Research on Application of LED Navaid Lighting in Airfield Area of Civil Airports

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Abstract. The energy consumption of airport lighting, especially that of navaid lighting in airfield area, accounts for a lion share of the total, rendering the energy saving and emission reduction of the navaid lighting system important in the construction of civil airports. Application of LED light source that is with certain advantages can largely lower energy consumption and maintenance costs. The dissertation compares the LED lighting source with its traditional brethren --- halogen lighting from the perspectives of service life, energy saving and emission reduction, operation and maintenance, and return on investment, and elaborates and explores the application and development of LED navaid lighting in civil airports around the world.

1. Introduction
Lighting systems at airports are most energy consuming, only outrun by heating ventilation air conditioning (HVAC). Today, building green airports highlighting energy conservation, environment protection, green elements, low-carbon and high efficiency has gradually become the trend of global airports. Among the family of energy-saving and consumption-reducing measures, the application of eco-friendly lighting has become one of the most important measures and is also effective to let green airports come into being. Well-designed LED lighting systems can be in service for quite a long time and the introduction of LED lighting source into the navaid lighting system project in the airfield of airports can result in significant improvement in the energy saving and emission reduction. Hereby, some discussions and studies are contributed to the application of LED lighting source in the navaid lighting system of the airfield of civil airports.

2. Comparison of LED navaid lighting and traditional lighting
Currently, halogen lighting is most ubiquitous in the navaid lighting in the airfield of domestic airports. As technologies rapidly evolve, the application of LED in the navaid lighting in airports has received increasing attention.

2.1 Comparison of service life
Halogen lighting can luminate 1500 hours before out of operation (the service life of a bulb of 100W or more is 1000 hours), and bulbs need to be replaced every three to four months. LED lighting source can be valid for 56,000 hours under the highest light level condition, 37 times that of the halogen lighting source, requiring only one replacement or even none for life. Therefore, the use of LED
lighting source can greatly reduce the loss incurred by frequent replacement of parts and time consumed. (As shown in Figure 1).

![Figure 1 Comparison of service life of LED lighting source and halogen lighting source](image)

The service life of LED lighting is directly subject to the use environment and service life of electronic components. Packaged circuit boards of LED lighting fail mostly due to moisture, water or stock of high current. While the impact of external water or moisture on the core components of LED lighting can be prevented through technical research and technological innovation. Strong current and overvoltage may also affect the service life of LED lighting. The LED lighting are all equipped with overcurrent protection and overvoltage protection modules. However, even halogen lighting may see their bulbs burnt upon loop overcurrent or overvoltage.

So, under ideal conditions, the service life of LED lighting is more than 60 times that of halogen ones. Even considering issues such as circuit boards and electronic components, LED light depreciation etc., the service life of LED lighting can be more than 30 times that of halogen ones. Therefore, the use of LED lighting greatly saves the workloads and time needed for maintenance in the airfield.

### 2.2 Comparison of Energy Consumption

The one-way power consumption of the LED lighting generally does not exceed 20W, while that of the traditional halogen ones generally registers more than 50W. Some LED lighting may have the power of about 40W, while the equivalent halogen counterparts are with more than 100W, up to 75% energy being saved by the former. The application of LED lighting greatly reduces energy consumption and carbon emissions, saving two to four times’ energy. As shown in Figure 2.
2.3 Comparison of Operation and Maintenance

2.3.1 Operation and Maintenance Features of Halogen Lighting The halogen lighting need to have their filters replaced regularly. Lighting need to be opened for every replacement, damaging their encapsulation. Fix necessitates the renewal of the corresponding parts such as sealing rings and gaskets with high costs. The siphon phenomenon emerging while opening and closing lights, due to the high temperature of lighting per se, will cause dust or water vapor entering, rusting and corroding accessories. Changes in temperature expose prisms and lighting to defacement to larger extent, rendering maintenance and replacement of bulbs regular and maintenance costs higher.

2.3.2 Operation and Maintenance Features of LED Lighting With giving out monochromatic light a hallmark, the LED lighting emit more unified colors and are more recognizable in unfavorable weathers. For no filters are needed, the problem of filter damage does not exist, reducing the times of opening lighting and letting lighting maintain better encapsulation. The prisms of the LED lighting are cool enough to avoid the siphon phenomenon. Thus, no dust will be sucked in and the prisms are not easily defaced, reducing the frequency of maintenance and replacement, which further cuts down or even eliminates the costs of maintenance or regular replacement of luminaires. Less spare parts required and less LED lighting in the runway to be maintained lead to less maintenance personnel on the runway, improving safety and minimizing the possibility of runway incursions. The maintenance cost and manpower needed in down time for overhauling airplanes will also decrease correspondingly.

