Assessment of Energy Wastage in Street Lighting

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***Abstract*—Dwindling energy resources coupled with industrialization and the rise in the use of electronic and electrical appliances has given a cause to look at the end-use of electricity worldwide. A number of demand side management (DSM) and energy efficiency (EE) programmes have been embarked upon worldwide to minimize energy consumption while achieving the same output. This work sought to determine the potential of street lighting for energy saving in Ghana. 185 street lamps comprising 119 manually controlled and 66 photocell controlled lamps were monitored for a 30-day period to determine the daily burning hours. An ideal daily lamp burning hours obtained from the study was used to determine the daily wasted energy. The results show that about 25.269MWh of energy could be saved yearly if the 185 street lamps studied were efficiently operated.**

Keywords—Demand side management, Energy efficiency, Energy wastage and Street lighting

I. INTRODUCTION

Population growth, industrialization and the increasing number of electrical and electronic appliances has resulted in an increase in electricity demand. This coupled with the high cost of fuel sources with accompanying environmental risks has resulted in greater emphasis now being placed on Demand Side Management (DSM) and Energy Efficiency(EE) activities [1].

DSM is the implementation of policies and measures which serve to control, influence and generally reduce electricity demand. DSM affords benefits such as deferral of capital expenditure on generation, transmission and distribution facilities, improved system load factor, better customer relations and better data for load forecasting and system planning from a utility point of view. Reduction or stable electricity costs, improved value of service, and improved lifestyle and productivity are some of the benefits derived by consumers from DSM. Social benefits such as reduced environmental degradation, conservation of resources, protection of global environment and reduced foreign debt, low business cost and maximum customer welfare are also derived from DSM [1-3].

EE on the other hand aims at using less energy to provide the same level of energy service. Energy efficiency offers a powerful and cost-effective tool for achieving a sustainable energy future. Improvements in energy efficiency can reduce the need for investment in energy infrastructure, cut fuel costs, increase competitiveness and improve consumer welfare. Environmental benefits can also be achieved by the reduction of greenhouse gases emissions and local air pollution. Energy security can also profit from improved energy efficiency by decreasing the reliance on imported fossil fuels. Energy efficiency policies and technologies are being promoted in buildings, appliances, transport and industry, as well as end-use applications such as lighting [4, 5].

A number of DSM and EE programmes such as municipal water pumping, solar hot water, time-of-use tariffs for industrial and commercial customers, refrigerator and air-conditioning labeling and standards, and street lighting have been implemented worldwide to achieve energy sustainability [1].

As part of efforts to solve an energy crisis in 2007 as a result of low rainfall, the Government of Ghana in 2008 distributed six (6) million Compact Fluorescent Lamps (CFLs) to the public to replace installed incandescent lamps. Fluorescent lamps at security agencies were also replaced with energy efficient T5 fluorescent lamps. An estimated reduction in peak demand of 120MW was realized at the end of the programme in the first quarter of 2008 [6].

Most countries spend huge sums of money in generating energy to continuously maintain a good street lighting system albeit in some cases substantial amounts could have been saved if energy wastages were checked. Street lighting accounts for about 5% of all the electricity use in America and the European Union. However, Street lights waste 2-3% of the monthly energy of the EU [7]. The Electricity Company of Ghana (ECG) in a media briefing hinted that ECG was unable to maintain street lights because the levy paid by the public was extremely low [8]. This challenge points to the fact that a critical look must be taken into street lighting especially with the view of identifying and dealing with wastage.

Conventional street lighting employs manually controlled switches. Late switching off and early switch on which characterize manual switching could cause lights to be on for more hours in the day. Additionally, some lights could be left on for days, weeks and even months. Such irregular switching patterns bring about substantial energy wastage. Over design in selected areas as well as ad hoc installation of street lighting systems as housing expands in communities are other causes of energy wastage in street lighting. Modern street lights use photocells, dimmer and timers to switch the lights on and off in order to reduce energy wastage.

This work sought to determine if substantial energy savings could be achieved by looking at street lighting in Ghana.

II. METHODOLOGY

A preliminary field survey was conducted in some communities namely: Kwame Nkrumah University of Science and Technology, Ayeduasi, Ayigya, Bomso and Kotei to determine the methods of switching street lamps on and off. A number of street lamps were then selected for monitoring. The selected lamps were monitored for a 30-day period to determine the average daily burning hours of the lamps in the selected areas. The lamp burning hours were determined using the formula below.

$$Lamp\ burning\ hours = Switch\ on\ time(h) - Switch\ off\ time\ (h)$$

71, 25, 15 and 7 manually controlled(MC) lamps were studied at Ayigya, Bomso, Ayeduasi and Kotei respectively. The study also covered 27 photocell controlled(PC) lamps at Kotei and two sets of photocell controlled lamps at KNUST; 22 along the Paa Joe road and 18 along the Great hall road.

