

An asset-management model for use in the evaluation and regulation of public-lighting systems



Mohammad Javad Mirzaei ^{a,*}, Reza Dashti ^{a,*}, Ahad Kazemi ^a,
Mohammad Hassan Amirioun ^b

^a Iran University of Science and Technology, Department of Electrical Engineering, Iran

^b University of Tehran, School of Electrical and Computer Engineering, Iran

ARTICLE INFO

Article history:

Received 4 May 2014

Received in revised form

8 December 2014

Accepted 8 December 2014

Available online 16 December 2014

Keywords:

Public-lighting systems

Asset management

Optimal management strategy

Failure-rate estimation

ABSTRACT

In this paper, an asset-management model is proposed to address challenges facing regulators, managers, and operators of public-lighting systems and suggest optimal performance strategies. A new method is presented to estimate the failure rate of lamps based on the normal distribution function. The impact of technology improvement in lamp manufacturing as well as the growth and extension of lighting systems on the failure rate are investigated. In order to achieve satisfaction of customers and risk reduction, a method for establishing a performance standard for lamp failure rates is presented. Considering technical and economic issues, a procedure for selecting the best lamp in the market and then estimating costs associated with system operation is described. Finally, a methodology is proposed for evaluating performance in public-lighting systems. Results of a case study for the public-lighting system of the newly constructed suburb of the city of Isfahan, Iran, show the efficacy of the proposed method.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

The public-lighting system is an important municipal function that plays a remarkable role in public health and social welfare. Moreover, it is significantly effective in reducing social offenses and enhancing personal security (Rabaza et al., 2013). In other words, the distribution of lighting can influence overall social well-being (Haans and de Kort, 2012). It has also been noted that improvement in areas having weak lighting systems can reduce driving accidents up to 35 percent (Jackett and Frith, 2013).

Asset management is defined as the active management of the financial and physical assets of a company (or other entity) especially in order to optimize the return on investment. The main purpose is to make optimal spending decisions that will return the greatest stakeholder value from the available budget. All decisions are made according to a set of stakeholder-driven criteria (Dashti and Yousefi, 2013; Brown and Humphrey, 2005). Customers request electricity distribution companies to provide them with

services with high quality and minimal cost. To do so, distribution companies must develop asset-management policies and strategies to optimize system performance (Hoskins et al., 1999).

For public-lighting systems, asset management and optimization strategies involve different players, including government regulators (Radulovic et al., 2011). In fact, in addition to public satisfaction, efficient performance of the public-lighting system can be valuable to governments in terms of economic benefits. Consequently, optimal asset-management strategies for the lighting sector are a regulatory priority.

In previous research (Miletić and Karavidović, 2013), a method for informing short-term and long-term maintenance actions has been presented. Moreover, an approach has been proposed capable of giving managers advice on optimal decision-making about issues such as asset status, system reliability, and budgetary impacts. Keeping optimal balance between predictive and preventive maintenance actions has been presented as an approach to minimize grid operational costs (Hilber et al., 2007). Other research (Cossent and Gómez, 2013) has focused on the evaluation of investment efficiency for optimal grid management. To achieve this, using predictive plans with mechanisms such as contracts with profit sharing, has been suggested.

There are significant human resource constraints that limit the capacity and hence the potential effectiveness of energy regulatory

* Corresponding author.

E-mail addresses: mj_mirzaei@elec.iust.ac.ir (M.J. Mirzaei), rdashti@iust.ac.ir (R. Dashti), kazemi@iust.ac.ir (A. Kazemi), m.h.amirioun@gmail.com (M.H. Amirioun).

agencies in developing countries. Also, human-resource management can be significantly important in terms of overall economic development (Pollitt and Stern, 2011). Thus, decision tools and performance standards that enhance regulatory capability are needed.

Remaining lifetime and failure-rate estimation are of the most important functions used in reliability-centered asset management. These functions are extremely vital in planning, maintenance, system-design improvement, cost analysis, and generally in the optimization of management strategies (Si et al., 2012; Bagkavos and Patil, 2008). Researchers have investigated the aging of lighting lamps (Mockey Coureaux and Manzano, 2013). The design, production, operation, and maintenance of lamps are relevant parameters in the aging process.

Previous researches have compared different lamps used in the public-lighting system, such as high-pressure mercury (HPM), high-pressure sodium (HPS), light-emitting diode (LED), etc. The evaluation has been done to improve the public-lighting system management from different points of view. These aspects include the impact of lamps on the visual perception of people (Rodrigues et al., 2011; Luo et al., 2008), lifetime (Vahl et al., 2013), waste disposal (Long et al., 2009), and economic considerations (Kostic et al., 2009).

