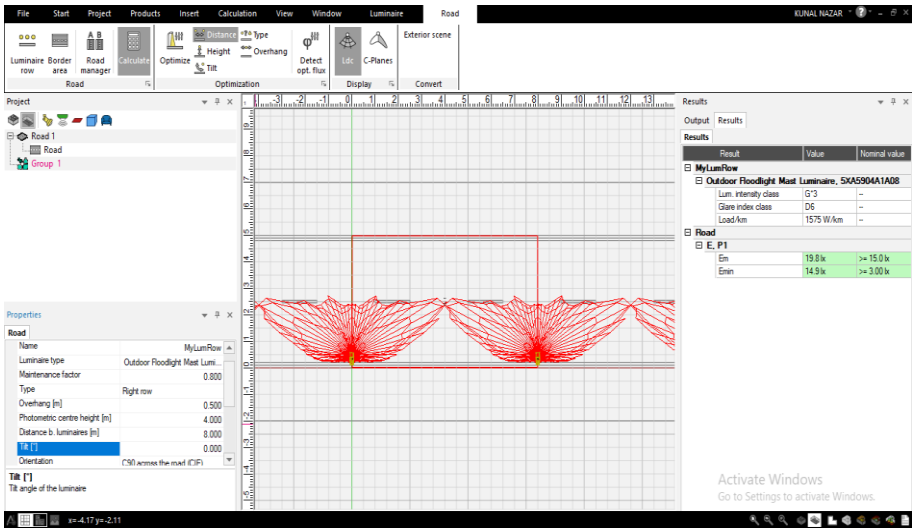

Fig. Variation of distance

In this figure under properties of road some parameters can be seen.The parameters are:

- Distance between Luminaires
- Photometric height
- overhang.

In the below diagrams we have used our 1st parameter Pole spacing to see how it effects the light intensity.

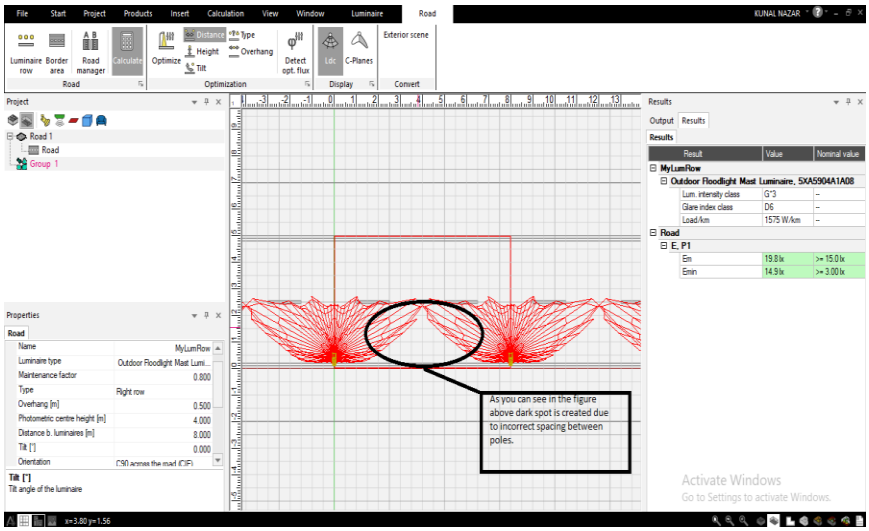

Fig. Pole distance=8 Meters by keeping overhang length=0.5Metre

Dark spot is created due to incorrect spacing. Spacing between pole is 8 metre which is more as compared to desired spacing.

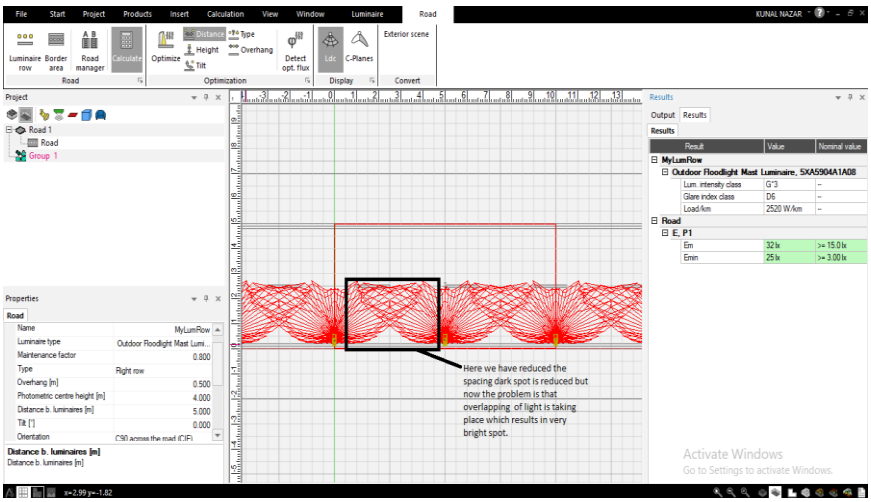

Fig. Blind spot created due to incorrect spacing

Here as have reduced the spacing dark spot is reduced but now the problem arises is that overlapping of light is taking place which results in very bright spot and un-necessary increase in no of poles for a given area.

