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FEASIBILITY STUDY FOR INSTALMENT OF NEW EE STREET LIGHT SYSTEM FOR MUNICIPALITY OF NOVI GRAD

Disclaimer

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4 INTRODUCTION

The fact is that energy, i.e. the availability of energy at affordable prices, is a key prerequisite for achieving economic and social development of any society. However, it is also a fact that energy production and its use significantly affect the environment, causing pollution of local and regional character, but also problems such as global warming and climate change.

Therefore, it is clear that the energy sector in Bosnia and Herzegovina, the European Union, and around the world is facing the challenge of sustainable development - development that enables secure energy supply, while reducing negative environmental impacts.

High energy consumption, but also great potential for savings, have made energy efficiency a priority, and for it to have increasingly important place in the public sector in Bosnia and Herzegovina, which has significant potential for energy conservation in the region. Bosnia and Herzegovina can base its long-term economic development and creation of new jobs on measures to improve energy efficiency. There is high potential to conserve energy in the public lighting system.

Special importance to the application of energy efficiency principles is given by the fact that public lighting in use today was mainly designed at the time when high-effective lighting technology was not available and when electricity was significantly cheaper. Currently, the public lighting systems are one of the main sources of electricity consumption with 3,19% of global electricity production being allocated for the public lighting.

This amount is higher than the production of all hydro or nuclear power plants and it is equal to the production from natural gas. It is known the public lighting is the sector characterized by excessive and disproportionate energy consumption compared to the quality and functionality of the service offered to citizens. Investing in optimal measures to improve energy efficiency of the public lighting system has become strategic for economic, technological and social development of cities.

Therefore, it is necessary to design and construct the public lighting in accordance with the energy efficiency principles, and existing ones, if possible, should be adapted and adjusted. Improving efficiency of energy consumption is one of the most important pillars of modern energy policy, and it is the key and economically the most effective mechanism to achieve goals of sustainable development of the energy sector.

Improving efficiency of energy consumption reduces costs and contributes to the competitiveness of national economy. Energy efficiency means consuming less energy for same product or service. Energy efficiency offers many benefits, depending on type of intervention. It can:

- reduce the burden of rising energy prices,
- increase energy security,
- increase the necessary energy supply investment,
- reduce air pollution and slow down climate change,
- improve the employment of skilled and unskilled work force,
- reduce burden on budgets,
- increase economic competiveness.

Existing situation has to be defined in order to assess saving potential of public lighting. In other words, following basic activities have to be established:

- preparation,
- inspection/review,
- description of the current situation and identified measures,
- energy estimate and,
- economic estimate.

It is important to point out that the energy efficiency cannot seen as energy saving. Namely, *saving*always implies certain sacrifices, while *efficiency*means maintaining, in this case, the default level of lighting by using smaller amounts of electricity.

Costs of public lighting are becoming an increasing burden on budgets of different levels of government from year to year. Newer technologies and more economical light fixtures offer the possibility of saving while keeping the existing or even improving the quality of lighting. Municipalities can reduce allocations for exploitation of public lighting system by using newer technologies and with acceptable investments, thus creating possibility to redirect funds saved in such manner to further expand the system, development or some other priority purposes.

Therefore, there is a need to increase energy efficiency in the field of lighting. This has also been recognized by the international community, and through various analyses, general directives and guidelines have been created that are used to influence the increase of this efficiency.

These directives and guidelines are defined within EU under the title EU Directive 2002/91/EC, and in Bosnia and Herzegovina they are translated and adopted under the title **BAS EN 12464-1:2012** for indoor lighting and **BAS EN 1838** for panic lighting, while for the outdoor lighting they are adopted under titles:

- **BAS CEN/TR 13201-1:2016** - Road lighting - Part 1: Selection of lighting classes,
- **BAS EN 13201-2:2017** – Road lighting - Part 2: Performance requirements,
- **BAS EN 13201-3:2017** - Road lighting - Part 3: Performance estimates,
- **BAS EN 13201-4:2017** – Road lighting – Part 4: Methods for measuring road lighting characteristics,
- **BAS EN 13201-5:2017** – Road lighting - Part 5: Energy performance indicators.

As a technology to reduce emissions and costs, LED public lighting should be the first instance of every municipality's investment. The latest energy efficient LED light bulbs can achieve energy savings between 50- 70%. LED public lighting offers instant savings in terms of energy, maintenance and running costs.

5 GENERAL PART

5.1 Geographical position

Municipality of Novi Grad is located in north-east part of BiH, in RS entity and it consists of 48 local communities (Ahmetovci, Blagaj Japra, Blagaj Rijeka, Blatna, Bosanski Novi, Cerovica, Crna Rijeka, Čađavica Donja, Čađavica Gornja, Čađavica Srednja, Ćele, Devetaci, Dobrljin, Donje Vodičevo, Donji Agići, Donji Rakani, Gornje Vodičevo, Gornji Agići, Gornji Rakani, Grabašnica, Hozići, Johovica, Jošava, Kršlje, Kuljani, Lješljani, Mala Krupska Rujiška, Mala Novska Rujiška, Mala Žuljevica, Maslovare, Matavazi, Mazić, Petkovac, Poljavnice, Prusci, Radomirovac, Rakovac, Rašće, Ravnice, Rudice, Sokolište, Suhača, Svodna, Trgovište, Vedovica, Velika Rujiška, Velika Žuljevica i Vitasavci). Municipality of Novi Grad (old name: Bosanski Novi) takes up the surface of 38,42 km^2 which is 0,16% RS territory (24.525,5 km^2), 0,075% of BiH territory (51.209,2 km^2). M4 main road goes through the municipality (it connects border crossing Bosanski Novi with Croatia, Prijedor, Banja Luka, Doboj, Tuzla andorder crossing granični Karakaj, near Zvornika, and it is 260 km long), te and main road M14 (connecting Bihać and Croatian state road D47 towards Jasenovac, via border crossing GP Gradina, and it is 130 km long). Total length of the railway is 57 km. Themuniciplaity has direct access to railway knot with directions towards: Dobrljinu (border crossing - 15 km), Zagrebu (CRO) and Ljubljana (SLO), Banja Luka and Sarajeco, Bihać and Splitu. Altitude of Novi Grad Municipality of 122 m with mild continental climate. Official languages used by majority are Serbian and Bosnian language. Image 1 shows the positions of Novi Grad Municipality in RS and BiH.

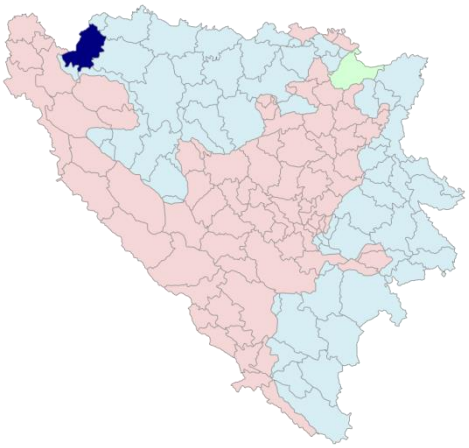

Image 1: Position of Municipality Novi Grad in RS and BiH [1]

5.2 Overview of socio-economic situation

The municiplaity of Novi Grad has 27.115 residents according to 2013 census[2], while according to data of Development Strategy for Novi Grad Municipality for the period 2017-2026, the umber is estimated to 11.698 residents.

Relative density is 25 residents on 1 km^2. Accoridng to age structure, there are 1.738 youth up to 14 years of age, 10.084 residents of 15-64 years of age and 1.587 who are over 65. Natural growth in 2010 was -144, and natality and mortality rates in 2010 were 6,12 and 11,04 respectively. Current percentage of population living in urban area is approximately 10.120 or 37,3%, while in 1991 the same indicator was 13.588 or38,2%,

[1] Unsko-sanska turistička regija

[2] http://www.statistika.ba/?show=12&id=20567

showing there is migration of population from urban to rural areas. Novi Grad Municipality is recording negativemigration saldo which was -110 in 2009, and in 2010 it was -89. Difficult economic situation is primary reason why population is leaving (primarily to other countries). According to 2013 census the majority of population were Serbs 74,2%, Bosniaks 23,7%, Croats 0,7% and Others 1,4%.

Within business activity according to organization type, in 2015 in the register of independent entepreneurs was registered 455 independent entpreneurs or by 1% more compared to 2014 (447 of independent entepreneurs). The biggest percentage are trading store (176 independent entepreneurs or 39%), followed by cafes/restaurants (109 or 24%) and entepreneurs shops in field od manufacturing industry, including agriculture and construction (83 or 18), while others shops are from field of other services (87 or 19%).[3] Gross domestic product per capita was 3.855,74 KM in 2007 which is less compared to GDP in 2010 (4.353.29 KM), recording the growth of 12,9%. Accoridng toAPIF, the total export of companies from area of teh Municipality in the period 2012-2014 recorded growing trend, and in 2015

(total export in 2015 was 20,7 million KM) it was by 3,8% lower compared to 2014. The biggest exporters of the Municipality are companies from the field of wood processing, textiles and companies from the field of cattle food production. Municipality of Novi Grad has extremely negative foreign trade saldo in 2015 in the amount of -57,1 million KM. Average net salary in the Municipality was 726 KM in 2014. Variations of average net salary were recorded in the past five years, the highest in 2011 when it was 730 KM and the lowest in 2010 when it was 691 KM net average.[4] The Municipality of Novi Grad duuing the period 2013-2015 recorded growth of emloyed people from 3.754 to 3,931 in 2015 by 4,7%. Image 2 gives overview of employed in the period 2013-2015.

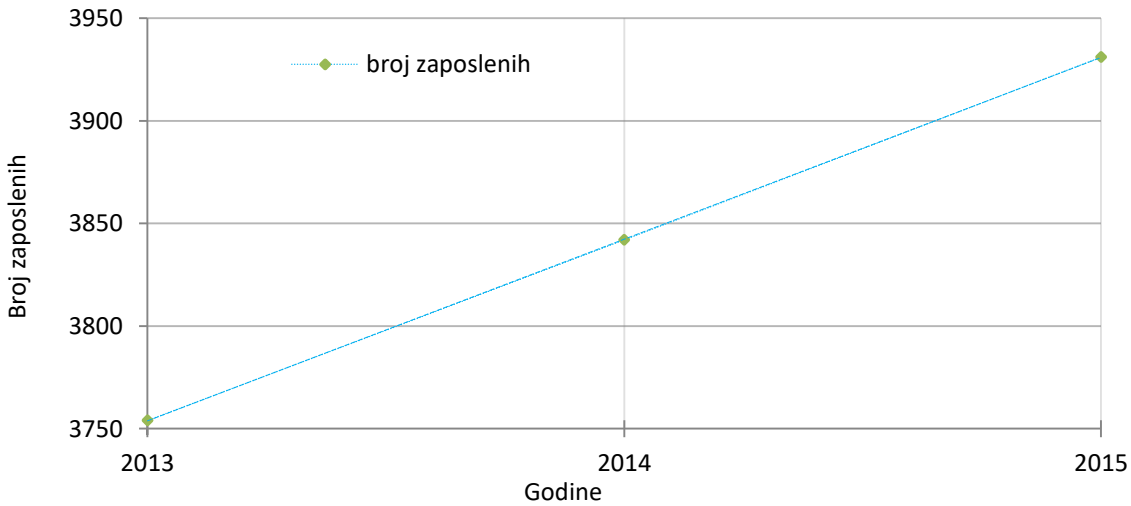

Image 2: Overview of employed ini Novi Grad Municipality

Reason number of employed increased can be connected to increase of number of companies in the private sector. However, in teh same period the number of unemployed reduced from 2.971 in 2015, which is 7,1% less compared to 2014. It can be noted there is increase of number of unemployed youth (up to 30 years of age) and in 2015 at Employment Offce were registered 1.415 unemployed youth or almost quarter of unemployed (23,7%). Number of enemployed in 2015 is higher by 21,6% compared to 2005. According to

[3] Analiza stanja privrede Opštine Novi Grad sa prijedlogom mj

2015. godinu, Opština Novi Grad, Odjeljenje za privredu

[4] Statistiic annual book RS 2015

the age structure the highest number of unemployed is 31-50 years of age, 1.389 people or 46,8%. In the are of Novi Grad Municipality in ugust 2016 were registered 4.741 pensioners[5]. Ration of employed and pensioners if 1:1,24, which is extremely unfavorable from the viewppoint of providing financial sources that pay pensions (salary contribution).

Number of people with healthcare insurance, for whom JZU (public healthcare instituion) Healthcare Center Novi Grad is the institution of primary healthcare protection, was 13.082 in 2015, making 45,4% of the total population. The problem to be resolved in teh future is the fact thatapproximately 54,6% of population does not have healthcare insurance on any basis. In 2015, 11.969 users used different kinds of aid od Center for social work, of which women were 60% of users. Number of users reduced 2011-2014 and in 2014 there were 1.507 users of social benefit, 42,8% less comapred to 2011 when the number of users was 2.152

5.3 State of public infrastructure of electricity network

ZDP ,,Elektrokrajina" Banja Luka is supplying 252.348 buyers with the electricity with average annual consumption of 2.034.960 MWh, while average annual consumption per household is 3.517 KWh. On the surface of 8.802 km^2 there is 4.198 TS of total installed power 1.303,92 MVA. In the are are power lines of 35 kV, 20 kV, 10 kV, 6 kV and 0,4 kV, total lenghts 21.853,25 km.[6] ,,Elektrodistribucija" Bosanski Novi is operating as part of dependent state company for electricity distribution ZDP ,,Elekrokrajina" Banja Luka, as one fo the 10 working stations. Elektrodistribucija has approximately 12.000 consumers in household groups, and numbers are growing, in area where its operating, and approximately 1.000 consumers from other categories, to which it delivers annually on average 40 GWh of electricity. Supplying users with electricity is done via big number of energy buildings: 1.257 km of electro-distributive measure and 170 TS. PJ ,,Elektrodistribucija" Bosanski Novi with the help of ZDP,,Elektrokrajina" Banja Luka is trying to overcome all difficulties and problems they encounter during the work, caused by the war and old equipment.
Electricity distributive network in area of Novi Grad Municiplaity is 1.452 km, of which 416 is high voltage and 1.036 is low voltage. 11.192 users were connected to teh network in 2014, 10.262 being households.

5.4 Analysis of socio-economic survey of population

5.4.1 Introduction

As part of the Feasibility Study for the installation of new energy efficient public lighting systems for the city of Novi Grad, a survey of the population of the city of Novi Grad was conducted with the aim of assessing citizens' satisfaction with the quality of key dimensions of public lighting performance.

A survey questionnaire was chosen as the method for collecting primary data. The survey was conducted in the period from July 14 to September 1, 2020. The survey questionnaire was distributed in electronic (web) form with the aim of increasing the response of citizens. The number of citizens of Novi Grad is 27.115, and 108 respondents took part in the survey, with the reliability level of 95% and reliability interval of 9,4. the survey was anonymous, and respondents were previously informed about aims of the survey.

5.4.2 General information on respondents

Of totalnumber of respondents (108), 75,93% were male and 24,07% were women (Image 3).

[5] Association of pensioners of Novi Grad Municiplaity

[6] https://www.elektrokrajina.com/osnovni-tehnicki-podaci/?lang=bs

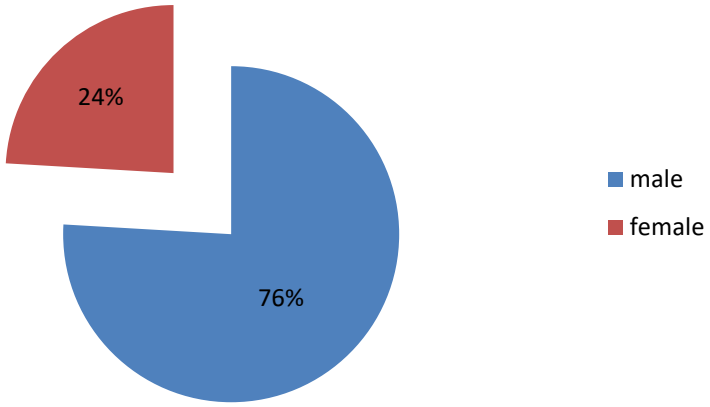

Image 3: Gender structure of respondents

Respondents' age was categorized in four age groups: 18 – 29; 30 – 39; 40 – 49; 50 – 64; 65+. In the sample the most represented is the age group 40 – 49 (32,41%), followed by the group 30– 39 (27,78%), respondents in the age group 50 – 65 (21,3%), and the age group 18-29 (14,81%). The least represented are respondents in the age group 64+ (3,7%). The mentioned structure according to the age shows that in the survey participated almost equal percentage of the respondents belonging to younger and older population, thus respecting the equality when it comes to the age groups.

Percentage share of respondents who are employed is higher 78,7% and the share of unemployed is 21,3%. In addition, the highest number of respondents had university level education (VSS)/baccalaureate 45,37%, while percentage of respondents with hiigh school is 17,59% and students status 7,41%. Percentage share of respondents with collecge level education (VSŠ) is 11,11% and with MA degree 18,52%. %. Respondents with PhD degree did not participate in the survey, same as tho respondents who completed 6-year education and have the title M.D. (Image 4).

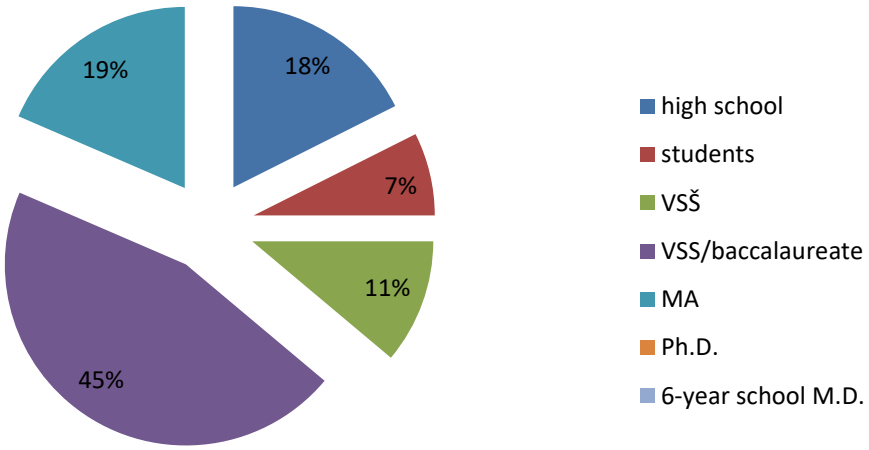

Image 4: Struktura ispitanika po nivou edukacije

5.4.3 Energy efficiency and population satisfaction with quality of key dimensions of public lighting performance

Knowledge of energy efficiency is key to understanding the need to implement EE measures. Therefore, a set of 3 questions was formed, which were created with the aim of identifying the existing knowledge of the respondents about energy efficiency. 91,44% respondents answered they know what is EE, and 5,56% answered they do not know. 97,22% respondents of the survey stated that EE is related ot environment protection, while 2,78% answered they do not what is that. When it comes to costs of public lighting in Novi Grad municipality, majority of respondents, 73,15%, is not familiar with public lighting costs, while 26,85% is informed about public lighting costs in area of Novi Grad Municipality. (Image 5).

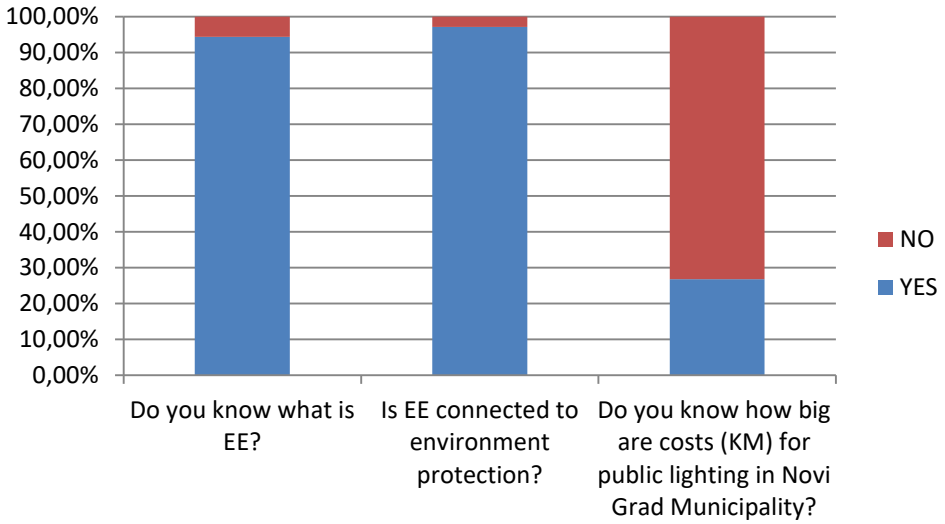

Image 5: Knowledge of respondents on energy efficiency

According to the opinion of respondents whether Novi Grad Municiplaity is taking some of energy efficiency measures, majority 53,7% answered that measures are implemented in the form of changing existing light bulbs with LED light bulbs, while 21,3% answered that there are no implemented measures. Additionally, as the measure implemented respondents noted turning off lights in the percentage of 14,8%, 3,7% respondents stated that Novi Grad Municipality is implementing dimming of the light as the energy efficiency measure, 6,48% noted that measures of dimming light, turning light on and off by sensor movement are being implemented (Image 6).

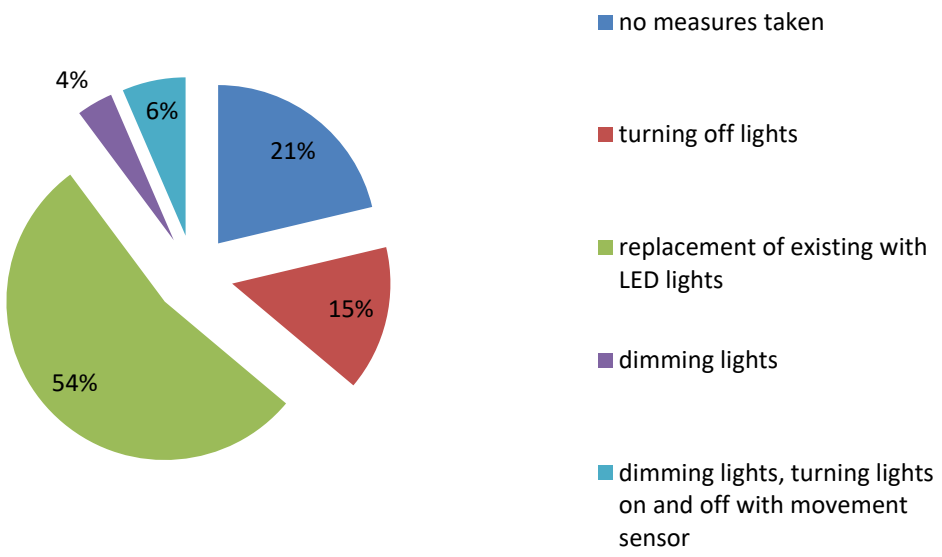

Image 6: Percentage of respondents answer to question: Is City of Novi Grad implementing any EE measures in your opinion?

Taking into account the instruction on Liker scale, where one = minimum to five = maximum, the respondents expressed their satisfaction with the current public lighting. Out of the total number of respondents, 37,04% gave the grade three, 24,07 % of respondents gave the grade four to the current situation of public lighting. 18,52% expressed their satisfaction with the grade five. 9,26% gave the lowest grade to the situation of public lighting in Municipality of Novi Grad (Image 7). According to answers in total, respondents are mostly satisfied.

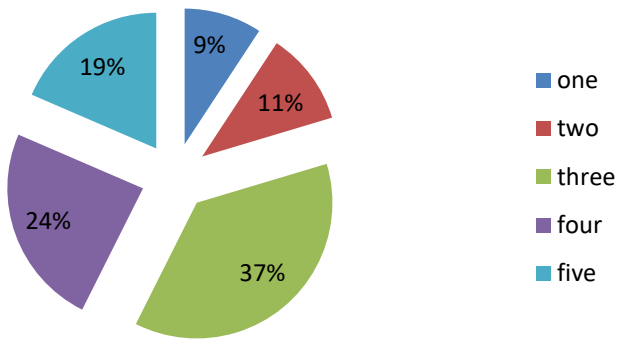

Image 7: Percentage of respondents' answers to the question: Your degree of satisfaction with the current public lighting?