3. Coordination of LED Navaid Lighting and Other Airport Systems

3.1 Impact on the Power Supply System
The LED lighting are designed and produced to replace halogen counterparts in existing power supply loop for the halogen lighting without affecting the original power supply and dimming model. As the LED lighting operate in a way somewhat different from their halogen brethren (the LED lighting are voltage driven and halogen ones are current driven), it is recommended to choose power supply equipment looped with sine wave dimmers when selecting power supply units in the light station, which can maximize the energy saving and prevent unstable loop operation incurred by harmonic interference in the loop without any influences on the operation of the existing loop.
3.2 Impact on Monitoring System of Single Light
According to relevant regulations of the General Technical Requirements for LED Navaid Lighting Used in Civil Airports and FAA, the LED lighting should be with the function of fault self-detecting. Using the LED lighting cooperatively with the single light control device or other light control devices confronts no technical or normative obstacle and exemplifies no essential difference from the conventional halogen lighting with the single light control device. Since single lighting monitoring is underlain by the power carrier wave communication mode, its actual working results, detection results and stability need to be considered and tested. Using the LED lighting in conjunction with single-lighting monitoring system has no problem in theory, and there have been many successful cases internationally.

4. Return on Investment of LED Navaid Lighting
In the following, the construction of a new runway with 3600m length and 50m width will be taken as an example to analyze the return on investment. As shown in Figure 3.

Figure 3 Investment comparison between LED lighting and halogen lighting

In the simulated new airport, including a runway and a taxiway, the investment by installing the LED lighting is about 30% higher compared to that of halogen lighting. However, according to the data in the figure, the airport can recover its costs after two years of operation. After that, the airport can start to make profits, and it can save energy worth RMB500,000 per year. More than RMB800,000 maintenance costs can be saved. If all equipment will be replaced for every five years, the total investment of the halogen lighting is about RMB12.79 million and the total investment of LED lighting is about RMB7.68 million. The use of the LED lighting can reduce the investment of the airport by more than RMB5 million and carbon emissions by more than 230 tons.

5. Application Status of LED Navaid Lighting System at Airport
5.1 Application at Global Airports
The LED navaid lighting system is applied at overseas airports for quite a while. According to current statistics, there are more than 45 hub airports in the United States, over 70 regional hub airports in Asia Pacific Region (including Australia), 10 plus international hub airports in the Middle East, 150 odd international hub airports in Europe, no less than 20 international hub airports in Africa and over 20 international hub airports in South America using the LED lighting in their runways and taxiways. More than 1,000 hub airports worldwide use LED navaid lighting in taxiways. The Hartsfield-Jackson Atlanta International Airport in US, Birmingham Airport in UK, Cape Town International Airport in South Africa, London Gatwick Airport and Heathrow International Airport in UK all use LED lighting in their runway lighting systems.
5.2 Application at Airports in China
At present, most of the civil airports in China use the halogen lighting because of their simple structure, low cost, and easy control and adjustment of brightness. The LED lighting are most widely used as taxiway edge lights and taxiway centerline lights. LED taxiway edge lights have been successfully applied at major airports such as Beijing Capital International Airport, Shanghai Hongqiao International Airport, Nanjing Lukou International Airport and Tianjin Binhai International Airport. Almost all new airports are also considering the use of the LED lighting as their taxiway edge lights. In addition, LED taxiway center line lights have been maturely applied in some airports in Chengdu, Chongqing, Zhengzhou, Shenyang, and East China Region. The LED lighting was successfully applied to the stop boards of the second phase of Nanjing Lukou International Airport. Xi'an Xianyang International Airport is the first domestic hub airport to fully use the LED lighting as its taxiway lights. According to statistics, the energy-saving effect is obvious. During the night flight hour from April 22 to May 22, 2014, the taxiway center line lights in LED saved 19.38% compared to halogen lighting, and the taxiway edge lights in LED saved 40.77% more than halogen version. As shown in Figure 4.

6. Conclusion
The halogen lighting have shorter service life and higher consumption while LED lighting are of energy conservation, environmental protection and small size, and can improve the visibility of lights and lengthen service life. It requires less spare parts, maintenance time and cost by personnel. With all the above edges, the LED lighting can be regarded as the future direction of navaid lighting development. The LED lighting also suffers some shortcomings. In case of extremely severe weathers such as blizzard, untimely snow removal will affect the light intensity. With more in-depth research and innovation on navaid lighting system and LED technology, more innovative ideas and technologies will surely appear. The application of LED technology in navaid lighting will be more promising in the future.

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