In one study (Manzano and San Martín, 1999), the number of failed lamps regarding to the installed ones in a random sample of streets was used as an estimator of the percentage of permanent failed luminaries. Even though sampling a set of stochastic data and extending the features to all data is an available statistical method, it does not promise enough accuracy. Lower accuracy in failure-rate estimation results in lower accuracy in cost estimation and consequently poor management of the system. Moreover, in the referenced study (Manzano and San Martín, 1999), only annual operating costs are considered and other upcoming challenges in the public-lighting system are neglected. Another study (www.gonenergy.in/download) notes that the failure rate of lamps is determined based on historical data. Due to insufficient historical and experimental data, this method will not be efficient if different lamp types or new lamp technologies are utilized in the network. Despite more than two centuries of lighting lamp applications, statistical analysis in lifetime and failure rate of lamps is quite primary (Bebbington et al., 2008). Leff proposed the use of the Weibull function to model the lamps lifetime in 1990. He assumed the value of parameter α in the survival function of Weibull to be 5 in order to provide more adaption to experimental data (Bebbington et al., 2008). Others (Agrawal and Menon, 1998; Menon and Agrawal, 2003, 2007) have investigated the reliability features of different lamps by comparing theoretical models of lamp lifetime to experimental data. Some researchers (Menon and Agrawal, 2006) have proposed an improved model to determine lamps lifetime based on physical rules, modeling the failure process of lamps that takes place due to Tungsten discharge through a hot string by a binomial distribution; their results are closely similar to experimental data.

There is no comprehensive research literature on the role of failure-rate estimation in addressing the economic challenges of public-lighting system management. Thus, research comparing failure rates of different lamps used in public lighting should be very beneficial. Previous research provided the normal distribution function for use in modeling the lifetime of public-lighting lamps (Bebbington et al., 2008). This paper applies an extended model based on this standard normal distribution function to estimate the annual lamp failure rate.

Research in this area can help minimize risk and optimize management strategies. A first step is to survey the economic challenges facing the public-lighting system in order to identify

aims, expectations, and possible actions. A second step is to develop optimal management strategies.

In this paper, a new method is proposed to analyze the annual failure rate of lamps. Using the proposed methodology, lamp provision and replacement costs can be estimated. The results of the cost estimation are applicable to budget allocation for the public-lighting system. The impact of system annual growth and extension on the failure rate of lamps is investigated. Moreover, the impact of technology improvement on failure rates for lamps available in the market is also reviewed. Finally, a method for regulators to use in evaluating performance in the public-lighting system is presented.

The rest of the paper is organized as follows:

The public-lighting management structure is introduced in Section 2 and key challenges are also presented. In Section 3, the proposed method for calculating the failure rate of lamps is described. The proposed model for addressing challenges facing the regulator is also presented in this section. Section 4 presents the analysis and results. Finally, a conclusion is given in Section 5.

2. Structures and functions of public-lighting systems

As shown in Fig. 1, the provision of public lighting may involve distinct structural entities that provide three distinct functions: regulation, management, and operation. Lighting regulators are responsible for general policies and protecting the rights of lighting managers and operators. Asset management policies and budgeting are determined at this level. The Ministry of Energy provides this role in Iran. Lighting managers usually own lighting-system assets, receiving budgetary resources from the regulator. Managers are responsible for implementing asset-management policies and ensuring responsiveness and stability. Managers also design and execute contracts with operators. In Iran, distribution companies fulfill this function. Lighting operators have administrative responsibility and are expected to make optimal use of resources by promoting performance and efficiency. In Iran, the private contractors fulfill this function.

Each of the structural entities encounters a set of concerns. The lighting regulator faces the following challenges and questions:

- What level of resources should be dedicated to covering operational costs?
- How should the performance of public lighting systems be evaluated?
- What costs in public lighting are associated with growth and development?

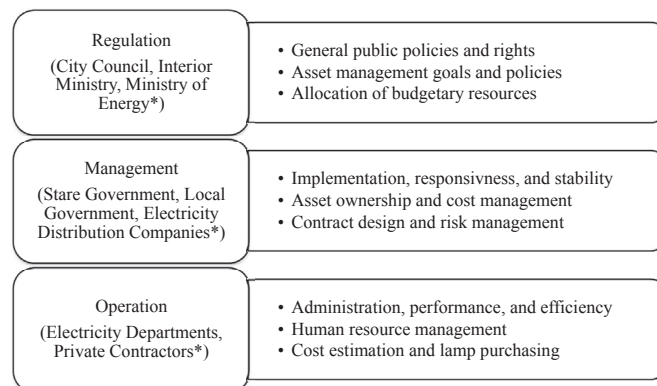


Fig. 1. Structures and functions of public-lighting systems. *Responsible entity in Iran.

Download English Version:

<https://daneshyari.com/en/article/1000103>

Download Persian Version:

<https://daneshyari.com/article/1000103>

[Daneshyari.com](https://daneshyari.com)