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ANALYSIS OF TREND OF INSTALLING SOLAR STREET LIGHTS IN PESHAWAR CANTONMENT AREAS

Shaheer Shaida Durrani
CECOS University,Peshawar,Kpk, Pakistan
shaheerdurrani@hotmail.com

Muhammad Hilal Khan
CECOS University,Peshawar,Kpk, Pakistan
hilal@cecos.edu.pk

Muhammad Imran Khan
CECOS University,Peshawar,Kpk, Pakistan
Imran446bg@hotmail.com

Abstract
A stand alone solar photovoltaic (SPV) street lighting system (SLS) is an outdoor lighting unit used for illuminating a street or an open area. The equipment and maintenance costs associated with a stand-alone solar-powered system are compared with the cost of using electricity to run grid connected street lights. The project focused on the viability of using solar energy to power the lights in the area surrounding Peshawar Cantt, Peshawar. An economic analysis is performed to determine if the project is cost effective or not.This paper focuses about the feasibility to replace grid-powered street lamps with a stand-alone system street .The renewable energy source selected for this project is a solar photovoltaic panel. The study was undertaken to determine the capabilities of a stand-alone systems and to analyze the decision to replace the grid connected street lights.The viability of solar energy in Peshawar is determined by weather conditions and the amount of solar insolation that the area received throughout the year. A comparison will be made between commercially stand-alone systems against grid tied system for street lights.

Keywords
Solar photovoltaic, street lighting system, sodium lights.

1. Introduction

How fast the system can recoup the installation cost depends on the yearly intensity of the sunlight. The energy that reaches the ground is called the solar isolation value. The Southeast Pakistan will recover the initial cost about two and a half times faster than systems in the Northeast, because the reddish brown area, in Figure 1, displays a high solar output region and the yellowish displays weak output locations. The number of sunny days compared with cloudy days determines the color variations, with the sunnier regions being in reddish brown [3]. In winter, the farther a location is from the equator the less available energy there is due to shorter days.

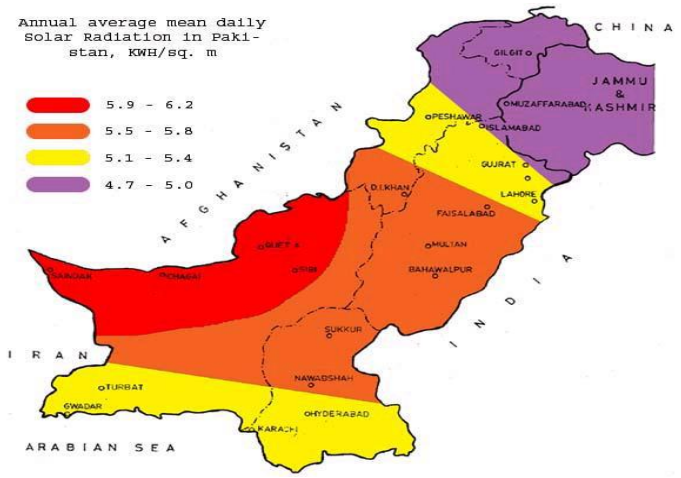

Figure 1, Solar Irradiance In Pakistan.

Figure 1 compiles the average amount of sunlight that reaches the ground every day, and is compared to the number of hours of usable sunlight from two hours after sunrise to an hour and a half before sundown. Peshawar is among the Northern cities that receive on average 4,500 watt hours per day. The percent of the sun's energy that reaches the ground is determined by how many days were clear, partly cloudy, or overcast.

The other parts of this paper is divided into; cost estimation, economic analysis of various lightning system, discussions of comparative analysis of HPS as well as conclusion.

1. COST ESTIMATIONS

The cantonment board authority has decided to replace 4,000 street lights (sodium lights) of 250 watts with 70 watts LED bulbs in most of the area in its domain.[1]The Peshawar Cantonment Board has recently installed 170 solar units, consisting of 340 streetlights, on the Mall Road and Khalid Bin Walid Park in the cantonment. The total cost of the units installed on Mall Road and Khalid Bin Walid Park is Rs10 million. The conventional streetlight per unit was about Rs80, 000 while price of the solar one comprising pole, panel and two high efficiency energy saver bulbs was up to Rs180, 000.

Figure.2. Solar PV System installed on Mall Road,Peshawar,Courtesy of Cantonment Board Peshawar

[2]Installing solar system initially required a huge investment because solar panels and other equipment were expensive as compared to the conventional lighting system. For the stand-alone system to replace grid powered lights, the operational cost of the system had to meet or be below the cost of grid powered street lights.

