Regulating Solar LED Array with Vehicle Detection to Turn Streetlight On or off To Save Energy

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***Abstract*— Vehicle detection mechanism would save energy and that energy can be given to grid station. If any movable object is 60m at a distance then streetlight will be switched on to lux a road and when object crossed then same will be switched off. Streetlights are on along local roads, motorway, highway but to name a few, for all times as they are not having an automatic control to drive LED (Light Emitting Diode) path light either on in the time of evening and night or off in day time with detection of light dependent resistor. Specially, implementing solar driven LED way lights will decrease wastage of energy due to revealing of rays intensity by LDR. This segment, LED Streetlights, is important for public as it will reduce accidents and severe incidents occurring along road. Resourceful programmed sensor will be an all-time active component of this very smart system. Inventive mechanism to make less use of, besides being proficient, Photovoltaic panels to light LED-Array motorway tower would be an added edge to a poor country where road are not getting light so that public could travel along it without having hesitation there any source of light. LED Solar arrays is being implemented with single axis solar tracker to make efficiency high and motion sensor to detect vehicle nearby 60m to on the streetlight.**

***Index Terms*— Automation, Control, Energy Crisis, Energy, Light Dependent Resistor, Light Emitting Diode Shortfall, Mechanism, Regulate, Streetlights, Solar Driven Intensity.**

I. INTRODUCTION

THIS smart streetlight mechanism is a need of an hour, twenty years back, there were less quantity of streetlights because in that time urbanization was not in rapid pace to grow higher and higher. At the moment as people are shifting from rural vicinities to urban neighborhoods, so number of streetlights seem to be increased so that people could enjoy their living and travelling along roads happily without any danger. Little investment was being done in this segment of energy but nowadays major concentration is going on to boost up solar powered driven LED streetlights as they are easy to implement, reliable, flexible, need low maintenance cost and no repair they need again and again [1] [2].

Design of LED highway lights will encounter several consideration with respect to multiple factors, like efficiency of solar panels, either to use crystalline family cells, which are mono crystalline and polycrystalline, or to make use of amorphous silicon cells, and other factors are cost, reliability duration to name a few. Monocrystalline gives more efficiency than both polycrystalline and amorphous, but its cost is more also. And amorphous silicon is less efficient than both crystalline cells. However, cost effectiveness and efficiency of streetlights are the two major concerns of this research work.

Solar motion detector is the edge of this research as it will sense vehicle and any other object nearby it to by 60m along one particular streetlight to be switched on and when there is no traffic on road then all streetlights would be off to save energy to supply it to grid station. Orthodoxly, low and high pressure sodium streetlights were being used along with metal halides, but now LED streetlamp arrays have strength and more comfortable characteristics to replace those traditional streetlight like metal halide, low pressure mercury vapor and so on [3] [5]. LED lampposts are durable to use while other road lanterns are having less efficacy than formers. Electrical power is available in this deprived nation-state in less extent, its public must use those means that consume less power white they must be vigorous and healthy for environment [4] [7].

II. COMPARISON OF HIGH PRESSURE SODIUM BULB AND LED ARRAY ALONG MOTORWAY

For given distance, HPS (High pressure Sodium) lamps consumes more wattage than growth-oriented LED array.

Table 1
Comparative investigation of HPS lights and LED Arrays

Region	Height Pole	High Pressure Sodium	LED Collections/Arrays	Using LED for 5000 poles saving power
Division/Sector	8 m	80 W	45 W	175,000 Watts
Service Lane	14 m	160 W	90 W	350,000 Watts
Highway/Motorway	18 m	250 W	120 W	650,000 Watts

Survey was made and investigated on highway when one streetlight of HPS was consuming 250 Watts while LED giving

same lightening lumen of lux with 120 Watts, on service lane, HPS is getting 160 Watts for illuminating road where LED array needs only 90 Watts to brighten that region's service lane. Moreover HPS bulb needed 80 Watts to provide lightening to sector while 45 Watts of LED does same function on less power. Installation of 20,000 poles for certain city of Pakistan, by doing this we could save a lot of energy by switching from traditional bulbs, such as low pressure mercury fluorescent lamps and energy tubular fluorescent lamps to LED streetlamps. When these LED arrays will be used with solar power then obviously huge burden of energy crisis will be reduced. As solar power is easy to be received from Solar rays so it is vital combination of LED arrays for sensor based streetlight lux and Solar driven power through Photovoltaic panels, made from PV cells, to be used to fill up gap of energy shortfall. Lux is the SI unit of illumination, equal to one lumen per square meter [5] [6].