Majority of the respondents, 31,48%, rated the maintenance of the public lighting in the Municipality of Novi Grad with the grade three, while 26,85 gave the grade four, and 20,37% gave the grade four. According to the data showed on the Image 8, over 79% of the respondents gave the grades three, four or five to the maintenance of the public lighting, while 7,41% gave the grade two, and 12,96% gave the lowest grade, one. According to the results of the survey, it can be concluded that the majority of questioned residents of the Municipality of Kalesija are satisfied with the current way of the maintenance of the public lighting.

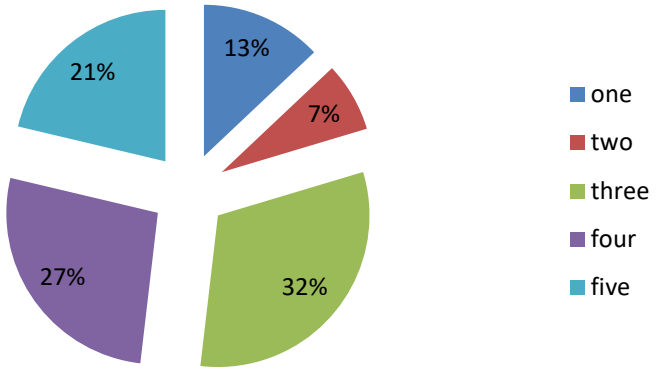

Image 8: Percentage of respondents' answers to the question: Does the Municipality of Kalesija regularly maintain the public lighting?

For the investments in innovative technologies when it comes to the public lighting in the Municipality of Novi Grad, majority of the respondents answered that it is the grade three, 31,48%, while 23,15% stated it is grade two. The smallest number of the respondents, 10,19%, stated that the level of the investment in innovative technologies is at the highest grade, five.

63,89% of the respondents stated that in the Municipality of Novi Grad there are lightbulbs that are covered by trees, objects, billboards, while 36,11% of the respondents stated it is not the case (Image 9).

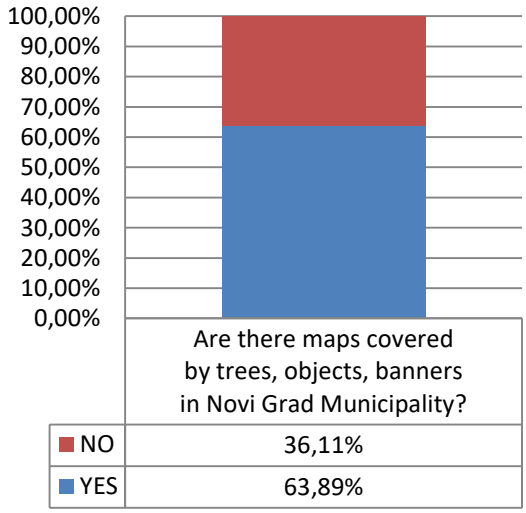

Image 9: Percentage of respondents' answers to the question: Does the Municipality of Novi Grad invest enough in the innovative technologies (in this case e.g. in LED lighting or automatic management of the public lighting system)?

Through the survey the respondents were also asked about the characteristics of the current lighting, and they answered the questions related to the light pollution and glare effect. Majority of rrespondents gave the grade three in the case of the existence of light bulbs that cause the light pollution, while 23,15% gave the lowest grade. When it comes to the existence of light bulbs causing the glare effect, 84,26% of the respondents, who represent the majority, rated it with the grades one, two or three, while 15,74% rated it with the grades four or five (Image 10).

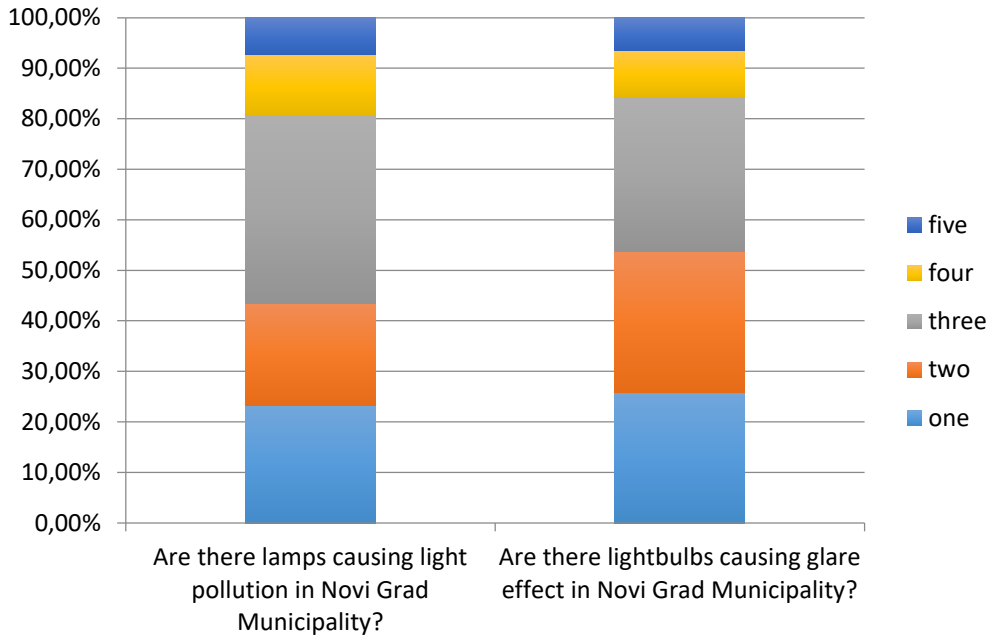

Image 10: Percentage of respondents' answers to the question on characteristics of the current public lighting in the Municipality of Novi Grad

Through the conducted survey, the respondents had the opportunity to list the areas or facilities in the Municipality of Novi Grad that they believe should be illuminated by dynamic lighting. According to the answers of the respondents, the highlighted areas / facilities that need to be illuminated by dynamic lighting are as follows: Quay wall, promenade, access to central part of the city.

5.5 Overview of trends of energy efficient public lighting

The trend of using public lighting starts from the discovery of fire, which man used as a source of heat and light. Lighting in public areas was primarily used for safety when the ancient Romans and Greeks illuminated their streets to prevent looting and maintain the safety of citizens. The era of electric lighting began only with the invention of the incandescent light bulb, Thomas Alva Edison's first commercial lamp in 1879. Until then, oil lamps, candles and torches were used to produce light from oil or gas.

The first electric lighting in Bosnia and Herzegovina began to be used in 1890 in Semizovac near Sarajevo. The first electric lighting in Sarajevo began to be used on May 1, 1895 (the first test ignition was performed on April 3, 1895). Thanks to technological advances, and the evolution of ideas, humanity has been able to create an artificial light source that is used daily in the lighting of public spaces. Electricity is generated to light in light sources, on the principle of luminescence or temperature radiation.Over the years, the lamps have experienced rapid development. All today's light sources are divided into two basic groups: sources with bursts in precious gases or metal vapors and sources with incandescent filament. In the public lighting system, electric sources based on electroluminescence are mainly used, i.e. they convert energy directly into light, without gas discharge and these are:

- High pressure sodium lamp -NAV,
- High pressure mercury lamp - HQL,
- High pressure metal halide lamp – HQI,
- Low pressure sodium tube –SOX-E,

- Low pressure fluorescent tube –L.

Image 11 shows the trend of using individual lighting sources, and the following will describe the trends in the use of individual lamps and the use of additional technologies to increase the energy efficiency of public lighting.

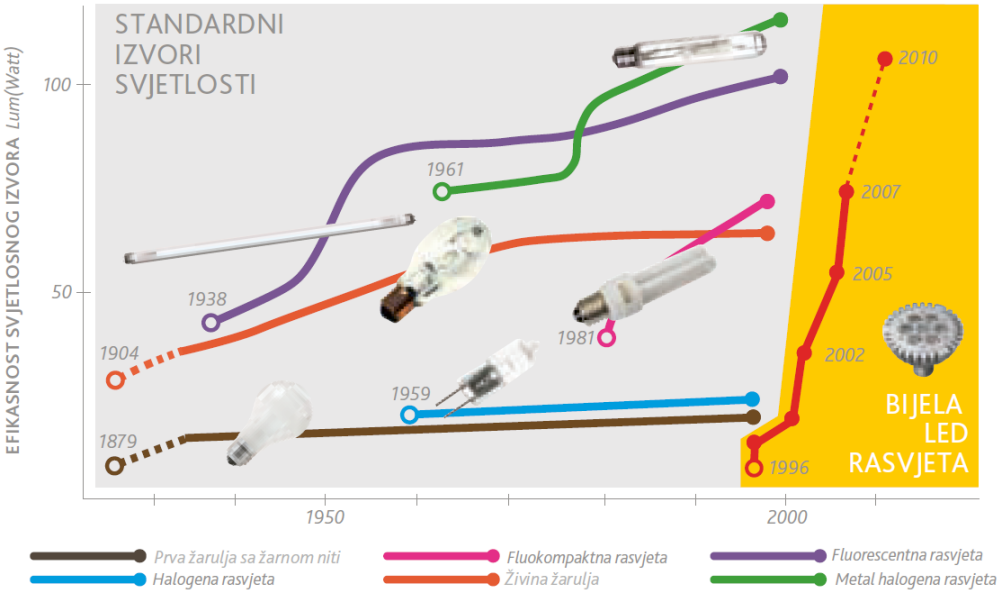

Image 11: Development trend of some light sources[7]

High pressure sodium lightbulb (NAV)

High-pressure sodium lamps (NAV) are light sources that operate on the basis of high-pressure sodium vapor eruptions up to 10 millibars, emitting a yellow light color, with good color rendering, which allows their wide application, especially in public lighting systems.Light efficiency is between 95 and 150 lm / W. The lamp can reach a lifespan of up to 24,000 hours, electricity 1,000 W, and a color temperature of up to about 2,000 K. The lamp consists of a glass balloon inside which is a ceramic weevil. The outer glass balloon is usually transparent, tubular or ellipsoidal in shape, having a thin white layer on the inside that lowers the luminance to only 4 to 30 cd / cm², which is advantageous for use in road lighting.

Image 12: High-pressure sodium lightbulb[7]

High pressure mercury lightbulb (HQL)

[7] www.osram.hr

High-pressure mercury lamps (HQL) are one of the first light sources to be used in public lighting systems. They work on the basis of the eruption,through mercury vapors, of high pressure into the lamp coil, creating visible and invisible ultraviolet radiation, blue or green. In its most common variant, this lamp gives a neutral white color of light and has a very weak color rendering index reaching from 23 to 50. Electrical power ranges from 50 W to 1,000 W. This type of lamp has good luminous efficiency (from 40 to 60 lm / W) and a lifespan of about 8,000 to 10,000 hours. The color of mercury lamps is monochromatic and therefore their application is limited to places where color recognition is not required but it is important to achieve good illumination over a large area. They are produced in a large selection of strengths, different designs and dimensions. They are used to illuminate highways, squares, streets, parks, etc. According to the EU Eco design Directive no. 2005/32 / EC, which requires the phasing out of inefficient forms of lighting, the year of cessation of use of high-pressure mercury lamps is 2015.

Image 13: High pressuer mercury lightbulb

High pressure metal halide lightbulb (HQI)

High-pressure metal halide lamps (HQI) are a special version of high-pressure mercury lamps. They were created to obtain a light source with an improved spectrum. As with high-pressure mercury lamps, mercury is added to the weevil, but also a number of other compounds such as iodine with sodium and indium with thallium. The high-pressure metal halide lamp is a modern light source with high light efficiency, good color rendering and high durability. The HQI light color is warm white, neutral white, or daylight color. The life of the lamp is about 15,000 hours, the color temperature depends on the exact composition of the inert gas and can reach from about 3,000 K to 20,000 K, and the efficiency ranges from 67 to 95 lm / W. Because it has a wide power range, it is compact in shape and has a good color rendering index. It is used in public lighting mainly in urban areas, where good color reproduction is required. According to the EU Eco design Directive no. 2005/32 / EC, which requires the phasing out of inefficient forms of lighting, the year of cessation of use of high-pressure metal halide lamps is 2015.

Image 14: High pressure metal halide lightbulb

Low Pressure Sodium Tubes (SOX)

Low pressure sodium tubes (SOX) produce light based on the eruption of low pressure sodium vapor. They are similar in mode of operation to mercury lamps, except that they contain sodium instead of mercury. This produces a monochromatic distinct yellow-orange color of light. The color rendering of the low-pressure sodium tube is extremely weak because the white color is reproduced as yellow and all the others as shades of black.The wavelength of the maximum radiation of this light source is very close to the

wavelength at which the human eye is most sensitive and thus makes them suitable for conditions and spaces where increased visual acuity is required, namely roads with frequent fog. They emit a yellow-orange color of light that numbs the ambience and puts people to sleep. The color temperature of the low-pressure sodium lamp is 1,750 K, the lifespan is about 16,000 hours, and the electricity takes values up to 180 W. The main advantage of low-pressure sodium lamps is their high light efficiency of up to about 180 lm / W. The dimensions of low-pressure sodium bulbs are relatively large, and this in combination with the low color rendering index is one of the reasons why they are almost never used. According to the EU Eco design Directive no. 2005/32 / EC, which requires the phasing out of inefficient forms of lighting, the year of cessation of use of the low-pressure sodium lamp is 2012.

Image 15: Low pressure sodium tube –SOX-E

Fluorescent tube (CFL)

Fluorescent tubes (CFLs) are light sources based on the evaporation of low-pressure vapor through mercury, which produces ultraviolet radiation that is converted into visible light by a phosphor applied to the inside of the glass tube wall. Fluorescent tubes are filled with krypton and argon gases with little presence and mercury. They are energy efficient and have good color rendering, but poor optical monitoring capabilities. Rare products do not drastically reduce the luminous flux by dropping the ambient temperature. A special group of fluorescent tubes with improved color rendering properties, better light efficiency and greater durability are fluorescent with the commercial name LUMILUX. Important light sources that are increasingly found in road lighting systems are DULUX compact fluorescent luminaries. They are small in strength, small in size, but of great economy. DULUX is a small bent fluorescent tube with a special ballast integrated in the luminaire instead of a ballast and starter. Fluorescent tubes and fluorescent lamps are also produced in different designs, powers, light colors and dimensions. They are connected directly to a voltage of 230 V. According to the EU Ecological Design Directive no. 2005/32 / EC, which requires the phasing out of inefficient forms of lighting, the year of cessation of use of a fluorescent lamp is 2012.

Image 16: CFL lightbulb

LED based lightbulb

LED (Light Emitting Diode) is a semiconductor element that in a conductive state, when connecting electrons and cavities, emits light of a certain wavelength. As with diodes, an LED consists of a chip made of a semiconductor material to create a PN junction. By the action of voltage, electrons pass from the N to the P side, merge with cavities, pass into lower energy levels, and by releasing energy create Imagens. There are two ways to produce white LED light. The first is that the LED itself emits white light, and the second way is to get white light by mixing the three primary colors. Another advantage of LED lighting is that it has an almost instantaneous response to voltage changes, and the flicker is almost imperceptible. When using an LED lighting system that uses a color temperature of up to 3500 K, very good contrast sensitivity, color recognition and minimal light pollution are achieved. A color temperature that exceeds 4000 K and reaches 5000 K is extremely unfavorable because it contains a large proportion of blue light. The law stipulates that roads with motor traffic do not exceed the temperature of LED lights at 4000 K, because the share of blue light is much lower. The advantage of LED lighting is its high energy efficiency.The lifespan of LEDs is more than 50,000 hours (lamps used in the study for 100,000 hours) and this largely depends on the cooling quality of the LEDs. Color rendering and light efficiency characteristics improve significantly from year to year. The current efficiencies of this type of diodes in use in public lighting range from 50 - 70 lm / W, while the color rendering index is 60 - 80.Their use in public lighting has led to major changes in lamp design. The compact shape and relatively low intensity of the LEDs require the use of a larger number of diodes in the lamp and the direction of the light flux of each diode separately.

Image 17: LED lightbulb

Organic light emitting diode lamp (OLED)

The latest trends in electric lighting speak of OLED lighting, which is the next step in LED lighting, the letter "O" in the abbreviation OLED stands for "organic", but it is still LED lighting. The difference is that organic materials are used to make OLED lighting, which is claimed to be mechanically more flexible, which can lead to OLED lamps being made or printed using a 3D printer one day, while the principle of operation of the LED remains the same. As light emitting diodes will reach the maximum possible theoretical efficiency, OLED technology, even if it replaces them, will not be due to efficiency but due to some other trends, i.e. if it manages to be cheaper than LED lighting. Also, if some new artificial light sources appear, it is questionable whether it will be profitable to develop them and replace LED lighting with them because they cannot be more efficient than LED technology, and LED technology will become very cheap and accessible to everyone. Therefore, the only ways to increase the energy efficiency of public lighting today is to replace existing luminaires with LED technology and to manage public lighting and use additional technologies such as solar panels, rather than creating new light sources.

Trends in the use of additional technologies to increase the energy efficiency of public ligh

Currently, the world believes that LED lighting sources have reached the pinnacle of technology, and the possibility of increasing energy efficiency is reflected in technological additions to LED sources such as solar panels and lighting control.

The basic principle of solar lighting is that the Image-voltaic PV module located at the top of the pole converts solar radiation into electricity that accumulates in batteries. The accumulation itself is electronically monitored via a regulator that keeps the battery charging voltage within the allowable limits. Solar public lighting has proven to be a very cost-effective, economical and durable solution in many situations where bringing electricity networks is too expensive or the terrain is ungrateful for laying cables or electrification poles. The advantages of solar public lighting are:

– no digging, laying cables or mounting electrification transmission poles,
– simple project implementation requires minimal human resources,
– no need for transformer installation, calculation of KS currents and voltage drops,
– environmental friendliness,
– economic profitability - no electricity bills.

Image 18: Example of solar LED public lighting (island of Murter – croatia)

The current trend of public lighting management has mostly relied on the following ways:

1. Manual control,
2. By means of a time relay
3. By means of a Imagecell,
4. A combination of different commands.

Previous systems have made it possible to manage public lighting in terms of turning on the lights at the end of the day and turning them off at the beginning of the day. The new systems enable the management of public lighting during the night as well. Technological advances have made it possible to replace the traditional public lighting management system with a more modern system that is energy efficient, simplifies maintenance and reduces their costs, is more environmentally friendly and improves pedestrian and road traffic.

Such system includes the use of equipment and services such as:

- on / off switch depending on the light intensity or depending on a fixed (desired) on / off schedule,
- fault signaling part,
- remote control of the on / off switch lighting (WSN wireless sensors) enabling remote communication and control
- calculation of lighting costs from a remote central point (central technical monitoring of the system),
- dimming of lighting,
- turning on public lighting on a motion sensor, etc.

Nowadays, more and more cities are accepting the urban way of city development and acquiring the name "Smart City". The goal is to increase comfort and living standards through advanced information and communication technology solutions and Internet interfaces. Precisely these types of technology bring many advantages and improvements in the management and optimization of public services, and among them are transportation and parking, public lighting, surveillance and maintenance of public areas, collection of waste,preservation of cultural heritage, etc.Data collected in this way can be used to increase transparency and promote local government action.Furthermore, a very important component of a smart city concept is precisely the public lighting system. By using information and communication technologies and the Internet, smart cities strive to improve the quality of urban services and their energy efficiency. As the percentage of urbanization increases and the economy develops, the public lighting system becomes one of the key items of every modern city.

Thus, smart public lighting is used through advanced surveillance; it reduces electricity consumption, optimizes energy efficiency, increases safety and reduces maintenance costs. The latest public lighting systems consist of an LED lamp, a solar panel and a smart pole.Such systems can be used for various purposes such as: wireless remote control system, electric advertisements, digitalized traffic signs, power station for electric vehicles (cars and bicycles), traffic monitoring sensors, traffic counter, speakers, air quality sensors, decorative lighting, water level display, Push- to- talk service, Wi- Fi and mobile network, cameras, etc. (Image 19).

Image 19: Example of smart solar lighting

One or more different control network protocols are used for continuous communication between individual components in the smart public lighting system as well as the public lighting system and the central computer system. Thus, such a network protocol is a set of rules and standards that allow the display and verification of collected data and the detection and verification of possible errors in the public lighting system. If the geographical area is wider, then there are several public lighting networks, and each has its own control network protocol. Most often, these control protocols are not connected and each network system requires a separate central control system. The most commonly used control network protocols in public lighting are: DALI (Digital Addressable Lighting Interface), TCP / IP (Transmission Control Protocol / Internet Protocol), 6LoWPAN (Low power Wireless Personal Area Networks), ZIGBEE, KNX (Konnex), 0 - 10V analog type control protocol and PLC (Power Line Communication).

6 PUBLIC LIGHTING ENERGY CHARACTERISTICS ANALYSIS AND ENERGY CONSUMPTION AND EXPENSES MANAGEMENT CHARACTERISTICS

6.1 General

According to development strategy of municipality Novi Grad, internal powers analysis, electronetwork and lighting is well developed. Main streets are illuminated , as most rural streets. However, existing public lighting has low energy efficiency. Table 1 gives general data on public lighting system, and table 2 gives a list of overviewed streets.

Amenable administration	Opština Novi Grad	Street	Petra Kočića	No.	2
Contact person	Zoran Mijatović	Phone	+387 52 720 468		
Cell phone	+387 65 881 630	Mail:	zoran.mijatovic@opstina-novigrad.com		
Public lighting (type) goal			Street lighting, walking zone lighting, suburb residental zone lighting		
First year of building					
Lamp operating system			ʏ Imagecell ʏ Time reley □ Timer switch		
Daily operating time (h)			Summer: 8 pm – 4 am Winter: 4:30 pm – 8 am Average: approx 11 hours		
Operating system			Not regulated		
Subject obligated/under contract for public lighting maintenance			"Elektrospin" d.o.o. Novi Grad		
Contact person					
Phone					
Electricity supplier			ZP "Elektrokrajina"		

Table 1: General informations on public lighting system

Ordinal No.	Street name
1	Ive Andrića
2	Roga
3	Želj. stanica
4	Jablanica
5	Silos
6	Prekosanje
7	Karađorđa Petrovića
8	Petra Kočića
9	Nadežde Petrović

Ordinal No.	Street name
10	Kej Vojvode Stepe
11	Njegoševa
12	Miloša Obilića
13	Caprag
14	Kej Krajiških brigada
15	Dositeja Obradović
16	Gavrila Principa
17	Pionirska
18	Tunjica
19	Repovac
20	Topić brdo
21	Dobrile Grubor
22	Nikole Pašića
23	Kožinac
24	Dom zdravlja
25	Svodna
26	Dobrljin
27	Rudice
28	S Čulići
29	Vodičevo Šljok.
30	Donje Vodičevo
31	Ravnice Šindr.
32	Ravnice
33	Ravnice Kovač.
34	Dobrljin-Tomašev.
35	Svodna-želj. stanica
36	Poljavnice
37	Petkovac
38	-Hotel
39	Poljavnice-Lazići
40	Poljavnice 1
41	Karakolo
42	Ravnice-Crnobrnje
43	Mlakve
44	Blagaj Rijeka
45	Blagaj Japra
46	Suhača-Halilov.
47	Blag. Japra-Troske
48	D.Rakani-Astor
49	Rudice
50	D.Rakani-motel
51	Kršlje
52	S.grad-kasl. Ograde

Ordinal No.	Street name
53	Hozići
54	Suhača
55	Vitasovci
56	Čelopek
57	Radišići-Rudice
58	Stadion Mlakve
59	Nadvožnjak
60	Vitasovci 3
61	Izbj. naselje-Rudice
62	Maslovare
63	Šuća brdo
64	Gornji Agići 1
65	Asf. baza Poljavnice
66	Donji Hozići
67	M. Novska Rujiška
68	Donje Vodičevo-lug
69	V. Žuljevica-Gajići
70	Silos-pijaca
71	Gornji Agići 2
72	Petkovac mlin
73	Poljavnice Radišići 1
74	Blatna 3
75	Blatna 1 poligon

Table 2: Streets listed for an overview[8]

6.2 Energy characteristics analysis

Municipality Novi Grad does construction, management and public lighting and device maintenance. Outside lighting in the Municipality shares into: street, urban and spotlight lighting. Street lighting or traffic lighting provides:
- safe, quick and comfortable movement for motor vehicle drivers, bikers and cyclists,
- safe walking, in terms of providing possibilities to notice a threat, to orient themselves and recognize other walkers,
- repair a night look for traffic proximate surrounding.

