

# SOLAR POWERED LED STREETLIGHT WITH AUTOMATIC INTENSITY CONTROL

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**Abstract:** As we all know that energy consumption has increased a lot and sources of energy are limited so in order to meet the increasing demand of energy use of renewable sources of energy is a must. Keeping this in mind in this paper we are discussing about SOLAR LED STREET LIGHT WITH AUTO INTENSITY CONTROL.This street light is driven by solar energy and apart from this it also controls its intensity from dusk to dawn depending upon the brightness. A case study is also done to show advantages of solar led street light compare to that of traditional street light. This street light can save a large amount of electricity compared to the tradition one which are alight to their maximum intensity at all times after they are switched on.

**Keywords:** Lux, lumens, efficacy, colour retention.

## I. INTRODUCTION

The main function of the streetlight is to illuminate the street at dark hours. Earlier, the street lighting was very simple and also accounted for less investment as the number of streets were less . But, with rapid urbanization the number of streets increased rapidly and this led to increase in number of street lights and investment associated with them.[1]. For designing a proper street light various factors are to be considered which includes its efficiency to provide proper lighting on the street, its harmful environmental effect, installation and running cost etc. So before designing a street light all these factors should be considered properly and efforts should be made to incorporate technologies which are mosrecost effective like the one we have discussed here “SOLAR LED STREET LIGHT WITH AUTOMATIC INTENSITY CONTROL”.[2]There are various types of street lights according to the lamp used such as incandescent light, mercury vapour light, metal halide light, high pressure sodium light, low pressure sodium light, fluorescent light, compact fluorescent light, induction light and LED light..For the past several years high and low pressure sodium lamps have been used for street and security lighting but improved LED technology and their lower prices have the potential to replace them in future. The efficacy and life span of various street lighting technologies are shown in table1.[3]

TABLE 1: COMPARISON OF EFFICACY AND LIFE SPAN

Type of lamp	Luminous efficacy (lm/w)	Colourretentation property	Lamp life (in hr)
High pressure sodium	50-150	Fair	15,000-24,000
Low pressure sodium	100-190	Very poor	18,000-24,000
High pressure mercury vapour	35-65	Fair	10,000-15,000
Metal halide	70-130	Excellent	8,000-12,000
Low pressure mercury fluorescent lamp	30-90	Good	5,000-10,000
Energy efficient tubular fluorescent lamp	100-120	Very good	15,000-20,000
Light emitting diode	70-160	Good	4,000-90,000

Led can easily replace traditional street light lamps because they have higher efficacy and longer life apart from this they are compact, robust and requires comparatively less power. They are very flexible towards new technology so concept of automatic intensity control

is easily applicable to them. Automatic intensity control is a simple and beneficial concept in which street light controls its intensity according to the brightness of the surrounding. Street light is automatically switched ON when the sunlight goes down and is automatically switched OFF when there is sufficient sunlight. This function is done by a sensor called Light Dependant Resistor (LDR) which senses the light actually like our eyes. This system removes manual work of switching ON and OFF of street light.

## II. A CASE STUDY FOR REPLACING CONVENTIONAL STREET LIGHTING SYSTEM (HPS) BY SOLAR LED STREET LIGHT.[4]

A comparative study between traditional HPS street light and LED street (for 1km) was done at three different locations in Gr.noida. Table below shows wattage of HPS bulb and LED array for same lux.[5]. Table 2 gives wattage comparison of HPS and Led array for the same lux and pole length.

TABLE 2: HPS vs LED WATTAGE

Area	Hps	Led array	Pole length
Highway	250 W	110 W	20 m
Service Lane	150 W	90 W	15 m
Sector	70 W	40 W	10 m

Fig 1 is graphical representation of table 2

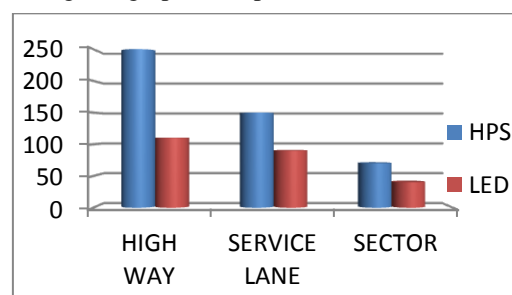


FIG:3 WATTAGE COMPARISON

A plot for lux vs distance from the pole on either side is shown in Fig. 2. It is showing the distribution pattern of lux.