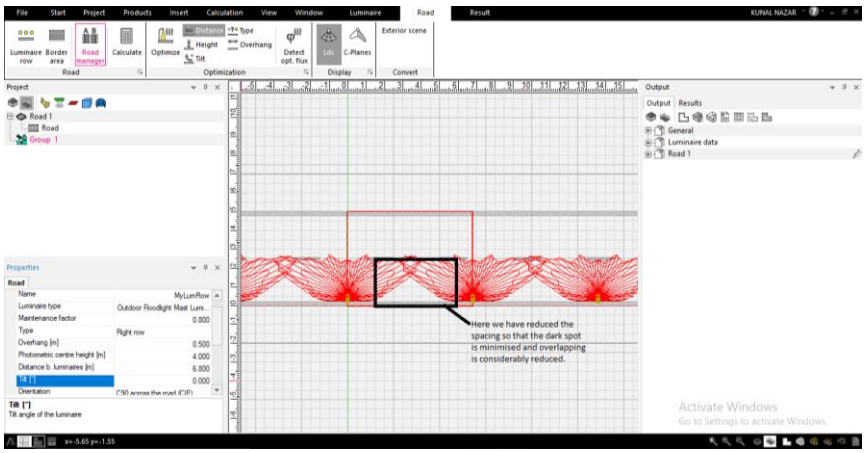

Fig. Blindspot is reduced to min by reducing distance

Here, spacing is adjusted in such a way that the darkspot is minimized and overlapping of light intensity is considerably reduced which also satisfies the E_m and E_{min}.

Now we will be using our 2nd Parameter which is the boom angle to show how it will affect the light intensity of the solar street light led system.

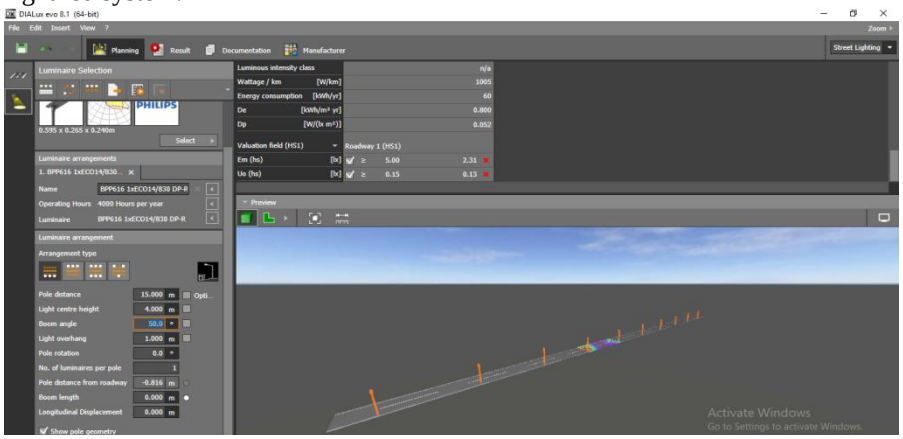

Fig. Boom angle=50 degree

In this figure under luminaire arrangement, Boom angle is seen. Both Em and Uo are not satisfied with 50 Degree boom angle.

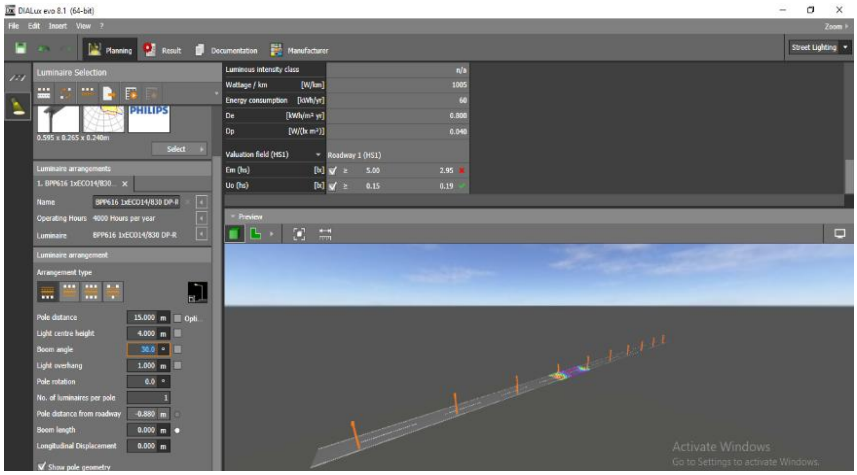

Fig. Boom angle=30 degree

In this figure, by changing boom angle by 30 Degree one parameter Uo is satisfied but other parameter Em is not.