Urban lighting meets a need for creating ambient atmosphere on public places, squares and streets. Spotlight lighting emphasizes architectual work and significant historic monuments. Image 20 shows public lighting system elements.

[8] Informations given by Amenable Administrating Service

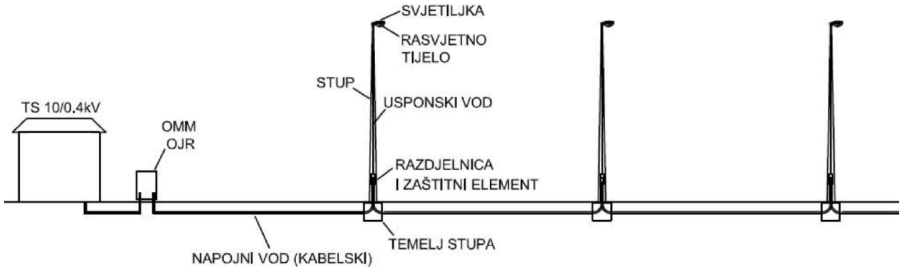

Image 20: Public lighting system elements

Energy characteristics analysis consists of light source optical and technical characteristics analysis, measuring points and substation, poles, conductiors/lines and geolocation coordinates of poles and lighting bodies. Detailed information on all anaysis and collected data are shown on the following pages.

6.2.1 Lighting source optical and technical characteristics

Subject part of public lighting Study in Municipality of Novi Grad is installed mostly with sodium lamps, LED and mercury lamps. Public lighting in certain villages and on regional road (Maršala Tita) is conducted by using LED technology, while metal halogen reflector lamps are used in the playgrounds near schools. Lamp box is mostly built in a mechanical protection IP65 degree. Table 3 shows a lighting source overview on subject streets, partaking lighting sources are shown in Image 21.

Ordinal No.	Street name	Light source type	Rated power per source (W)	Lighting sources (pcs)
1	Ive Andrića	Mercury	125	51
2	Ive Andrića	LED	100	20
3	Roga	Mercury	125	53
4	Želj. stanica	Mercury	125	15
5	Jablanica	Mercury	125	65
6	Jablanica	Sodium	100	18
7	Jablanica	LED	100	2
8	Silos	Sodium	100	25
9	Silos	LED	100	10
10	Prekosanje	Mercury	125	50
11	Prekosanje	LED	100	2
12	Karađorđa Petrovića	Sodium	70	62
13	Karađorđa Petrovića	Mercury	125	11
14	Petra Kočića	LED	100	25
15	Petra Kočića	Metal halogen	200	2
16	Nadežde Petrović	Mercury	125	10
17	Kej Vojvode Stepe	Mercury	125	63
18	Njegoševa	Mercury	125	6
19	Njegoševa	Sodium	70	7
20	Njegoševa	Sodium	100	5
21	Njegoševa	LED	100	4
22	Miloša Obilića	Mercury	125	17

Ordinal No.	Street name	Light source type	Rated power per source (W)	Lighting sources (pcs)
23	Caprag	Sodium	100	15
24	Caprag	Mercury	125	3
25	Caprag	LED	100	5
26	Kej Krajiških brigada	LED	100	14
27	Dositeja Obradović	LED	100	5
28	Gavrila Principa	Mercury	125	16
29	Gavrila Principa	LED	100	10
30	Pionirska	LED	100	6
31	Tunjica	Mercury	125	70
32	Tunjica	LED	100	4
33	Repovac	Sodium	100	30
34	Repovac	Mercury	125	3
35	Repovac	LED	100	14
36	Topić brdo	Sodium	100	15
37	Topić brdo	Mercury	125	9
38	Topić brdo	LED	100	2
39	Dobrile Grubor	LED	100	4
40	Nikole Pašića	Mercury	125	14
41	Kožinac	Mercury	125	29
42	Kožinac	LED	100	3
43	Dom zdravlja	Mercury	125	6
44	Dom zdravlja	LED	100	4
45	Svodna	Mercury	125	59
46	Dobrljin	Mercury	125	67
47	Dobrljin	LED	100	53
48	Rudice	Mercury	125	45
49	Čulići	Mercury	125	26
50	Vodičevo Šljok.	Mercury	125	42
51	Donje Vodičevo	Mercury	125	16
52	Ravnice Šindr.	Mercury	125	19
53	Ravnice Šindr.	LED	100	2
54	Ravnice	Mercury	125	19
55	Ravnice Kovač.	Mercury	125	16
56	Dobrljin-Tomašev.	Mercury	125	39
57	Svodna-želj. stanica	Mercury	125	30
58	Poljavnice	Sodium	70	24
59	Poljavnice	Mercury	125	7
60	Poljavnice	LED	100	17
61	Poljavnice	LED	20	1
62	Petkovac	Mercury	125	6

Ordinal No.	Street name	Light source type	Rated power per source (W)	Lighting sources (pcs)
63	-Hotel	Mercury	125	17
64	Poljavnice-Lazići	Mercury	125	34
65	Poljavnice 1	Mercury	125	20
66	Poljavnice 1	LED	100	1
67	Karakolo	Mercury	125	22
68	Ravnice-Crnobrnje	Mercury	125	21
69	Mlakve	Mercury	125	21
70	Mlakve	LED	100	2
71	Blagaj Rijeka	Mercury	125	43
72	Blagaj Japra	Mercury	125	52
73	Blagaj Japra	LED	100	1
74	Suhača-Halilov.	Mercury	125	28
75	Suhača-Halilov.	LED	100	2
76	Blag. Japra-Troske	Mercury	125	28
77	D.Rakani-Astor	Mercury	125	36
78	Rudice	Mercury	125	10
79	D.Rakani-motel	Mercury	125	20
80	Kršlje	Mercury	125	16
81	S.grad-kasl. Ograde	Mercury	125	4
82	S.grad-kasl. Ograde	LED	100	3
83	Hozići	Mercury	125	18
84	Hozići	LED	100	1
85	Suhača	Mercury	125	30
86	Vitasovci	Sodium	100	14
87	Vitasovci	LED	100	1
88	Čelopek	Mercury	125	23
89	Čelopek	LED	100	1
90	Radišići-Rudice	Mercury	125	33
91	Radišići-Rudice	LED	100	1
92	Radišići-Rudice	Metal halogen	200	3
93	Stadion Mlakve	Mercury	125	18
94	Nadvožnjak	LED	100	4
95	Vitasovci 3	Mercury	125	22
96	Vitasovci 3	Sodium	100	18
97	Izbj. naselje-Rudice	Mercury	125	15
98	Maslovare	Sodium	70	9
99	Maslovare	Fluorescentna	22	1
100	Šuća brdo	Mercury	125	11
101	Gornji Agići 1	Mercury	125	5
102	Gornji Agići 1	LED	100	14

Ordinal No.	Street name	Light source type	Rated power per source (W)	Lighting sources (pcs)
103	Asf. baza Poljavnice	Sodium	70	5
104	Asf. baza Poljavnice	LED	100	8
105	Donji Hozići	Mercury	125	17
106	Donji Hozići	Sodium	70	3
107	Donji Hozići	LED	100	1
108	M. Novska Rujiška	Mercury	125	8
109	Donje Vodičevo-lug	Mercury	125	54
110	Donje Vodičevo-lug	LED	100	6
111	V. Žuljevica-Gajići	Mercury	125	17
112	Silos-pijaca	Sodium	70	8
113	Gornji Agići 2	Mercury	125	30
114	Petkovac mlin	LED	100	8
115	Poljavnice Radišići 1	Mercury	125	1
116	Poljavnice Radišići 1	LED	100	11
117	Blatna 3	LED	100	16
118	Blatna 1 poligon	Mercury	125	36
TOTAL				

Table 3: Lighting types by subject streets

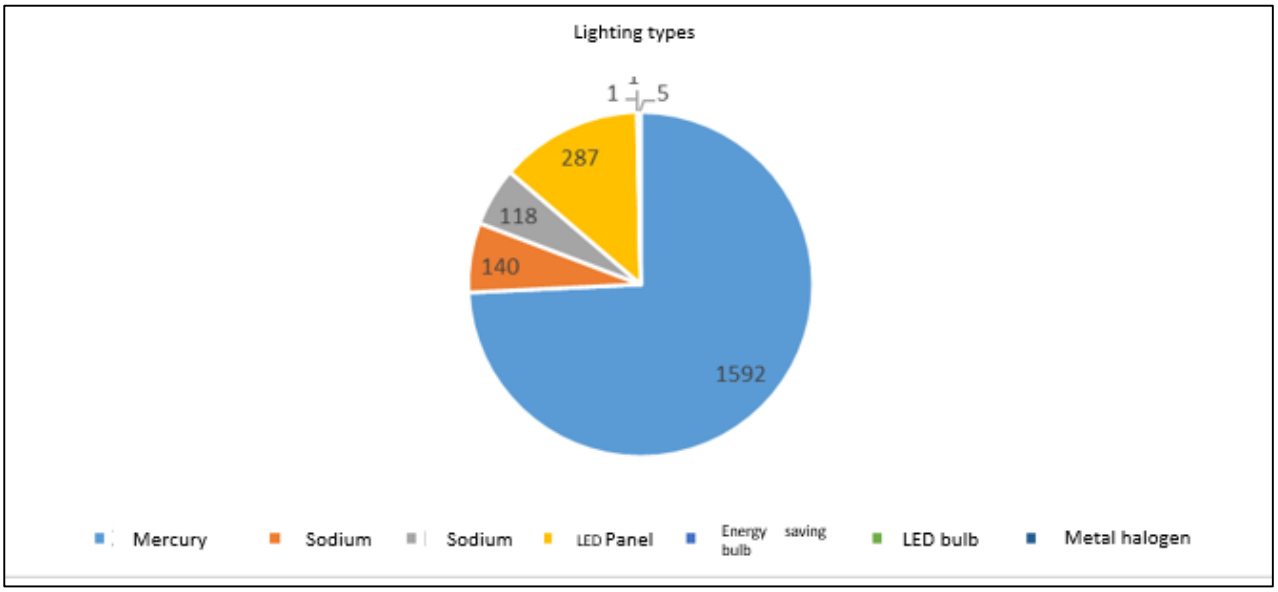

Image 21: Partaking lighting source types

Image 22 i image 23 show an existing public lighting lamps overview in the Municipality of Novi Grad. Due to lighting source obsolescence, lamps are filthy and that characteristic is a poor one for illumination. Lighting engagement regime especially has a seasonal character due to different day lengths in a year. Table 3 shows a conclusion on outdated inadequate lighting system which has a certain unwanted consequences, and they are:

- frequent malfunctions in public lighting system,

- extra damaging as a consequence due to poor gear quality,
- maintenance expenses,
- great electricity consumption,
- lamps without (quality) reflector lead to dispersing luminocity on unintended surfaces, flare and extra unnecessary energy loss,
- outdated lamp design,
- luminous environment pollution in terms of unintended sky illuminations and obstructing light.

Image 22: Sodium lamps

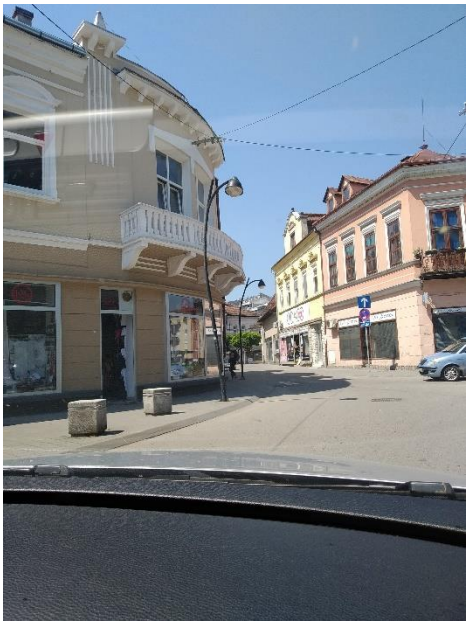

Image 23: Mercury lamps

Image 24: LED lamps

6.2.2 Geolocation coordinates of poles and lighting bodies

Public lighting mapping is done by using GARMIN GPS73 instrument and a mobile application SW Maps. Mapped lamps are lamps located on parts of traffic roads with different lamp order, done in a way of moving –from lamp to lamp and marking a lamp/pole and found on vertical axis of a lamp, picturing significant lamps. After done lamp mapping, data was delivered into computer program QGIS. In QGIS there was installed an addition for OpenStreetMap map and addition for import/export of Images. Processing data, we get a mapped lamp overview (Image 25).

Image 25: Laser measuring parameter example

Mapping comes to expression when it is necessary to write down several distribution cabinet, substations and extra lamp types, etc. Detailed report on geolocation coordinates is shown in annex. Besides mapping

distances between poles are measured and tested, lamp console length, pole height, road to pole distance with an instrument – Leica DISTO D210 and in a QGIS program. Image 6 shows a measuring example. Data on all measurings is shown in the following chapters.

MUNICIPALITY NOVI GRAD, PUBLIC LIGHTING KARAKOLO
STREET: KARAKOLO
125W High-pressure sodium
Image 26: Pole and lamp mapping example

6.2.3 Measuring points and substations

Total number of measuring points (OMM) in the system reffering to this study, there are 75 measuring points for measuring public lighting system energy consumption. Releys are installed in central building for controlling power of installed lamps. It is a partial convinient management system, due to it is not necessary to set a new time interval in every central building for turning public lighting on/off.

Circuits are protected with automatic fuses usually Hager on which there are no signs of damaging on fuses. Main switches are operable and new. Switchboards fulfill current demands of the right standard STN.While operating, there is no greater risk of electric shock. Leading cables for all public lighting distributors are mechanically protected. Control and safety parts are mostly protected with casings in case of possible electric shock and they are not life threatening while maintaining.

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	Reg dev fun (ye
01/A	01812720	JR Rasavci	yes		Time relay	yes	no	no regulation	-
02/A	07150060	TS 35-10	yes		Time relay	yes	no	no regulation	-
05/A	07150150	TS Urije-zidana	yes	11	Time relay	yes	no	no regulation	-
06/A	07150210	TS Želj. stanica	yes	11	Time relay	yes	no	no regulation	-
07/A	07150240	TS Jablanica	yes	11	Time relay	yes	no	no regulation	-
08/A	07150270	TS Urije „Crpna“	yes	11	Photocell	yes	no	no regulation	-
09/A	07150300	TS Silos Novi Grad	yes	11	Time relay	yes	no	no regulation	-
10/A	07150330	TS Prekosanje	yes	11	Time relay	yes	no	no regulation	-
11/A	07150360	TS Emina	yes	11	Photocell	yes	no	no regulation	-
12/A	07150390	TS Unska obala	yes	11	Photocell	yes	no	no regulation	-
13/A	07150420	TS Vujanovići	yes	11	Time relay	yes	no	no regulation	-
14/A	07150450	TS Stari grad	yes	11	Photocell	yes	no	no regulation	-
15/A	07150480	TS Jaruga	yes	11	Photocell	yes	no	no regulation	-
16/A	07150510	TS Caprag	yes	11	Photocell	yes	no	no regulation	-
17/A	07150540	TS G. Principa	yes	11	Time relay	yes	no	no regulation	-
18/A	07150600	TS Ograde II	yes	11	Photocell	yes	no	no regulation	-
19/A	07150660	TS V. Gortan	yes	11	Time relay	yes	no	no regulation	-

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	R d f (
20/A	07150720	TS Tunjica	yes	11	Time relay	yes	no	no regulation	-
21/A	07150750	TS Repovac	yes	11	Time relay	yes	no	no regulation	-
22/A	07150780	TS Topić brdo	yes	11	Photocell	yes	no	no regulation	-
23/A	07150810	TS Ograde I	yes	11	Time relay	yes	no	no regulation	-
24/A	07150840	TS Urije-Kožinac	yes	11	Photocell	yes	no	no regulation	-
25/A	07150900	TS Dom zdravlja	yes	11	Photocell	yes	no	no regulation	-
26/A	85030793	JR Svodna	no	11	Time relay	yes	no	no regulation	-
27/A	85030794	JR Dobrljin	yes	11	Time relay	yes	no	no regulation	-
28/A	85030795	JR Rudice	no	11	Photocell	yes	no	no regulation	-
29/A	85030796	JR STS Čulići	no	11	Photocell	yes	no	no regulation	-
30/A	85030798	JR Vodičevo TS Šljok.	yes	11	Time relay	yes	no	no regulation	-
31/A	85030799	JR Donje Vodičevo	yes	11	Time relay	yes	no	no regulation	-
32/A	85030800	JR Ravnice TS Šindr.	yes	11	Time relay	yes	no	no regulation	-
33/A	85030801	JR Ravnice	yes	11	Time relay	yes	no	no regulation	-
34/A	85030802	JR Ravnice TS Kovač.	yes	11	Time relay	yes	no	no regulation	-
35/A	85030803	JR Dobrljin-Tomašev.	yes	11	Time relay	yes	no	no regulation	-
36/A	85030804	JR Svodna-želj. stanica	yes	11	Time relay	yes	no	no regulation	-
37/A	85030893	TS Poljavnice	yes	11	Photocell	yes	no	no regulation	-
38/A	85030894	JR Petkovac	no	11	Time relay	yes	no	no regulation	-
39/A	85034315	JR TS-Hotel	yes	11	Photocell	yes	no	no regulation	-
40/A	85035115	JR Poljavnice-Lazići	yes	11	Time relay	yes	no	no regulation	-
41/A	85042970	JR Poljavnice	no	11	Photocell	yes	no	no regulation	-
42/A	85042972	JR Karakolo	yes	11	Time relay	yes	no	no regulation	-

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	Reg dev fun (ye
43/A	85056999	JR Ravnice-Crnobrnje	yes	11	Time relay	yes	no	no regulation	-
44/A	85057000	JR Mlakve	yes	11	Time relay	yes	no	no regulation	-
45/A	85057001	JR Unska obala	yes	11	Photocell	yes	no	no regulation	-
46/A	85057002	JR Blagaj Rijeka	yes	11	Photocell	yes	no	no regulation	-
47/A	85057017	JR Blagaj Japra	no	11	Photocell	yes	no	no regulation	-
48/A	85057018	JR Suhača-Halilov.	yes	11	Time relay	yes	no	no regulation	-
49/A	85057019	JR Blag. Japra-Troske	no	11	Time relay	yes	no	no regulation	-
50/A	85057021	JR D.Rakani-Astor	no	11	Photocell	yes	no	no regulation	-
51/A	85057021	JR Rudice	no	11	Photocell	yes	no	no regulation	-
52/A	85057022	JR D.Rakani-motel	no	11	Time relay	yes	no	no regulation	-
53/A	85061299	JR Kršlje	no	11	Photocell	yes	no	no regulation	-
54/A	85064737	JR S.grad-kasl. Ograde	no	11	Photocell	yes	no	no regulation	-
55/A	85064755	JR Hozići	no	11	Photocell	yes	no	no regulation	-
56/A	85064975	JR Suhača	no	11	Time relay	yes	no	no regulation	-
57/A	85065955	JR Vitasovci	no	11	Time relay	yes	no	no regulation	-
58/A	85074660	JR Čelopek	no	11	Photocell	yes	no	no regulation	-
59/A	85076354	JR Radišići-Rudice	no	11	Time relay	yes	no	no regulation	-
60/A	85098679	JR Stadion Mlakve	yes	11	Photocell	yes	no	no regulation	-
61/A	85098680	JR Nadvožnjak	no	11	Photocell	yes	no	no regulation	-
62/A	85098815	JR Vitasovci 3		11		yes	no	no regulation	-
63/A	85105226	JR Izbj. naselje-Rudice	no	11	Time relay	yes	no	no regulation	-
64/A	85113022	JR Maslovare	no	11	Photocell	yes	no	no regulation	-
65/A	85113023	JR Šuća brdo	no	11	Photocell	yes	no	no regulation	-

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	R d f (
66/A	85113024	JR Gornji Agići 2		11		yes	no	no regulation	-
67/A	85113025	JR Asf. baza Poljavnice	no	11	Time relay	yes	no	no regulation	-
68/A	85113026	JR Donji Hozići	no	11	Time relay	yes	no	no regulation	-
69/A	85113028	JR M. Novska Rujiška	no	11	Time relay	yes	no	no regulation	-
70/A	85113029	JR Donje Vodičevo-lug	no	11	Time relay	yes	no	no regulation	-
71/A	85113030	JR V. Žuljevica-Gajići	no	11	Time relay	yes	no	no regulation	-
72/A	85113031	JR Silos-pijaca	no	11	Photocell	yes	no	no regulation	-
73/A	85113032	JR Gornji Agići 2	no	11	Photocell	yes	no	no regulation	-
74/A	85117103	JR Petkovac mlin	no	11	Photocell	yes	no	no regulation	-
75/A	85117104	JR Poljavnice Radišići 1	no	11	Time relay	yes	no	no regulation	-
76/A	85117105	JR Blatna 3	no	11	Time relay	yes	no	no regulation	-
77/A	85117106	JR Blatna 1 poligon	no	11	Photocell	yes	no	no regulation	-

Table 4 shows data on measuring points (OMM), and Image 27 shows OMM overview.

