LED Luminaire Replacement in Puerto Rico Electric Power Authority San Juan Steam Plant

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Abstract *— With the objective of finding the best economical alternative to High-Pressure Sodium exterior luminaires, this paper looked to determine if Light-Emitting Diode lights could provide a lower cost replacement. The analysis focused on three main type of costs: initial replacement cost, maintenance costs, and energy consumption costs. Because this project is centered on the San Juan Steam Plant of the Puerto Rico Electric Power Authority, the costs were based on data from this site. The findings of this study show that when replacing High-Pressure Sodium luminaires with Light-Emitting Diodes, initial costs for replacing existing luminaires were high, but annual maintenance and energy consumption costs provided savings for the organization.*

INTRODUCTION

The Puerto Rico Electric Power Authority (PREPA), as many other organizations and enterprises, look to apply cost-effective solutions to many of their system. One such system is the lighting equipment installed on site that provides illumination in the work area. The San Juan Steam Plant, the first electrical producing plant based on steam that was constructed on the island, currently has installed High-Pressure Sodium (HPS) luminaires on the exterior of the site. Newer technologies, such as Light-Emitting Diode (LED), raises the possibilities of implementing a more cost-effective luminaire that would help an organization, such as PREPA, in lowering costs in an ever-changing competitive market.

The objective of this project is to perform a cost analysis of replacing HPS luminaire with LED lighting, without affecting the illumination in the different areas. To do this, this project will analyze the cost of replacing these technologies, as well as comparing maintenance and energy costs of both technologies. With this analysis, this project will determine which of these technologies will generate the most cost-effective impact for the organization.

LITERATURE REVIEW

When LED luminaires started to be installed in public places, there appear to be a flaw in this technology. Because the main purpose of LED lighting was to lower energy consumption, the requirements to meet this limited the spectrum of color to white, while emitting blue light. This blue light contrasted heavily to a more natural color emitted by the High-Pressure Sodium luminaire. With the passing of time, manufacturers were able to develop LED technology into emitting a more natural color spectrum without sacrificing efficiency [1].

When comparing the costs of LED lighting versus High Pressure Sodium, the costs of installation, maintenance, and energy consumption must be observed. Studies show that the initial costs of LED lighting is higher than High Pressure Sodium, but the fact that High Pressure Sodium has more components and a lower life expectancy make the maintenance costs of this technology higher. In addition, energy consumption savings are higher with LED technology as LED luminaires achieve similar lighting standards as High-Pressure Sodium while consuming less energy [2]-[3].

Some of the benefits that LED lighting presents compared to High Pressure Sodium lighting are the energy efficiency, the spectrum of color, life expectancy and reliability. Additionally, the efficiency and performance of LED lighting allow this technology to be integrated to smart systems and solar energy systems [4]-[5].

ANALYSIS APPROACH

This project focused on three type of costs: initial replacement costs, annual maintenance costs, and energy consuming costs.

Initial Replacement Costs

The initial replacement costs consisted of the materials and labor surrounding the installation of new LED luminaire where HPS is currently installed. An assumption in this analysis is the use of an external contractor due to PREPA personnel limitations. In addition, the costs of the new luminaire are the based on the available type of luminaire in the site's warehouse.

Annual Maintenance Costs

The annual maintenance costs are based on the costs associated with repairing and replacing faulty luminaires during the day-to-day activities. The personnel doing this maintenance are going to be PREPA personnel so, in addition to salary, this analysis takes into considerations marginal benefits. Material costs are based on the material currently on the site's warehouse.

Energy Consumption Costs

Energy consumption costs are based on 12-hours daily operations and the cost per kilowatt-hour would and estimated similar to the current rate. These calculations will yield the consumption cost each type of luminaire.

RESULTS

Initial replacement costs were obtained by combining the material costs, labor, and contractor profit margin. Table 1 shows the results. These costs are based on replacing all 380 luminaires and an installation would take approximately 190 hours, or 24 days.

Table 2 shows a comparison between the annual maintenance costs of HPS and LED luminaires. According to this data, LED would cost approximately $,308.70 less than HPS. Because this work would be done by PREPA personnel, labor costs must include marginal benefits.

Table 3 reveals that when assuming 12-hours daily operations for the lighting fixtures and a 0.21 dollars per kilowatt-hour, the organization would be saving $24,498.60 since LED lighting consumes 80 watts compared to 150 watts of HPS. To obtain these results, the consumption of the fixture is multiplied by the daily hours of operation and by 365 days in a year. Finally, that result multiplied by the cost rate of energy yields the energy consumption of each lamp.

Table 1
Initial LED Replacement Costs

Cost Concept	Cost
Materials	$60,800.00
Labor	$7,030.00
Profit Margin (25% of installation costs)	$16,957.50
Total	$84,787.50

Table 2
Annual Maintenance Costs

Cost Concept	HPS Cost	LED Cost
Materials	$4,045.08	$2,750.98
Labor	$12,544.48	$8,529.92
Total	$16,589.60	$11,280.90

Table 3
Annual Energy Consumption Costs

Cost Concept	HPS Cost	LED Cost
Cost of one lamp	$137.97	$73.50
Total	$52,428.60	$27,930.00

Payback Period

To further understand the impact of replacing HPS lighting with LED, the payback period was calculated to determine the time it would take to recover the initial investment. Equation (1) shows how the payback period is calculated. For this project, the payback period is 2.84 years.

$$Payback\ Period = \frac{Initial\ Invesment}{Cash\ Flow\ per\ Period} \quad (1)$$

From this information it can be determined that, while initial investment for replacing all HPS lighting with LED technology may be as high as approximately $85,000, the annual maintenance ($5,308.70) and energy consumption savings ($24,498.60) prove that LED impact the organization in more cost-effective way than HPS. Furthermore, payback period of the replacement of technologies resulted in less than 3 years.

CONCLUSION

The objective of this project was to determine if replacing HPS luminaires with LED fixture would result in a positive impact in terms of cost-effectiveness. To do this, three type of cost were analyzed: initial replacement, annual maintenance, and energy consumption. The results of this analysis would be used in determining whether this implementation would be beneficial to an organization.

This analysis found that initial costs were as high as almost $85,000, due to the materials and labor. Nevertheless, annual maintenance and energy consumption of LED light provided a saving of approximately $30,000. This meant that the initial investment would be recover in less than 3 years. Considering the longevity of LED, this short payback period means that the organization would benefit from those savings for many years after the investment is recovered. These results imply that organizations, in this case the Puerto Rico Electric Power Authority, should move towards implementing these changes.

These results also imply the need to analyze future replacements. Indoor lighting and specialized equipment with required lighting would benefit of a similar analysis and organization could implement changes that make them more cost-effective.

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