III. ELECTRICITY COST YEAR WISE INCREASING IN HIGH PRESSURE MERCURY VAPOR AND HPS

In table 2, here only one hundred lights are being examined, just take an assumption if installation of LED arrays will be made then there will be not yearly and monthly billing.

Table 2
Cost Analysis for HPS 50 Streetlights in one year

Data	Rate/Cost
Power for 100 lights(250W per HPS)	25 kW
Connection with power factor 0.9	27.7 Kva
Streetlight running 9 hours daily	225 kWh
Streetlight running 9 hours yearly	82125 kWh
Price 11 per kWh, Energy(1) cost	903,375 PKR
ToD (Time of Day) Tariff (15 percent on energy cost (2)	135,506 PKR
Static Charges 200PKR per kVA for 140kW (3)	28,000
(4)->Additional cost on (3) with 8 percent yearly	2,240
(5)->Extra cost as surcharge of 7 percent on (1) and (2) yearly	72,721
(6)->Electricity Tax of 6 percent on (1) and (2)	62,332
(7)->Billing for One Year (1)+(2)+(3)+(4)+(5)+(6)	1,204,174

Only maintenance and repair cost would be there, but in HPS there will be monthly billing and inflation should also be considered as rates of electric power is increasing time and again.

IV. INFLATION RISE ON ELECTRICITY BILLING

If we consider inflation for next twenty years with 4 percent inflation per year, so increment on billing would be there year by year. This analysis is given in table 3.

Table 3
Increment year by year in electricity billing

Next years	Electricity Billing PKR	Rise by 4 percent on previous year's bill PKR	Resultant Billing after rise of previous years PKR
2nd	1,204,174	48,166	1,252,340
3rd	1,252,340	50,093	1,302,433
4th	1,302,433	52,097	1,354,530
5th	1,354,530	54,181	1,405,711
6th	1,405,711	56,288	1,461,939
7th	1,461,939	58,477	1,520,416
8th	1,520,416	60,816	1,581,232
9th	1,581,232	63,249	1,644,481
10th	1,644,481	65,779	1,710,260
11th	1,710,260	68,410	1,778,670
12th	1,778,670	71,146	1,849,816
13th	1,849,816	73,992	1,923,808
14th	1,923,808	76,952	2,000,708
15th	2,000,708	80,030	2,080,738
16th	2,080,738	83,229	2,163,967
17th	2,163,967	86,558	2,250,525
18th	2,250,525	90,021	2,340,546
19th	2,340,546	93,621	2,434,167
20th	2,434,167	97,366	2,532,533

Now referring to table 4, installation cost of these 100 HPS or low pressure mercury fluorescent lamp lampposts is around 600,000. Therefore 100 HPS lights cost PKR **3,132,533** a very hefty amount.

Table 4
Total expenditures after 20 years

After 20 years Billing	2,532,533
Installation cost per 100 HPS lights	6,000,000
Total Cost after 20th year	3,132,533

In table 5, now we would examine the 100 LED arrays based on Solar driven power.

Table 5
Comparative analysis between 100 Solar based LED arrays and 100 HPS lamps powered by WAPDA

Total cost of 1 LED Array	100 LED array sets cost for 20 years	100 HPS total cost for 20 years	Saving per 4 km	Saving per 400 km (10000 LED Array set)
15000	1,500,000	3,132,533	1,632,533	163,253,300

It will familiar us how LED solar arrays are cost effective as compared to traditional low and high pressure mercury or sodium lamps running on electric power supplied by grid stations.

V. LDR MECHANISM AND INTENSITY REGULATION

It is highly needed that streetlights should be switched on through detection by LDR (Light Dependent Resistor) from dusk to dawn (evening to morning). LDR senses light according to Sun rays intensity, it generates proportional voltages, and so through circuit it is being operated on which level of ray's intensity, LED Solar array street lantern will be giving lux of lumen as illumination [4]. LDR is shown in Figure 1.

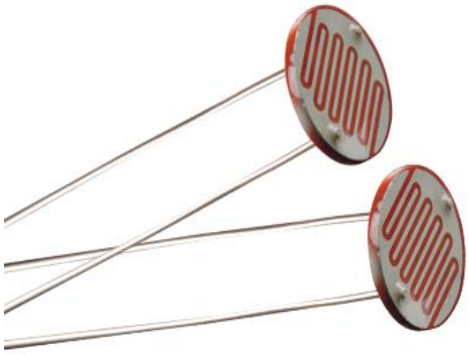

Fig 1. Light Dependent Resistor

In night time as illumination (lux) from Sun rays as intensity is not preset, therefore LDR's resistance gets high, when dusk gets conversion into dawn, finally in clear morning and daytime on the whole, LDR's resistance decreases as luminance from Sun rays reaches more and more [5] [6]. Figure 2 depicts the scenario.