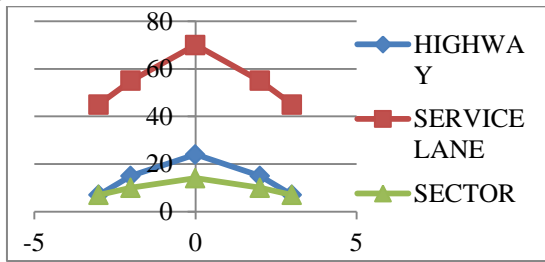


FIG:2 LUX VS DISTANCE FROM THE POLE

### A. CASE STUDY 1 NOIDA-GR.NOIDA EXPRESS WAY

Noida-Gr.noida express way was inaugurated in 2002. It was built at a cost of Rs.400 crore. It begins at sector 15 and ends at Alpha commercial belt in Gr.noida. It has six lanes and extends upto 24.53 km[6].250 watt hps bulbs are used in these streetlights and there are 50 streetlights in 1Km.

#### A1. COST CALCULATION FOR FIRST YEAR i.e. ELECTRICITY BILL+ INSTALLATION COST[7]

Table 3 gives the installation cost of 50 HPS street light along with the total electricity bill for one year.

TABLE 3: TOTAL COST FOR FIRST YEAR

TOTAL POWER NOT DRAWING FROM GRID IN KW	12.5
IF WE TAKE A CONNECTION OF 12.5 @0.9 p.f.(KVA)	13.8888889
FIXED CHARGE PER KVA IS@ 150(A)	25000
ENERGY PER YEAR AT pf 0.9=kWh/0.9=kVAh	60833.33333
ENERGY CHARGE PER kVAh IS @5.85=(B)	355875
TOD SURCHARGE ON ENERGY CHARGES@ 20%=(C)	71177
SURCHARGE ON FIXED CHARGE@8%=(D)=(A*0.08)	2000
SURCHARGE ON ENERGY CHARGE@8%=(B+C)*0.08)	34164
ELECTRICITY TAX@5% ON ENERGY CHARGE=(F)=(B+C+E)*0.05)	23060.7
TOTAL BILL FOR ONE YEAR=(T)=(A+B+C+D+E+F)	511274.7
INSTALLATION COST FOR 1 STREETLIGHT	5000
INSTALLATION COST FOR 50 STREETLIGHTS=(I)	250000
TOTAL COST FOR FIRST YEAR=(T+I)	761274.7

#### A2.ELECTRICITY BILL FOR 25 YEARS CONSIDERING AN YEARLY INFLATION OF 5% IN ELECTRICITY CHARGE.

In table 4 we have calculated the total amount which is to be paid in 25 years assuming 5% inflation in electricity cost. We have calculated this so that we can show that in long run solar led street light will be efficient both in performance and cost.

TABLE 4: 25 YEAR ELECTRICITY BILL

Year	Previous year bill	Inflation=B=(A*0.05)	NEXT YEAR BILL=(A+B)
2	511274.7	25563.74	536838.435
3	536838.4	26841.92	563680.3568
4	563680.4	28184.02	591864.3746
5	591864.4	29593.22	621457.5933
6	621457.6	31072.88	652530.473
7	685157	34257.85	719414.8465
8	719414.8	35970.74	755385.5888

9	755385.6	37769.28	793154.8682
10	793154.9	3965.74	832812.6116
11	832812.6	41640.63	874453.2422
12	874453.2	43722.66	918175.9043
13	918175.9	45908.8	964084.6995
14	964084.7	48204.23	1012288.935
15	1012289	50614.45	1062903.381
16	1062903	53145.17	1116048.55
17	1116049	55802.43	1171850.978
18	1171851	58592.55	1230443.527
19	1230444	61522.18	1291965.703
20	1291966	64598.29	1356563.988
21	1356564	67828.2	1424392.188
22	1424392	71219.61	1495611.797
23	1495612	74780.59	1570392.387
24	1570392	78519.62	1648912.006
25	1648912	822445.6	1731357.6

Apart from electricity bill there will also be maintenance cost for every year with some inflation. Total cost for each year will be sum of electricity bill and maintenance cost. Similarly, we have done the same calculation for LED array street light for same lux. From the table above we know that 250 watt HPS bulb can be replaced by 110 watt LED array for same lux. As solar led streetlight is driven by solar energy so there is no electricity bill. The entire cost for first year is only the installation cost. Table 5 shows the installation cost involved in 50 Solar LED array street lights.