Image 27: OMM (left – Regionalni road - Kalimanići, right – Regionalni road - Petriča)

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	Regulation device functional (yes / no)	Public lighting power lines in OMM	Labels for the right circuits	Power line type for PL (overground/ underground/ mix)
01/A	01812720	JR Rasavci	yes		Time relay	yes	no	no regulation	-	1	01/A/1	overground
02/A	07150060	TS 35-10	yes		Time relay	yes	no	no regulation	-	1	02/A/1	overground
05/A	07150150	TS Urije-zidana	yes	11	Time relay	yes	no	no regulation	-	1	05/A/1	overground
06/A	07150210	TS Želj. stanica	yes	11	Time relay	yes	no	no regulation	-	1	06/A/1	overground
07/A	07150240	TS Jablanica	yes	11	Time relay	yes	no	no regulation	-	1	07/A/1	overground
08/A	07150270	TS Urije „Crpna“	yes	11	Photocell	yes	no	no regulation	-	1	08/A/1	overground
09/A	07150300	TS Silos Novi Grad	yes	11	Time relay	yes	no	no regulation	-	1	09/A/1	overground
10/A	07150330	TS Prekosanje	yes	11	Time relay	yes	no	no regulation	-	1	10/A/1	overground
11/A	07150360	TS Emina	yes	11	Photocell	yes	no	no regulation	-	1	11/A/1	underground
12/A	07150390	TS Unska obala	yes	11	Photocell	yes	no	no regulation	-	1	12/A/1	underground
13/A	07150420	TS Vujanovići	yes	11	Time relay	yes	no	no regulation	-	1	13/A/1	underground
14/A	07150450	TS Stari grad	yes	11	Photocell	yes	no	no regulation	-	1	14/A/1	underground
15/A	07150480	TS Jaruga	yes	11	Photocell	yes	no	no regulation	-	1	15/A/1	underground
16/A	07150510	TS Caprag	yes	11	Photocell	yes	no	no regulation	-	1	16/A/1	underground

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	Regulation device functional (yes / no)	Public lighting power lines in OMM	Labels for the right circuits	Power line type for PL (overground/ underground/ mix)
17/A	07150540	TS G. Principa	yes	11	Time relay	yes	no	no regulation	-	1	17/A/1	overground
18/A	07150600	TS Ograde II	yes	11	Photocell	yes	no	no regulation	-	1	19/A/1	underground
19/A	07150660	TS V. Gortan	yes	11	Time relay	yes	no	no regulation	-	1	21/A/1	underground
20/A	07150720	TS Tunjica	yes	11	Time relay	yes	no	no regulation	-	1	23/A/1	overground
21/A	07150750	TS Repovac	yes	11	Time relay	yes	no	no regulation	-	1	24/A/1	underground
22/A	07150780	TS Topić brdo	yes	11	Photocell	yes	no	no regulation	-	1	25/A/1	overground
23/A	07150810	TS Ograde I	yes	11	Time relay	yes	no	no regulation	-	1	26/A/1	underground
24/A	07150840	TS Urije-Kožinac	yes	11	Photocell	yes	no	no regulation	-	1	27/A/1	overground
25/A	07150900	TS Dom zdravlja	yes	11	Photocell	yes	no	no regulation	-	1	28/A/1	mixed
26/A	85030793	JR Svodna	no	11	Time relay	yes	no	no regulation	-	1	29/A/1	overground
27/A	85030794	JR Dobrljin	yes	11	Time relay	yes	no	no regulation	-	1	30/A/1	overground
28/A	85030795	JR Rudice	no	11	Photocell	yes	no	no regulation	-	1	31/A/1	overground
29/A	85030796	JR STS Čulići	no	11	Photocell	yes	no	no regulation	-	1	32/A/1	overground
30/A	85030798	JR Vodičevo TS Šljok.	yes	11	Time relay	yes	no	no regulation	-	1	33/A/1	overground

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	Regulation device functional (yes / no)	Public lighting power lines in OMM	Labels for the right circuits	Power line type for PL (overground/ underground/ mix)
31/A	85030799	JR Donje Vodičevo	yes	11	Time relay	yes	no	no regulation	-	1	34/A/1	overground
32/A	85030800	JR Ravnice TS Šindr.	yes	11	Time relay	yes	no	no regulation	-	1	35/A/1	overground
33/A	85030801	JR Ravnice	yes	11	Time relay	yes	no	no regulation	-	1	36/A/1	overground
34/A	85030802	JR Ravnice TS Kovač.	yes	11	Time relay	yes	no	no regulation	-	1	37/A/1	overground
35/A	85030803	JR Dobrljin-Tomašev.	yes	11	Time relay	yes	no	no regulation	-	1	38/A/1	overground
36/A	85030804	JR Svodna-želj. stanica	yes	11	Time relay	yes	no	no regulation	-	1	39/A/1	overground
37/A	85030893	TS Poljavnice	yes	11	Photocell	yes	no	no regulation	-	1	40/A/1	overground
38/A	85030894	JR Petkovac	no	11	Time relay	yes	no	no regulation	-	1	41/A/1	overground
39/A	85034315	JR TS-Hotel	yes	11	Photocell	yes	no	no regulation	-	1	42/A/1	underground
40/A	85035115	JR Poljavnice-Lazići	yes	11	Time relay	yes	no	no regulation	-	1	43/A/1	overground
41/A	85042970	JR Poljavnice	no	11	Photocell	yes	no	no regulation	-	1	44/A/1	overground
42/A	85042972	JR Karakolo	yes	11	Time relay	yes	no	no regulation	-	1	45/A/1	overground
43/A	85056999	JR Ravnice-Crnobrnje	yes	11	Time relay	yes	no	no regulation	-	1	46/A/1	overground
44/A	85057000	JR Mlakve	yes	11	Time relay	yes	no	no regulation	-	1	47/A/1	overground

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	Regulation device functional (yes / no)	Public lighting power lines in OMM	Labels for the right circuits	Power line type for PL (overground/ underground/ mix)
45/A	85057001	JR Unska obala	yes	11	Photocell	yes	no	no regulation	-	1	48/A/1	underground
46/A	85057002	JR Blagaj Rijeka	yes	11	Photocell	yes	no	no regulation	-	1	49/A/1	overground
47/A	85057017	JR Blagaj Japra	no	11	Photocell	yes	no	no regulation	-	1	50/A/1	overground
48/A	85057018	JR Suhača-Halilov.	yes	11	Time relay	yes	no	no regulation	-	1	51/A/1	overground
49/A	85057019	JR Blag. Japra-Troske	no	11	Time relay	yes	no	no regulation	-	1	52/A/1	overground
50/A	85057021	JR D.Rakani-Astor	no	11	Photocell	yes	no	no regulation	-	1	53/A/1	overground
51/A	85057021	JR Rudice	no	11	Photocell	yes	no	no regulation	-	1	54/A/1	overground
52/A	85057022	JR D.Rakani-motel	no	11	Time relay	yes	no	no regulation	-	1	55/A/1	overground
53/A	85061299	JR Kršlje	no	11	Photocell	yes	no	no regulation	-	1	56/A/1	overground
54/A	85064737	JR S.grad-kasl. Ograde	no	11	Photocell	yes	no	no regulation	-	1	57/A/1	underground
55/A	85064755	JR Hozići	no	11	Photocell	yes	no	no regulation	-	1	58/A/1	overground
56/A	85064975	JR Suhača	no	11	Time relay	yes	no	no regulation	-	1	59/A/1	overground
57/A	85065955	JR Vitasovci	no	11	Time relay	yes	no	no regulation	-	1	60/A/1	overground
58/A	85074660	JR Čelopek	no	11	Photocell	yes	no	no regulation	-	1	61/A/1	overground

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	Regulation device functional (yes / no)	Public lighting power lines in OMM	Labels for the right circuits	Power line type for PL (overground/ underground/ mix)
59/A	85076354	JR Radišići-Rudice	no	11	Time relay	yes	no	no regulation	-	1	62/A/1	overground
60/A	85098679	JR Stadion Mlakve	yes	11	Photocell	yes	no	no regulation	-	1	63/A/1	overground
61/A	85098680	JR Nadvožnjak	no	11	Photocell	yes	no	no regulation	-	1	64/A/1	overground
62/A	85098815	JR Vitasovci 3		11		yes	no	no regulation	-	1	65/A/1	overground
63/A	85105226	JR Izbj. naselje-Rudice	no	11	Time relay	yes	no	no regulation	-	1	69/A/1	overground
64/A	85113022	JR Maslovare	no	11	Photocell	yes	no	no regulation	-	1	70/A/1	overground
65/A	85113023	JR Šuća brdo	no	11	Photocell	yes	no	no regulation	-	1	71/A/1	overground
66/A	85113024	JR Gornji Agići 2		11		yes	no	no regulation	-	1	72/A/1	overground
67/A	85113025	JR Asf. baza Poljavnice	no	11	Time relay	yes	no	no regulation	-	1	73/A/1	overground
68/A	85113026	JR Donji Hozići	no	11	Time relay	yes	no	no regulation	-	1	75/A/1	overground
69/A	85113028	JR M. Novska Rujiška	no	11	Time relay	yes	no	no regulation	-	1	77/A/1	overground
70/A	85113029	JR Donje Vodičevo-lug	no	11	Time relay	yes	no	no regulation	-	1	78/A/1	overground
71/A	85113030	JR V. Žuljevica-Gajići	no	11	Time relay	yes	no	no regulation	-	1	79/A/1	overground
72/A	85113031	JR Silos-pijaca	no	11	Photocell	yes	no	no regulation	-	1	80/A/1	overground

Measuring point unique ID (based on electricity supplier numeration)	Label OMM (officially based on EE overview numeration)	Substation name/label	OMM is located inside substation (yes / no)	Average lighting daily working hours (h)	Management type	Switching device functional (yes / no)	Light flux regulation (yes / no)	Regulation type	Regulation device functional (yes / no)	Public lighting power lines in OMM	Labels for the right circuits	Power line type for PL (overground/ underground/ mix)
73/A	85113032	JR Gornji Agići 2	no	11	Photocell	yes	no	no regulation	-	1	81/A/1	overground
74/A	85117103	JR Petkovac mlin	no	11	Photocell	yes	no	no regulation	-	1	84/A/1	overground
75/A	85117104	JR Poljavnice Radišići 1	no	11	Time relay	yes	no	no regulation	-	1	85/A/1	overground
76/A	85117105	JR Blatna 3	no	11	Time relay	yes	no	no regulation	-	1	86/A/1	overground
77/A	85117106	JR Blatna 1 poligon	no	11	Photocell	yes	no	no regulation	-	1	87/A/1	overground

Table 4: Data on measuring points (OMM)

6.2.4 Poles and support brackets

Lighting construction support is made out of lighting poles and support brackets (also called ''Lire'') mounted on poles. Lighting places in a circle of overviewed part of the network are made out of reinforced concrete poles and metal poles, there are no wooden poles.

Most poles are installed as one-sided and in zig-zag pattern. Existing steal poles are corroded on some places and it is necessary to protect adequately with protective coating and paint them. Supporting brackets on some places are smaller , which leads to uneven lighting.

Metal poles are made as an anchor, concrete poles are secured with concreate foundations.Depending on zone and part of network, poles are set on green surfaces, as on walking and traffic surfaces. Lamps are mounted under 5 degrees with a console set on poles. Console length is from 0,5 to 1 m. Console length is from 0,2-0,5 m. Pole height varies from 4 and 12 m. Table 5 shows data on pole construction.

Ordinal No.	Municipality	Metal (pcs)	Reinforced concrete (AB) (pcs)	Total
1	NOVI GRAD	1804	340	2144
		84,14%	15,86%	100%

Table 5: Pole construction

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	C ler
1	Ive Andrića-Rasavci	40	One-sided	8	yes	
2	Roga	40	One-sided	8	yes	
3	Ive andrića-Urije -zidana	30	One-sided	8	yes	
4	Želj. stanica	40	One-sided	8	yes	
5	Jablanica	30	One-sided	8	yes	
6	Ive andrića-Urije „Crpna“	30	One-sided	8	yes	
7	Silos	30	One-sided	9	yes	
8	Prekosanje	30	One-sided	8	yes	
9	Karađorđa Petrovića	30	One-sided	8	yes	
10	Petra Kočića	20	One-sided	8	yes	

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	Co leng
11	Nadežde Petrović	20	Two-sided	4	no	
12	Kej Vojvode Stepe	20	One-sided	4	no	
13	Karađorđa Petrovića-Vujanovići	20	One-sided	4	no	
14	Njegoševa	20	One-sided	8	yes	0
15	Miloša Obilića	20	One-sided	8	yes	
16	Caprag	30	One-sided	8	yes	
17	Kej Krajiških brigada	20	One-sided	8	yes	0
18	Dositeja Obradović	20	One-sided	8	yes	0
19	Gavrila Principa	20	One-sided	8	yes	0
20	Pionirska	20	One-sided	6	yes	
21	Gavrila Principa - V. Gortan	20	One-sided	8	yes	
22	Tunjica	40	One-sided	8	yes	0
23	Repovac	40	One-sided	6	yes	0
24	Topić brdo	40	One-sided	6	yes	0
25	Dobrile Grubor	20	One-sided	8	yes	0
26	Nikole Pašića	20	One-sided	8	yes	0
27	Kožinac	40	One-sided	8	yes	0
28	Dom zdravlja	20	One-sided	4	no	
29	Svodna	30	One-sided	8	yes	0
30	Dobrljin	30	One-sided	8	yes	0
31	Rudice	¸40	One-sided	8	yes	0
32	Čulići	30	One-sided	8	yes	
33	Vodičevo Šljok.	40	One-sided	8	yes	0
34	Donje Vodičevo	40	One-sided	8	yes	0

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	C ler
35	Ravnice Šindr.	40	One-sided	8	yes	
36	Ravnice	40	One-sided	8	yes	
37	Ravnice Kovač.	40	One-sided	8	yes	
38	Dobrljin-Tomašev.	30	One-sided	8	yes	
39	Svodna-želj. stanica	30	One-sided	8	yes	
40	Poljavnice	30	One-sided	8	yes	
41	Petkovac	30	One-sided	8	yes	
42	-Hotel	20	One-sided	4	no	
43	Poljavnice-Lazići	30	One-sided	8	yes	
44	Poljavnice 1	30	One-sided	8	yes	
45	Karakolo	30	One-sided	8	yes	
46	Ravnice-Crnobrnje	40	One-sided	8	yes	
47	Mlakve	40	One-sided	8	yes	
48	Kej Vojvode Stepe - Unska obala	20	One-sided	4	no	
49	Blagaj Rijeka	40	One-sided	8	yes	
50	Blagaj Japra	30	One-sided	8	yes	
51	Suhača-Halilov.	40	One-sided	8	yes	
52	Blag. Japra-Troske	30	One-sided	8	yes	
53	D.Rakani-Astor	30	One-sided	8	yes	
54	Rudice	40	One-sided	8	yes	
55	D.Rakani-motel	30	One-sided	8	yes	
56	Kršlje	30	One-sided	8	yes	
57	S.grad-kasl. Ograde	20	One-sided	8	yes	
58	Hozići	30	One-sided	8	yes	

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	Co leng
59	Suhača	40	One-sided	8	yes	0
60	Vitasovci	40	One-sided	8	yes	0
61	Čelopek	30	One-sided	8	yes	0
62	Radišići-Rudice	40	One-sided	8	yes	0
63	Stadion Mlakve	40	One-sided	8	yes	0
64	Nadvožnjak	40	One-sided	8	yes	0
65	Vitasovci 3	40	One-sided	8	yes	0
66	Izbj. naselje-Rudice	30	One-sided	8	yes	0
67	Maslovare	30	One-sided	8	yes	0
68	Šuća brdo	30	One-sided	8	yes	0
69	Asf. baza Poljavnice	30	One-sided	8	yes	
70	Donji Hozići	30	One-sided	8	yes	0
71	M. Novska Rujiška	40	One-sided	8	yes	0
72	Donje Vodičevo-lug	40	One-sided	8	yes	0
73	V. Žuljevica-Gajići	50	One-sided	8	yes	0
74	Silos-pijaca	40	One-sided	8	yes	0
75	Gornji Agići 2	30	One-sided	8	yes	0
76	Petkovac mlin	30	One-sided	8	yes	
77	Poljavnice Radišići 1	40	One-sided	8	yes	0
78	Blatna 3	30	One-sided	8	yes	0
79	Blatna 1 poligon	30	One-sided	8	yes	0

Table 6, image 8 i image 9 show technical characteristics for pole geometry and consoles.

Image 28: Poles (Reinforced concrete - left, metal - desno)

Image 29: Console overview

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	Console length (m)	Console incline (%)	Pole distanced from the road
1	Ive Andrića-Rasavci	40	One-sided	8	yes	0,3	30	1,5
2	Roga	40	One-sided	8	yes	0,3	30	1
3	Ive andrića-Urije -zidana	30	One-sided	8	yes	0,5	10	1
4	Želj. stanica	40	One-sided	8	yes	0,5	10	1
5	Jablanica	30	One-sided	8	yes	0,5	10	1
6	Ive andrića-Urije „Crpna“	30	One-sided	8	yes	0,5	50	1
7	Silos	30	One-sided	9	yes	1	0	1
8	Prekosanje	30	One-sided	8	yes	0,5	50	1
9	Karađorđa Petrovića	30	One-sided	8	yes	0,5	10	1
10	Petra Kočića	20	One-sided	8	yes	0,5	10	1
11	Nadežde Petrović	20	Two-sided	4	no	-	-	0,5
12	Kej Vojvode Stepe	20	One-sided	4	no			0,5
13	Karađorđa Petrovića-Vujanovići	20	One-sided	4	no			2
14	Njegoševa	20	One-sided	8	yes	0,5	10	1
15	Miloša Obilića	20	One-sided	8	yes	1	10	1

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	Console length (m)	Console incline (%)	Pole distanced from the road
16	Caprag	30	One-sided	8	yes	1	10	1
17	Kej Krajiških brigada	20	One-sided	8	yes	0,5	10	1
18	Dositeja Obradović	20	One-sided	8	yes	0,5	10	1
19	Gavrila Principa	20	One-sided	8	yes	0,5	10	1
20	Pionirska	20	One-sided	6	yes	1	10	1
21	Gavrila Principa - V. Gortan	20	One-sided	8	yes	1	10	1
22	Tunjica	40	One-sided	8	yes	0,5	50	1
23	Repovac	40	One-sided	6	yes	0,5	50	1
24	Topić brdo	40	One-sided	6	yes	0,5	30	1
25	Dobrile Grubor	20	One-sided	8	yes	0,5	10	1
26	Nikole Pašića	20	One-sided	8	yes	0,5	10	1
27	Kožinac	40	One-sided	8	yes	0,5	50	1
28	Dom zdravlja	20	One-sided	4	no	-	-	1
29	Svodna	30	One-sided	8	yes	0,5	10	3
30	Dobrljin	30	One-sided	8	yes	0,5	50	1

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	Console length (m)	Console incline (%)	Pole distanced from the road
31	Rudice	¸40	One-sided	8	yes	0,3	30	2
32	Čulići	30	One-sided	8	yes	1	30	2
33	Vodičevo Šljok.	40	One-sided	8	yes	0,5	50	1
34	Donje Vodičevo	40	One-sided	8	yes	0,5	50	1
35	Ravnice Šindr.	40	One-sided	8	yes	0,5	50	1
36	Ravnice	40	One-sided	8	yes	0,5	50	1
37	Ravnice Kovač.	40	One-sided	8	yes	0,5	50	1
38	Dobrljin-Tomašev.	30	One-sided	8	yes	0,5	50	1
39	Svodna-želj. stanica	30	One-sided	8	yes	0,5	50	1
40	Poljavnice	30	One-sided	8	yes	0,5	10	1
41	Petkovac	30	One-sided	8	yes	0,5	30	3
42	-Hotel	20	One-sided	4	no	-	-	1
43	Poljavnice-Lazići	30	One-sided	8	yes	0,5	10	1
44	Poljavnice 1	30	One-sided	8	yes	0,5	10	1
45	Karakolo	30	One-sided	8	yes	0,5	50	1

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	Console length (m)	Console incline (%)	Pole distanced from the road
46	Ravnice-Crnobrnje	40	One-sided	8	yes	0,5	50	1
47	Mlakve	40	One-sided	8	yes	0,3	30	1,5
48	Kej Vojvode Stepe - Unska obala	20	One-sided	4	no	-	-	0,5
49	Blagaj Rijeka	40	One-sided	8	yes	0,5	10	2
50	Blagaj Japra	30	One-sided	8	yes	0,5	10	1
51	Suhača-Halilov.	40	One-sided	8	yes	0,5	10	2
52	Blag. Japra-Troske	30	One-sided	8	yes	0,5	30	1
53	D.Rakani-Astor	30	One-sided	8	yes	1	30	2
54	Rudice	40	One-sided	8	yes	1	30	3
55	D.Rakani-motel	30	One-sided	8	yes	1	30	2
56	Kršlje	30	One-sided	8	yes	0,5	30	2
57	S.grad-kasl. Ograde	20	One-sided	8	yes	1	10	0,5
58	Hozići	30	One-sided	8	yes	1	30	1
59	Suhača	40	One-sided	8	yes	0,5	30	3
60	Vitasovci	40	One-sided	8	yes	0,5	10	1

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	Console length (m)	Console incline (%)	Pole distanced from the road
61	Čelopek	30	One-sided	8	yes	0,5	30	1
62	Radišići-Rudice	40	One-sided	8	yes	0,3	30	2
63	Stadion Mlakve	40	One-sided	8	yes	0,3	30	2
64	Nadvožnjak	40	One-sided	8	yes	0,3	30	2
65	Vitasovci 3	40	One-sided	8	yes	0,5	10	2
66	Izbj. naselje-Rudice	30	One-sided	8	yes	0,3	30	2
67	Maslovare	30	One-sided	8	yes	0,5	30	1
68	Šuća brdo	30	One-sided	8	yes	0,5	10	1
69	Asf. baza Poljavnice	30	One-sided	8	yes	1	30	1
70	Donji Hozići	30	One-sided	8	yes	0,5	10	1
71	M. Novska Rujiška	40	One-sided	8	yes	0,3	5	2
72	Donje Vodičevo-lug	40	One-sided	8	yes	0,5	50	1
73	V. Žuljevica-Gajići	50	One-sided	8	yes	0,5	50	1
74	Silos-pijaca	40	One-sided	8	yes	0,5	50	1
75	Gornji Agići 2	30	One-sided	8	yes	0,5	0	2

Ordinal No.	Street name	Average distance between poles (m)	Pole schedule (two-sided in a line, two-sided apart or one-sided)	Pole height (m)	Lamp mounted on a console (yes/ne)	Console length (m)	Console incline (%)	Pole distanced from the road
76	Petkovac mlin	30	One-sided	8	yes	1	30	1
77	Poljavnice Radišići 1	40	One-sided	8	yes	0,5	10	1
78	Blatna 3	30	One-sided	8	yes	0,3	10	2
79	Blatna 1 poligon	30	One-sided	8	yes	0,3	10	2

Table 6: Technical characteristics of geometry poles and consoles

6.2.5 Lines/Cables

Public lighting powering is done accordant to instructions received from amenable power company, which is defined in previous electricity approval. Powering poles is done over ground (concrete poles) and under ground (metal poles). Over ground conductors are isolated.

From distribution cabinet to public lighting poles, a cable type Cu 4x10 mm^2 to Cu 4x25 mm^2 are layed down. All cables are dimensioned accordant to installed power in a circuit and power demands (accordant with subject standards), long approx from 50 to 1.200 meters. Underground power cables are connected onto a divider on metal poles, by upright cable connection is made and asures lamp powering, lighting body. Lamps powered by air cable are connected directly onto grid. Lighting circuits (power cables) have up to 100 lighting spots, poles. Image 30 shows the ways cabling is conducted.

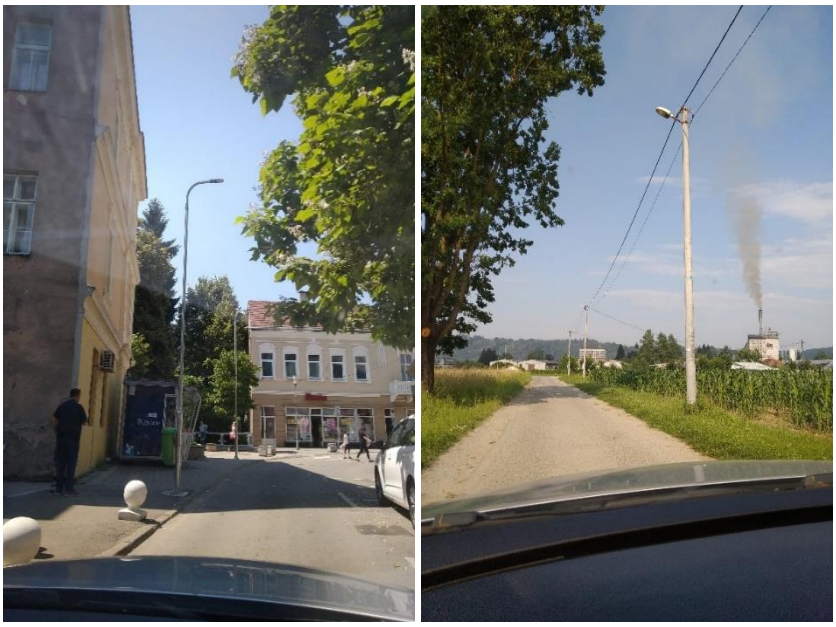

Image 30: Poles (undergound cabling – left, overground cabling - right)

6.3 Measurings

6.3.1 Measuring electric parameters and electricity quality anaysis

Analysis is done based on measuring electric values (voltage, electricity, cosϕ , power). Measurings of electric parameters are published accordant to Law of electricity in Federation Bosnia and Herzegovina (''Official Gazzete FBiH'', No. 66/13) and a Rulebook on determining fulfillment of terms for doing periodical examinations, measurings on electric energy facilities, electric devices, electric installations and issuing documentation ('' Official Gazzete Federation of Bosnia and Herzegovina'', No. 18/15).Measuring we have a referencal energy parameters of public lighting system. Manpower is set for every measuring point (OMM) based on implemented measures and based on completed budgets.

