Reduction of Lighting Energy Consumption by 25% Site Wide

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Abstract

The lighting energy consumption is typically overlooked at Department of Defense facilities because, if it works and provides sufficient lighting, no one complains. The key to achieving energy savings through lighting, is to follow Illuminating Engineering Society Standard on luminance. The causes for energy waste, are utilizing old lighting technologies as Metal Halide and lack of controls. In an effort to reduce energy consumption at one site in Fort Gordon Georgia, the implementation of Light Emitting Diodes was researched. It was found that the lighting energy consumption could be reduced by 37% by just changing the light fixtures. An additional energy saving between 43% and 50% could be achieved by adding lighting controls such as motion sensors and photosensors. All the phases of improvement listed in this paper can be implemented in a phase approach to limit impact to site personnel and to allow budget planning.

Introduction

The Department of Defense agencies are on a strict budget due to the present government budget deficits. Agencies are searching for ways to reduce spending on building infrastructures and reallocate that money to new technology to keep American military supremacy. The author selected the campus where he works in, at Ft. Gordon, GA for this paper; that was built in 2009 as a candidate for lighting energy consumption reduction. The third biggest energy consumption in commercial buildings is lighting [1].

Motivation on this topic emerges because the author has noticed the lack of controls on the building lighting and the excessive waste of energy by lighting fixtures. The areas studied for this paper are exterior lights at the facility and the operation building lighting. Once an area is lit up, no one thinks of the energy consumption other than the building owner or the bill payer. The main objective of this paper is to provide adequate luminance while reducing by 25% the energy consumption of the light fixtures through the site. The main focus of this paper is to provide recommendation to the Site Command on how to reduce energy consumption through lighting and implementing future projects on site and other localities.

Background

The lights discovery can be dated to 70,000 year ago, with the gas and oil being the first source of light introduced in 1790 [2]. This method was not efficient and dangerous; it destroyed a lot of houses in the early years. In 1879 the first model of incandescent light was created and only provided 13.5 hours of illumination [2]. The initial fluorescent light was discovered in 1904, but it needed high voltage and special connectors to operate and was not a big hit with the customer base [2]. After the florescent light, the high intensity light was discovered and it was highly used because of its high lumen capability and slightly compact footprint. The iterations of fluorescent light have come a long way from when it was first discovered. Today it's the second largest type of light used. The fluorescent light nowadays consumes low energy and provides average lifespan. The latest technology advancement in lighting has come for light emitting diode (LED). The LED consumes up to ¼ of what the florescent lamps consumes and provides up to four times the lifespan [2]. The LED also runs cooler and can be activated more times without any delay on the light lumens.

Metal Halide (MH) light has been typically used in high ceiling applications and outdoors because of the high lumen output. The largest negative characteristic MH has is the short lifespan both the bulb and the ballast have. A typical MH bulb will last around 15,000 hours, but once the light has been used about 30%, the light output drastically lowers while still consuming the full power rated [3]. Many companies that utilized the MH have to change them every 2 years depending on how long they are used to maintain the required foot-candles. Every time the light needs to be changed the company has to spend money on material and labor, so in the long run these costs add up.

Procedure of Analysis

Employee Survey

The survey method was conducted by email to all site employees in regard to specific lighting question. The survey consisted of ten questions total: three for exterior lighting, six for interior lighting and one for shift hours. The goal of the survey was to find a focus area through site.

Phase 1 Exterior Lighting- Gather the information of the five existing light fixture types. Research the new light fixtures with higher light output and LED technology to account for the survey feedback and energy savings.

Phase 2 & 3 Operations (OPS) building Lower & First Level- Compile the information of the existing eight light fixture types per floor, and research new light fixtures with LED technology with similar distribution and light output.

Lighting Controls

The two researched lighting controls are motion sensor and photosensor to maximize the energy savings.

Results

The survey yielded low participation by the work force because the questions were left open ended instead of providing multiple answer selection. The survey still provided a clear focus on the exterior lights that do not have sufficient luminance, that have caused near miss incident reports. On the OPS interior lighting it was glare from recessed circular MH lighting that is causing migraines. Employee also mentioned that some of the bulbs in the circular recessed lights have chattered over existing desks in the past.

