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Outdoor lighting system upgrading based on Smart Grid concept

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Abstract

The article studies the matters of Smart Grid concept implementation within outdoor lighting systems. Present work examines technical and economic mechanism of evolutionary modernization of external lighting systems in one of the largest Russian universities on the basis of implementation of intelligent systems of control over LED-illuminants. The goal of the upgrade project, which involves Smart Grid technologies, is stepping up efficiency and operation reliability. This paper evaluates the payback period of the modernization project – the outdoor lighting system of a university campus – based on light emitting diode lamps, which feature enhanced operational reliability. The payback period of initial investment taking into account the repayment target financing is 4 years and 10 months.

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Keywords: Smart Grid; energy saving; energy efficiency; lighting system; repayment target financing

1. Introduction

The priority area of the state policy for the development of energy infrastructure of the Russian Federation is the performance of activities relating to energy saving in all spheres of the national economy. The electricity consumption for lighting represents 19% of the world's total electricity consumption [1]. Lighting of street and buildings accounts for up to 75% in electricity demand of lighting [2]. Therefore, the issue of energy saving in street lighting systems is a very important. The main trend of lighting products development is to increase the requirements for energy efficiency and environmental performance of products and improve the performance of the produced products [3-5]. Streetlights are equipped with modern electronic control gear for monitoring and control [3, 6-8]. One of the central focus areas of increasing efficiency of complex street lighting systems is the implementation of automated control

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systems. Modern automated outdoor lighting systems allow operative from a central console to manage the completely lighting system and each luminaire separately [9-12].

The analysis of various literature sources shows that the main task of the developers of advanced systems of automated street lighting control is to increase reliability and durability of control networks, as well as to increase the level of safety of people and traffic safety [13-15], to increase the quality and efficiency of street lighting and court area lighting, to reduce operational costs relating with maintenance of street lighting control networks, to reduce financial costs of payment for electricity consumed in order to ensure outdoor lighting.

2. Implementation of the Smart Grid concept within outdoor lighting systems

Currently experts in the Russian Federation are working on the development and implementation of the new generation of Smart Grids within the energy sector. Implementation of the Smart Grid concept within outdoor lighting systems stipulates for availability of the possibility of customized control and diagnostics of each lamp, which enables to increase energy efficiency and operational reliability of outdoor lighting networks [16, 17]. The energy saving effect can be achieved largely owing to dimming of lighting fixtures (flexible adjustment of brightness of lamps) during the day depending on conditions of natural lighting and special requirements to natural brightness and to the intensity of illumination depending on the time of day. Dimming of lighting fixtures can be technologically achieved by applying special electronic devices, which are built inside lighting fixtures. At the same time, the modern approach to creating a system of street lighting control with the dimming function provides for the implementation of a function of targeted dispatch of control commands from automated power sources to lighting fixtures. This enables to perform customized or group-level adaptable control of operation of lighting fixtures by introducing differentiated modes of reduced (dimmed) brightness of lamps and accounting for the requirements to the quality of outdoor lighting of certain segments of roads.

The result of implementation of this function is the achievement of the maximum possible savings of electric energy while ensuring the required level of brightness. Customized dimming provides additional opportunities for energy savings.

Control of operating modes and technological parameters of lighting fixtures in real time mode enables to improve the quality of operation of lighting networks as it enables to quickly obtain information about the status of a particular lamp and identify possible faults in lighting networks.

In outdoor lighting systems, there are various types of lamps used. For example, LED lamps (light emitting diode lamps), high-pressure sodium arc lamps (HPS), plasma lamps, light emitting diode lamps, etc. Despite the high-energy efficiency of LED sources of light, their utilization in street lighting systems is constrained by their high cost. In the forecasted period, the trend for replacement of mercury arc lamps with energy efficient light sources and lighting fixtures based on this technology will continue; also outdoor lighting fixtures will be equipped with advanced ECG systems (electronic control gear) in order to control and manage operation of lighting fixtures.

This is why the hybrid system of street lighting is the optimum one, as it enables to control operability and ensures real time flexible control of various types of lighting fixtures.

Advanced hybrid systems of automated street lighting control are based on a three-tier architecture, which includes:

- Local control block of a lamp or a group of lamps inside a street lighting fixture
- Zonal control level cabinet (street or quarter)
- Area’s central server

The new methods of street lighting control based on network technologies enable to configure street lighting in real time mode and in a scientifically justifiable and dynamic manner. This solution is able to not only save a great amount of electricity but also reduce environmental pollution relating with the generation of electric energy.

The three-tier system of automated street lighting control is shown in Fig. 1.