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SOLUTIONS TO ACHIEVE ENERGY SAVING THROUGH AUTOMATION OF THE STREET LIGHTING SYSTEM

Pazletdinov Ilyosbek
Junior Teacher, Andijan Machine-Building Institute, Uzbekistan, Andijan
E-mail: ilyosbekpazletdinov@gmail.com

Abstract
Energy consumption in the general lighting system is the largest part of the society's energy consumption, while the maintenance and operation of the system requires a large cost for each city. The article focuses on the types of street lighting and innovative innovative methods, and proposes an intelligent system-based consumption reduction solution for remote metering and light control technologies for LED lights. The results show that significant energy savings are achieved and the service life of the lights is extended.

Keywords: street lighting control, intelligent control system.

Introduction

General lighting for roads and public areas ensures traffic safety and improves the feeling of security on the streets. However, public lighting consumes a lot of electricity. With 636 million street lights, the public lighting sector, in particular, accounts for about 19 percent of global electricity consumption [1].

The carbon dioxide produced to generate this electricity accounts for nearly 70 percent of global emissions from passenger cars and three times that of aviation. Therefore, reducing energy consumption for street lighting is beneficial not only for individual cities, but also globally [2].

Street lighting can be defined as the artificial lighting of streets when the available natural light falls below a predetermined level.

This public service provides a safer environment for its users, including: facilitating traffic flow and reducing nighttime accidents, increasing the sense of personal safety, and encouraging business/public facilities at night [3].

Most existing public lighting systems still use outdated technology - some as old as the high-pressure mercury lamp systems of the 1960s.

By switching to modern and more efficient systems that use lighting control technology, energy bills can be dramatically reduced and carbon emissions reduced [4].

There are many different solutions for controlling street lights. Manual control is error-prone, wastes energy, and manual light control in the middle of the night is a challenge. Also, dynamic light level monitoring is not done manually.

The current trend is to introduce automation and remote-control solutions for street lighting control [5]. Remote control systems with automation technology allow you to control lights, adjust light levels, and report lamp or component failures.

In addition to energy saving benefits, adjusting light levels can help reduce environmental pollution [7].

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Light levels can be adjusted flexibly, dynamically or intelligently in remote lighting control systems. When the light level can be adjusted in real time or according to a predetermined schedule, the lighting system is called adaptive or dynamic.

An adaptive or dynamic lighting control system can be intelligent when light levels are adjusted in real time based on predefined parameters [7] [10].

A typical feature list for an intelligent lighting control system includes:

- reporting of malfunctions and conditions: malfunctioning lights, incorrect power factor, etc.;
- reporting of faults and conditions at the level of street location;
- ensuring the lighting device is switched on and off;
- Provision of shut-off device and energy accounting;
- Provision of other operational data, such as access and traffic detection, etc.

In addition, the system must be able to withstand the expected environmental conditions, as well as be suitable for installation using normal operating methods [9].

Our research focuses on innovation for lighting equipment and street lighting, and offers a consumption saving solution based on an intelligent system for remote measurement and control with light control technologies for LED lights.

Street lighting is a technical condition.

In Europe, the recommended average brightness of the road surface is 0.3 - 2 kd/m2, and in the USA it is in the range of 0.3 - 1.2 kd/m2 [6]. Currently, street lighting calculations and measurements in Europe comply with the European standard EN 13201-3.

Currently, high pressure sodium (HPS) and LED lights are the most widely used light sources in road lighting. HPS lamps are used due to their long life and high luminous efficiency, and LED lamps offer high luminous efficiency, good color rendering properties and good peripheral visibility at low light levels [6].

Usually, street lights are manually controlled. An example is shown in Fig. 1a. Street lights can be automatically turned on/off using timers (Fig. 1b) or photocells (Fig. 2a). Our photocell design solution is presented in the picture. 2b.