Phase 1 Exterior Lighting- The drawing in Figure 1 shows all the exterior light fixtures that are impacted at site. Overall energy savings of 53% compared to existing light fixtures as shown in Table 1. Total phase cost of $750K and the payback is within 11.45 years. The new selected lights meet the nighttime friendly light fixture standard, except the flag light that is pointed at an angle upward. The main criteria for nighttime friendly light fixtures are to have a full cut off of luminance above 90 degrees to reduce the lighting pollution on the surrounding environment. The energy annual consumption per light type and the cost is shown in Figure 2.

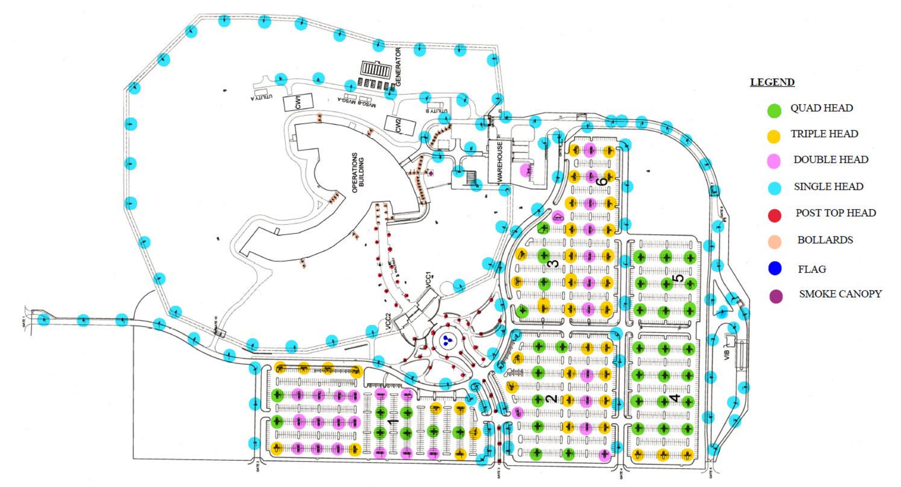

Figure 1
Site Exterior Lighting

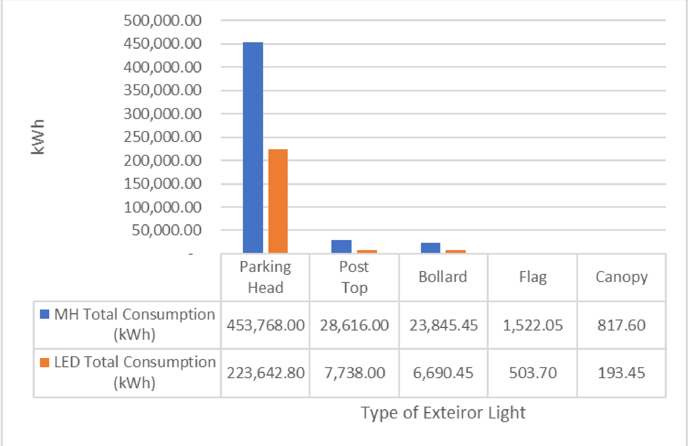

Figure 2
Exterior Light Annual Energy Consumption

Table 1
Phase 1 Cost Analysis Summary

	Cost of the Project	LED Total Consumption (kWh)	MH Total Consumption (kWh)	Energy Saving
Parking Head	$ 638,095.54	223,642.80	453,768.00	$ 20,711.27
Post Top	$ 50,201.76	7,738.00	28,616.00	$ 1,879.02
Bollard	$ 55,321.07	6,690.45	23,845.45	$ 1,543.95
Flag	$ 1,947.13	503.70	1,522.05	$ 91.65
Canopy	$ 877.04	193.45	817.60	$ 56.17
Total	$ 746,442.54	238,768.40	508,569.10	$ 24,282.06
Total Energy Saving Cost			$ 24,282.06	
Total Energy Saving %			53%	
Total Pay Back (Yrs)			11.45	

Phase 2 OPS building lower level- Overall energy saving of 40% compared to existing light fixtures. Total phase cost of $1.372M and the payback is within 4.66 years as shown in Table 2. The new selected lights will be the same make and LED model to the best extent. The recessed downlight will be changed out to a narrow light distribution to minimize the glare issue of employees. The lower level has eight fixture types. The benefit of adding motion sensors to the lower level is shown in Figure 3, the total energy savings improve from 40% to 46%.

