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# ADJUST BRIGHTNESS OF LED LIGHTS IN ACCORDANCE WITH AMBIENT LIGHT

**R. Ildarabadi** * **A.M. Gholizadeh**

*Electrical and Computer Engineering, Hakim Sabzevai University, Sabzevar, Iran*
*r.ildar@hsu.ac.ir, amir.mgzs67@gmail.com*
**. Corresponding Author*

**Abstract-** Today, street lighting is one of the most important factors in cultural, economic and security growth in society. Also, street lighting constitutes a significant part of the country's energy consumption during peak hours, so street lighting is one of the most important components of distribution networks and its optimization is of particular importance. In this article, with a different perspective on energy optimization from the point of view of managing the amount of light at sunrise and sunset, a new method has been proposed based on it, which will reduce the energy consumption of roads by about 2.1%. Another feature of the proposed method is the possibility of removing the street lighting wire, which can lead to a significant reduction in the cost of street lighting. Clear suggestions are given in two scenarios and their results. An attempt has been made to comprehensively explain each scenario with a flowchart to make the content more eloquent and psychological. The practical results of different scenarios indicate the accuracy of the claims of the proposed method.

**Keywords:** Passage Lighting, LED Lamps, Lighting Intensity Adjustment, Energy Efficiency Optimization.

## 1. INTRODUCTION

Providing the necessary lighting for the possibility of movement of people and vehicles on the roads at night has been considered since late. With the growth of cities and residential areas, street lighting systems have been created for this purpose. The lighting of the passages, in addition to providing lighting, can also ensure urban security.

Although before the invention of electric lighting, it was not possible to achieve the lighting standard, but with the development of electric lighting to provide acceptable lighting of passages, comprehensive standards were developed. In this regard, the Energy Research Institute in 1392 compiled the publication No. 614 entitled "Standard of general technical and executive specifications of street lighting" [1].

According to the mentioned standard, the amount of light can be varied according to criteria such as the amount of traffic, traffic speed, and the width of the passage. Due to the fact that the values considered in the lighting standard are minimal values and reducing the brightness of these limits is not allowed, and the use of optical dimmers during the night due to increased traffic speed and the possibility of accidents, and reduced road safety, should not be done. But from another point of view, reducing and optimizing energy consumption is of great importance today. In this regard, different methods have been presented from different perspectives.

Reference [2] has shown that by applying proper planning, energy consumption can be optimized in production futures and industrial units. From the point of view of the type of facade of the reference buildings [3], it has been shown that green cover can be of great help in minimizing energy consumption. Reference [4], while pointing to the importance of optimal energy consumption, emphasized that this will reduce air pollution.

Reference [5] discusses the increase in demand and its compensation by renewable sources and has implemented its proposal on a case-by-case basis in Khalkhal city of Iran, which has resulted in a reduction in losses and the cost of electricity consumption.

Reference [6] has examined the reduction of electrical energy losses in the electricity system of Azerbaijan and has shown that with proper energy management, the rate of losses can be reduced from 21.7% in 2009 to 11.6% in 2015. Reference [8] optimizes the energy of current limiters in networks including wind farms and magnetic energy storage.

Power management for proper operation of batteries and diesel generators can reduce energy consumption [9]. Reference [10] has tried to optimize energy consumption by managing energy resources for hybrid vehicles.

Reference [11] Manage energy consumption by managing the distribution of reactive power in the power system with a competitive market. There are various other ways to optimize energy consumption.

However, considering that the cost of energy consumption in the field of street lighting is about 4700 GWh, which is equivalent to 4.4% of the total energy of the electricity network. Therefore, optimization of this component of the electrical power system can also be of great importance [12].

The street lighting system enters the circuit only when the streets are dark. In most areas this time coincides with the peak load. Simultaneous loading of road lighting and peak load can double the destructive effect of sudden loading [13].

There are different ways to bring the light load of the passages into the network; Such as the use of sensors to detect the brightness of passages such as photocells, the use of electronic calendars or with the help of intelligent techniques based on optimal load management [1].

The use of energy-saving lamps with LED technology is one of the effective methods that can be used [14]. Reference [15] discusses the effect of replacing LED lamps instead of other commonly used lamps and in its case, study has shown that this replacement can reduce electricity consumption by up to 12%. Another advantage of these lamps is the ability to control their light intensity relatively continuously.