TABLE 5: INSTALLATION COST

COST OF 110watt LED array	Rs.7500
COST OF 50 SETS(A)	Rs.375,000
ELECTRICITY COST	Rs.0.0
INSTALLATION COST OF 1 STREETLIGHT	Rs.13,000
INSTALLATION COST OF 50 STREETLIGHTS(B)	Rs.650,000
TOTAL COST=(A+B)	Rs.1025,000

Similarly, 25 year bill is calculated which is shown in table 6. There will be no electricity cost. So only cost which has to be paid is maintenance cost at the given inflation rate (let it be 5%)

TABLE 6: 25 YEAR ELECTRICITY BILL

Year	Inflation in electricity cost	Electricity cost	Total cost(rs/km)
2nd	0	0	M.C(1.05) <sup>1</sup>
3rd	0	0	M.C(1.05) <sup>2</sup>
4th	0	0	M.C(1.05) <sup>3</sup>
5th	0	0	M.C(1.05) <sup>4</sup>
6th	0	0	M.C(1.05) <sup>5</sup>
7th	0	0	M.C(1.05) <sup>6</sup>
8th	0	0	M.C(1.05) <sup>7</sup>
9th	0	0	M.C(1.05) <sup>8</sup>
10th	0	0	M.C(1.05) <sup>9</sup>
11th	0	0	M.C(1.05) <sup>10</sup>
12th	0	0	M.C(1.05) <sup>11</sup>
13th	0	0	M.C(1.05) <sup>12</sup>
14th	0	0	M.C(1.05) <sup>13</sup>
15th	0	0	M.C(1.05) <sup>14</sup>
16th	0	0	M.C(1.05) <sup>15</sup>
17th	0	0	M.C(1.05) <sup>16</sup>
18th	0	0	M.C(1.05) <sup>17</sup>
19th	0	0	M.C(1.05) <sup>18</sup>
20th	0	0	M.C(1.05) <sup>19</sup>
21th	0	0	M.C(1.05) <sup>20</sup>
22nd	0	0	M.C(1.05) <sup>21</sup>
23rd	0	0	M.C(1.05) <sup>22</sup>
24th	0	0	M.C(1.05) <sup>23</sup>
25th	0	0	M.C(1.05) <sup>24</sup>

## B.CASE STUDY 2 SERVICE LANE

This is done for service lane. Service lanes are local roads that run parallel interstate highway or expressway and it provides access to the property bordering it. 150 watt HPS bulbs are used in service lane streetlights and there are 42 streetlights in 1km.

B1.COST CALCULATION FOR FIRST YEAR i.e ELECTRICITY BILL+INSTALLATION COST HPS  
Table 7 gives the installation cost of 42 HPS street light along with the total electricity bill for one year.

TABLE 7: TOTAL COST FOR FIRST YEAR

TOTAL POWER NOT DRAWING FROM GRID IN KW	6.3
IF WE TAKE A CONNECTION OF 6.3 @0.9 p.f(KVA)	7
FIXED CHARGE PER KVA IS@ 150(A)	12600
ENERGY PER YEAR AT pf 0.9=kWh/0.9=kVAh	30660
ENERGY CHARGE PER kVAh IS @5.85=(B)	179361
TOD SURCHARGE ON ENERGY CHARGES@ 20%=(C)	35872.2
SURCHARGE ON FIXED CHARGE@8%=(D)=(A*0.08)	1008
SURCHARGE ON ENERGY CHARGE@8%=(B+C)*0.08)	17218.656
ELECTRICITY TAX@5% ON ENERGY CHARGE=(F)=[(B+C+E)*0.05]	11622.5928
TOTAL BILL FOR ONE YEAR=(T)=(A+B+C+D+E+F)	257682.4488
INSTALLATION COST FOR 1 STREETLIGHT	4000
INSTALLATION COST FOR 42 STREETLIGHTS=(I)	168000
TOTAL COST FOR FIRST YEAR=(T+I)	425682.4488

## B2.ELECTRICITY BILL FOR 25 YEARS CONSIDERING AN YEARLY INFLATION OF 5% IN ELECTRICITY CHARGE.

In table 8 we have calculated the total amount which is to be paid in 25 years assuming 5% inflation in electricity cost. This is done in similar way as we have done earlier.

In the above calculation we have not considered the maintenance cost of each year but there will be maintenance cost also with some inflation each year.