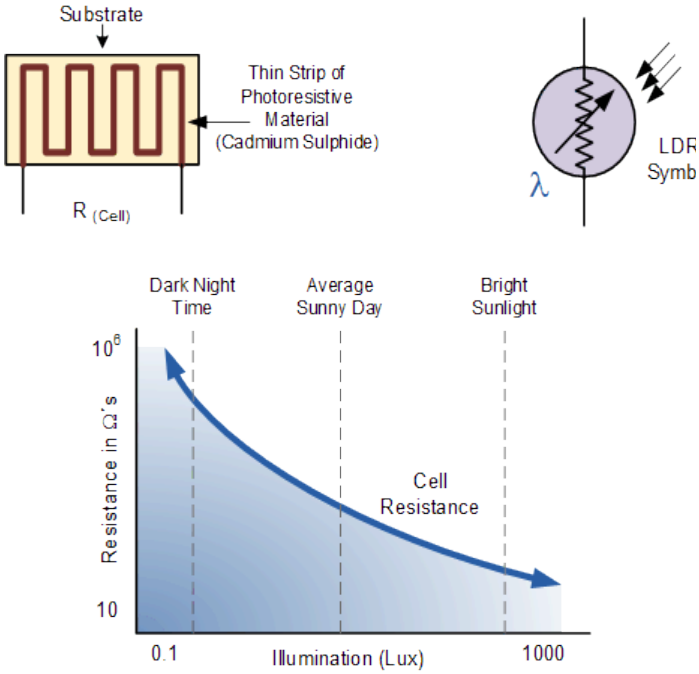

Fig 2. Ohm vs lux curve of Light Dependent Resistor

VI. BATTERY CHARGING AND DISCHARGING WITH GRID STATION CONNECTIVITY

Battery, Figure 3, is attached to pole it gets charging during day time while in night time it gets discharge to alight LED array. If there is sufficient energy is present in more or less batteries at 7am, of 1000 (2500kW) LED arrays' batteries, then this large amount of stored power goes to grid station so that an additional wattage should be added for consumption in households or other usage by public [8]. Voltage Sensor would investigate required number of batteries either they are having voltage at 7am to share with grid station or not.

Fig 3. Streetlight Batteries charged by Solar Panels

Inverter would be needed to convert DC into AC so that this supply could easily be transported into grid station [9] [10]. Sharing of energy from LED arrays' batteries to grid station is shown in figure 4. Therefore DC/AC converter is must. And beside this charge controller will be in between solar panel and battery to regulate storage from PV cells.

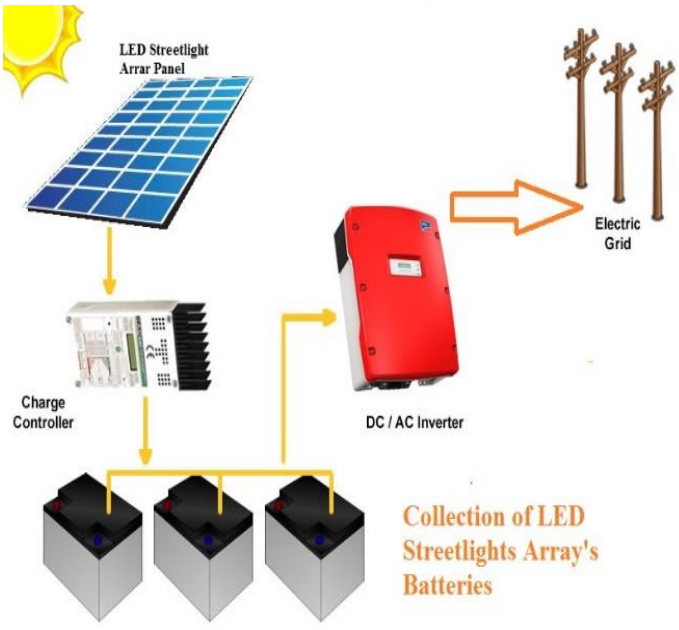

Fig 4. Supply from Batteries to Grid Station

VII. MOVEMENT OF SLOPE ANGLE FOR SOLAR PANEL

Due to changes in weather Sun rays intensity changes via direction, for that solar panel slope should be adjustable from 10 degrees to 20 or even 30 degrees, figure 5, so that by manually or automatically (expenses will increase) solar casing

for panel would be moved according to Sun rays direction in such a ways that rays should hit panel in parallel manner.