This in itself can overcome the limitations of existing classic lamps. One of these limitations, which can be overcome by LED lamps, is the gradual entry and exit of lighting load, while observing the standard of brightness. To illuminate the features of LED lamps compared to other lamps that are used in street lighting. In the continuation of this article, first the classification of street lighting lamps and the comparison between them, especially LED lamps and high-pressure sodium vapor, which is one of the most widely used lamps in the street lighting system, is presented in the second part.

The third section examines the intensity of ambient light at sunrise and sunset, and in the field in the city of Sabzevar, Iran. The proposed method for the gradual entry and exit of the street lighting system with its implementation in two scenarios is presented in Section 4. Section 5 describes the advantages and features of the proposed method. The conclusion of the article is also stated in Section 6.

## 2. LAMPS USED IN STREET LIGHTING

Due to the variety of lamps used in street lighting, it is necessary to have enough information to choose a lamp [16]. Since one of the most important steps in designing a street lighting system is the choice of lamp, this choice should be made according to economic, aesthetic and performance considerations of the lighting system. Figure 1 shows the lamps used in street lighting in the form of a tree diagram [17].

Incandescent bulbs are almost never used in street lighting today. In other groups, each of these lamps has advantages and disadvantages over each other. Table 1 summarizes the characteristics of these lamps [1].

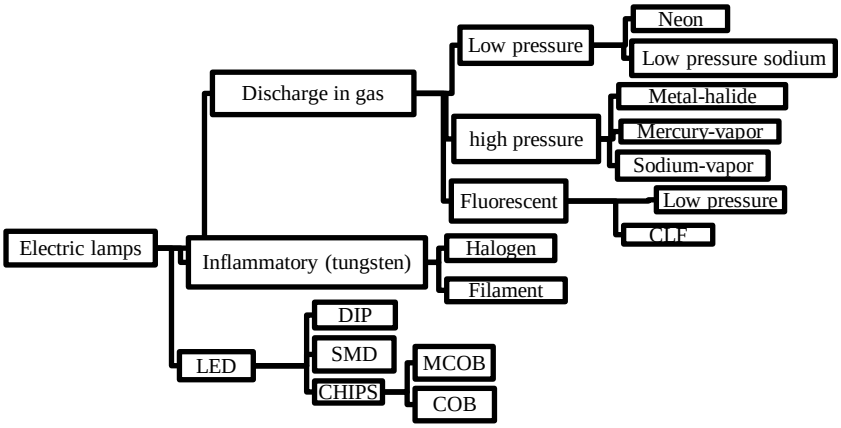


Figure 1. Classification of types of electric lamps for street lighting [17]

Table 1. Important parameters of street lighting lamps [1]

| Parameter | Fluorescent | Metal-halide | High pressure mercury vapor | Low pressure sodium vapor | High pressure sodium vapor | LED |
|---|---|---|---|---|---|---|
| Average lifespan (thousand hours) | 8 | 12 | 16 | 16 | 24 | 50 |
| Optical gain (Lm/W) | 70 | 115 | 70 | 200 | 130 | 120< |
| Light color temperature (K) | 3.2-6.5 | 3-7 | 3.2-4.2 | - | *2-2.7* | 20-70 |
| price | good | medium | Very good | Good | good | Expensive |
| Color reversal coefficient ($R_a$) | good | Very good | Medium | Very weak | weak | good |
| Environmental Protection | weak | medium | Harmful | medium | medium | excellent |
| Variety in choice | >1 W | >50 W | >50 W | >8 W | >35 W | >1 W |
| Possibility of dimming the light | good | medium | Weak | Weak | weak | Very weak |
| No dependence on ambient temperature | medium | very good | very good | medium | very good | weak |
| Main application | Office and interior lighting | Lighting of exhibitions and streets adjacent to shopping malls | Street lighting | Intersection lighting | Street lighting | It is used everywhere |

Table 2 shows another comparison between a high-pressure sodium vapor lamp and a 100-watt LED lamp, both made by OSRAM.