The daily burning hours of each monitored lamp was used to calculate the average daily lamp burning hours (H) of studied lamps in each area. H was determined as follows:

Let,

X_{nm} = *Observed burning hours of lamp n* on day *m*

$$where\ \ n = 1,2,3,...,N$$
$$m = 1,2,3,...,30$$

Y_m = *Average burning hours of N lamps for each observed day m.* Hence,

$$Y_m = \frac{\sum_{n=1}^{N} Xnm}{N},$$

$$H = \frac{\sum_{m=1}^{30} Ym}{30}$$

Daily wasted energy of studied lamps, E_W, was determined as follows:

Wasteful lamp burning hours, $W_H = H_{actual} - H_{ideal}$

Energy wasted daily due to longer burning hours of each 250W lamp, $E_{W250} = 1.2 \times 250 \times W_H$

Energy wasted daily due to longer burning hours of each 400W lamp, $E_{W400} = 1.14 \times 400 \times W_H$

Energy wasted daily due to the use of each 400W lamps instead of recommend 250W lamps in the useful lighting period,

$$E_{W400-250} = 1.14 \times (400 - 250) \times H_{ideal}$$

Hence,

$$E_W = E_{W250} + E_{W400} + E_{W400-250}$$

The formula takes into consideration ballast losses of 14% of the nominal lamp wattage of 400W mercury vapour lamp(MVL) and 20% of the nominal power of 250W high pressure sodium lamp(HPSL)[9,10].

III. RESULTS AND DISCUSSION

Two types of lamps were observed to be in use. These are: 250W high pressure sodium lamp(HPSL) and 400W mercury vapour lamp(MVL). Table 1 shows the number and wattages of lamps in selected areas of the studied communities together with the switching mechanisms employed.

Table 1: Ratings of studied lamps

Community	Lamp type and number in use	
	HPSL(250W)	**MVL(400W)**
Ayeduasi(MC)	13	2
Ayigya(MC)	40	31
Bomso(MC)	3	22
Kotei(MC)	-	7
Kotei(PC)	23	4
KNUST, Paa Joe road(PC)	22	-
KNUST, Great Hall road(PC)	18	-
TOTAL	**119**	**66**

119 of the studied lamps were 250W HPSLs while 66 were 400W MVLs. The Electricity Company of Ghana (ECG) recommends 250W lamps for street lighting. Thus 36 percent of the fixtures were over rated hence constituting energy wastage. Table 2 shows the average daily burning hours of the 250W HPSLs in the

studied areas. Table 3 also shows the average daily burning hours of the 400W MVLs.

Table 2: Average daily burning hours of 250W HPSLs in the studied areas

Community	**No. of lamps**	**Average lamp hours**
Ayeduasi(MC)	13	12.36
Ayigya(MC)	40	13.48
Bomso(MC)	3	12.93
Kotei(PC)	23	12.11
KNUST, Paa Joe road(PC)	22	12.10
KNUST, Great Hall road(PC)	18	13.2

Table 3: Average daily burning hours of 400W MVLs in the studied areas

Community	**No. of lamps**	**Average Lamp hours**
Ayeduasi(MC)	2	12.36
Ayigya(MC)	31	13.48
Bomso(MC)	22	12.93
Kotei(MC)	7	13.53
Kotei(PC)	4	12.11

The highest of the burning hours was recorded at Kotei, while the least was observed at KNUST-Paa Joe road. The ideal average lamp burning hours for the study period in the localities studied was found to be 12.10 hours. The unexpectedly high lamp burning hours observed for the street lights along the Great hall road of KNUST is due to the nature of the vegetation there. The presence of tall trees there make the place a bit dark when other areas are bright thus increasing the number of hours that the lamps there will be on. The number of lamps in which wastages were identified are as follows: Sixty six (66) 400W MVLs and Ninety seven (97) 250W HPSLs. 62 of the 400W lamps were manually controlled while 56 of the 250W lamps were manually controlled. The energies wasted daily by the studied lamps in the various communities have been tabulated in table 4.

Table 4: Daily wasted energies

No.	*Community*	*No. of studied Lamps*	*Daily energy wastage (kWh)*
1	Ayeduasi(MC)	15	1.34004
2	Ayigya(MC)	71	43.38306
3	Bomso(MC)	25	12.19602
4	Kotei(MC)	7	6.27627
5	Kotei(PC)	27	0.09408
6	KNUST, Paa Joe road(PC)	22	0
7	KNUST, Great Hall road(PC)	18	5.94
TOTAL		**185**	**69.2295**

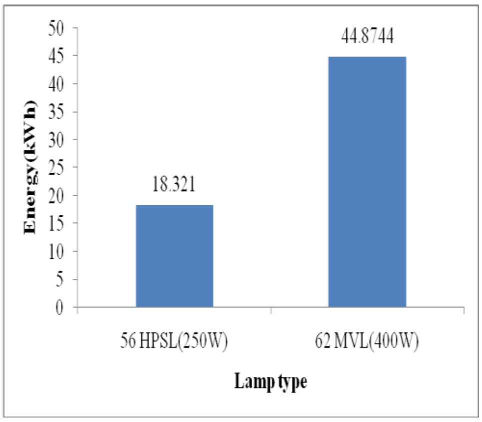

Figure 1: Daily energy wastage from manually controlled lamps

Figure 1 shows the daily energy wastage from manually controlled lamps alone. A total of 69.2295kWh is wasted daily by the 185 street lamps in the 5 communities. Out of this total, 8.7161% is due to the inefficient operation of photocell switches while the remaining 91.2839% is due to manual switching. 250W lamps contribute 28.991% of the daily energy wastage due to manual switching alone while manually controlled 400W lamps contribute the remaining 71.009%.

IV. Conclusion

A study has been carried out to investigate the potential of making significant energy savings from street lighting. The study covered 119 manually controlled lamps and 66 photocell controlled lamps. 36% of the studied lamps were found to be overrated. It was also realized that daily energy savings of 69.2295kWh could be realised if the street lamps were operated efficiently. The placement of photocell controlled lamps directly under trees could lead to wasteful daily burning hours of 1.1.

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