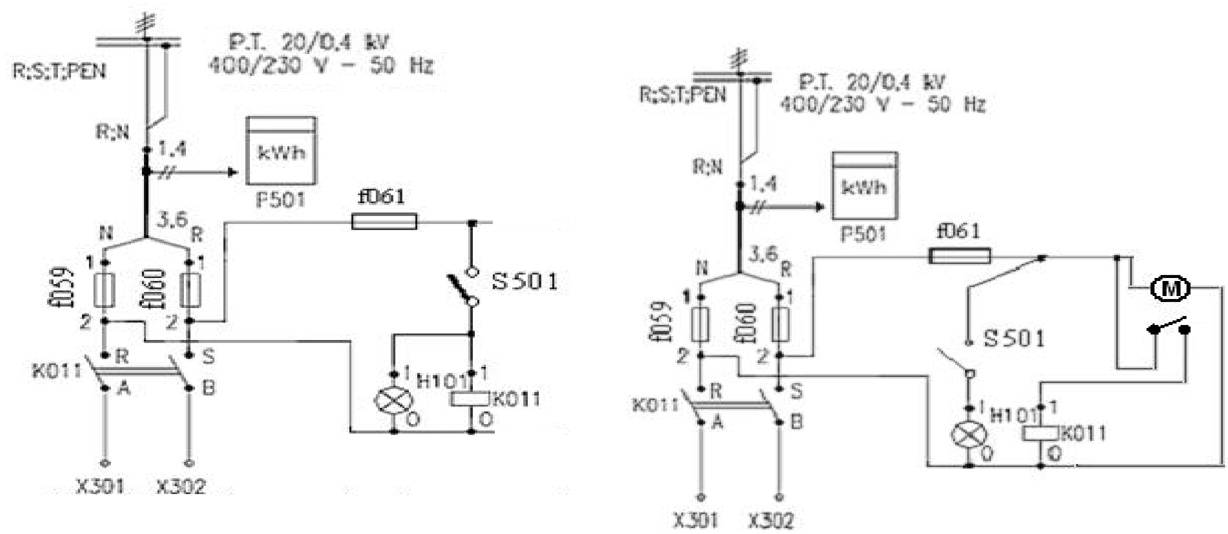

Figure 1. Turn on/off street lights: a) manually; b) by timer

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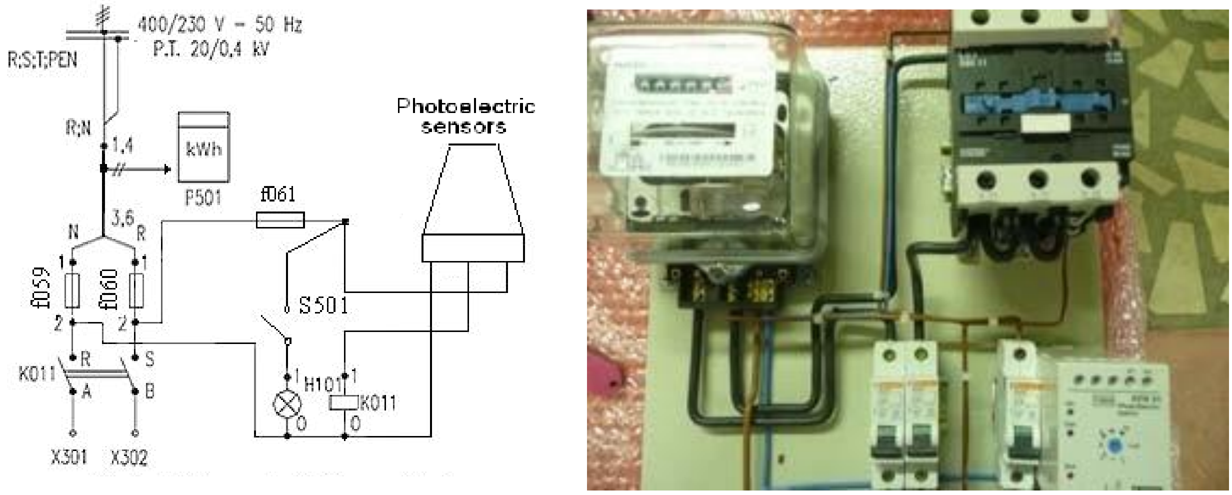

Figure 2. Control of street lights through photocells

In order to save energy, intelligent street lighting control systems are increasingly being used. The system architecture consists of a control center, remote terminal units, lighting control units and lights.

The control center (hardware and software) collects and processes data from the lights, makes decisions on control parameters, and stores the processed data.

Remote terminal units collect data from light control units and send the information to the control center, receive commands from the control center and transmit them to the light control units.

Light control units receive commands from the remote terminal unit and execute the command. They also transmit information about the state of the lights to the remote terminal unit.

Although intelligent street lighting control systems are similar, the control parameters and control strategies vary depending on the specific situation, budget and decision makers.

Time table-based step-by-step control is currently a widely used control strategy in street lighting control systems [10].

The timetable is based on experience and previous traffic density analysis. The lamp's light output is centrally controlled and can be adjusted to two to four levels of control according to pre-set schedules.

In North America, after 2000, several devices of remote control of street lighting with time reduction were built [9]. Timetable-based remote lighting control systems have been widely used in China since 2000 [10].

Until now, there are no internationally accepted guidelines for dynamically changing the light level in road lighting, and light control strategies have been developed based on lighting requirements and engineers' experiences [11].