Phase 3 OPS building first level- Overall energy saving of 28% compared to existing light fixtures. Total phase cost of $1.227M and the payback is within 4.91 years as shown in Table 3. The new selected lights are the same as for the OPS lower level. The benefit of adding motion sensors to the first level are energy savings from 28% to 35%. The savings increase when photosensors are combined with motion sensors to 54%, as shown in Figure 4.

Table 2
Phase 2 Cost Analysis Summary

	Cost of the Project	LED Total Consumption (kWH)	Existing Fixture Total Consumption (kWh)	Energy saving
Pendant 4' & 8'	$ 586,571.68	415,802.16	500,502.60	$ 7,623.04
Recessed 1x4	$ 47,101.08	30,046.80	39,858.00	$ 883.01
Recessed 2x4	$ 210,364.72	115,369.20	249,966.60	$12,113.77
Utility 1x4 & 1x8	$ 238,845.06	132,604.50	68,328.00	$10,229.49
4" Downlight Open Areas	$ 33,341.28	36,792.00	328,354.00	$ 2,838.24
4" Downlight Rooms	$ 238,845.06	176,806.00	328,354.00	$13,639.32
Stairwell 1x4	$ 7,039.32	6,570.00	17,082.00	$ 946.08
Restroom Vanity	$ 10,553.76	9,110.40	11,563.20	$ 220.75
Total	$1,372,661.95	923,101.06	1,544,008.40	$48,493.70
Total Energy Saving Cost		$ 48,493.70		
Total Energy Saving %		40%		
Total Pay Back (Yrs)		4.66		

Table 3
Phase 3 Cost Analysis Summary

	Cost of the Project	LED Total Consumption (kWh)	Existing Fixture Total Consumption (kWh)	Energy saving
Pendant 4' & 8'	$ 817,368.90	579,474.00	697,515.00	$10,623.69
Recessed 1x4	$ 126,764.92	81,126.36	107,616.60	$ 2,384.12
Recessed 2x4	$ 19,864.40	10,774.80	23,345.40	$ 1,131.35
Utility 1x4 & 1x8	$ 50,719.45	28,053.90	336,515.40	$ 2,164.16
4" Downlight Open Areas	$ 163,263.80	181,200.60	40,237.60	$13,978.33
4" Downlight Rooms	$ 29,479.46	21,666.40	40,237.60	$ 1,671.41
Stairwell 1x4	$ 4,999.52	4,599.00	11,957.40	$ 662.26
Restroom Vanity	$ 14,679.26	12,754.56	16,188.48	$ 309.05
	$ 1,227,139.73	919,649.62	1,273,613.48	$32,924.37
Total Energy Saving Cost		$ 32,924.37		
Total Energy Saving %		28%		
Total Pay Back (Yrs)		4.91		