Measurements are taken using Metrel Mi 2892 and AC CLAMP METER MT 486 A devices, and budgets are calculated accordant to methodology and defined standard En 13 201. Metrel MI 2892 is a device with three

phase energy control quality. It has a LCD screen that works in real time. Owns an option for simultaneous writing down parameters, tracking events providing users with a possibility for detailed energy quality analysis and corelation of occasional events. Data on types and powers of existing lighting sources is collected on a field visit, while losses in dimmers, accordant with EN 13201-2 standard are taken as 15% of rated lighting source power on discharge. Table 7 shows measurment results,and Image 31 shows an example of measuring electric parameters.

Image 31: Electric parameters measuring analyzer

Measurements are taken in three phase system and an instrument during measuring is connected as Image 32 shows. Electric coils are individually taken phases L_1, L_2, L_3 i N guide, while voltage clamps were attached on metal conductable parts of the phases L1, L2, L3 under voltage and zero N guide which was on the ground potential. Before measuring, it was necessary to ground a device and check a connection if the same power and voltage connectors are connected on a same phase, because otherwise, measurements would not be correct.

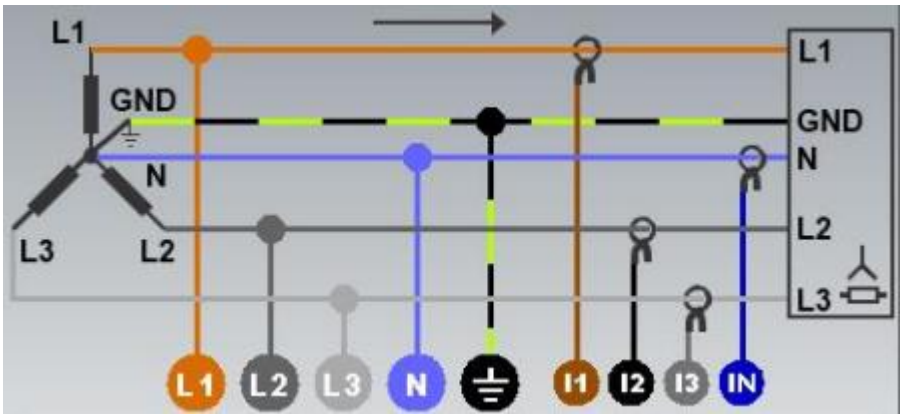

Image 32: Measuring instrument connection overview

Measuring voltage has generated sinus wave forms as Image 33 shows. It is visible on a Image that voltages inside phases are mutually moved closely to 120° per phase and their maximum and minimum values are around ±230 V.

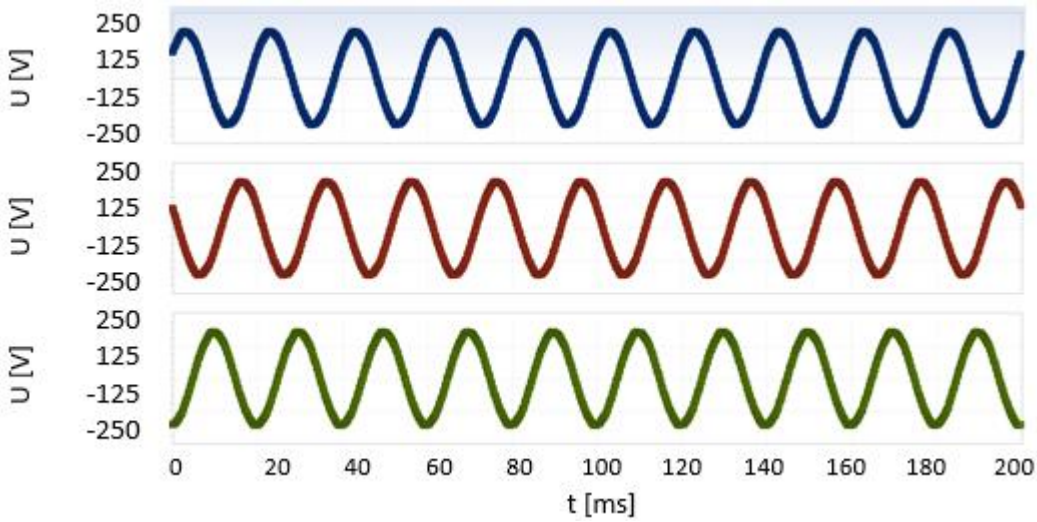

Image 33: Sinus wave form of measured voltage during 10 periods

Besides sinus wave form, a linear voltage overview is generated (Image 34). During turning public lighting on, voltage on effective value was the lowest, while reactive power component was vannishing, that is how voltage was growing inside overviewed time period of 20 minutes and in that moment it had a maximum effective value.

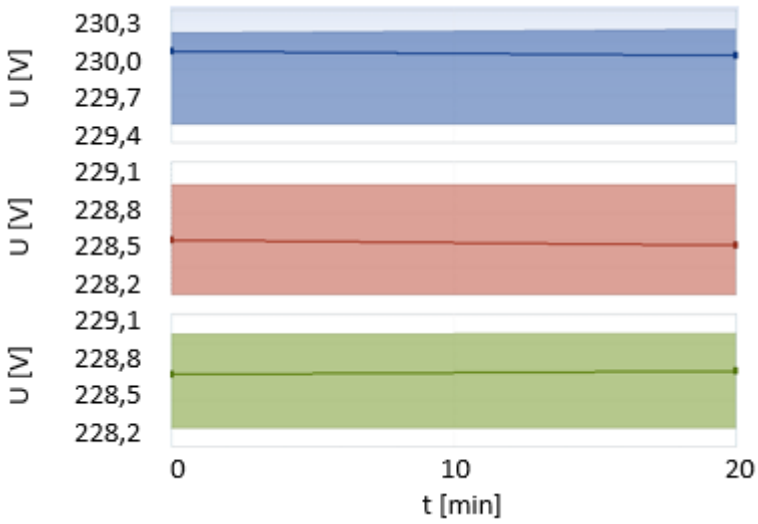

Image 34: Voltage effective values overview

Measuring power, similar review was given same as voltage. Image 5 shows a sinus wave power form which is deformed due to reactive power activity that is energy which is necessary for this lighting type. From sinus wave power form, it is closer to more pointed wave form due to which is necessary to enhance cross-sections surfaces for the purpose of stopping destruction of isolation during heating up guides.

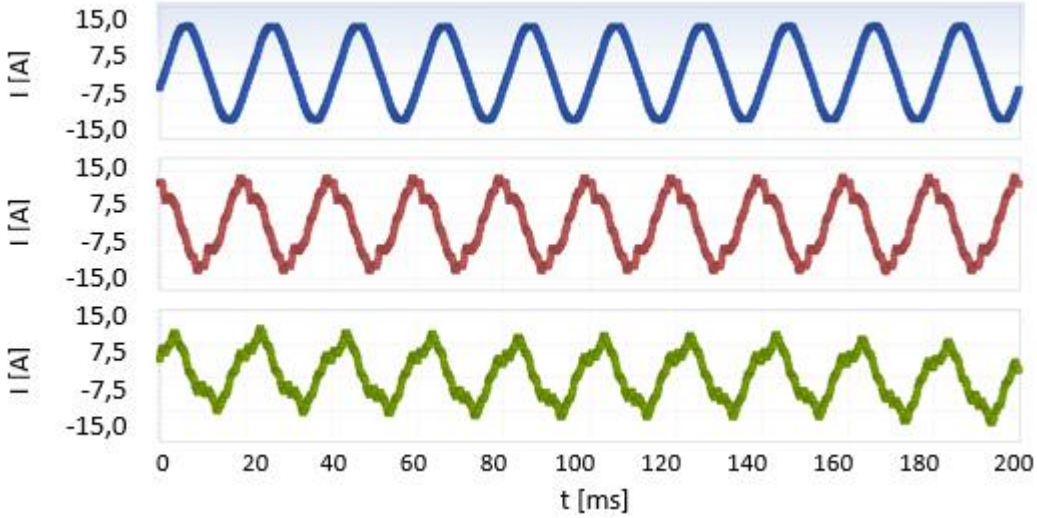

Image 35: Sinus wave form of measured voltage during 10 periods

Unlike voltage effective characteristics where there was a rise while need for reactive power was lowering, that is energy at power effective characteristics while there is no significant change in value (Image 36).

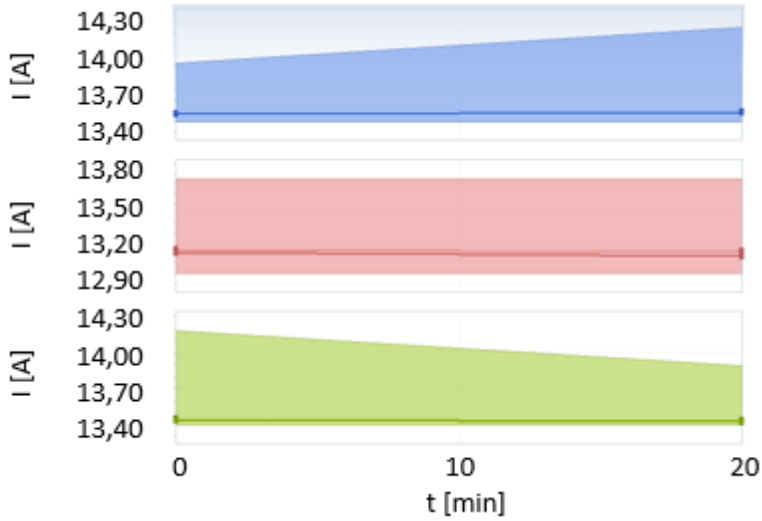

Image 36: Power effective value overview

During measuring voltage and power, effective display for active, reactive and apparent power triangle is generated. Great partaking in apparent power has a reactive power shown in Image 37 which needs to be compensated due to measured cosφ is lower than 0,95.

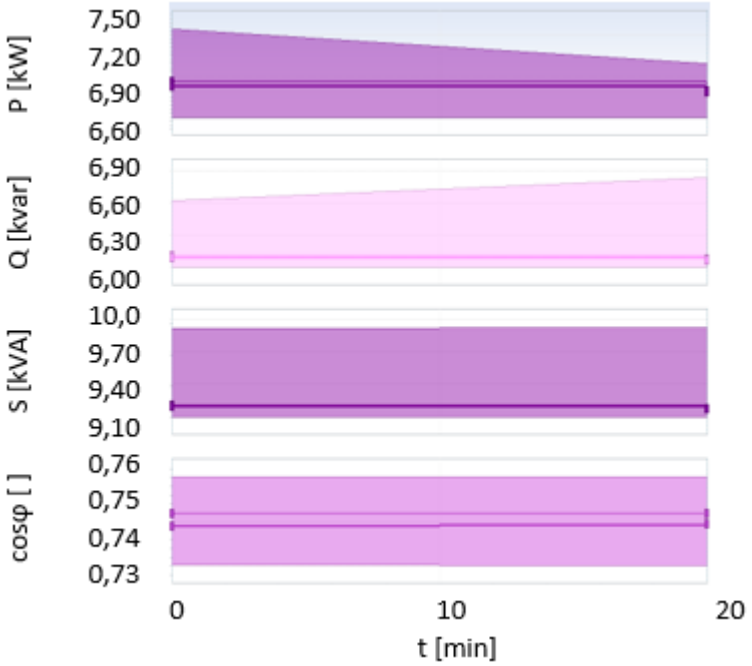

Image 37: Active, reactive, apparent powers and cosφ overview

Measured active and reactive energy follows power values in measuring period shown in Image 38.

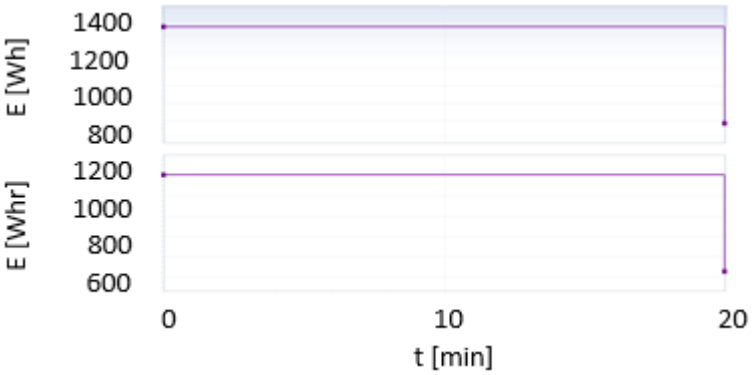

Image 38: Active and reactive energy

During measuring THD voltages are noted as general harmonics while from higher harmonics 5, 7 and 11 were noted and in total harmonic deformation approx 1% of total rated voltage value. Image 39 shows first 49 harmonics and total THD.

Image 39: Column overview THDU

Image 4040 shows maximum (top line) and average (bottom line) values of THDU during overlooked period.

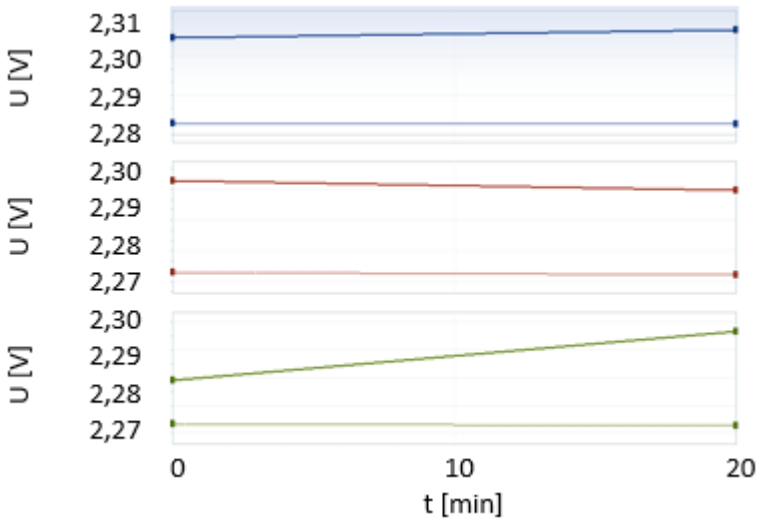

Image 40: Maximum and average value of THDU

Unlike voltages, power has greater harmonic deformation. Apperance of higher harmonics causes unlinearity consumption, that is pre-connected consumption device that makes them. During analysis of THDI, odd harmonics are noted up to 37th. Total harmonic deformation of power is approx 19%. Image 41 shows an overview of higher power harmonics up to 49th harmonic.

Image 41: Column overview THDI

Image 2 shows maximum (top line) and average (bottom line) values of THDi during overlooked period. Table 7 shows measuring results.

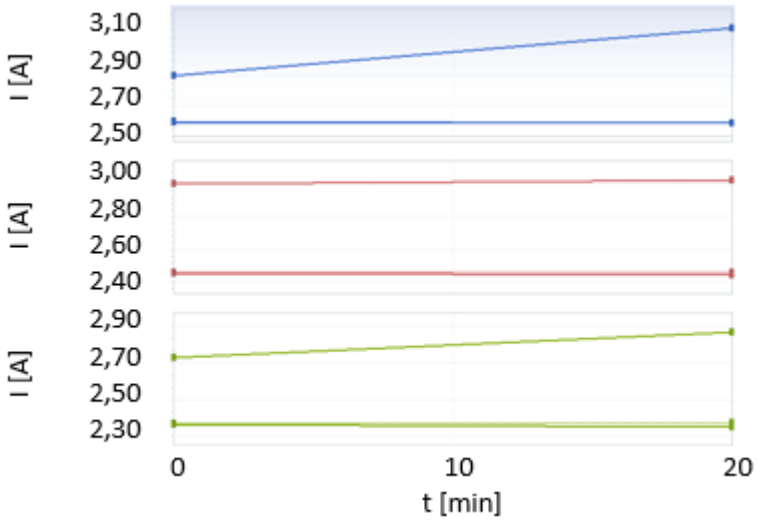

Image 42: Maximum and average value of THD

OMM name	Cable	Voltage (V)			Electricity (A)			Power (kW)			Cosϕ		
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
PL Rasavci	4x10mm2 Cu	233,9	236	228,5	2,50	2,81	3,05	0,44	0,43	0,45	0,75	0,65	0,64
SS 35-10	4x25mm2 Cu	228,2	227,3	229,1	24,54	20,18	21,66	3,81	3,81	3,92	0,68	0,83	0,79
SS Urije-zidana	4x10mm2 Cu	226,7	232,4	233,3	5,04	4,72	5,02	0,82	0,82	0,78	0,72	0,75	0,67
SS Želj. stanica	4x10mm2 Cu	234,5	235,7	237,8	4,16	4,86	5,02	0,78	0,74	0,78	0,8	0,65	0,65
SS Jablanica	4x25mm2 Cu	232,1	226,7	228,5	23,01	20,99	25,89	3,84	3,47	3,84	0,72	0,73	0,65
SS Urije „Crpna“	4x10mm2 Cu	227,9	233,3	236,3	8,52	8,13	8,60	1,26	1,27	1,30	0,65	0,67	0,64
SS Silos Novi Grad	4x16mm2 Cu	231,2	226,4	228,5	11,20	10,39	13,16	2,10	1,90	2,13	0,81	0,81	0,71
SS Prekosanje	4x16mm2 Cu	231,8	226,7	233,6	11,55	14,17	12,81	2,19	2,25	2,15	0,82	0,7	0,72
SS Emina	4x16mm2 Cu	227,3	232,7	235,4	16,08	17,03	17,71	2,89	2,85	2,67	0,79	0,72	0,64
SS Unska obala	4x16mm2 Cu	236	233,3	227,6	14,92	13,22	15,28	2,39	2,28	2,23	0,68	0,74	0,64
SS Vujanovići	4x10mm2 Cu	231,2	234,5	227,6	2,76	2,56	3,04	0,44	0,44	0,45	0,69	0,74	0,65
SS Stari grad	4x16mm2 Cu	230,3	233	226,7	15,45	12,65	15,17	2,28	2,39	2,37	0,64	0,81	0,69
SS Jaruga	4x16mm2 Cu	237,5	226,7	229,1	16,85	17,08	14,49	2,76	2,56	2,52	0,69	0,66	0,76
SS Caprag	4x16mm2 Cu	236	237,5	236,9	12,06	11,78	9,47	1,91	1,93	1,84	0,67	0,69	0,82
SS G. Principa	4x10mm2 Cu	227,6	237,5	228,5	4,03	3,34	3,33	0,62	0,61	0,62	0,68	0,77	0,82
SS Ograde II	4x10mm2 Cu	236,6	232,4	236,3	0,52	0,57	0,46	0,09	0,09	0,09	0,75	0,68	0,82
SS V. Gortan	4x16mm2 Cu	235,4	236,3	232,4	13,08	12,25	11,04	2,00	2,03	2,00	0,65	0,7	0,78
SS Tunjica	4x10mm2 Cu	232,7	238,1	228,2	6,64	7,51	6,81	1,28	1,30	1,27	0,83	0,73	0,82
SS Repovac	4x16mm2 Cu	232,1	228,8	233,6	11,86	11,54	10,59	1,76	1,69	1,78	0,64	0,64	0,72
SS Topić brdo	4x10mm2 Cu	233,3	235,7	226,4	6,40	6,58	6,43	1,18	1,19	1,18	0,79	0,77	0,81
SS Ograde I	4x10mm2 Cu	233,3	230,6	231,5	1,06	1,17	1,33	0,18	0,18	0,20	0,73	0,67	0,64
SS Urije-Kožinac	4x10mm2 Cu	232,7	237,2	229,4	6,99	6,50	7,33	1,12	1,03	1,11	0,69	0,67	0,66

OMM name	Cable	Voltage (V)			Electricity (A)			Power (kW)			Cosϕ		
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
SS Dom zdravlja	4x10mm2 Cu	236,9	227	233,6	1,70	1,74	1,68	0,30	0,31	0,31	0,75	0,79	0,78
PL Svodna	4x10mm2 Cu	234,5	227,9	230,9	8,33	8,12	8,67	1,37	1,26	1,32	0,7	0,68	0,66
PL Dobrljin	4x10mm2 Cu	229,1	232,4	232,4	6,26	6,06	6,48	1,00	1,04	1,05	0,7	0,74	0,7
PL Rudice	4x10mm2 Cu	234,5	231,5	236,9	2,36	2,28	2,30	0,45	0,42	0,45	0,81	0,79	0,82
PL STS Čulići	4x10mm2 Cu	236	228,5	231,5	1,28	1,58	1,32	0,23	0,23	0,21	0,77	0,64	0,7
PL Vodičevo TS Šljok.	4x10mm2 Cu	234,2	226,4	237,2	2,77	2,93	3,25	0,54	0,55	0,53	0,83	0,83	0,68
PL Donje Vodičevo	4x10mm2 Cu	235,7	230	228,8	2,45	3,02	2,46	0,46	0,46	0,46	0,79	0,67	0,81
PL Ravnice TS Šindr.	4x10mm2 Cu	233	235,1	237,2	2,26	2,19	1,87	0,34	0,34	0,35	0,65	0,65	0,78
PL Ravnice	4x10mm2 Cu	230,3	229,1	226,4	3,09	2,92	2,77	0,50	0,48	0,47	0,7	0,72	0,75
PL Ravnice TS Kovač.	4x10mm2 Cu	236,6	231,2	230,3	1,69	1,68	2,05	0,33	0,30	0,31	0,82	0,77	0,65
PL Dobrljin-Tomašev.	4x10mm2 Cu	237,5	233,9	233	3,68	4,17	3,66	0,65	0,65	0,67	0,74	0,67	0,78
PL Svodna-želj. stanica	4x10mm2 Cu	230,9	232,1	227	3,51	3,75	3,65	0,65	0,64	0,67	0,8	0,74	0,81
SS Poljavnice	4x10mm2 Cu	233,6	236	233	1,36	1,37	1,38	0,24	0,24	0,24	0,76	0,74	0,73
PL Petkovac	4x10mm2 Cu	233,9	237,8	232,7	0,43	0,48	0,48	0,07	0,08	0,08	0,75	0,67	0,69
PL TS-Hotel	4x10mm2 Cu	229,7	233,9	230,3	2,58	3,02	2,76	0,47	0,48	0,48	0,8	0,68	0,75
PL Poljavnice-Lazići	4x10mm2 Cu	227,3	227,6	229,4	6,69	6,95	6,79	1,09	1,01	1,08	0,72	0,64	0,69
PL Poljavnice	4x10mm2 Cu	230,9	234,2	231,8	3,32	3,19	2,97	0,52	0,57	0,57	0,68	0,76	0,83
PL Karakolo	4x10mm2 Cu	237,8	236	228,5	2,43	2,15	2,28	0,39	0,38	0,41	0,67	0,76	0,79
PL Ravnice-Crnobrnje	4x10mm2 Cu	227	235,4	234,2	1,25	1,15	0,93	0,18	0,18	0,17	0,64	0,65	0,8
PL Mlakve	4x10mm2 Cu	226,4	228,2	233,9	2,21	2,09	2,11	0,37	0,38	0,35	0,75	0,8	0,71
PL Unska obala	4x10mm2 Cu	227,9	227	227	1,01	1,13	0,94	0,16	0,16	0,17	0,69	0,64	0,82