Architectural elements of intelligent lighting system

The control center performs the following functions:

- monitoring individual blocks and reporting lamp failures;

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- measuring/writing data;
- control of lighting on/off times;
- record the replacement time;
- Record manual controls.
- Input 1 - remote transmission of lighting network activation;
- Input 2 - transmission of information about the deterioration of the light point;
- Introduction 3.4 - network data transfer.

The output can be adapted to the following functions:

- Exit 1 - mandatory connection of lighting according to the activity of the technical service team;
- Exit 2 - switch off the sensor to protect against vandalism;
- Output 3 - control of protection elements from that point when sensors are activated at maximum voltage;
- Exit 4 - activation of the civil protection alarm system;
- Output 5 – turn on lighting for special occasions;
- Output 6 – activation of special installation for season timer (winter);
- Output 7 – turning on the lighting signal to warn of danger;

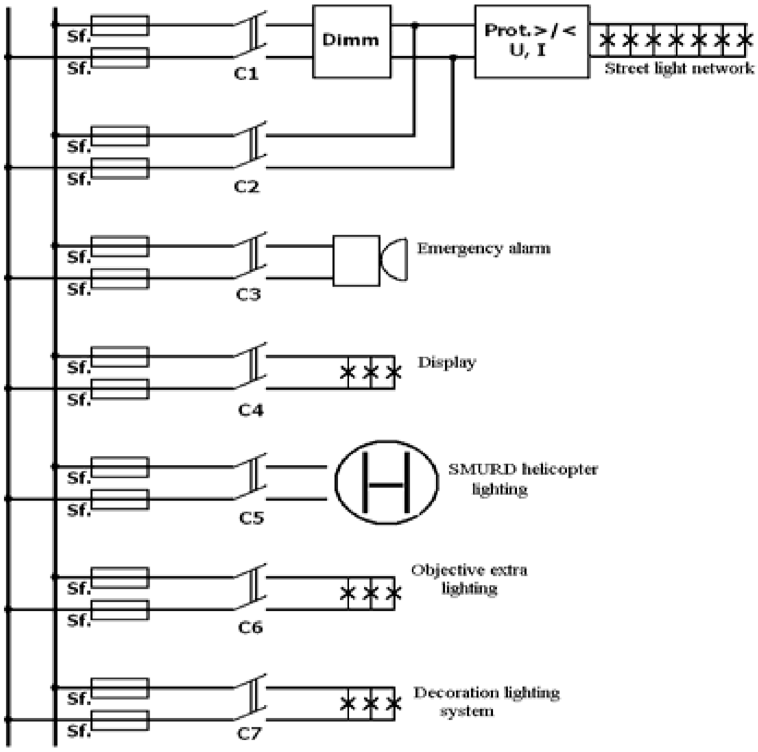

Figure 3. The structure of a light point using a GSM modem

Research results

The project we propose is a project with the highest level of complexity of the fourth group "Embedded systems and systems with atypical functionality", and this project is created on the example of a 3 km street.

The type of lighting is lantern, each lantern uses 3 lamps to illuminate the roadway. Each lamp is made of 150w LED lights.

On one side of the street, on average, there are 75 lanterns, each lantern is equipped with 3 LED lights to illuminate the road. It consists of 150 lanterns in 2 rows, a total of 450 LED lights. The power of each LED lamp is 150w, the power of 450 LED lamps is 67.5 Kw/h.

In the conditions of the climate of Uzbekistan, it requires an average of 14 hours of road lighting in the winter season and 7 hours in the summer season. This equates to an average of 3,832 hours per year.

If we take into account that the average capacity of our line is 67.5 kWh. It requires 258,000 Kw/h of energy per year.

Table 1

Oddiy yoritish tizimida energiya istemoli				
	Yoritishni talab etuvchi soatlar	Energiya sarfi kw/soat	Energiya sarfi kw/kun	Energiya sarfi (o'rtacha) kw/yil
Yoz faslida	7	67.5	472	258.000
Qish faslida	14	67.5	944	
O'rtacha	10.5	67.5	708	

Algorithm of operation

Energy efficiency can be achieved in the lighting system by leaving intelligent systems. For this, it is necessary to pay attention to the condition of the place requiring lighting, traffic flow and traffic safety.

To organize this system, PLS systems, a light sensor, and a motion sensor are needed.

The main means of commanding the system are light and motion sensors. The first signal is given by the light sensor when the light decreases. If the device signals No, it signals to turn off the main line. If the device says Yes. Signals the motion sensor.

In turn, if the motion sensor detects motion, it will signal Yes and start supplying 100% power to the line for 10 minutes. If the motion sensor does not detect motion, it commands the line to turn on 33% power (Figure 4).