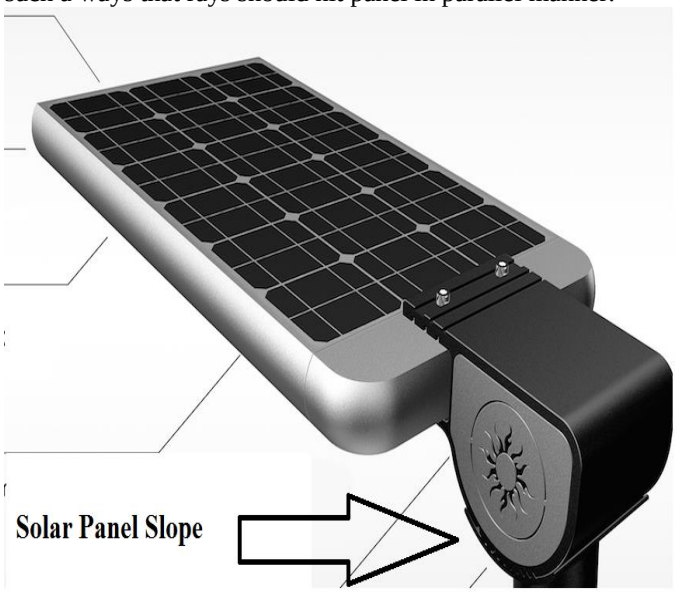

Fig 5. Slope from 10 to 20 degrees for movement of panel

In southern Pakistan, polycrystalline is optimum while in northern areas of Pakistan, monocrystalline should be implemented to charge the batteries as it gives good efficiency even in foggy and cold weather. Amorphous should not be used anywhere in Pakistan's streetlights as it has lower efficiency than both cells of crystalline family.

VII. RANGE SENSOR FOR OPTIMIZATION OF ENERGY USE AND SUPPPY TO GRID STATION

Distance detector is key component of this smart streetlight arrangement. Figure 6 gives insight to this phenomenon, with help of it, any object coming near to LED streetlight array by sixty meter, that particular light would get switched on when object crosses that streetlight and moves way 60m then that same LED array set will get off to save the energy from wastage and share with grid supply.

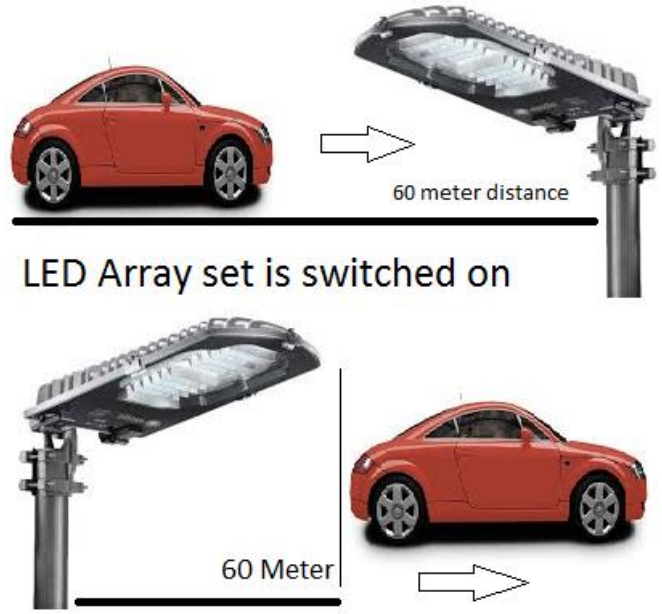

Fig 6. Range Sensor phenomenon

The integrated system of these components, batteries, range sensors, LED arrays, solar panels, LDRs and to name a few, are most vital for this clever module for path lighting.

IX. RESULTS

By implementing suggested solar LED arrays streetlights arrangement, certainly as it was investigated in tables 1, 2, 3, 4, and 5, there appeared such a gigantic advantage to use LED array sets over orthodox metal halides and low pressure sodium lamps to name a few. Over 3 billion Pakistan rupees would be saved in case of installation of 8000km with 200,000 LED streetlights over HPS traditional lamps. Lux given by 110W LED array set are same as given by high consumable 250W HPS bulbs, therefore it is need of an hour to replace HPS with LED array sets and that is why no one needs to use HPS as streetlight now. Therefore Pakistan's government would save 3,265,066,000 (More than 3 Billion only for 200,000 streetlights in 8000km), now just imagine if consideration is made on all installed streetlamps by replacing with LED Solar array sets of Pakistan's streets, highways, motorways and local roads then clearly a more big amount would be saved for national exchequer. 50,000 kW (50MW) would be added daily or on alternative day.