OMM name	Cable	Voltage (V)			Electricity (A)			Power (kW)			Cosϕ		
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
PL Blagaj Rijeka	4x10mm2 Cu	235,7	233,9	232,1	4,10	3,77	4,48	0,72	0,73	0,69	0,74	0,83	0,66
PL Blagaj Japra	4x16mm2 Cu	230	228,5	228,5	13,50	13,15	13,53	2,36	2,22	2,32	0,76	0,74	0,75
PL Suhača-Halilov.	4x10mm2 Cu	233	229,1	229,7	1,38	1,49	1,53	0,22	0,24	0,24	0,7	0,7	0,67
PL Blag. Japra-Troske	4x10mm2 Cu	230,6	228,5	233,3	1,02	1,35	1,22	0,20	0,21	0,20	0,83	0,69	0,7
PL D.Rakani-Astor	4x10mm2 Cu	237,2	233,9	235,4	1,86	1,99	1,69	0,32	0,33	0,31	0,72	0,71	0,79
PL Rudice	4x10mm2 Cu	235,1	236	233,3	0,59	0,55	0,52	0,10	0,10	0,09	0,71	0,76	0,76
PL D.Rakani-motel	4x10mm2 Cu	229,4	233,6	233,6	2,03	2,09	1,94	0,33	0,34	0,36	0,71	0,7	0,79
PL Kršlje	4x10mm2 Cu	232,7	235,7	228,8	1,52	1,32	1,40	0,26	0,23	0,25	0,72	0,75	0,77
PL S.grad-kasl. Ograde	4x10mm2 Cu	229,7	236,9	235,7	4,41	3,89	4,97	0,75	0,74	0,77	0,74	0,8	0,66
PL Hozići	4x10mm2 Cu	231,8	230,9	236,6	1,15	1,05	1,16	0,20	0,19	0,20	0,74	0,8	0,72
PL Suhača	4x10mm2 Cu	235,4	230	235,1	1,15	1,20	0,99	0,19	0,20	0,19	0,71	0,72	0,83
PL Vitasovci	4x10mm2 Cu	228,5	228,8	229,1	0,52	0,58	0,47	0,09	0,09	0,09	0,75	0,72	0,82
PL Čelopek	4x10mm2 Cu	227,9	229,7	229,7	3,70	4,61	3,64	0,67	0,70	0,69	0,8	0,66	0,83
PL Radišići-Rudice	4x10mm2 Cu	235,1	229,1	236	4,48	4,01	4,09	0,71	0,68	0,68	0,67	0,74	0,71
PL Stadion Mlakve	4x10mm2 Cu	236,3	233,3	226,7	1,62	1,64	1,46	0,25	0,25	0,27	0,66	0,65	0,8
PL Nadvožnjak	4x10mm2 Cu	234,5	238,1	233,3	0,89	0,83	0,87	0,15	0,16	0,16	0,72	0,79	0,79
PL Vitasovci 3	4x10mm2 Cu	230,3	237,8	236,3	7,23	7,08	7,44	1,25	1,26	1,25	0,75	0,75	0,71
PL Izbj. naselje-Rudice	4x10mm2 Cu	230	229,1	229,7	0,43	0,42	0,38	0,07	0,07	0,07	0,7	0,72	0,81
PL Maslovare	4x10mm2 Cu	234,2	228,2	236,6	1,53	1,63	1,68	0,27	0,26	0,28	0,74	0,71	0,7
PL Šuća brdo	4x10mm2 Cu	230	226,4	230,6	2,40	2,22	2,18	0,35	0,36	0,37	0,64	0,71	0,74

OMM name	Cable	Voltage (V)			Electricity (A)			Power (kW)			Cosϕ		
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
PL Gornji Agići 2	4x10mm2 Cu	227	232,7	237,2	6,90	5,85	7,52	1,02	1,12	1,14	0,65	0,82	0,64
PL Asf. baza Poljavnice	4x10mm2 Cu	227	231,5	233,6	1,58	1,55	1,55	0,27	0,27	0,26	0,75	0,76	0,72
PL Donji Hozići	4x10mm2 Cu	229,7	237,8	229,1	1,56	1,14	1,40	0,23	0,22	0,23	0,65	0,82	0,72
PL M. Novska Rujiška	4x10mm2 Cu	227,6	228,2	230,9	1,23	1,10	1,30	0,20	0,21	0,20	0,72	0,83	0,67
PL Donje Vodičevo-lug	4x10mm2 Cu	234,5	236	236,6	5,66	4,98	4,54	0,88	0,88	0,88	0,66	0,75	0,82
PL V. Žuljevica-Gajići	4x10mm2 Cu	231,5	233,6	232,1	1,00	1,00	0,96	0,17	0,19	0,18	0,74	0,8	0,82
PL Silos-pijaca	4x10mm2 Cu	227,9	234,8	236	1,79	1,65	1,57	0,29	0,26	0,27	0,7	0,67	0,73
PL Gornji Agići 2	4x10mm2 Cu	229,1	237,5	233,6	2,78	3,26	3,14	0,52	0,51	0,50	0,82	0,66	0,68
PL Petkovac mlin	4x10mm2 Cu	230,6	230,9	228,8	1,13	1,19	1,26	0,21	0,20	0,21	0,8	0,74	0,72
PL Poljavnice Radišići 1	4x10mm2 Cu	230,9	233,3	230,9	1,96	1,95	2,06	0,37	0,36	0,39	0,81	0,78	0,81
PL Blatna 3	4x10mm2 Cu	237,5	233,6	228,8	0,86	0,79	0,78	0,13	0,13	0,12	0,65	0,69	0,68
PL Blatna 1 poligon	4x10mm2 Cu	236	233,6	233,6	7,49	8,58	7,65	1,41	1,46	1,45	0,8	0,73	0,81

Table 7: Electric parameters measuring results

6.3.2 Measuring luminosity intensity

Luminosity intensity analysis is done based on luminosity intensity measurements. For mentioned analysis the following standards are used:

- **BAS CEN/TR 13201-1:2016** – Traffic lighting - Part 1: Lighting class selection,
- **BAS EN 13201-2:2017** – Traffic lighting - Part 2: Performance requests,
- **BAS EN 13201-3:2017** – Traffic lighting - Part 3: Performance budget,
- **BAS EN 13201-4:2017** – Traffic lighting - Part 4: Traffic lighting characteristics of measuring methods,
- **BAS EN 13201-5:2017** – Traffic lighting - Part 5: Energy working characteristics indicators.

Bosnia and Herzegovina does not have accepted luminous pollution protection Law. For measuring luminosity intensity, we used measuring instrument LUX meter UNI-T UT383 and METREL. Image 43 shows luminosity intensity measuring example.

Image 43: Horizontal luminosity intensity measurement (left) and vertical luminosity intensity measurement (right)

Measuring is done in artificial lighting conditions. According to measured values, mostly it satisfies required values defined by standard. However, in parts where horticultural design where luminosity intensity unsatisfies required values defined by standard due to tree positioning which block a lamp (Image 44).

Image 44: Lamp covered by trees example

By removing branches or other solutions it can concluded that current lighting as it's intensity satisfies issued values defined by standard.

6.4 Energy characteristics analysis in electricity consumption system

6.4.1 Public lighting electricity consumption budget

Standardized annual electricity consumption calculates in a way:

$$E_{ref}=(P_{is}+P_{gub})*T_{ref} \quad (1.)$$

$$E_{ref}=P_{ref}*T_{ref} \quad (2.)$$

where the following is:
Eref – standardized annual electricity consumption (kWh/annually);
Pis –lamp source power;
Pgub – ballast losses;
Pref – total reference power - Pis+Pgub;
Tref – reference value of working hours for public lighting system (4.100 hours) – accordant to BAS EN 15900:2011 standard.

Lamp source installed power overview, working periods are taken from BAS EN 15900:2011 standard and total standrdized annual consumption is shown in table 8.

Street name	Lamp source type	(Pis) - Lamp source power	Quantity	(Tref) - Working period	Eref) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Ive Andrića	Mercury	125	51	4100	30.058,13
Ive Andrića	LED	100	20	4100	9.430,00
Roga	Mercury	125	53	4100	31.236,88
Želj. stanica	Mercury	125	15	4100	8.840,63
Jablanica	Mercury	125	65	4100	38.309,38
Jablanica	Sodium	100	18	4100	8.487,00
Jablanica	LED	100	2	4100	943,00
Silos	Sodium	100	25	4100	11.787,50
Silos	LED	100	10	4100	4.715,00
Prekosanje	Mercury	125	50	4100	29.468,75
Prekosanje	LED	100	2	4100	943,00
Karađorđa Petrovića	Sodium	70	62	4100	20.463,10
Karađorđa Petrovića	Mercury	125	11	4100	6.483,13
Petra Kočića	LED	100	25	4100	11.787,50
Petra Kočića	Metal halogen	200	2	4100	1.886,00
Nadežde Petrović	Mercury	125	10	4100	5.893,75
Kej Vojvode Stepe	Mercury	125	63	4100	37.130,63
Njegoševa	Mercury	125	6	4100	3.536,25
Njegoševa	Sodium	70	7	4100	2.310,35
Njegoševa	Sodium	100	5	4100	2.357,50
Njegoševa	LED	100	4	4100	1.886,00
Miloša Obilića	Mercury	125	17	4100	10.019,38
Caprag	Sodium	100	15	4100	7.072,50
Caprag	Mercury	125	3	4100	1.768,13
Caprag	LED	100	5	4100	2.357,50
Kej Krajiških brigada	LED	100	14	4100	6.601,00
Dositeja Obradović	LED	100	5	4100	2.357,50
Gavrila Principa	Mercury	125	16	4100	9.430,00
Gavrila Principa	LED	100	10	4100	4.715,00
Pionirska	LED	100	6	4100	2.829,00
Tunjica	Mercury	125	70	4100	41.256,25
Tunjica	LED	100	4	4100	1.886,00
Repovac	Sodium	100	30	4100	14.145,00
Repovac	Mercury	125	3	4100	1.768,13
Repovac	LED	100	14	4100	6.601,00
Topić brdo	Sodium	100	15	4100	7.072,50
Topić brdo	Mercury	125	9	4100	5.304,38
Topić brdo	LED	100	2	4100	943,00
Dobrile Grubor	Mercury	100	4	4100	1.886,00

Street name	Lamp source type	(Pis) - Lamp source power	Quantity	(Tref) - Working period	Eref) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Nikole Pašića	LED	125	14	4100	8.251,25
Kožinac	Mercury	125	29	4100	17.091,88
Kožinac	LED	100	3	4100	1.414,50
Dom zdravlja	Mercury	125	6	4100	3.536,25
Dom zdravlja	LED	100	4	4100	1.886,00
Svodna	Mercury	125	59	4100	34.773,13
Dobrljin	Mercury	125	67	4100	39.488,13
Dobrljin	LED	100	53	4100	24.989,50
Rudice	Mercury	125	45	4100	26.521,88
Čulići	Mercury	125	26	4100	15.323,75
Vodičevo Šljok.	Mercury	125	42	4100	24.753,75
Donje Vodičevo	Mercury	125	16	4100	9.430,00
Ravnice Šindr.	Mercury	125	19	4100	11.198,13
Ravnice Šindr.	LED	100	2	4100	943,00
Ravnice	Mercury	125	19	4100	11.198,13
Ravnice Kovač.	Mercury	125	16	4100	9.430,00
Dobrljin-Tomašev.	Mercury	125	39	4100	22.985,63
Svodna-želj. stanica	Mercury	125	30	4100	17.681,25
Poljavnice	Sodium	70	24	4100	7.921,20
Poljavnice	Mercury	125	7	4100	4.125,63
Poljavnice	LED	100	17	4100	8.015,50
Poljavnice	LED	20	1	4100	94,30
Petkovac	Mercury	125	6	4100	3.536,25
-Hotel	Mercury	125	17	4100	10.019,38
Poljavnice-Lazići	Mercury	125	34	4100	20.038,75
Poljavnice 1	Mercury	125	20	4100	11.787,50
Poljavnice 1	LED	100	1	4100	471,50
Karakolo	Mercury	125	22	4100	12.966,25
Ravnice-Crnobrnje	Mercury	125	21	4100	12.376,88
Mlakve	Mercury	125	21	4100	12.376,88
Mlakve	LED	100	2	4100	943,00
Blagaj Rijeka	Mercury	125	43	4100	25.343,13
Blagaj Japra	Mercury	125	52	4100	30.647,50
Blagaj Japra	LED	100	1	4100	471,50
Suhača-Halilov.	Mercury	125	28	4100	16.502,50
Suhača-Halilov.	LED	100	2	4100	943,00
Blag. Japra-Troske	Mercury	125	28	4100	16.502,50
D.Rakani-Astor	Mercury	125	36	4100	21.217,50
Rudice	Mercury	125	10	4100	5.893,75

Street name	Lamp source type	(Pis) - Lamp source power	Quantity	(Tref) - Working period	Eref) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
D.Rakani-motel	Mercury	125	20	4100	11.787,50
Kršlje	Mercury	125	16	4100	9.430,00
S.grad-kasl. Ograde	Mercury	125	4	4100	2.357,50
S.grad-kasl. Ograde	LED	100	3	4100	1.414,50
Hozići	Mercury	125	18	4100	10.608,75
Hozići	LED	100	1	4100	471,50
Suhača	Mercury	125	30	4100	17.681,25
Vitasovci	Sodium	100	14	4100	6.601,00
Vitasovci	LED	100	1	4100	471,50
Čelopek	Mercury	125	23	4100	13.555,63
Čelopek	LED	100	1	4100	471,50
Radišići-Rudice	Mercury	125	33	4100	19.449,38
Radišići-Rudice	LED	100	1	4100	471,50
Radišići-Rudice	Metal halogen	200	3	4100	2.829,00
Stadion Mlakve	Mercury	125	18	4100	10.608,75
Nadvožnjak	LED	100	4	4100	1.886,00
Vitasovci 3	Mercury	125	22	4100	12.966,25
Vitasovci 3	Sodium	100	18	4100	8.487,00
Izbj. naselje-Rudice	Mercury	125	15	4100	8.840,63
Maslovare	Sodium	70	9	4100	2.970,45
Maslovare	Fluorescent	22	1	4100	103,73
Šuća brdo	Mercury	125	11	4100	6.483,13
Gornji Agići 1	Mercury	125	5	4100	2.946,88
Gornji Agići 1	LED	100	14	4100	6.601,00
Asf. baza Poljavnice	Sodium	70	5	4100	1.650,25
Asf. baza Poljavnice	LED	100	8	4100	3.772,00
Donji Hozići	Mercury	125	17	4100	10.019,38
Donji Hozići	Sodium	70	3	4100	990,15
Donji Hozići	LED	100	1	4100	471,50
M. Novska Rujiška	Mercury	125	8	4100	4.715,00
Donje Vodičevo-lug	Mercury	125	54	4100	31.826,25
Donje Vodičevo-lug	LED	100	6	4100	2.829,00
V. Žuljevica-Gajići	Mercury	125	17	4100	10.019,38
Silos-pijaca	Sodium	70	8	4100	2.640,40
Gornji Agići 2	Mercury	125	30	4100	17.681,25
Petkovac mlin	LED	100	8	4100	3.772,00
Poljavnice Radišići 1	Mercury	125	1	4100	589,38
Poljavnice Radišići 1	LED	100	11	4100	5.186,50
Blatna 3	LED	100	16	4100	7.544,00

Street name	Lamp source type	(Pis) - Lamp source power	Quantity	(Tref) - Working period	Eref) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Blatna 1 poligon	Mercury	125	36	4100	21.217,50
Total (kWh/god)					1.183.474,43
Number of lighting sources (kom)					2.144
Specific annual consumption (kWh/lighting sources annually)					551,99

Table 8: Calculated public lighting electricity consumption overview

From table 8 we can notice that there are LED lamps which are energy efficient, therefore it is necessary to make a calculation and overlook electricity consumption of existing system that is not energy efficient, that is lamps that are not LED. Standardized annual electricity consumption of unefficient public lighting is calculated in the following:

$$E_m=E_{ref} - E_{LED} \quad (3.)$$

where the following is:
Em – standardized annual electricity consumption that is unefficient public lighting (kWh/annually);
Eref – standardized annual electricity consumption (kWh/annually);
E_{LED} – standardized annual consumption of LED lamps (kWh/annually).

Total standardized annual electricity consumption overview of unefficient public lighting by lamp types is shown in table 9, while Image 48 shows percentaged partking of total standardized consumption Em) by unefficient public lighting types. Ballast losses are 15%.

Lamp source type	(Em) – Total standardized annual electricity consumption of unefficient public lighting (kWh/annually)	Lamp sources (pcs)	Specific annual consumption (kWh/per lighting source annually)	Expenses (KM/annually)	Expenses (EUR/annually)
Sodium	104955,90	258	406,81	17286,24	8838,31

Mercury	932023,48	1583	588,77	153504,27	78485,49
Metal halogen	4715,00	5	943,00	776,56	397,05
Total	1041694,38	1846	564,30	171567,06	87720,85

Table 9: Calculated consumption and unefficient public lighting electricity expenses overview

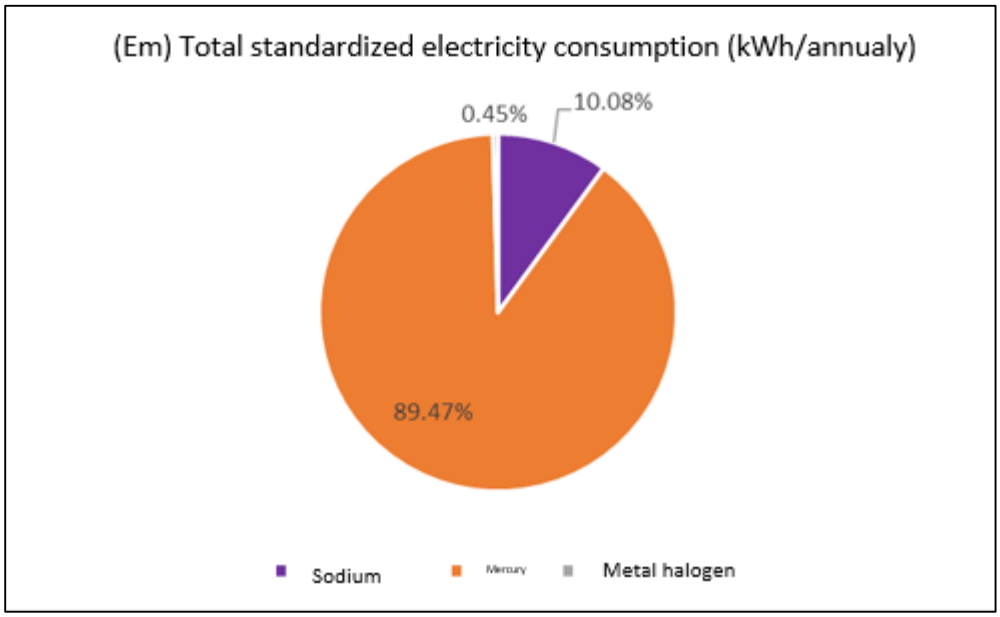

Image 45: Total standardized (Em) electricity consumption by unefficient public lighting types overview (kWh/annually)

Total standardized annual electricity consumption overview of unefficient public lighting per street classification from chapter ''Light - based technical requests and street classifications'' shown in table 10 while Image 46 shows percentaged partaking of total standardized consumption (Em) per types of unefficient public lighting.

Street classification	(Em) – Total standardized annual electricity consumption of unefficient public	Lighting sources (pcs)	Specific annual consumption (kWh/per lighting source	Expenses (KM/annually)	Expenses (EUR/annually)
M3/P2	68603,25	154	445,48	11298,96	5777,06
M4	23692,88	41	577,88	3902,22	1995,17
M5	491194,56	853	575,84	80899,74	41363,38
M5/P1	56580,00	96	589,38	9318,73	4764,59
M6	401623,70	702	572,11	66147,42	33820,64
Ukupno	1041694,39	1846	564,30	171567,06	87720,85

Table 10: Calculated consumption overview and electricity expenses of unefficient public lighting by street classifications

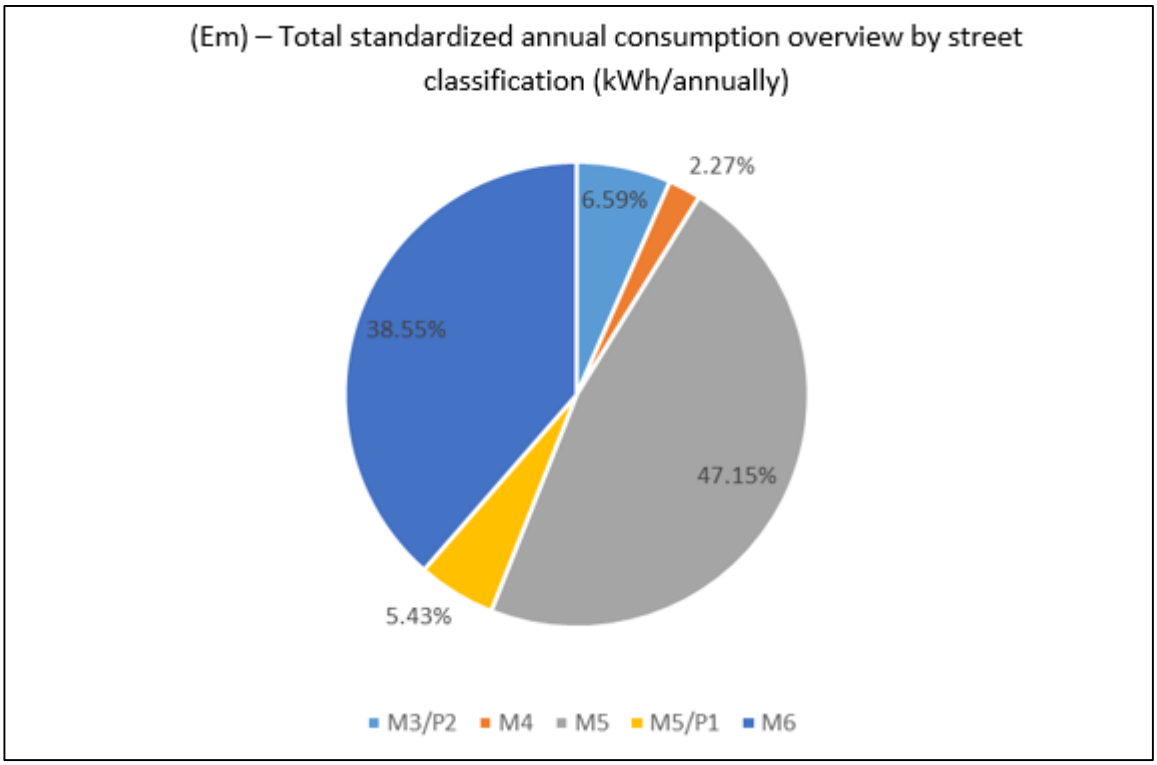

Image 46: Total standardized (Em) electricity consumption overview by street classifications of unefficient public lighting (kWh/annually)

6.5 System regulation and management analysis

In Municipality of Novi grad, there is no installed gear per OMM for central survilance and management over public lighting systems.

A way and type of management per OMM is shown in table from previous chapter ''Measuring points and substations''. Percentaged partaking of management devices per OMM (Image cells, time releys, manual, etc.) is shown in Image 47.

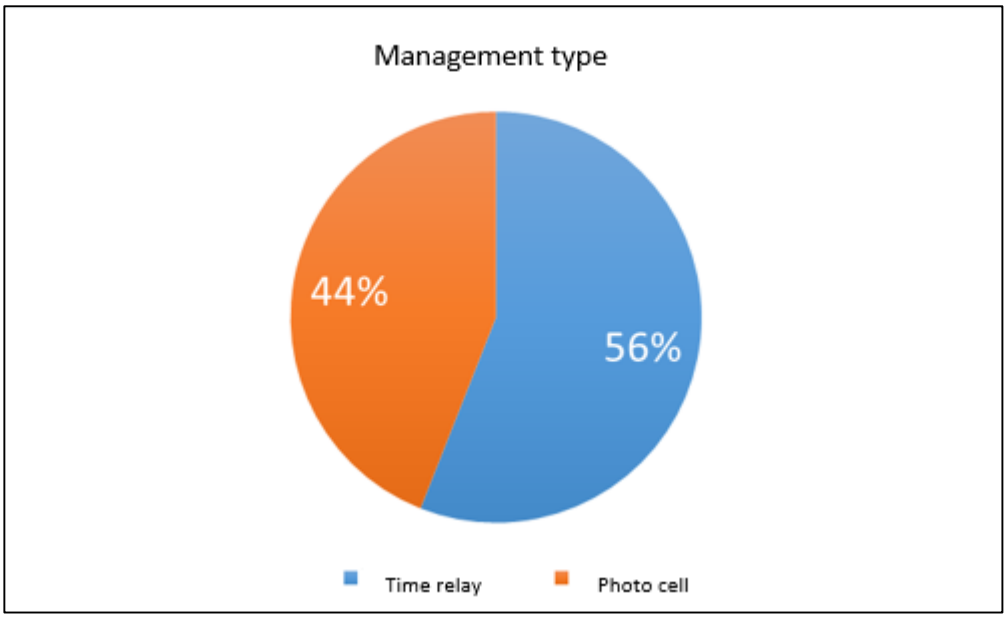

Image 47: Percentaged partaking overview of management device per OMM

6.6 Public lighting maintenance analysis

User self-initiatively and accordant to possibilities replaces lighting source. However, according to given informations from Municipality of Novi Grad, Municipality does not have precise data about maintenance, and these informations are not given to the consultant.