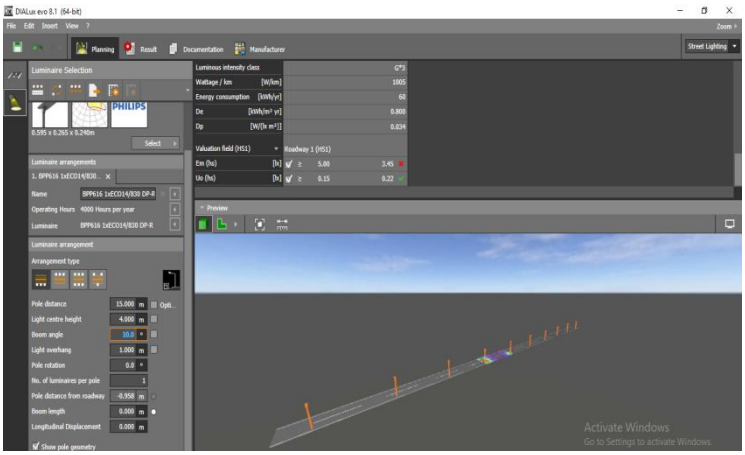

Fig. Boom angle=10 Degree

Here you can see in the figure boom angle is kept at 10 degree value of Uo is satisfied but Em is not satisfied.

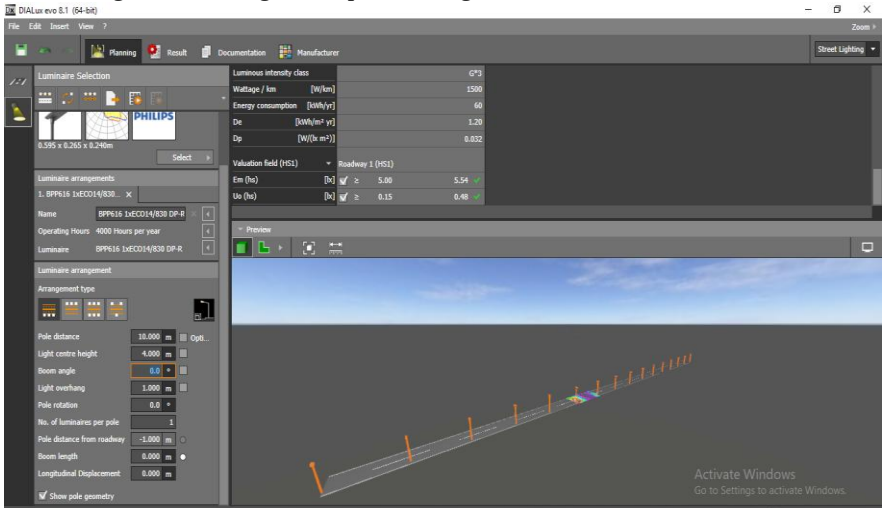

Fig. Boom angle =0 Degree

In this figure, boom angle is kept at 0 degree both the parameter values Em and Uo are satisfied which means that now the light intensity which will fall on the ground will be according the norms.

- After finalizing the parameters by using software we further went to the SolidWorks software for designing the solar street light led system.
- While designing solar led street light system we kept in mind various parameters such as boom angle, pole spacing, overhang length, panel mounting, pole height, LED wattage, Battery size and lightning class in mind and incorporate it into the pole. So after completion of design we fabricated the pole wherein we have given the panel 360 degree rotation plus 0-180 degree inclination angle so that we can change the orientation of panel according to seasonal variation. Overhang is also flexible we can set it to any angle between 0-180 degree depending on the needs of the user. Battery Box is also flexible wherein we can set it at any height we want.

VII.RESULTS

Case: Only one-side arrangement:

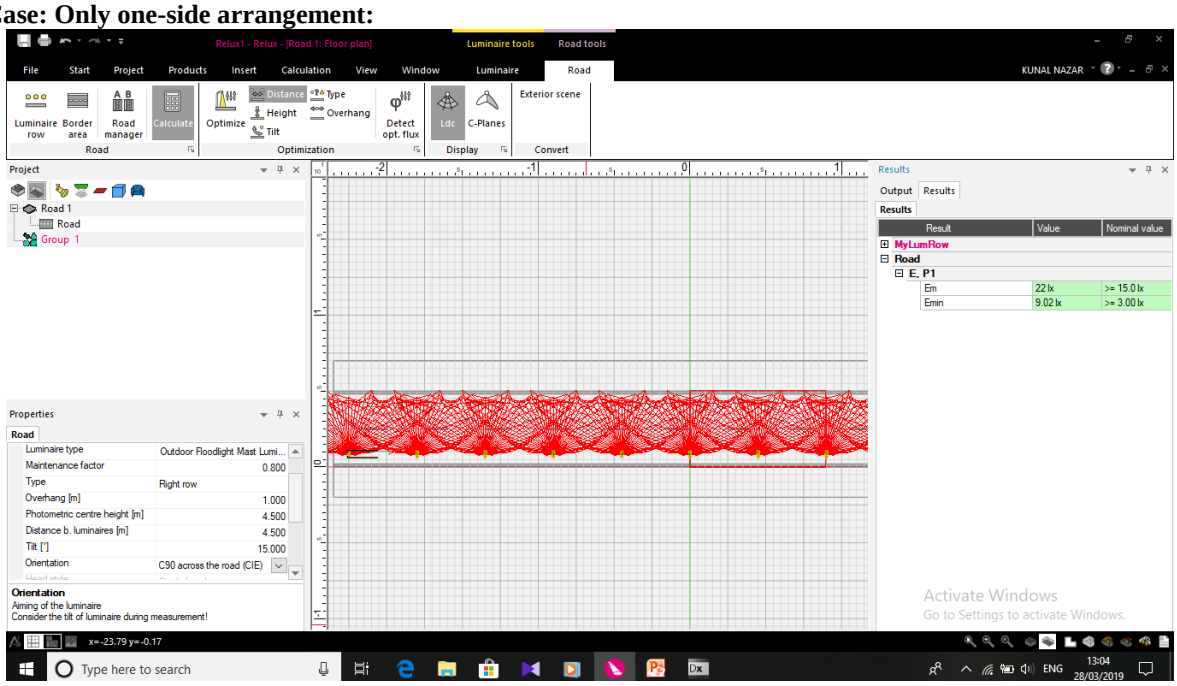

Fig. LDC of only one-side arrangement

In this figure, relux software was used and parameters such as overhang length, boom angle, photometric height were given as input to the software and checked whether the values of E_m and E_{min} are satisfied. Arrangement of pole is kept one-sided.

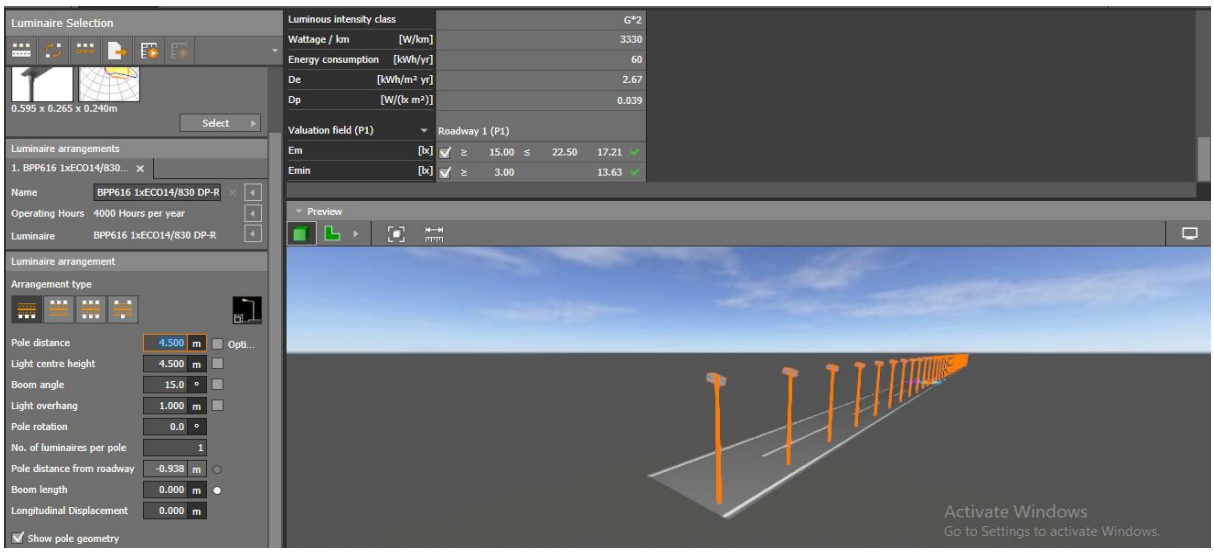

Fig. Only one side arrangement

In this figure, we have used Dialux-evo software and given the same values of parameters as given to relux software and checked whether the E_m and E_{min} are satisfied. Arrangement of pole is also kept one-sided.