Table 6

Saving in 20 years by replacing HPS with Solar LED array sets

Saving from LED arrays to grid supply 50,000 kWh daily	Saving In one month	Saving in one year	Saving in 20 years
2.2 million For 4 hours sharing	66 million	24.09 billion	481.8 billion

Saving of around 482 billion in 20 years by installing 200,000 LED streetlights based on solar energy integrated with grid supply in reducing burden of energy crisis being faced by Pakistan.

X. CONCLUSION

This smart street lighting system sounds good as each and everything was being investigated in tables and figures by examining root feature from every corner and nadir vs zenith points were also considered. It has been proposed that assimilated solar driven LED streetlights connected to grid supply would be an edge to nation grid supply and we would get rid of energy wastage. Such a huge saving would be made to serve needy people of this pitiable nation-state. Public of this poor country needs resource to fill gap of energy demand and supply of 4554 MW as our generation of electricity is only around 12,586 MW against demand of approximately 17,140 MW. Saving given by LED arrays will be 482 billion in 20 years. Moreover, the electric supply which is going on to alight high power sodium and metal halides streetlamps that wastage of energy will also be stopped by installing LED array sets. Lumen of traditional HPS depreciates day by day and quality in LED road lights is high as it reduces severe incidents and

crimes. LED array sets have extensive and anticipated life while high power sodium light bulbs do not have broad life and they are highly consuming wattage bulbs (LPS or HPS).

References:

[1] Wu Yue, Zhang Xianghong, Shi Changhong, and Yang Wei. "Design of new intelligent street light control system, Control and Automation". Conference ICCA, 2010 8th IEEE International Conference on, p.1423, 1427, June, 9 to 11, 2010.

[2] Yang Tao, Hu Jian-Bin, Lingbo Kong, Yinyang Wang and Chen Zhong. "A Simulative Platform Evaluate the Power-Saving Rate of the Intelligent Street Lamp System", 9th International Conference on Autonomic & Trusted Computing (UIC/ATC). Ubiquitous Intelligence & Computing

[3] Yusaku Fujii, Noriaki Yoshiura, Akihiro Takita, Naoya Ohta. "Smart street light system with energy saving function based on the sensor network". DOI: 10.1145/2487166.2487202, Conference: Proceedings of the fourth international conference on Future energy systems

[4] Alexander Malaver, Felipe Gonzalez, Nunzio Motta, Peter Corke. "Development and Integration of a Solar Powered Unmanned Aerial Vehicle and a Wireless Sensor Network to Monitor Greenhouse Gases", Sensors 2015, 15, 4072-4096; doi: 10.3390/s150204072, Sensors ISSN 1424-8220 www.mdpi.com/journal/sensors

[5] P. P. Desal, Prof. P.Panchal, V.H. Atodariya, A.P.Parmar. "Solar LED Streetlight Using Motion Sensor and Single Axis Control" published in International Journal of Advancements in Research & Technology, Vol. 2, Iss. 5, May-2013 ISSN 2278-7763 480

[6] Ahmed Sharique Anees, Ayushy Chowdhary, Anupriya, Shalini Dubey, Shweta Verma. "Solar Powered LED Streetlight with Automatic Intensity Control" published in (IJIREEICE) International Journal of Innovation Research in Electronics, Electrical, Instrumentation and Control Engineering, Volume. 3, Issue 6, June 2015, 10.17148/IJIREEICE.2015.3606 32

[7] Akshay Balachandran, Shriram K. Vasudevan, V. Parthasarathi, Murali Siva, Surya. "An Innovation in the Field of Street Lighting System with Cost and Energy Efficiency" published in Indian Journal of Science and Technology, Volume 8, Aug 2015

[8] Y M Jagadeesha, S Karthika, S Akilesha, and Prasantha. "Intelligent Street Lights" Science Direct Elsevier Ltd. SMART GRID Technologies, August 6-8, 2015, 2212-0173 © 2015, doi: 10.1016/j.protcy.2015.10.050, www.sciencedirect.com

[9] Shagun Malhotra, Vivek Kumar. "Smart Street Lighting System: An Energy Efficient" International Journal of Science and Research (IJSR), Volume 5 Issue 2, February 2016, ISSN (Online): 2319-7064, Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611, www.ijsr.net

[10] Parkash, Prabu V, Dandu Rajendra, "Internet of Things Based Intelligent Street Lighting System for Smart City" "International Journal of Innovative Research in Science, Engineering and Technology". An ISO 3297: 2007 Certified Organization) Volume. 5, Issue 5, May 2016, IJIRSET DOI:10.15680/IJIRSET.2016.0505181 7684

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