7 ANALYSIS OF ENERGY EXPENSES AND FORECASTING FUTURE CONSUMPTION

The analysis of electricity consumption was done on the basis of data from the bills received from the customers (UNDP) for 2017 and 2018. Consultant did not receive bills for 2019. The tables and graphs in the following chapters show the electricity consumption for public lighting. Electricity is supplied from the public electricity distribution network, PC "Elektroprivreda RS - ZP" ''Elektrokrajina'', through 79 measuring points.

The expenses balance presents the total expenses for electrical energy, whereby the energy and expenses balances were prepared on the basis of the received bills on consumed electricity for 2017., 2018. Total annual electricity consumption is shown in the energy balance. The energy balance is shown in the chapter above.

Electricity measuring point measures energy consumption, and it is measure consumption of active power. Total expenses for electricity are presented in the expenses balance, which is divided into two types (electricity and network charges) and tariff elements. The following tables provide an overview of electricity consumption and expenses by electricity measuring points.

The average price of electricity for the analyzed period is **0,1647 KM/kWh ili 0,0842 EUR/kWh.**

Month	Municipality Novi Grad					
	2017.			2018.		
	kWh	KM	EUR	kWh	KM	EUR
January	85.977,00	14.114,11	7.216,43	58.670,00	9.641,06	4.929,40
February	90.734,00	14.885,69	7.610,93	54.051,00	8.889,67	4.545,22
March	73.307,00	12.059,04	6.165,69	55.601,00	9.142,32	4.674,39
April	58.442,00	9.647,93	4.932,91	42.615,00	7.025,61	3.592,14
May	51.346,00	8.496,96	4.344,43	36.286,00	5.993,98	3.064,67
June	47.493,00	7.872,00	4.024,89	35.401,00	5.849,72	2.990,91
July	41.202,00	6.851,60	3.503,17	35.004,00	5.785,01	2.957,83
August	46.611,00	7.728,94	3.951,74	35.635,00	5.887,87	3.010,42
September	60.982,00	10.062,40	5.144,82	43.964,00	7.245,49	3.704,56
October	71.231,00	11.724,79	5.994,79	54.378,00	8.942,97	4.572,47
November	76.121,00	12.517,95	6.400,33	57.131,00	9.391,71	4.801,91
December	87.142,00	14.305,55	7.314,31	67.720,00	11.117,72	5.684,40
Total	**790.588,00**	**130.266,97**	66.604,44	**576.456,00**	**94.913,14**	48.528,32

Table 11: Electricity consumption and expenses for the analyzed periodic measuring PL Hotel

Detailed consumption of electric energy by EMP is given in the annex. A more detailed analysis of electricity consumption by months and years, shown in the following figures and pages, can be very useful for proposing energy efficiency measures. This is especially evident when the nature of public lighting is taken into account, which directly affects the way electricity is consumed. After a more detailed analysis of consumption and Expenses, measures can be suggested to reduce or increase energy efficiency

Image 8 shows a diagram of electricity consumption and its Expenses by months in 2017. It can be concluded that monthly consumption varies significantly throughout the year. Variations are noticeable by months within the season (winter or summer), and trend lines (added to the diagram) show a marked decline in consumption during the summer. The reason for the drop in consumption is the reduced use of artificial light. Consumption in June is the lowest due to the shortest nights of the year.

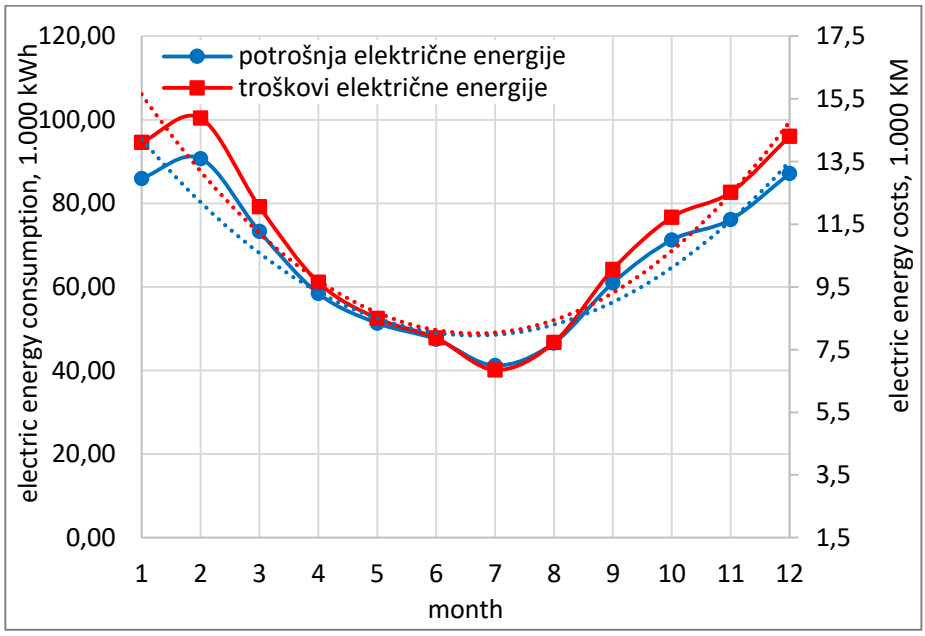

Image 48: Overview of total electricity consumption and Expenses during 2017

Image shows diagrams describing electricity consumption and its Expenses by months in 2018.

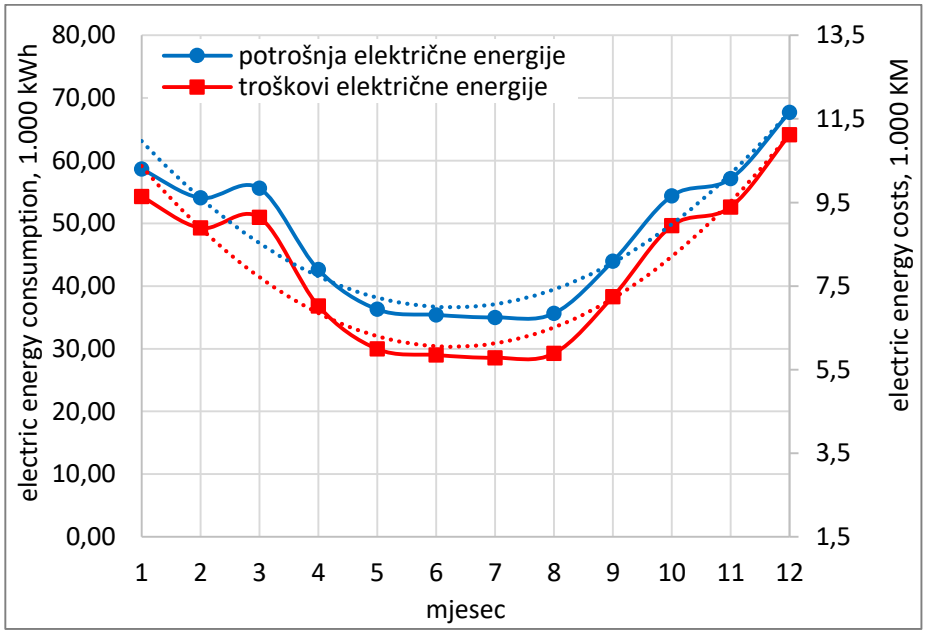

Image 49: Overview of total electricity consumption and Expenses during 2018.

It can be concluded that the consumption and Expenses have similar trends compared to those of the previous year (as shown by the trend line). In some months, consumption is slightly increased or decreased, which is the difference caused by the dynamics of use, or weather conditions.

Consumption data are available for all three years, and it is noticeable that the consumption profile is relatively similar. Occasionally there are deviations that can be explained by changes in weather conditions. As can be seen, consumption is almost constant. **Pogreška! Izvor referencu nije pronađen.** shows a diagram of total convertible marks (KM) and specific (Kf / kWh) electricity Expenses in the period from 2017 to 2019. As can be seen, the lowest price was 2017. godine, due to the lower electricity pricing. The electricity transmission tariff has remained constant in all three years.

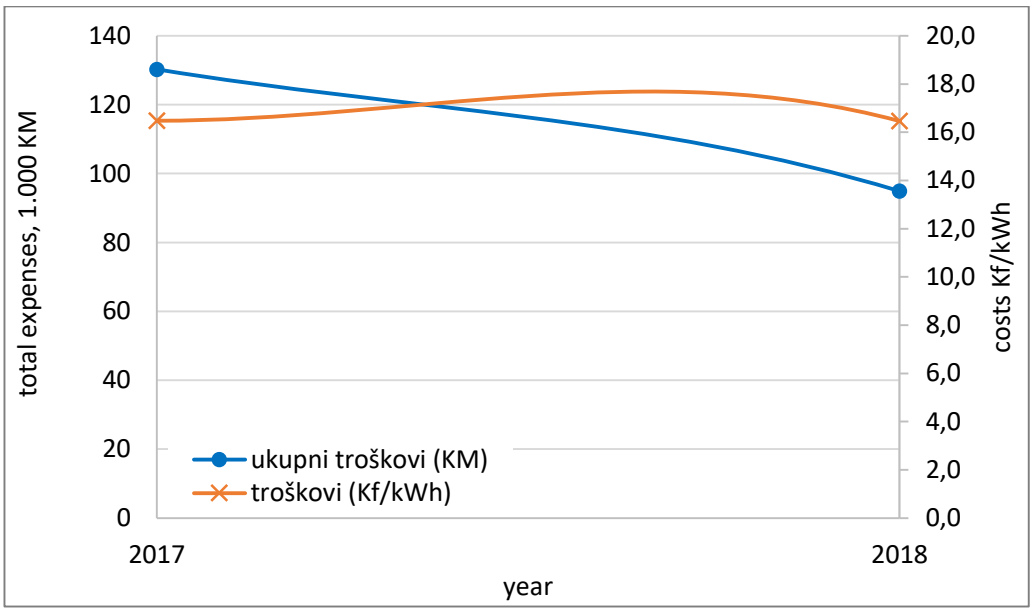

Image 50: Overview of total electricity consumption and Expenses in period from 2017. to 2018.

If some energy efficiency measures are implemented, both consumption and Expenses could fall. In the future we can expect a further price increase, which has happened in the last three years by electricity suppliers and distributors, it is to be expected that the price of kWh will continue to rise.

8 IMAGEMETRIC ANALYSIS

Imagemetric analysis was performed according to the defined requirements for the design of outdoor lighting, apropos the following norms: BAS CEN/TR 13201-1:2016 - Roadway lighting - Part 1: Selection of lighting classes, BAS EN 13201-2:2017 - Roadway lighting - Part 2: Performance requirements, BAS EN 13201-3:2017 - Roadway lighting - Part 3: Performance calculation, BAS EN 13201-4:2017 - Roadway lighting - Part 4: Methods of measuring roadway lighting characteristics, BAS EN 13201-5:2017 - Roadway lighting - Part 5: Indicators of energy performance in outdoor areas.

With medium brightness E_m , determined in lux (lx), it is necessary to calculate the uniform illuminance U_0, which is determined by the ratio of the minimum and average value of illuminance (E_{min}/E_m) and must be greater than or equal, specified in the norm. The budget also needs to determine glare control. The calculation of the level of illumination in a mathematical way is obtained by the lighting calculation. The designer is obliged to determine by calculation how many lamps are needed for a certain purpose and with which light sources to determine the level of illumination. The maintenance factor has a major role in the design of lighting, and the designer when calculating must take into account the reduction of the luminous flux of the lamp through the time calculated according to this relation:

$$MF = LLMF \times LSF \times LMF\ (\times SMF)\ \text{(outdoor areas)}, \qquad (4.)$$

MF maintenance factor, indicates how quickly the light intensity in a system decreases

LLMF lamp lumen maintenance factor, indicates the minimum luminous flux the luminaire has at the end of its useful life

LSF Lamp survival factor, indicates how the total failure of individual bulbs should be assessed

LMF Luminaire maintenance factor, indicates how the luminous flux of the luminaire decreases due to contamination

RMF room maintenance factor, indicates how the luminous flux decreases due to contamination of the room

SMF surface maintenance factor, takes into account the reduced reflection due to impurities on the illuminated surface (outdoor lighting)

During the creation a proposal and the optimal lighting solution, it is necessary to take into account the following basic principles:
- that the solution relies on the existing electrical installation,
- to propose a rational solution that satisfies the necessary lighting standards relating to a given category of roadway, to satisfiest he required levels of brightness with a minimum number of quality lamps,

- to reduce the maintenance of the lighting installation to a minimum by choosing the appropriate types of lamps, without the need to clean the lamps and replace the protectors, and
- to significantly reduce electricity consumption and CO2 emissions.

8.1 Light – based technology requirements and street classification

Light – based technology requirements and calculation must be corensponded with the required conditions of the roadway lighting class in accordance with the Standards BAS CEN/TR 13201-1:2016 - Roadway lighting - Part 1: Selection of lighting classes, BAS EN 13201-2:2017 - Roadway lighting - Part 2: Performance requirements, BAS EN 13201-3:2017 - Roadway lighting - Part 3: Performance calculation, , BAS EN 13201-4:2017 - Roadway lighting - Part 4: Methods of measuring roadway lighting characteristics, BAS EN 13201-5:2017 - Roadway lighting - Part 5: Energy performance indicators. The suggested lighting solution must satisfy all parameters prescribed by the competent legislation as well as the relevant standards, in accordance with the rules of public lighting design. The requirements for the calculation of lighting as well as the geometry of the road they cover and the method of calculation must be identical to those applied in the calculation of the reference condition. During selection of lamps and light sources to optimize public lighting should only be used existing lighting poles and connection points, and the newly constructed condition must be based on the existing infrastructure (installation) so that the minimum power of the lamps satisfies the required levels of illumination. The lighting must be such as to significantly reduce the consumption of electricityand maintenance, which should be accordance with the laws, guidelines and recommendations of BiH (Smjernice za projektovanje, građenje, održavanje i nadzor na putevima / FBiH i RS), and in accordance with the recommendations of International Commission on Illumination CIE1 - No. 88/90, No. 115/95, No.15/2-10, European Standard EN 13201-2 do 4 / EN 12464, and Summaries of EU Legislation CEN/TC 169/WC 6/9. The suggested light – based technology solution should be suitable and appropriate quality and performed in such a way that during operation it satisfies the projected lighting technical and electrical parameters (according to the attached Imagemetric calculation and technical specification).

In order to perform a Imagemetric calculation, it is primarily necessary to classify the roadway according to Table 1-Table 3 of the above standards. To determine the class of the street and for the Imagemetric calculation, input data are required on: vehicle speed, number of street lines, average distance between light poles, light pole height, the ratio of the lamp mounted on the console, the inclination... The input data was collected by the consultant ZGI d.o.o. Mostar. The Imagemetric calculation and determination of the street class is define by the appropriate equations from the established norms. Nowadays, computer softwares are used for Imagemetric calculation and determination of street class. Imagemetric analysis and Imagemetric calculation for the subject study was done in Dialux software, and "Road Wizard" software was used to determine the street class. Ecological characteristics must also be taken into account during calculating and selecting lamps. It is important to mention that mercury gas discharge lamps (VTF) as well as sodium lamps (NaVT) need to be dispatch and properly disposed of as well as existing lamps. Newly installed lamps must satisfy all environmental requirements and standards. According to the BiH adjustment program to EU standards, and according to the EU directive on ecological design no. 2005/32 / ECU which require decommissioning inefficient forms of lighting, lighting that is not coordinate with the

requirements of sustainable development and environmental protection, stop using certain types of light sources in 2012. for: fluorescent lamps 38 mm / 26mm, high-pressure lamps, low-pressure lamps, high-pressure lamps and metal-halide lamps. As a large number of such light sources are present within the existing public lighting system, this is another of the additional motives to approach the optimization of the public lighting system, replacement of existing light sources with LED sources.

In the course of proposing and analyzing measures for the reconstruction of the public lighting system, it is necessary to respect the following minimum parameters and project guidelines for the public lighting system:

- light efficiency of the light source: minimal 100 lm/W;
- correlated temperature of the shade of white light - maximum 4000 K;
- shade design - full cut off (straight) ili semi cut off (slightly rounded shading);
- bulb protection
- light sources lifetime - minimum 50.000 h;
- lamp ingress protection code IP66;
- impact protection - minimum IK08;
- input voltage 220-240V
- frequency of current 50 Hz;
- uninterrupted operation of the lamp in the temperature range of -20°C to +35°C;
- surge protection

Maximum permissible ULOR factor in accordance with the light pollution protection zone:

- E0, Areas of natural light, Nearby observatories, Dark sky parks, ULOR ≤ 0
- E1, Areas of dark landscape, Mostly unlit long-distance local roads, ULOR ≤ 0
- E2, Areas of low ambient light, habitat zones, ULOR ≤ 2,5
- E3, Areas of medium ambient light, Communication, industrial and trade zones, ULOR ≤ 5
- E4, Areas of high ambient light, Urban areas of commercial character with a high degree of night activity, ULOR ≤ 15

The process simulation is performed for characteristic sections of the public lighting system. The characteristic section is defined by the following parameters:

- classification of the illuminated surface in accordance with the norm BAS EN 13201;
- illumination zone (E0-E4);
- road width and number of lanes (W);
- width of the sidewalk (on the side of light pole, on the opposite sideof light pole);
- lightpole height – lamp height (H);
- average distance between light poles (S);
- console tine length (K)
- tine console inclination (N)
- light pole position (one-sided, two-sided, opposite);
- estimate the distance of the optical axis from the road edge (lamp suspension height) (O);
- road surface classification (R1, R2, R3 i R4).
- the type and power of the lamp illuminating the section

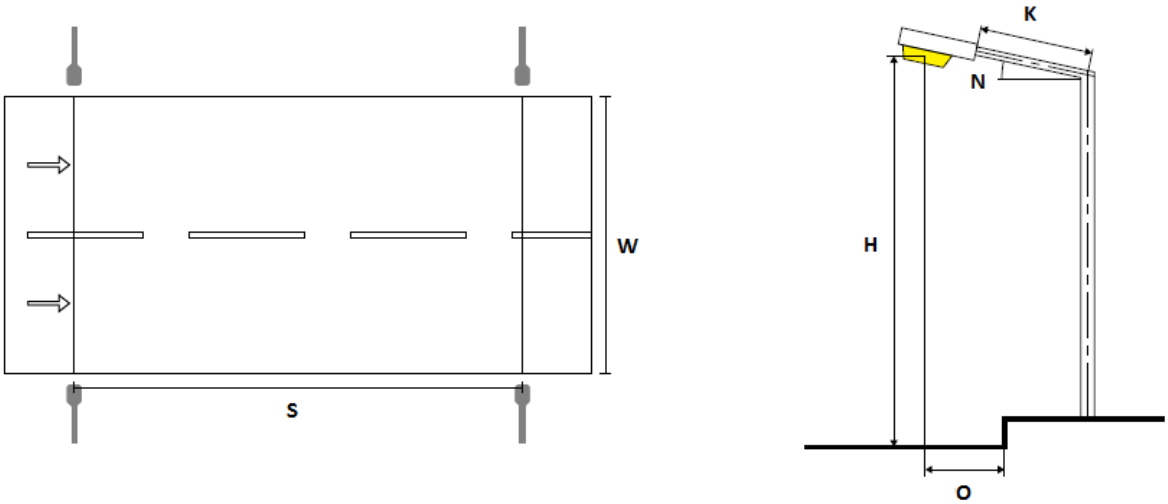

Image 51: Geometric display of characteristics parameters

Image 52 gives an example of Imagemetric calculation and determination of street class in software.

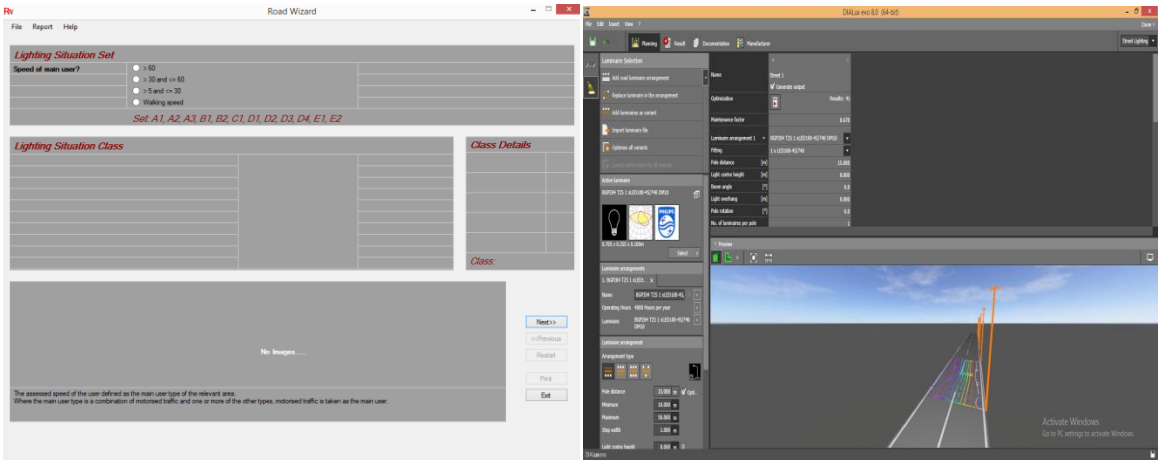

Image 52: Left - example of determining the class of the street in the software "Road Wizard", right - example of Imagemetric calculation of the road in the software "Dialux "

For the purposes of the study, a calculation of completely new lighting was made on all the above streets from the previous chapter, and it is attached: "Imagemetric calculation".

It was determined that the replacement of existing lamps will achieve significant savings, all in accordance with the required values of the norms. Therefore, it can be concluded that this way of lighting will be satisfied by the law and the standard of the prescribed value. Table 11 gives certain classes of streets with all the input data necessary for Imagemetric calculations.

Image 53, Image 54, Image 55 and Image 56 show examples of a new lighting solution.