TABLE 8: 25 YEAR ELECTRICITY BILL

Year	Previous year bill(A)	Inflation=B =(A*0.05)	Next year bill=(A+B)
2	25768.45	12884.12	270566.5712
3	270566.6	13528.33	284094.8998
4	284094.9	14204.74	298299.6448
5	298299.6	14914.98	313214.627
6	313214.627	15660.73	328875.3584
7	328875.4	16443.77	345319.1263
8	345319.1	17265.96	362585.0826
9	362585.1	18129.25	380714.3367
10	380714.3	19035.72	399750.0536
11	399750.1	19987.5	419737.5563
12	419737.6	20986.88	440724.4341
13	440724.4	22036.22	462760.6558
14	462760.7	23138.03	485898.6886
15	485898.7	24294.93	510193.623
16	510193.6	25509.68	535703.3042
17	535703.3	26785.17	562488.4694
18	562488.5	28124.42	590612.8928
19	590612.9	29530.64	620143.5375
20	620143.5	31007.18	651150.7143
21	651150.7	32557.54	683708.2501
22	683708.3	34185.41	717893.6626
23	717893.7	35894.68	753788.3457
24	753788.3	37689.42	791477.763
25	791477.8	39573.89	831051.6511

Similarly, we have done the same calculation for LED array street light for same lux.

Table 9 shows the installation cost involved in 42 Solar LED array street lights. 150 watt HPS bulb can be replaced by 90watt LED array for same lux. As solar led streetlight is driven by solar energy so there is no electricity bill. The entire cost for first year is only the installation cost.

TABLE 9: INSTALLATION COST

COST OF 90watt LED array	Rs.4500
COST OF 42 SETS(A)	Rs.189000
ELECTRICITY COST	Rs.0.0
INSTALLATION COST OF 1 STREETLIGHT	Rs.10,000
INSTALLATION COST OF 42 STREETLIGHTS(B)	Rs.420000
TOTAL COST=(A+B)	Rs.609000

Similarly, 25 year bill is calculated which is shown in table 10. There will be no electricity cost. So only cost which have to be paid is maintenance cost at the given inflation rate (let it be 5%)

TABLE 10: 25 YEAR ELECTRICITY BILL

Year	Inflation in electricity cost	Electricity cost	Total cost(rs/km)
2nd	0	0	MC(1.05) <sup>1</sup>
3rd	0	0	MC(1.05) <sup>2</sup>
4th	0	0	MC(1.05) <sup>3</sup>
5th	0	0	MC(1.05) <sup>4</sup>
6th	0	0	MC(1.05) <sup>5</sup>
7th	0	0	MC(1.05) <sup>6</sup>
8th	0	0	MC(1.05) <sup>7</sup>
9th	0	0	MC(1.05) <sup>8</sup>
10th	0	0	MC(1.05) <sup>9</sup>
11th	0	0	MC(1.05) <sup>10</sup>
12th	0	0	MC(1.05) <sup>11</sup>
13th	0	0	MC(1.05) <sup>12</sup>
14th	0	0	MC(1.05) <sup>13</sup>
15th	0	0	MC(1.05) <sup>14</sup>
16th	0	0	MC(1.05) <sup>15</sup>
17th	0	0	MC(1.05) <sup>16</sup>
18th	0	0	MC(1.05) <sup>17</sup>
19th	0	0	MC(1.05) <sup>18</sup>
20th	0	0	MC(1.05) <sup>19</sup>
21th	0	0	MC(1.05) <sup>20</sup>
22nd	0	0	MC(1.05) <sup>21</sup>
23rd	0	0	MC(1.05) <sup>22</sup>
24th	0	0	MC(1.05) <sup>23</sup>
25th	0	0	MC(1.05) <sup>25</sup>

## C.CASE STUDY 3 SECTOR ALPHA 1

This is done for a sector in Gr.noida-ALPHA 1. Sector Alpha 1 is situated near PariChowk.70watt HPS bulbs are used in street lights installed here and there are 33 streetlights in 1Km.

C1.COST CALCULATION FOR FIRST YEAR i.e ELECTRICITY BILL+INSTALLATION COST HPS  
Table 11 gives the installation cost of 33 HPS street light along with the total electricity bill for one year.