Table 2

Energy consumption of the intelligent system.		Energy consumption Kw/h	Energy consumption Kw/day		Annual energy consumption Kw/h
In the summer months	4 hours/100%	67.5	270	337	176.500
	3 hours/30%	22.5	67.5		
During the winter months	7 hours/100%	67.5	472	629	
	7 hours/30%	22.5	157		
Average	5.5 hours/100%	67.5	371	483	
	5 hours/30%	22.5	112		

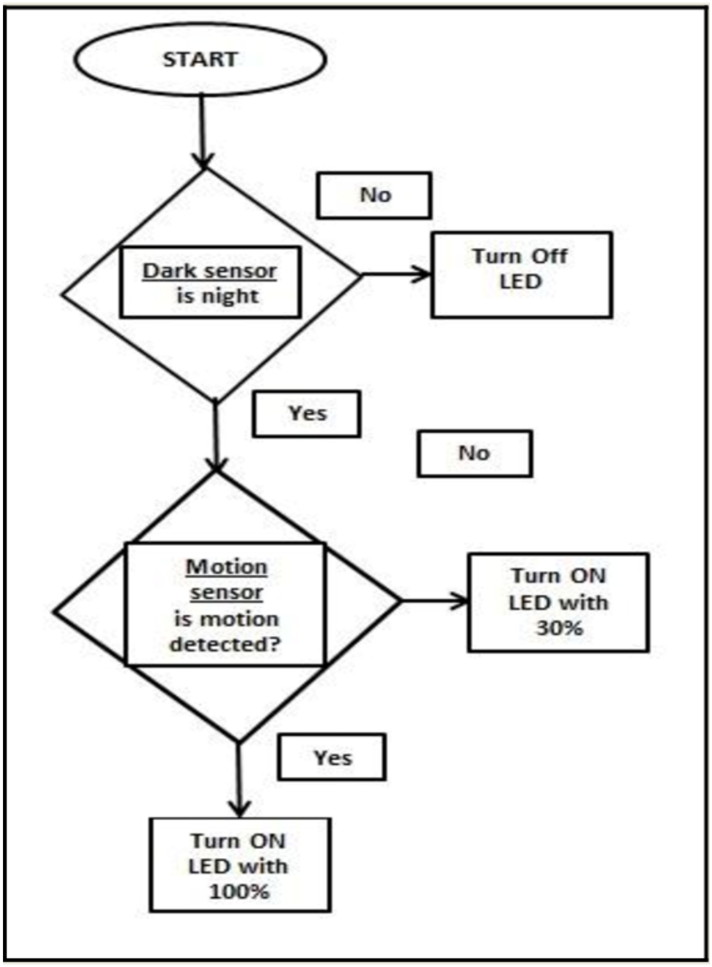

Figure 4. Intelligent system performance algorithm

As a result of the development of intelligent systems of the night lighting system, the reduction of electricity consumption, the development of a model of the automatic control and management system, an opportunity to save energy was created. The table below shows the calculation of system energy consumption.

Economic efficiency of the system Table 3

	Energy consump-tion of a typical lighting system	Energy consump-tion of the intelligent system.	Energy consump-tion of a typical lighting system	Energy consumption of the intelligent system.	Energy efficiency of the intelligent system	
	Daily Kw/h	Daily Kw/h	Yearly Kw/h	Yearly Kw/h	Daily Kw/h	Yearly Kw/h
In the summer months	472	337			135	
During the winter months	944	629	258.000	176.500	315	81.500
Average	708	483			225	

As can be seen from the table, the average efficiency of the system is 32%.

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Conclusions and suggestions.

Today, it is necessary to completely change the ideology of maintenance, repair and construction of the main and inner-quarter lighting of the city. Only the use of new technologies, materials and equipment will bring the lighting of the city to existing standards, change the aesthetic image of the city. Currently, most of the outdoor electric lighting networks need reconstruction and overhaul.

Measures to increase the reliability of outdoor lighting provide:

- maintenance of external lighting objects and networks in a technically sound condition;
- elimination of accidents in engineering infrastructure equipment and networks;

- maintenance of technically sound condition of street (outdoor) lighting networks;
- increase the aesthetic appeal of the city and the quality of life of the population;
- Creation of safe and comfortable living conditions for citizens in the city.

The use of an intelligent outdoor lighting control system ensures road safety, pedestrian safety, and significantly improves the city's architectural, tourism and commercial products. This system is not cheap at all, but a small part of the state budget is not spent on street lighting.

The intelligent street light control system is a remote control for street lights that can control the luminance and light level of each street light. It also guarantees the right amount of light in different conditions. So important that real-time feedback on any line changes reduces energy consumption and offers advanced maintenance optimization tools

As a result of the research of the intelligent systems of the night lighting system, the model of the device for automatic control and control of energy consumption was developed and the most cost-effective way was chosen for the implementation of the device model and 32% efficiency was achieved.

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