Results for one-sided arrangement:
We have taken parameters into consideration for giving or inputting values to the software and found that
For a 15 Watt LED street light (No of luminaries on pole=1)
Distance between pole should be = 4.5 Meters
Boom angle = 15 Degree
Overhang Length=1 Metre
Pole height = 4.5 Metre

Case: Both side arrangement:

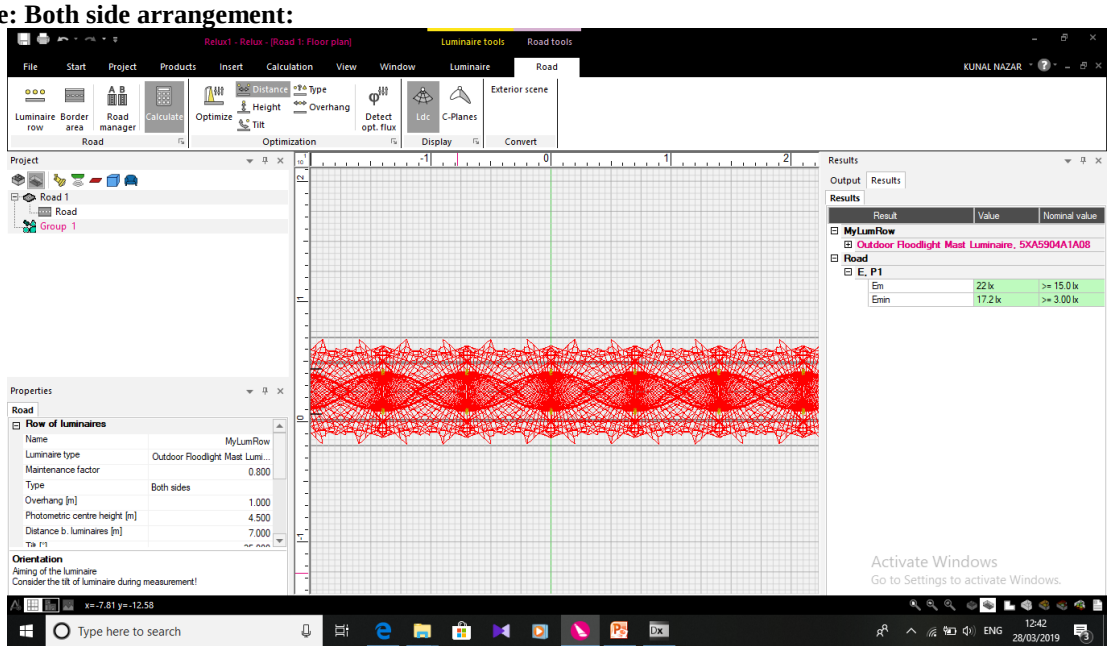

Fig. LDC of both side arrangements

In this figure, we have kept both side arrangements in relux software and given input to parametersand checked whether the values of E_m and $E_{min}$are satisfied or not.As the colour is green of both value and nominal value it means that our set of input values are correct.

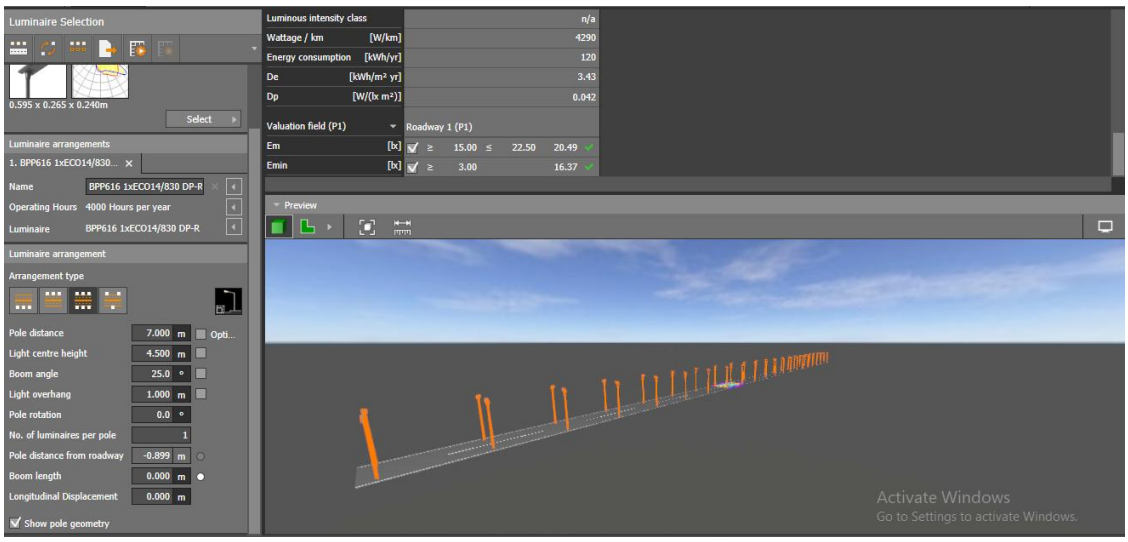

Fig. Both-side arrangement

In this Dialux-evo figure same parameter values are given as relux both sided arrangement. As it shows the green tick on both the values of E_m and E_{min}. It means that our range of input values are correct.