Table 2. Comparison between high pressure sodium vapor lamp and LED [18]

| Parameter | LED | Sodium vapor |
|---|---|---|
| Rated lamp power (W) | 100 | 100 |
| Minimum luminous flux (Lm) | 11000 | 9000 |
| Minimum Optical Efficiency (Lm/W) | 110 | 93 |
| Current intensity (A) | 0.47 | 1.2 |
| Power factor | 0.97 | 0.83 |
| Lamp life (h) | 50000 | 20000 |

According to Table 2, it can be seen that at equal electrical power, LED lamp has higher light efficiency, lower current consumption, higher power factor and longer life than sodium vapor. LED lamps also have the ability to adjust the brightness, while gas lamps have a special standard and their brightness cannot be adjusted. Also, gas lamps have a high starting current and draw several times their nominal current from the network, which will disrupt the network, while the current consumption of LED lamps is constant, and this problem can be solved by adjusting the brightness of the lights.

## 3. INTENSITY OF AMBIENT LIGHT AT SUNRISE AND SUNSET

Sunlight varies at different times of the day from sunrise to sunset, clear or cloudy weather, and its change curve also depends on the seasons of the year, geographical location. The maximum intensity of sunlight is reported to be 124 thousand lux in New Delhi [19]. Figures 2 and 3 show the intensity curve of the sun on two different days of the winter and summer seasons for this city. Since the amount of light required by the passages at night is much less (about 20-100 lux) than the natural light of the day, so the change of seasons only makes the day and night shorter and longer, and the time of sunrise and sunset is almost constant.

Due to the geographical location of India, which is located between the orbit of Cancer and the equator, as well as the geographical location of Delhi, the city has three seasons: winter (4 months), spring (5 months) and summer (3 months).

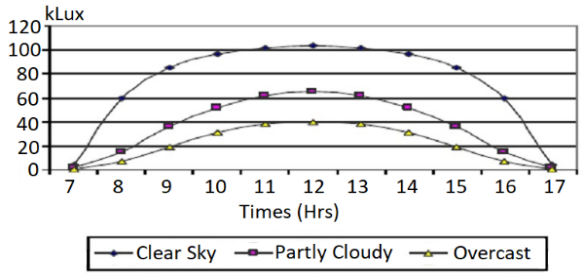


Figure 2. Delhi (India) city lighting curve on January 15 [14-19]

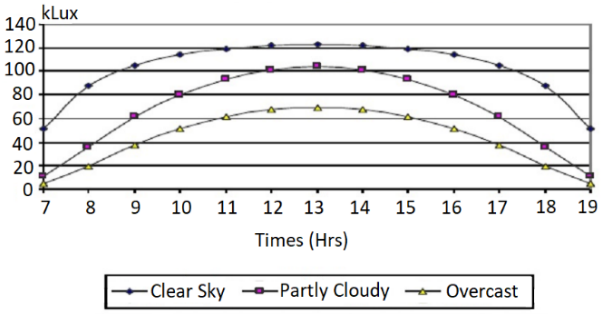


Figure 3. Delhi (India) city lighting curve on June 15 [19]

Figure 1 shows the light intensity curve of Delhi on one of the days of the third month of winter and it is observed that the time between sunrise and sunset is approximately 11 hours and the weather has no effect on the time of sunrise and sunset and only affects the amount of daily light. has it. Figure 2 shows the light intensity curve in the first 15 months of spring and it is observed that normally it is about 15 hours between sunrise and sunset, and as the weather worsens, this time will decrease.

Geographically and climatically, the southern cities of the country have two seasons, spring and summer, so the time difference between sunrise and sunset there will be more than the northern cities of the country.

Sabzevar city, considering that it has 4 seasons, has the most and the minimum time interval between sunrise and sunset, respectively, on 31 June, which is the longest day of the year and 30 Azar, which is the shortest day of the year, respectively.

According to the curves obtained from measuring the intensity of light at sunrise and sunset in Sabzevar, which is almost similar to the curves obtained in reference [19], and also because the required light in the passages is much less than natural light, so the curves of the results are almost the same throughout the year, and only the time of sunrise and sunset shifts, which has no effect on the experiment performed.