The cost to install one mile of single phase primary line was $105,000 without lights. The average was 21 street lights per mile. The cost of electricity to power one lamp was calculated at a maximum of $100 a year at a rate of $0.15 per kilowatt hour. The initial cost of the grid powered light comes to about $5,200 with the lamp. Over a twenty-year period, the estimated cost of the grid powered light comes to around $7,200.

2.ECONOMIC ANALYSIS OF THE VARIOUS LIGHTING SYSTEMS

Commercially available original parts list for the PV system with different combinations of lamps have been investigated for the possible best configurations for the street lights for comparison with the adopted LED lamp system by the Peshawar cantonment, in the following sections

2.1HPS (high pressure sodium) Pv system

The parts list selected so far to operate the lamp with a four day battery reserve. The enclosure is a metal container that could hold the two batteries, the MPPT, and the inverter. The PV System used plastic containers as replacements to save on cost, due to the main purpose of the enclosure is to guard against vandalism. The sodium light lamp has been selected for the project is 100W lamp that consumed 100W. Table.1. shows the parts list for the project.

This configuration will require replacement of the batteries every five years. The future cost of batteries is difficult to determine due to advancements in new batteries with improved performance that will affect the estimate.

SOLAR PANEL	PRICE IN US DOLLARS	WATTS
GE 165	780	165
BATTERIES	PRICE	AMP HRS (20)
ROLLS SURRETTE HT-8D	325	221
ROLLS SURRETTE HT-8D	325	221
SODIUM LIGHTS LAMP	PRICE	LUMENS
HPS 100 W BULB	13.00	9500
ENCLOSURE	PRICE	DIEMENSION W * D * H (IN)
MCMASTER-CARR 7561K78	300.81	30*12.625*36
MORNING STAR SUN SAVER 24 V	67	28.2 VCHARGE
24 V INVERTER	167	MAX 10 A
UNIRAC 400209	200	PANNEL SUPPORT
POLE WOOD	300	40 FT POLE
LAMP BRACKET	120	100W HPS LAMP
TOTAL INITIAL COST	2587.15	

Table.1. Shows the parts list for the project.Courtesy of www.thenizampur.com

2.2LPS (low pressure sodium) Pv system

The Low Pressure Sodium (LPS) bulb is the most common type used in commercial available systems. The parts list selected so far to operate the lamp with a six days battery reserve. The 55W LPS lamp requires less power than the 100W HPS lamp, but is not a desirable choice due color rendering issues. The initial cost of this system is higher due to the bulb and lamp assembly. Using a larger panel and batteries improves the number of days the lamp operates till dawn for the winter months.

SOLAR PANNEL	PRICE IN US DOLLARS	WATTS
KYOCERA KC 190GT	836	190 W
BATTERIES	PRICE	AMP HRS (20)
ROLLS SURRETTE 12 HHG	390	275
ROLLS SURRETTE 12 HHG	390	275
ENCLOSURE	PRICE	DIEMENSIONS W * D *H (IN)
MCMASTER-CARR 7561K78	300.81	30*12.625*36
SODIUM LAMP	PRICE	LUMENS
LPS 55W BULB	13.00	8000
MORNING STAR SUN SAVER	67.02	MAX 10 AMPERE
URINAC 400209	200	PANEL SUPPORT
POLE WOOD	300	40 FT POLE
LPS LAMP	529	100W HPS LOAMP
TOTAL INITIAL COST	3025.87	

Table.2. shows the parts list for the project.Courtesy of www.thenizampur.com

2.3. The LED System.

The LED system cost under $2,700 to build, with the major cost increase incurred by the LED lamp. The equipment price for the project is shown in Table 4 illustrates the cost in switching to the LED lamp. The lamp lacked the lumens level required for use on city streets. The long life spans of the LED lamp and solar panel are important aspects when looking at the long-term cost of a stand-alone system. The lifespan of 20 years for the solar panel and 10 years for the lamp means that the cost of operating the stand-alone system must be reevaluated to include cost of replacing the equipment. The cost of the lamp compared against the HPS looked at how often the bulbs would need replacement. It is assumed that about three new HPS bulbs would be needed over the 20-year period, compared against the one for the LED option. The replacement cost of the HPS is ten times less than the LED. The life cycle cost analysis of the stand-alone system requires long-term consideration to be taken into account that may impact the effectiveness of the study. The continuing advancements in LED lumens output must be considered every year to determine the drop in initial cost, and how much per kilowatt would make the stand-alone system feasible. The economic cost currently makes the stand-alone LED light extremely expensive in terms of dollars-per-lumen.