Results for both-sided arrangement:
For a 15 Watt LED street light (No of luminaries on pole=1)
Distance between pole should be = 7 Meters
Boom angle = 25 Degree
Overhang Length=1 Metre
Pole height = 4.5 Metre

Case: Staggered layout or arrangement:

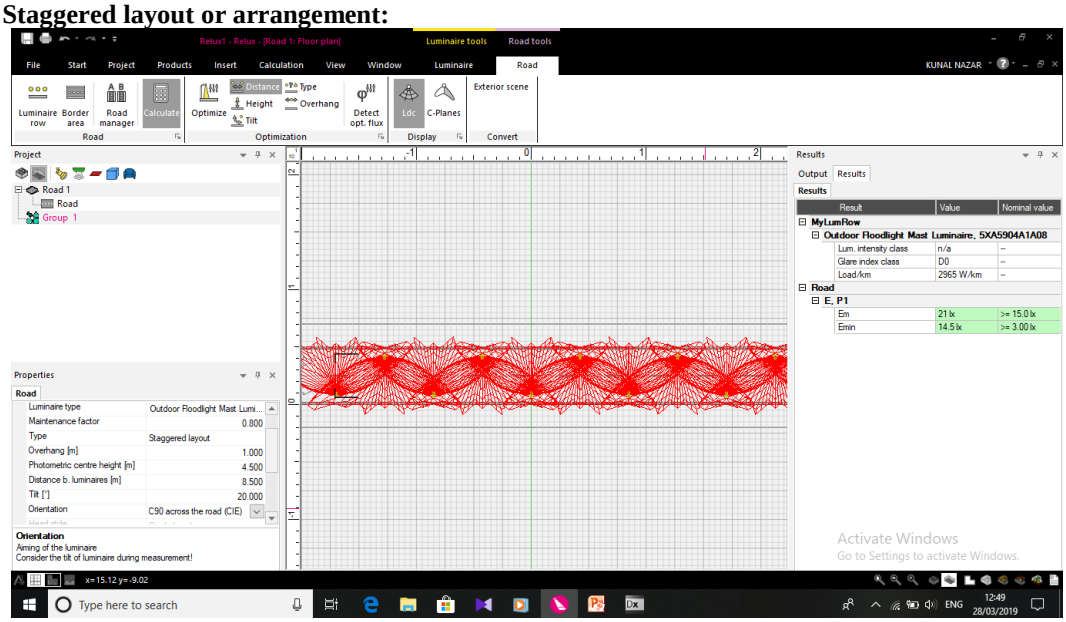

Fig. LDC of staggered layout

In this relux software figure, we selected staggered arrangement as layout and given the values of parameters to the software to satisfy the values of E_m and E_{min}.As the green colour is shown it means our range of values are correct.

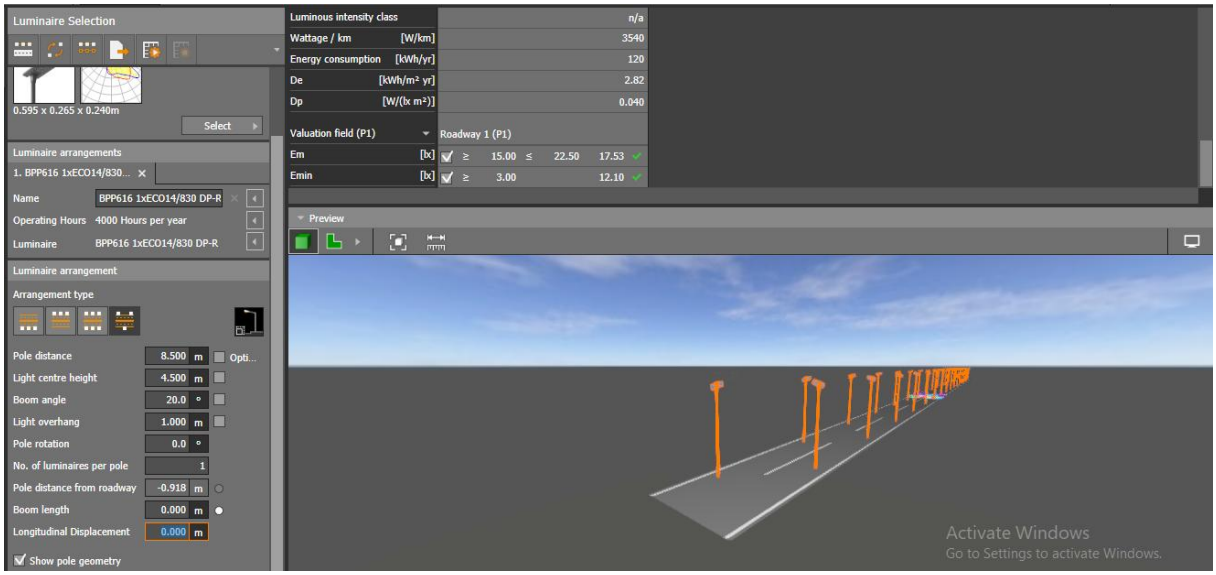

Fig. Staggered layout

In this Dialux-evo software figure same input values were given as relux software and arrangement was selected as staggered to satisfy the values E_m and E_{min}.As the green tick is shown it means that values given to parameters are correct.