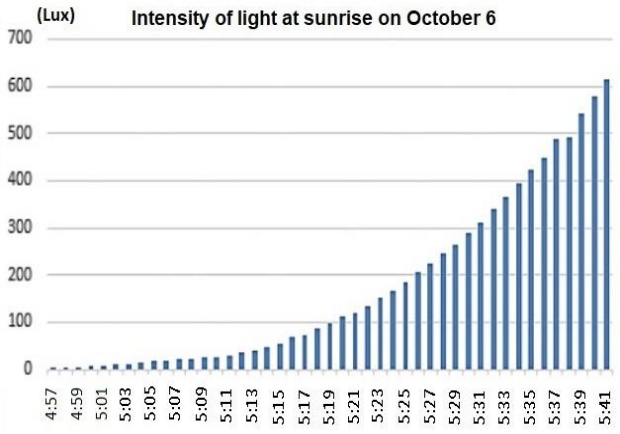


Figure 4. Measured light of sunset in Sabzevar city, Iran

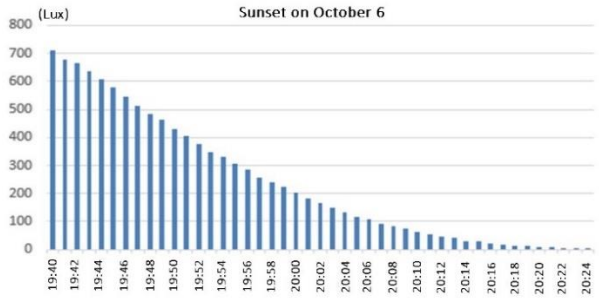


Figure 5. Measured light of sunset in Sabzevar city, Iran

The sunrise was on September 6, at 5:28 AM. Sunrise is the moment when the first rays of the sun are visible along the horizon from the east [20]. It is clear that the sunlight is not very noticeable at this moment. However, according to Figure 4, it can be seen that sunlight is gradually increasing. The same thing happens at sunset, which marks the moment when the last rays of the sun disappear in the direction of the horizon from the west, but in reverse, that is, over time at sunset, the intensity of light gradually decreases. Figure 5 shows the time of sunset on September 15, at 8:00 p.m. It should be noted that winter and summer hours are about an hour apart, because at the beginning of each year (approximately April 1) the official time in Iran is moved forward one hour and at the beginning of each year (approximately October 1). It is pulled back one hour again. This clock change should be observed for methods based on official clock, but has no effect on other methods and also presented in this article.

## 4. THE PROPOSED METHOD FOR THE GRAGUAL ENTRY AND EXIT OF STREET LIGHTING

Graphs of light intensity change in Figures 4 and 5 show that the light intensity of the passages at sunrise and sunset gradually increases and decreases, respectively.

Table 3 shows the minimum light intensity required for lighting. It should be noted that the minimum brightness is often created between two light bulbs and under the lamp itself, the brightness is higher than the required minimum brightness. According to the field study, when the light intensity is the minimum brightness of 7 lux passages, the measured light intensity under the light pole is 80.

Table 3. Minimum average light intensity for different passages [21]

| Type of way | Area type | (LUX) Medium light intensity | |
|---|---|---|---|
| | | Asphalt surface | Concrete surface |
| Freeway | All areas | 8 | 6 |
| Highway | Commercial | 13 | 9 |
| | Commercial-Residential | 11 | 7 |
| | Residential | 8 | 6 |
| Grade 2 artery (main) | Commercial | 16 | 11 |
| | Commercial-Residential | 12 | 8 |
| | Residential | 8 | 6 |
| Grade 2 artery (sub) | Commercial | 11 | 7 |
| | Commercial-Residential | 8 | 6 |
| | Residential | 6 | 4 |
| Local | Commercial | 8 | 6 |
| | Commercial-Residential | 7 | 5 |
| | Residential | 4 | 3 |

Another point that should be considered is that the intensity of light caused by sunlight in different parts of the passage is not affected by the distance from the point in question to the light pole. Existing ambient light control systems use a light-sensitive sensor known as a photocell. Refer to Table 3 to set the activation time of Photocell.

It is observed that these systems, by modifying the lighting system, suddenly increase the light intensity of the midpoint around the light pole twice as standard and the point below the power light up to several times the standard light intensity. For example, for local lighting, the photocell is set to a minimum light intensity of 8 lux (according to the standard in Table 3). Now according to the field study; the light intensity at the midpoint of two electric light poles suddenly doubles to 16 lux, and under the electric light the light intensity suddenly increases 88 times.