LED SYSTEM	PRICE IN US DOLLARS	SHIPPING
GE 165 W PANEL	$719	$163
ROLLS SURRETTE	$625.94	$111.11
LED LAMP	$725	$27.80
MORNING STAR SUN SAVER	$86.10	$15.21
UNIRAC 400209	$90.63	$18.64
POWER INVERTER	$89.99	$10.00
TOTAL INITIAL COST	$2,336.66	$345.65

Table.4. Shows the parts list for LED PV System. Courtesy of www.thenizampur.com

2.4. Comparative Analysis of HPS

Tabloid **r**esults of the HPS in the above discussion showed the lamp running all nightlong for the four days of inclement sky conditions, the cost of the project will make the HPS a viable option. The equipment used for the HPS Lamp is shown in Table .3; it also represents the purchase price of each piece. The total cost includes all the main components of the HPS PV System, but does not include the protective container for the MPPT, wiring, the light pole, and the battery trays that guard against spillage. The cost of shipping must be considered, due to the cost associated with the transport of the solar panel and batteries. When considering the use of a solar powered system, a life-cycle cost analysis must be done to determine the future cost of parts replacement and how long it would take to produce enough power to pay for the equipment [4]. The initial startup cost for the project is $2,000 the maintenance costs is considered to be small for the first 5 years after installation. After that time period, the effectiveness of the inverter, MPPT, and batteries diminishes due to cost of replacing the equipment. The cost of replacing the batteries alone pushes the replacement cost of the project to over $700, and this would have to be done every five to seven years depending on the reliability of the batteries. For the project to be considered, an alternative for street lights operation in stand-alone mode, the cost of electricity would have to be over $400 a year for the first five years and over $250 a year for the next five years to pay for the battery replacements. The cost savings from the electricity saved would need to be over $1,200 a year to cover the cost of this design. If the cost to power one high-efficiency street light is $0.15 per kW/h, and the number of hours the lamp is on is determined to be on average 12 hours a day, the yearly operational cost of each light would be less than $100 a year. For the assumed constraints, the overall effectiveness of this project fails as an option to replace the power grid as a source of power for the street lights. The design though is not a total loss when considered for locations that are far from the power grid. The price to run electricity to remote locations can be in the hundreds of thousands of dollars to run single phase power lines. The distance to some locations is very far from the main power grid for the utility to run power to the buildings. The cost of building and operating the stand-alone system would be far less expensive in this setting.

HPS SYSTEM EQIPMENT	PRICE IN US DOLLARS	SHIPPING CHARGES IN US DOLLARS
GE 165 W PANEL	**719**	**163**
ROLLS SURRETTE HT-8D	**625.94**	**111.00**
HIGH PRESSUE SODIUM LAMP	**80.45**	**0.00**
MORNING STAR SUN SAVER	**86.10**	**15.21**
UNIRAC 400209	**90.63**	**18.64**
POWER INVERTER	**89.99**	**10.00**
TOTAL INITIAL COST	**1692.11**	**317.85**

Table.3. shows the parts list for the HSP Lamp System, including shipment charges.Courtesy of www.thenizampur.com

3. Conclusion

From this study, it is evident that solar energy is an impractical source of power for year-long usage for a stand-alone system to operate public streets lights for continuous nighttime operations. Analysis done for Peshawar Cantonment determined that even during the most optimal years that the project would still fall short of the full power requirement for the sodium lights lamp. For solar isolation values to be considered favorable, the sun must not be obstructed for 80% of the day. Due to the power demands of the solar PV lamp, the battery reserve will be depleted in short span of time.

The requirement of three 200W panels and a minimum of six batteries guarantee that the lamp would work under the worst winter conditions. However, the cost of equipment outweighs the benefits of running the lights off the grid. It is however believed that solar lighting with the sodium lights could still be effective for area lighting where continuous nighttime lighting is not required. The use of timers to

control the amount of time the light is on increases the effectiveness of a stand-alone system. The sodium lamp does decrease the cost and equipment requirements, but the light quality is diminished, making this the worst case lighting option.

The cantonment board decision to install LED lamps for the PV system,needs to be reviewed because when LED lamps generate the equivalent of 9,200 lumens almost equals to HPS lamps ,the efficency of the system remain the same as that of HPS lamps,because the LED lights will consume the same amount of power as consumed by HPS. [5] The brighter lamp failed to operate through the night and the smaller load failed to illuminate the required area. The output lumens of the LED lamps are still the limiting factor that prevents the lamp from being used to light up streets.

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