TABLE 11: TOTAL COST FOR FIRST YEAR

TOTAL POWER NOT DRAWING FROM GRID IN KW	2.31
IF WE TAKE A CONNECTION OF 2.31 @0.9 p.f(KVA)	2.56666667
FIXED CHARGE PER KVA IS@ 150(A)	4620
ENERGY PER YEAR AT pf 0.9=kWh/0.9=kVAh	11242
ENERGY CHARGE PER kVAh IS @5.85=(B)	65765.7
TOD SURCHARGE ON ENERGY CHARGES@ 20%=(C)	13153.14
SURCHARGE ON FIXED CHARGE@8%=(D)=(A*0.08)	369.6
SURCHARGE ON ENERGY CHARGE@8%=(B+C)*0.08)	6313.5072
ELECTRICITY TAX@5% ON ENERGY CHARGE=(F)=[(B+C+E)*0.05]	4261.61736
TOTAL BILL FOR ONE YEAR=(T)=(A+B+C+D+E+F)	94483.56456
INSTALLATION COST FOR 1 STREETLIGHT	3000
INSTALLATION COST FOR 50 STREETLIGHTS=(I)	15000
TOTAL COST FOR FIRST YEAR=(T+I)	109483.564

**C2.ELECTRICITY BILL FOR 25 YEARS CONSIDERING AN YEARLY INFLATION OF 5% IN ELECTRICITY CHARGE.**

In table 12 we have calculated the total amount which is to be paid in 25 years assuming 5% inflation in electricity cost. This is done in similar way as we have earlier. In the above calculation we have not considered the maintenance cost of each year but there will be maintenance cost also with some inflation each year.

**TABLE 12: 25 YEAR ELECTRICITY BILL**

Year	Previous year bill (A)	Inflation=(B) =(A*0.05)	Next year bill=(A+B)
2	94483.56	4724.178	99207.74
3	99207.74	4960.387	104168.1
4	104168.1	5208.406	109376.5
5	109376.5	5468.827	114845.4
6	114845.4	5742.268	120587.6
7	120587.6	6029.382	126617
8	126617	6330.851	132947.9
9	132947.9	6647.393	139595.3
10	139595.3	6979.763	146575
11	146575	7328.751	153903.8
12	153903.8	7695.189	161599
13	161599	8079.948	169678.9
14	169678.9	8483.945	178162.9
15	178162.9	8908.143	187071
16	187071	9353.55	196424.5
17	196424.5	9821.227	206445.8
18	206245.8	10312.29	216558.1
19	216558.1	10827.9	227386
20	227386	11369.3	238755.3
21	238755.3	11937.76	250693
22	250693	12534.65	263227.7
23	263227.7	13161.38	276389.1
24	276389.1	13819.45	290208.5
25	290208.5	14510.43	304718.93

Similarly, we have done the same calculation for LED array street light for same lux.

Table 13 shows the installation cost involved in 33 Solar LED array street lights.

70 watt HPS bulb can be replaced by 40watt LED array for same lux. As solar led streetlight is driven by solar energy so there is no electricity bill. The entire cost for first year is only the installation cost

**TABLE 13: INSTALLATION COST**

COST OF 40watt LED array	Rs.3000
COST OF 33 SETS(A)	Rs.99000
ELECTRICITY COST	Rs.0.0
INSTALLATION COST OF 1 STREETLIGHT	Rs.8,000
INSTALLATION COST OF 50 STREETLIGHTS(B)	Rs.264000
TOTAL COST=(A+B)	Rs.363000

Similarly, 25 year bill is calculated which is shown in table 14. There will be no electricity cost. So only cost which have to be paid is maintenance cost at the given inflation rate (let it be 5%)

**TABLE 14: 25 YEAR ELECTRICITY BILL**

Year	Inflation in electricity cost	Electricity cost	Total cost(rs/km)
2nd	0	0	M.C(1.05)^1
3rd	0	0	M.C(1.05)^2
4th	0	0	M.C(1.05)^3
5th	0	0	M.C(1.05)^4
6th	0	0	M.C(1.05)^5
7th	0	0	M.C(1.05)^6
8th	0	0	M.C(1.05)^7
9th	0	0	M.C(1.05)^8
10th	0	0	M.C(1.05)^9
11th	0	0	M.C(1.05)^10
12th	0	0	M.C(1.05)^11
13th	0	0	M.C(1.05)^12
14th	0	0	M.C(1.05)^13
15th	0	0	M.C(1.05)^14
16th	0	0	M.C(1.05)^15
17th	0	0	M.C(1.05)^16
18th	0	0	M.C(1.05)^17
19th	0	0	M.C(1.05)^18
20th	0	0	M.C(1.05)^19
21th	0	0	M.C(1.05)^20
22nd	0	0	M.C(1.05)^21
23rd	0	0	M.C(1.05)^22
24th	0	0	M.C(1.05)^23
25th	0	0	M.C(1.05)^24

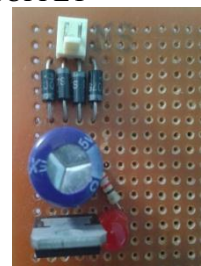
From the above three case studies we came to know that though the initial investment is much higher in case of solar LED street lights compared to traditional HPS street light, but as we know that solar streetlight is driven by solar energy so no electricity bill has to be paid as a result of this the extra investment made is received back within 3 to 4 years after that it is only saving. In our calculation we have not included the automatic intensity control part when that is included it would become even more effective.