Results for staggered layout:
For a 15 Watt LED street light (No of luminaries on pole=1)
Distance between pole should be = 8.5 Meters
Boom angle = 20 Degree
Overhang Length=1 Metre
Pole height = 4.5 Metre

Season	Tilt angle
Summer	10 Degree
Rainy	23 Degree
Winter	40 Degree

Table: Seasonal variation of Solar PV panel tilt angle:

Parameters	One-Sided	Both-Sided	Staggered
Pole Spacing	4.5 m	7 m	8.5 m
Pole Height	4.5 m	4.5 m	4.5 m
Boom angle	15°	25°	20°
Overhang Length	1 m	1 m	1 m
Road Width	5 m	5 m	5 m

Table:Parameters evaluation table for 15 watt LED

Parameters	One-Sided	Both-Sided	Staggered
Pole Spacing	5.5 m	8.5 m	9 m
Pole Height	5 m	5 m	5 m
Boom angle	0°	25°	15°
Overhang Length	1 m	1 m	1 m
Road Width	5 m	5 m	5 m

Table: Parameters evaluation table for 20 watt LED

Parameters	One-Sided	Both-Sided	Staggered
Pole Spacing	12 m	17 m	18 m
Pole Height	10 m	10 m	10 m
Boom angle	0°	20°	15°
Overhang Length	1 m	1 m	1 m
Road Width	5 m	5 m	5 m

Table: Parameters evaluation table for 50Watt LED

Parameters	Existing design	New Design
Panel Orientation	360° rotation only	At any direction possible(360° rotation + 180° tilt)
LED light	15 Watt LED fixed (movement not possible)	15 Watt LED light flexible in design(0° to 180°)
Battery Box	Fixed	Can be kept at any height as per requirement
Battery Charging Time	More	Less as compared to existing design
Light Intensity	Less luminance area	More luminance area(due to flexibility in design)
Price	Rs.16000(GST included)	Rs. 14500(GST included)

Table: Comparison of existing design and new design of solar led street light

Fig. New Design of solar LED street light

VIII. CONCLUSION

Design and performance improvement of a solar powered street light is itself a very complicated task as there are various governing parameters such as the mounting angle of panel, pole spacing, LED fixture angle or boom angle, battery sizing, pole height, LED wattage.

- As a rule of thumb, solar panels should be more vertical during winter to gain most of the low winter sun, and more tilted during summer to maximize the output.
- We have used software like Dialux-Evo and Relux basically a light designing software where we have input parameters which we observed such as Boom angle, spacing, Overhang length, which type of light to select and wattage of light etc. In this software we have used various luminaries catalogues to check whether or decision was right or wrong and go for further processing. Addition of dusk sensor gives an overwhelming advantage of auto turn on/off of light.
- Solar LED street lightning performs better with a solar charge controller connected to battery than with direct connection to battery. Installation cost of solar-powered street light is bit high but the running and maintenance cost is quite low.

IX. FUTURE SCOPE

Dimmable light with proximity sensor can be used which will help in energy savings. Automation can be given to panel orientation so that the panel will automatically change its direction with the sun to absorb more energy. Along with LED light on pole we can add camera for security which will run on solar energy.

REFERENCES

[1]. Ahmed, Sanjana , Ahmed Hosne Zenan, Nisat Tasneem, and Mosaddequr Rahman. "Design of a solar powered LED street light: Effect of panel's mounting angle and traffic sensing." In 2013 IEEE Conference on Sustainable Utilization and Development in Engineering and Technology (CSUDET), pp. 74-79. IEEE, 2013.

[2]. Abhinandan Sharma, Prof. (Dr.) B. K. SHARMA, Hari Singh, Bhanu Pratap Singh. "A Study of Solar Street Light and Optimization For Spacing In Poles And Cost." International Journal of Science, Engineering and technology (2014):1533-1543

[3]. Kumar, Nallapaneni Manoj, Anup Kumar Singh, and K. Vinay Kumar Reddy. "Fossil fuel to solar power: a sustainable technical design for street lighting in Fugar City, Nigeria." Procedia Computer Science 93 (2016): 956-966

[4]. Neha, H., S. Gugri, S. Mishra, and G. Dubey. "Advancements in solar based LED street light." International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering 2, no. 5 (2013): 1880-1884.