At sunrise, a field study in one of the alleys of Sabzevar shows that turning off the street lights is not in line with the standards, so that; the streetlights were turned off when the intensity of the sun reached 270 lux.

In this article, using the ability to continuously control the light intensity of LED lamps, the light intensity of the LED is gradually and continuously changed according to the intensity of sunlight, to provide the appropriate light intensity of the passage according to the standard. The minimum defined by the standards inside the passage should not always be less. At night, the minimum light intensity should be provided by street lighting and during the day by sunlight.

For this purpose, the light sensor is outside the range of the light of the passages (for example, above the headlights), so this sensor only measures sunlight.

Figure 6 shows the block control diagram of the passageways. In this figure, the ambient light intensity ($LUX_{Env}$), independent of the light produced by the LED lighting lamp ($LUX_{LED}$), is measured by a light-sensitive sensor, which is an optical resistor. The measured light intensity decreases from the base light intensity ($LUX_{Ref}$). If the result is positive, it is compensated by the intensity of the light produced by the LED lighting lamp ($LUX_{LED}$). The compensation method is based on PWM modulation.

As shown in Figure 6. In this figure, the light intensity of the passage ($LUX_{Road}$) will be the sum of the ambient light intensity (sun) and the light intensity produced by the LED lighting lamp. It should be noted that the control circuits of the proposed system are therefore not included in the system energy calculations.

Two scenarios are defined to evaluate the function of the proposed method.

### 4.1. The First Scenario

In this scenario, the performance of the proposed method was tested in a small environment (such as a box) according to Figures 7 and 8.

In this experiment, the location of the optical sensor and lamp by a wall is completely separate and only by opening and closing the front of the box, ambient light enters the box (Figures 7 and 8).

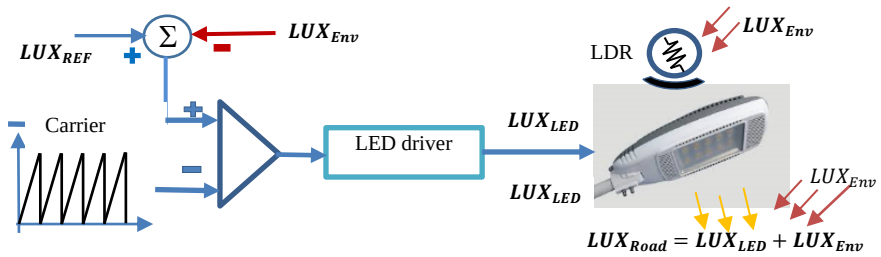


Figure 6. Lighting control diagram of passages

In this experiment, a mobile application (given that it has a relatively good sensitivity) was used to measure light intensity. This experiment shows that in order to provide the required brightness in proportion to the presence or absence of ambient light, the lamp light is adjusted to provide the required brightness and the measured results are shown in Figure 9 and Table 4.