**III. PROTOTYPE DESCRIPTION**

Keeping in view the advantages of SOLAR LED STREET LIGHT WITH AUTOMATIC INTENSITY CONTROL a prototype of this streetlight have been made.

**D.CIRCUITS INVOLVED**

**1. POWER SUPPLY**



**Fig4: POWER SUPPLY**

Power supply is a reference to a source of electrical power. It is used to provide power to the system. Here in our application we need a 5v DC power supply for all electronics involved in the project. This requires step down transformer, rectifier, voltage regulator, and filter circuit. Transformer reduces the voltage level from 220V AC to 12V AC. Rectifier converts this AC voltage to equivalent DC voltage. Capacitor working as filter removes ripple from the output of rectifier. 7805 voltage regulator is used which gives a constant 5V at its output.

## 2. CONTROL CIRCUIT

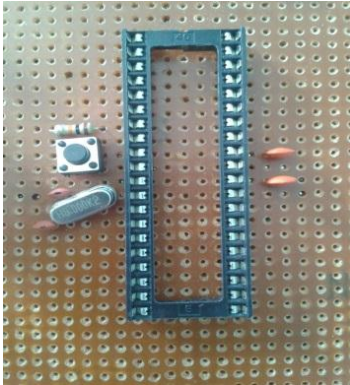


Fig:5: CONTROL CIRCUIT

Working of model is based on pulse width modulation. Crystal oscillator is used to generate frequency. Microcontroller ATMEGA16 is used to generate pulse based on the signal provided by LDR, it has analog to digital converter incorporated in it. Switch is used to reset the microcontroller.

## 3. LIGHT DEPENDENT RESISTOR(LDR)

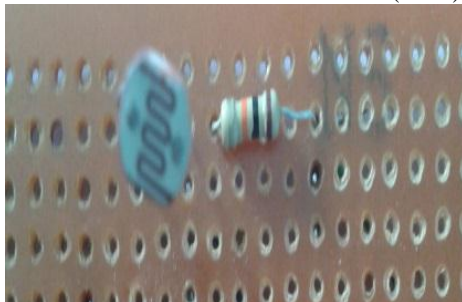


FIG:6 LDR

Photo resistor or light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity; in other words, it exhibits photo conductivity. Photo resistors are made of semiconductor materials, when light falling on them is of enough frequency, the photons absorbed by the semiconductor makes the bound electrons to reach in conduction band. As a result of this conduction increases resistance decreases. LDRs are made of cadmium sulphide which has very few or no free electrons. Its resistance is quite high. When it absorbs photons free electrons increases and so its conductivity also increases. The approximate relationship between the resistance and illumination is  $R = \frac{A}{E^a}$  where E is illumination in lux, R is resistance in ohms, A and a, are constants.

## IV. ADVANTAGES[8]

- 1) Solar street light is independent of grid as a result of this operating cost is much low.
- 2) Maintenance cost is much low compared to conventional street light.
- 3) Intensity of LED can be controlled effectively without changes in its light colour which is not possible in case of HPS.
- 4) Risk of accidents is very low.
- 5) It is environmental friendly, no harmful emissions.
- 6) Longer life compared to conventional street lights.
- 7) Power consumption is much lower.

## V. DISADVANTAGES

- 1) Initial investment is very high.
- 2) Rechargeable batteries have to be replaced from time to time
- 3) Non-availability of sunlight during rainy and winter seasons is a problem.
- 4) Dust accumulation on the surface of panel creates a problem.

## VI. CONCLUSION

Solar energy is a non-conventional, non-polluting and reliable source of energy. This paper shows how effectively we can use this energy to drive the street light apart from this automatic intensity control using LDR helps to save a large amount of electric power which is wasted in conventional HPS street lights. Though the initial investment is very high but the case study done shows that this investment is received back in 3 to 4 years after that the only investment needed is maintenance cost which is very less. Considering the above facts we come to know that solar led street light with automatic intensity control is better than any traditional street light in terms of energy saving and cost effectiveness. This technology is being improved and full conversion will help to save a large amount of energy.

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