[5]. Müllner, Reinhard, and Andreas Riener. "An energy efficient pedestrian aware Smart Street Lighting system." International Journal of Pervasive Computing and Communications 7, no. 2 (2011): 147-161

[6]. Ramadhani, Farah, Kamalrulnizam Abu Bakar, and Muhammad Gary Shafer. "Optimization of standalone street light system with consideration of lighting control." In Technological Advances in Electrical, Electronics and Computer Engineering (TAEECE), 2013 International Conference on, pp. 583-588. IEEE, 2013

[7]. Yoomak, Suntiti, Chaiyan Jettanasen, Atthapol Ngaopitakkul, Sulee Bunjongjit, and Monthol Leelajindakrairerk. "Comparative study of lighting quality and power quality for LED and HPS luminaires in a roadway lighting system." Energy and Buildings 159 (2018): 542-557

[8]. Ali, Mokhtar, Mohamed Orabi, Emad Abdelkarim, Jaber A. Abu Qahouq, and Abdelali El Aroudi. "Design and development of energy-free solar street LED light system." In Innovative Smart Grid Technologies-Middle East (ISGT Middle East), 2011 IEEE PES Conference on, pp. 1-7. IEEE, 2011

[9]. Aung, Nan Su Mon, and Zaw Htet Myint. "Design of Stand-Alone Solar Street Lighting System with LED." International Journal Of Scientific Engineering and Technology Research 3, no. 17 (2015): 3518-3522.

[10]. Myer, Seth Jamison. "Solar-powered light pole and LED light fixture." U.S. Patent 7,731,383, issued June 8, 2010.

[11]. Huang, Bin-Juine, Chun-Wei Chen, Po-Chien Hsu, Wei-Min Tseng, and Min-Sheng Wu. "Direct battery-driven solar LED lighting using constant-power control." Solar Energy 86, no. 11 (2012): 3250-3259

[12]. Vieira, José António Barros, and Alexandre Manuel Mota. "Implementation of a stand-alone photovoltaic lighting system with MPPT battery charging and LED current control." In Control Applications (CCA), 2010 IEEE International Conference on, pp. 185-190. IEEE, 2010.

[13]. Fadaee, M., and M. A. M. Radzi. "Multi-objective optimization of a stand-alone hybrid renewable energy system by using evolutionary algorithms: a review." Renewable and Sustainable Energy Reviews 16, no. 5 (2012): 3364-3369

[14]. Kovács, András, Roland Bátai, Balázs Csanád Csáji, Péter Dudás, Borbála Háy, Gianfranco Pedone, Tibor Révész, and József Váncza. "Intelligent control for energy-positive street lighting." Energy 114 (2016): 40-51.

[15]. Hariprakash, B., S. K. Martha, S. Ambalavanan, S. A. Gaffoor, and A. K. Shukla. "Comparative study of lead-acid batteries for photovoltaic stand-alone lighting systems." Journal of Applied Electrochemistry 38, no. 1 (2008): 77-82.

[16]. Rezk, Hegazy, and Abou Hashema M. El-Sayed. "Sizing of a standalone concentrated photovoltaic system in Egyptian site." International Journal of Electrical Power & Energy Systems 45, no. 1 (2013): 325-330.

[17]. Lagorse, Jeremy, Damien Paire, and Abdellatif Miraoui. "Sizing optimization of a stand-alone street lighting system powered by a hybrid system using fuel cell, PV and battery." Renewable Energy 34, no. 3 (2009): 683-691

[18]. Jeremy Lagorse, Damien Paire*, Abdellatif Miraoui"Sizing optimization of a stand-alone street lighting system powered by a hybrid system using fuel cell, PV and battery", (2008), pp.683-691.

[19]. Prof. Bhargav B Patel, Prajapati Kinjal, Gupta Vinnie, Patel Deval"Solar Smart LED Street Lighting System." International Journal of Advance Engineering and Research Development,vol.2.pp.1277-1282.2015

[20]. Mardikaningsih, Ika Shinta, Wahyudi Sutopo, Muhammad Hisjam, and Roni Zakaria. "Techno-economic feasibility analysis of a public street light with solar cell power." In Proceedings of the International MultiConference of Engineers and Computer Scientists, vol. 2, pp. 16-18. 2016.

[21]. Chauhan, Anurag, and R. P. Saini. "Techno-economic optimization based approach for energy management of a stand-alone integrated renewable energy system for remote areas of India." Energy 94 (2016): 138-156

Dhairyasheel Shivaji Ambhore, et. al. "Performance Enhancement of Solar Powered LED Street Light System." *International Journal of Computational Engineering Research (IJCER*), vol. 10, no.9, 2020, pp 20-35.