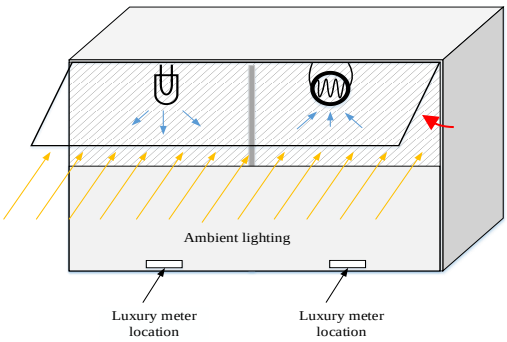


Figure 7. Schematic of the test environment

Figure 8. Real test environment

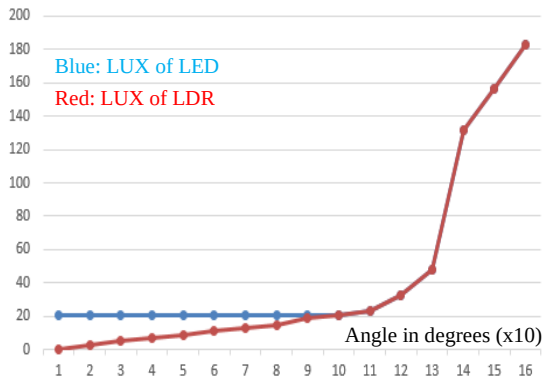


Figure 9. The curve obtained from the results of the first scenario

Table 4. Results obtained from the first scenario

| Box door angle (degree) | $LUX_{Env}$ | $LUX_{LED+outside}$ |
|---|---|---|
| 0 | 0 | 21 |
| 10 | 3 | 21 |
| 20 | 5 | 21 |
| 30 | 7 | 21 |
| 40 | 9 | 21 |
| 50 | 11 | 21 |
| 60 | 13 | 21 |
| 70 | 15 | 21 |
| 80 | 19 | 21 |
| 90 | 20 | 21 |
| 100 | 23 | 23 |
| 110 | 33 | 33 |
| 120 | 48 | 48 |
| 130 | 132 | 132 |
| 140 | 156 | 156 |
| 150 | 183 | 183 |

In the circuit designed for this scenario, 21 lux reference light was considered. According to the table, up to 80 degrees of the box door, the lack of ambient light inside the box is provided by LED, and due to the fact that the ambient light is sufficient in more sufferings, LED light is no longer needed and the LED turns off, so the light on both sides Will be equal. According to the diagram above, it can be said that when the box door is opened, the sunrise state is simulated, so the light on the photocell side changes almost linearly, but on the lamp side, the light is non-linear.

### 4.2. The Second Scenario

In this scenario, a headlamp is installed in an open environment according to Figure 10 and the control method presented in this paper is implemented on it.

Figure 10. Lighting of LED passages and installed environment to implement the second scenario

The amount of base light intensity is 96 lux. Figure 11 shows the results of this scenario. In this figure, the blue curve shows the light intensity of the passage without the presence of an LED light bulb. And the red curve shows the intensity of the passing light in the presence of LED lighting. Shows changes in ambient light intensity regardless of the brightness of the LED lamp and considering the light effect of the LED lamp.

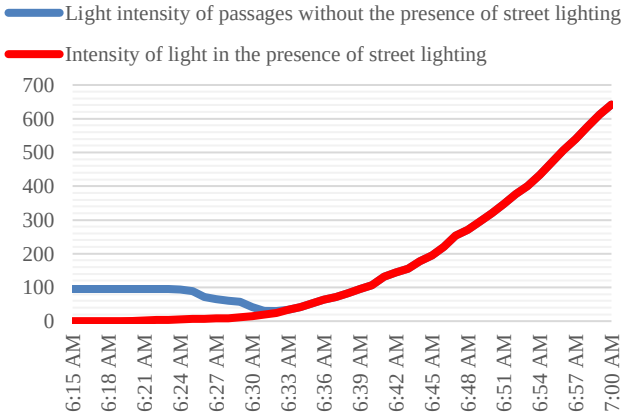


Figure 11. Passage light intensity curve in the second scenario

The light intensity of the LED lamp (street lighting) gradually decreases from 6:19 AM with the increase of sunlight intensity and turns off completely at 6:32 AM. As can be seen from Figure 11, the LED lamp at sunrise could not keep the light intensity under the light pole constant. This is because the LED lamp is controlled by the intensity of the sunlight above itself, and the intensity of the sunlight at this point is different from the intensity of the light under the LED lamp, when the sun rises. But this does not matter much. This is because the intensity of light in the passageway is not necessarily uniform during the time when the passageway light is provided by the passageway lighting. Another point to note in performing this scenario test is that the street lights near the test site were turned off at 6:41 a.m., at which time the intensity of the sunlight is 132 lux according to Figure 9.

## 5. FEATURES OF THE PROPOSED SYSTEM

### 5.1. In Terms of Energy Consumption

The lighting LED lamp used in the second scenario has a power of 12 watts at its maximum light intensity. If the photocell used to illuminate the passages is used to turn it off, according to a field study in the second scenario, the lamp should remain on at 130 lux at sunrise and then turn it off. The results of the implementation of the proposed system show that the power consumption at sunrise decreases with increasing sunlight. Figure 11 Power lamp consumption curve with two methods; Method on and off (blue curve) and in the case where the proposed system is applied on (red curve) in mill watts.