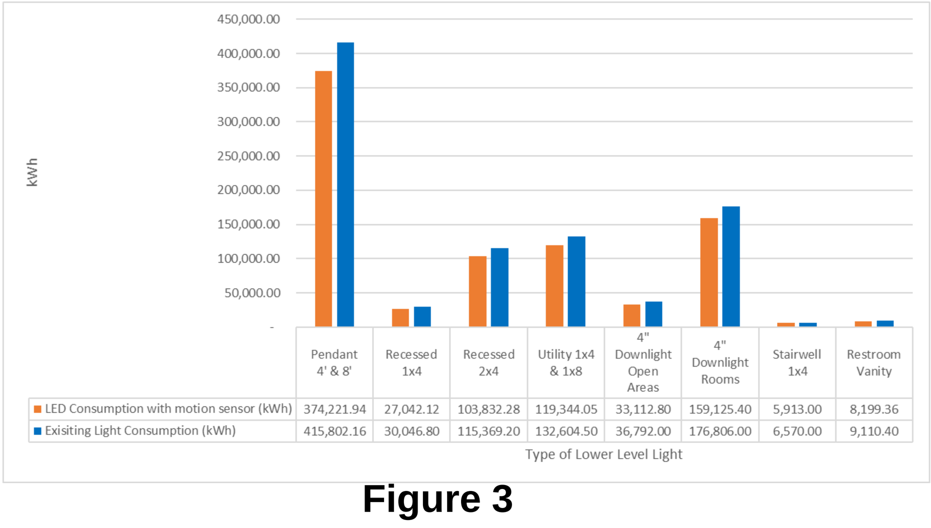

Figure 3
OPS Lower Level Yearly Energy Consumption with Motion Sensor Saving

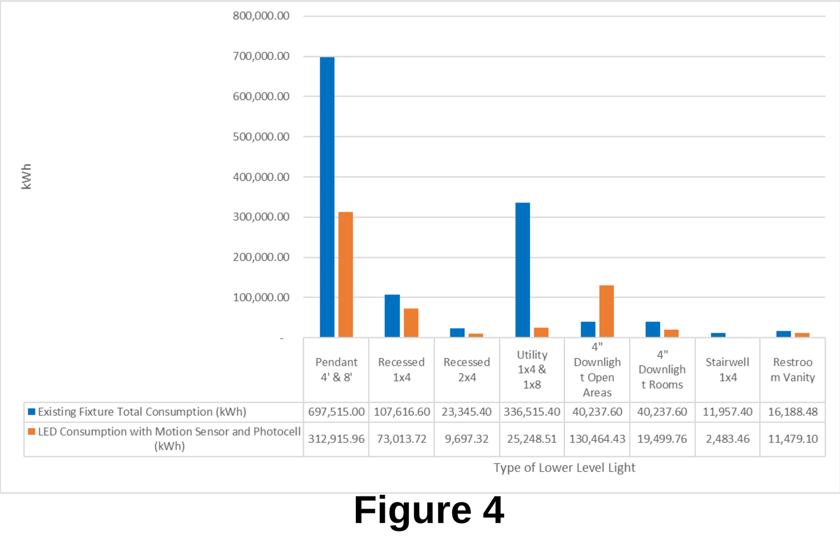

Figure 4
OPS First Level Yearly Energy Consumption with Motion Sensor & Photosensor Saving

Conclusion

As discussed at the beginning of this project a main objective and focus area was established and both were accomplished. The existing light fixtures were identified and through research and employee feedback, the selection of new LED fixtures was provided.

The findings provided an overall savings of energy consumption of 37% on the study areas exterior site lighting and OPS building. The 37% just accounted for a light fixture conversion of the focus area. If controls saving are to be considered, the site could save even more. The two lighting controls research in this paper were motion sensors and photosensors. No lighting controls where researched for the exterior lighting because those are controlled by timers. The motion sensor increases the savings of energy consumption to 43%. The other lighting control that increases the savings that can be applied at site is installing photosensors on lighting near the windows; this would save 50%.

The actions that need to be taken in the future will be to study all the outbuilding and to accurately survey the use of each room, to maximize the settings on the motion sensors. Point by point calculation for each area study in this paper could also provide more energy savings, by reducing the amount of fixture needed and still maintain adequate luminance. The result found in this paper can be applied in a phase approach to limit the impact to site and build the budget for them.

References

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[2] Holland, Andrew. (2018, October 25). "The History of Lighting and What the Future Holds." [Online] *Larson Electronics*, Available: https://www.larsonelectronics.com/blog/2018/10/24/industrial-lighting/the-history-of-lighting-and-what-the-future-holds/.
[3] Tol, Dave Van. (2011, November 4). "Metal Halide:The Shocking Truth In The Life Of A Metal Halide Bulb." [Online] *HLI-Top-Bar*, Available: http://hoveyelectric.com/hovey-electric-power-blog/bid/77000/Metal-Halide-The-Shocking-Truth-In-The-Life-Of-A-Metal-Halide-Bulb.