It can be seen that the level below the power consumption curve in the proposed method is much lower than the conventional method. According to the data of Figure 12, the amount of power consumed after 6:15 in the conventional and proposed methods is 17.28 and 11.7 kJ, respectively, for LED lighting by the LED lamp. The difference will be 5.58 kJ and will indicate the amount of energy savings by replacing the proposed method with the traditional method for the moment of sunrise. In the same way, you can get the amount of energy saved at sunset. This means that 11.16 kJ per day is achieved with this energy saving alternative. If it is assumed that on average 12 hours of street lighting is on in the conventional method, the light consumption of the conventional method with the LED lamp under test in the second scenario will be 518.4 kJ. Therefore, the amount of savings created after replacing the proposed method with the conventional method will be 2.1%.

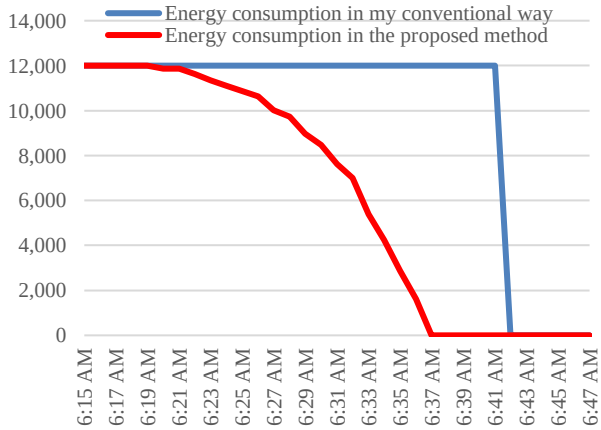


Figure 12. Power consumption curve of traffic lights for both conventional modes and the proposed method

### 5.2. Other Features

A. Ripple current: In the conventional method, a large number of light bulbs enter the circuit together and exit the circuit, while in the proposed light, the entry and exit of street lighting is done gradually.

B. Lighting wire removal: In the proposed method, each lamp is controlled independently of other lamps, so to feed them in the situation that the power supply of consumers (homes) passes through these beams, these phases can be fed to power. He also used a light bulb. Therefore, there is no need for street lighting wires.

C. Cost: According to paragraph B and also in case of mass production, the cost of implementing the proposed method will be much cheaper than the conventional method.

## 6. CONCLUSION

In this paper, a new street lighting system was presented that is able to adjust the light intensity of the street based on the intensity of sunlight and in accordance with the street lighting standards. In order to properly investigate the proposed performance, two scenarios with different practical environments were presented. The practical results of these two scenarios were shown by curves. If the proposed system is replaced with the existing lighting system, 2.1% of lighting energy consumption will be saved, while the street lighting load will gradually enter and leave the network, in addition to the possibility of removing the street lighting wire in many streets. Have an air power distribution system, it will be possible.

## NOMENCLATURES

**1. Acronyms**

LED Light-Emitting Diode
LDR Light Dependent Resistor
COB Chip-on-Board LED
MCOB Multiple Chips on Board LEDs
SMD LED Surface-Mounted Devices
DIP LED Direct In-line Package
LUX Lux in the standard SI measuring device is the amount of light intensity in terms of one lumen per square meter [22]
CARRIER The waveform of a saw tooth is compared to the reference signal to produce the pulse width modulation required [23]
CHIP An integrated circuit or monolithic integrated circuit [24]

**2. Symbols / Parameters**

$LUX_{REF}$: Light intensity decreases from the base light intensity in lumen
$LUX_{Env}$: The Ambient Light Intensity in lumen
$LUX_{LED}$: the LED lighting lamp in lumen
$LUX_{Road}$: The Light Intensity of The Passage IN lumen

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## BIOGRAPHIES

**Rahim Ildarabadi** was born in Sabzevar, Iran in 1975. He received the Ph.D. degree from Ferdowsi University of Mashhad (Mashhad, Iran) in 2010. He is a full-time faculty member at Sabzevar Tarbiat Moallem University (Sabzevar, Iran). He is currently an Assistant Professor of electrical engineering at Hakim Sabzevari University (Sabzevar, Iran). His main areas of interest are automation system, electrical machine derive, renewable energy, instruments and measurement.

**Amir Mohammad Gholizadeh** was born in Shirvan, Iran in 1988. He received his Master degree from Hakim Sabzevari University (Sabzevar, Iran) in 2018. He is researching and studying lighting intelligent systems. His main areas of interest are automation systems, electric car manufacturing, renewable energy, tools and measurements.