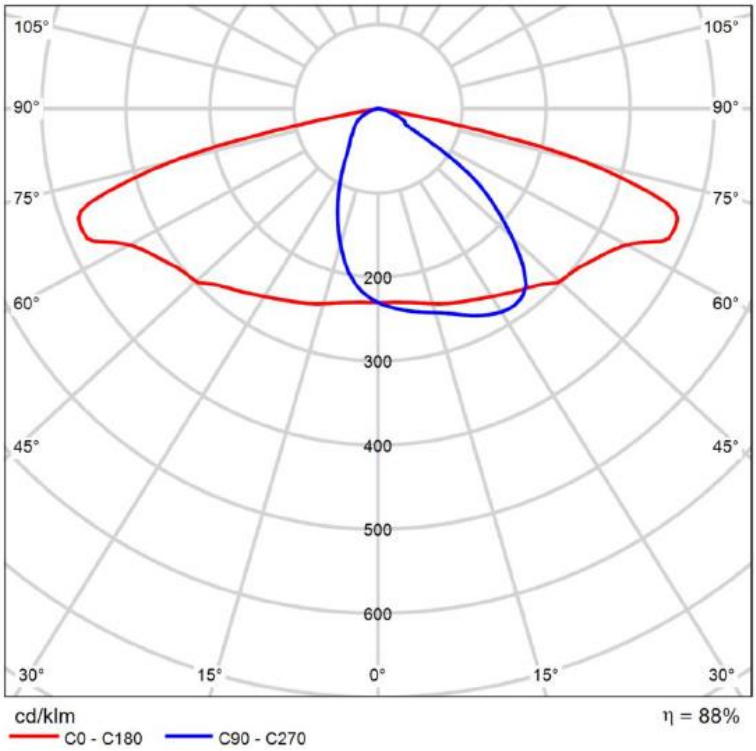

Image 53: Example of light emission calculation

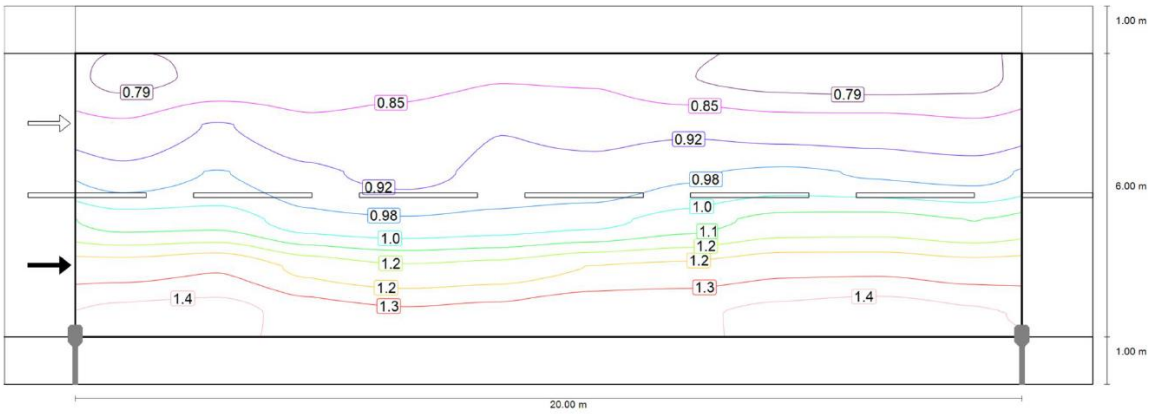

Image 54: Example of light intensity calculation and analysis results

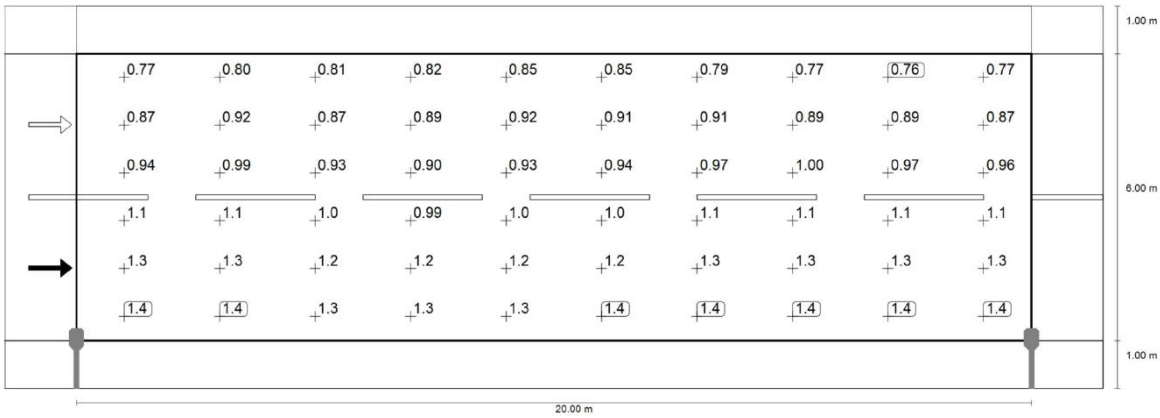

Image 55: Example of horizontal brightness calculation and analysis results

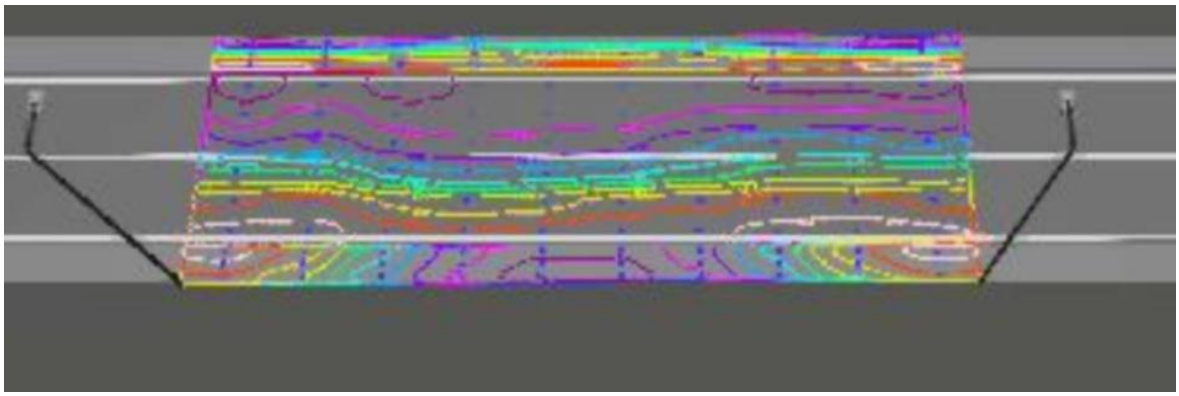

Image 56: Replacing the existing lighting with LED lightin

Ordinal number	Street name	Movement speed (km/h)	Number of lane	Total road width (m)	Sidewalk width 1 and 2 (m)	Average distance between light poles (m)	Arrangement of light poles	Light pole height (m)	Lamp mounted on tine / console (yes/no)	Tine / console length (m)	Inclination of the tine / console (%)	The distance of the light pole from the road (m))	Type of traffic participants	Road class
1	Ive Andrića-Rasavci	40	2	5	0/0	60	One-sided	8	da	0,5	10	1	mixed	M5
2	Roga	40	2	6	0/0	40	One-sided	8	da	0,3	30	1	mixed	M6
3	Ive Andrića	40	2	5	0/0	30	One-sided	8	da	0,5	10	1	mixed	M5
4	Želj. stanica	40	1	3	0/0	40	One-sided	8	da	0,5	10	1	mixed	M6
5	Jablanica	40	1	3	0/0	30	One-sided	8	da	0,5	10	1	mixed	M6
6	Ive andrića-Urije „Crpna“	40	2	5	0/0	30	One-sided	8	da	0,5	50	1	mixed	M3/ P2
7	Silos	40	2	6	1/0	30	One-sided	9	da	1	0	1	mixed	M3/ P2
8	Prekosanje	40	1	3	0/0	30	One-sided	8	da	0,5	50	1	mixed	M6
9	Karađorđa Petrovića	40	2	5	2/2	20	One-sided	8	da	0,5	10	1	mixed	M3/ P2
10	Petra Kočića	40	2	5	2/2	20	One-sided	8	da	0,5	10	1	mixed	M3/ P2
11	Nadežde Petrović	40	2	5	2/2	20	Two-sided	4	ne	-	-	0,5	mixed	M5/ P1
12	Kej Vojvode Stepe	5	2	6	1/0	20	One-sided	4	ne	-	-	0,5	pedestrians	M5/ P1

Ordinal number	Street name	Movement speed (km/h)	Number of lane	Total road width (m)	Sidewalk width 1 and 2 (m)	Average distance between light poles (m)	Arrangement of light poles	Light pole height (m)	Lamp mounted on tine / console (yes/no)	Tine / console length (m)	Inclination of the tine / console (%)	The distance of the light pole from the road (m))	Type of traffic participants	Road class
13	Karađorđa Petrovića-Vujanovići	40	2	5	2/2	20	One-sided	4	ne	-	-	2	mixed	M5/ P1
14	Njegoševa	40	1	3	0/0	20	One-sided	8	da	0,5	10	1	mixed	M6
15	Miloša Obilića	40	2	6	1/1	20	One-sided	8	da	1	10	1	mixed	M4
16	Caprag	40	2	6	1/1	30	One-sided	8	da	1	10	1	mixed	M3/ P2
17	Kej Krajiških brigada	40	2	5	0/0	20	One-sided	8	da	0,5	10	1	mixed	M4
18	Dositeja Obradović	40	2	5	0/0	20	One-sided	8	da	0,5	10	1	mixed	M4
19	Gavrila Principa	40	2	5	0/0	20	One-sided	8	da	0,5	10	1	mixed	M4
20	Pionirska	40	2	5	1/0	20	One-sided	6	da	1	10	1	mixed	M4
21	Gavrila Principa - V. Gortan	40	2	5	2/0	20	One-sided	8	da	1	10	1	mixed	M4
22	Tunjica	40	1	3	0/0/	40	One-sided	8	da	0,5	50	1	mixed	M6
23	Repovac	40	2	5	1/0	40	One-sided	6	da	0,5	50	1	mixed	M5
24	Topić brdo	40	2	5	0/0	30	One-sided	6	da	0,5	30	1	mixed	M5

Ordinal number	Street name	Movement speed (km/h)	Number of lane	Total road width (m)	Sidewalk width 1 and 2 (m)	Average distance between light poles (m)	Arrangement of light poles	Light pole height (m)	Lamp mounted on tine / console (yes/no)	Tine / console length (m)	Inclination of the tine / console (%)	The distance of the light pole from the road (m))	Type of traffic participants	Road class
25	Dobrile Grubor	40	2	5	1/0	20	One-sided	8	da	0,5	10	1	mixed	M4
26	Nikole Pašića	40	2	5	1/0	20	One-sided	8	da	0,5	10	1	mixed	M4
27	Kožinac	40	1	3	0/0	40	One-sided	8	da	0,5	50	1	mixed	M6
28	Dom zdravlja	40	2	5	0/0	20	One-sided	4	ne	-	-	1	mixed	M5/ P1
29	Svodna	40	2	4	1/1	30	One-sided	8	da	0,5	10	3	mixed	M5
30	Dobrljin	40	2	5	0/0	30	One-sided	8	da	0,5	50	1	mixed	M5
31	Rudice	40	2	6	0/0	40	One-sided	8	da	0,3	30	2	mixed	M5
32	Čulići	40	2	6	0/0	40	One-sided	8	da	1	30	2	mixed	M5
33	Vodičevo Šljok.	40	2	5	0/0	30	One-sided	8	da	0,5	50	1	mixed	M5
34	Donje Vodičevo	40	2	5	0/0	30	One-sided	8	da	0,5	50	1	mixed	M5
35	Ravnice Šindr.	40	1	3	0/0	40	One-sided	8	da	0,5	50	1	mixed	M6
36	Ravnice	40	1	3	0/0	40	One-sided	8	da	0,5	50	1	mixed	M6
37	Ravnice Kovač.	40	1	3	0/0	40	One-sided	8	da	0,5	50	1	mixed	M6

Ordinal number	Street name	Movement speed (km/h)	Number of lane	Total road width (m)	Sidewalk width 1 and 2 (m)	Average distance between light poles (m)	Arrangement of light poles	Light pole height (m)	Lamp mounted on tine / console (yes/no)	Tine / console length (m)	Inclination of the tine / console (%)	The distance of the light pole from the road (m))	Type of traffic participants	Road class
38	Dobrljin-Tomašev.	40	2	5	0/0	30	One-sided	8	da	0,5	50	1	mixed	M5
39	Svodna-želj. stanica	40	2	4	1/1	30	One-sided	8	da	0,5	50	1	mixed	M5
40	Poljavnice	40	1	3	0/0	30	One-sided	8	da	0,5	10	1	mixed	M6
41	Petkovac	40	2	6	0/0	30	One-sided	8	da	0,5	30	3	mixed	M5
42	-Hotel	40	2	5	1/0	30	One-sided	4	ne	-	-	1	mixed	M5/ P1
43	Poljavnice-Lazići	40	1	3	0/0	20	One-sided	8	da	0,5	10	1	mixed	M6
44	Poljavnice 1	40	1	3	0/0	30	One-sided	8	da	0,5	10	1	mixed	M6
45	Karakolo	40	1	3	0/0	30	One-sided	8	da	0,5	50	1	mixed	M6
46	Ravnice-Crnobrnje	40	1	3	0/0	40	One-sided	8	da	0,5	50	1	mixed	M6
47	Mlakve	40	1	4	0/0	40	One-sided	8	da	0,3	30	1,5	mixed	M6
48	Kej Vojvode Stepe - Unska obala	40	2	6	1/0	20	One-sided	4	ne	-	-	0,5	mixed	M5/ P1
49	Blagaj Rijeka	40	1	3	0/0	40	One-sided	8	da	0,5	10	2	mixed	M6
50	Blagaj Japra	40	2	5	0/0	30	One-sided	8	da	0,5	10	1	mixed	M5

Ordinal number	Street name	Movement speed (km/h)	Number of lane	Total road width (m)	Sidewalk width 1 and 2 (m)	Average distance between light poles (m)	Arrangement of light poles	Light pole height (m)	Lamp mounted on tine / console (yes/no)	Tine / console length (m)	Inclination of the tine / console (%)	The distance of the light pole from the road (m))	Type of traffic participants	Road class
51	Suhača-Halilov.	40	2	5	0/0	40	One-sided	8	da	0,5	10	2	mixed	M5
52	Blag. Japra-Troske	40	2	5	0/0	30	One-sided	8	da	0,5	30	1	mixed	M5
53	D.Rakani-Astor	40	2	6	0/0	30	One-sided	8	da	1	30	2	mixed	M5
54	Rudice	40	2	5	0/0	40	One-sided	8	da	1	30	3	mixed	M5
55	D.Rakani-motel	40	2	6	0/0	30	One-sided	8	da	1	30	2	mixed	M5
56	Kršlje	40	1	3	0/0	30	One-sided	8	da	0,5	30	2	mixed	M6
57	S.grad-kasl. Ograde	40	2	5	0/0	20	One-sided	8	da	1	10	0,5	mixed	M4
58	Hozići	40	2	5	0/0	30	One-sided	8	da	1	30	1	mixed	M5
59	Suhača	40	2	5	0/0	40	One-sided	8	da	0,5	30	3	mixed	M5
60	Vitasovci	40	2	4	0/0	40	One-sided	8	da	0,5	10	1	mixed	M6
61	Čelopek	40	2	5	0/0	30	One-sided	8	da	0,5	30	1	mixed	M5
62	Radišići-Rudice	40	2	6	0/0	40	One-sided	8	da	0,3	30	2	mixed	M6
63	Stadion Mlakve	40	1	4	0/0	40	One-sided	8	da	0,3	30	2	mixed	M5
64	Nadvožnjak	40	2	6	0/0	40	One-sided	8	da	0,3	30	2	mixed	M5

Ordinal number	Street name	Movement speed (km/h)	Number of lane	Total road width (m)	Sidewalk width 1 and 2 (m)	Average distance between light poles (m)	Arrangement of light poles	Light pole height (m)	Lamp mounted on tine / console (yes/no)	Tine / console length (m)	Inclination of the tine / console (%)	The distance of the light pole from the road (m))	Type of traffic participants	Road class
65	Vitasovci 3	40	2	4	0/0	40	One-sided	8	da	0,5	10	2	mixed	M5
66	Izbj. naselje-Rudice	40	1	3	0/0	30	One-sided	8	da	0,3	30	2	mixed	M6
67	Maslovare	40	2	5	0/0	30	One-sided	8	da	0,5	30	1	mixed	M5
68	Šuća brdo	40	1	3	0/0	30	One-sided	8	da	0,5	10	1	mixed	M6
69	Gornji Agići 2	40	2	4	0/0	30	One-sided	8	da	5	0	2	mixed	M5
70	Asf. baza Poljavnice	40	2	5	0/0	30	One-sided	8	da	1	30	1	mixed	M5
71	Donji Hozići	40	1	3	0/0	40	One-sided	8	da	0,5	10	1	mixed	M6
72	M. Novska Rujiška	40	1	3	0/0	40	One-sided	8	da	0,3	5	2	mixed	M6
73	Donje Vodičevo-lug	40	2	5	0/0	40	One-sided	8	da	0,5	50	1	mixed	M5
74	V. Žuljevica-Gajići	40	1	3	0/0	50	One-sided	8	da	0,5	50	1	mixed	M6
75	Silos-pijaca	40	2	5	1/0	40	One-sided	8	da	0,5	50	1	mixed	M3/P2
76	Gornji Agići 2	40	2	4	0/0	30	One-sided	8	da	0,5	0	2	mixed	M5
77	Petkovac mlin	40	2	6	0/0	30	One-sided	8	da	1	30	1	mixed	M5

Ordinal number	Street name	Movement speed (km/h)	Number of lane	Total road width (m)	Sidewalk width 1 and 2 (m)	Average distance between light poles (m)	Arrangement of light poles	Light pole height (m)	Lamp mounted on tine / console (yes/no)	Tine / console length (m)	Inclination of the tine / console (%)	The distance of the light pole from the road (m))	Type of traffic participants	Road class
78	Poljavnice Radišići 1	40	1	3	0/0	40	One-sided	8	da	0,5	10	1	mixed	M6
79	Blatna 3	40	2	6	0/0	30	One-sided	8	da	0,3	10	2	mixed	M5
80	Blatna 1 poligon	40	2	6	0/0	30	One-sided	8	da	0,3	10	2	mixed	M5

Table 12: An overview of specific classes

9 ANALYSIS AND SUGGESTION ON POSSIBLE MEASURES FOR ENHANCEMENT OF PUBLIC LIGHTING

Replacement of existing lamps with LED lamps is considered based on existing condition and Imagemetry budget. Lighting measures are meant for lowering consumption of lighting electricity while leaving quality of lighting intact. Besides direct profits (energy consumption savings, or electricityexpenses), implementation of this measure, like better lighting conditions, after implementation of previously mentioned measure, lowering negative effects on environment could be expected.

In the following, possible measures of improving energy efficiency of the facility are described and analyzed in detail. The following scenarios are analyzed:

1. Replacement of existing lighting with LED technology,
2. Lighting management analysis.

9.1 Replacement of existing lighting with LED technology

Replacement of existing lighting with LED technology is considered by 1 on 1 principle using existing electrical installations and existing lampposts for installing LED lamps. Based on Imagemetry budget, replacement of existing energy, not efficient lamps with LED lamps is suggested. Lighting bodies overview is found in table 13.

Ordinal number	Street name	Lighting source type	
1	Ive Andrića - Rasavci	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
2	Ive Andrića - Urije - Zidana	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
3	Ive Andrića - Urije "Crpna"	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	Type 1
4	Roga	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
5	Želj. stanica	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
6	Jablanica	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
7	Jablanica	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
8	Silos	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	Type 1
9	Prekosanje	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
10	Karađorđa Petrovića	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	Type 1
11	Karađorđa Petrovića	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	Type 5

Ordinal number	Street name	Lighting source type	
12	Petra Kočića	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	Type 1
13	Nadežde Petrović	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	Type 5
14	Kej Vojvode Stepe	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	Type 5
15	Njegoševa	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
16	Njegoševa	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
17	Njegoševa	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
18	Miloša Obilića	Type as Philips BGP282 LED54-4S/730 II DM12 D9 48/60S	Type 3
19	Caprag	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	Type 1
20	Caprag	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	Type 1
21	Gavrila Principa	Type as Philips BGP282 LED54-4S/730 II DM12 D9 48/60S	Type 3
22	Tunjica	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
23	Repovac	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
24	Repovac	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
25	Topić brdo	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
26	Topić brdo	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
27	Dobrile Grubor	Type as Philips BGP282 LED54-4S/730 II DM12 D9 48/60S	Type 3
28	Kožinac	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
29	Dom zdravlja	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	Type 5
30	Svodna	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
31	Dobrljin	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
32	Rudice	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
33	Čulići	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
34	Vodičevo Šljok.	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
35	Donje Vodičevo	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
36	Ravnice Šindr.	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
37	Ravnice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4

Ordinal number	Street name	Lighting source type	
38	Ravnice Kovač.	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
39	Dobrljin-Tomašev.	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
40	Svodna-želj. stanica	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
41	Poljavnice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
42	Poljavnice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
43	Petkovac	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
44	-Hotel	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	Type 5
45	Poljavnice-Lazići	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
46	Poljavnice 1	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
47	Karakolo	Tyep as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
48	Ravnice-Crnobrnje	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
49	Mlakve	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
50	Blagaj Rijeka	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
51	Blagaj Japra	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
52	Suhača-Halilov.	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
53	Blag. Japra-Troske	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
54	D.Rakani-Astor	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
55	Rudice	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
56	D.Rakani-motel	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
57	Kršlje	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
58	S.grad-kasl. Ograde	Type as Philips BGP282 LED54-4S/730 II DM12 D9 48/60S	Type 3
59	Hozići	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 7
60	Suhača	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
61	Vitasovci	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
62	Čelopek	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
63	Radišići-Rudice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4

Ordinal number	Street name	Lighting source type	
64	Radišići-Rudice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
65	Stadion Mlakve	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
66	Vitasovci 3	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
67	Vitasovci 3	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
68	Izbj. naselje-Rudice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
69	Maslovare	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
70	Maslovare	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
71	Šuća brdo	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
72	Gornji Agići 1	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
73	Asf. baza Poljavnice	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
74	Donji Hozići	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
75	Donji Hozići	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
76	M. Novska Rujiška	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
77	Donje Vodičevo-lug	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	Type 7
78	V. Žuljevica-Gajići	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
79	Silos-pijaca	Type as Philips BGP283 LED100-4S/730 II DM12 D9 48/60S	Type 2
80	Gornji Agići 2	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8
81	Poljavnice Radišići 1	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	Type 4
82	Blatna 1 poligon	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	Type 8

Table 13: Lighting bodies overview for which energyefficiency measures are suggested

Installed power overview (W) and total annual consumption (kWh) per particular lighting body types for which enhancement of lighting energyefficiency as suggested measure is given in the following chapters by streets.

9.1.1 Electricity consumption budget by applying replacement measures of existing lighting with LED technology

Electricity consumption budget by applying replacement measures of existing lighting with LED technology was made by equation:

$$E_{m1}=(P_{isLED}+P_{gubLED})*T_{ref} \quad (5.)$$

$$E_{m1}=P_{refLED}*T_{ref} \quad (6.)$$

where the following is:
Em1 – standardized annual electricity consumption for considered measures 1 – M1 (kWh/annually);
PisLED –LED lamp source power;
Pgub – ballast losses;
PrefLED – total reference power – Pis + Pgub;
Tref – reference value number of public lighting system working hours (4.100 hours) – according to BAS EN 15900:2011 standard.

Ballast losses of LED lighting is calculated into total lamp power and standardized annual budget for account consumption as $E_{m1}=P_{refLED}*Tref$, where into P_{refLED} , a lamp manufacturer included losses and lamp power sources shows as total power with ballast losses.

Installed power overview (W) and total annual consumption (kWh) by particular lighting bodies types for which is suggested energy efficiency enhancement measure found in table 14.

Street name	Light source type	PrefLED – Total reference power	Quantity	(Tref) - Working period	((Em1) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Ive Andrića - Rasavci	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	12	4100	2140,20
Ive Andrića - Urije - Zidana	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	11	4100	1668,70
Ive Andrića - Urije "Crpna"	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	58	28	4100	6658,40
Roga	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	53	4100	4780,60
Želj. stanica	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	15	4100	1353,00
Jablanica	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	65	4100	5863,00
Jablanica	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	18	4100	1623,60

Street name	Light source type	PrefLED – Total reference power	Quantity	(Tref) - Working period	((Em1) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Silos	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	58	25	4100	5945,00
Prekosanje	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	50	4100	4510,00
Karađorđa Petrovića	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	58	62	4100	14743,60
Karađorđa Petrovića	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	41	11	4100	1849,10
Petra Kočića	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	58	2	4100	475,60
Nadežde Petrović	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	41	10	4100	1681,00
Kej Vojvode Stepe	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	41	63	4100	10590,30
Njegoševa	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	6	4100	541,20
Njegoševa	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	7	4100	631,40
Njegoševa	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	5	4100	451,00
Miloša Obilića	Type as Philips BGP282 LED54-4S/730 II DM12 D9 48/60S	37,5	17	4100	2613,75
Caprag	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	58	15	4100	3567,00
Caprag	Type as Philips BGP282 LED85-4S/730 II DM12 D9 48/60S	58	3	4100	713,40
Gavrila Principa	Type as Philips BGP282 LED54-4S/730 II DM12 D9 48/60S	37,5	16	4100	2460,00

Street name	Light source type	PrefLED – Total reference power	Quantity	(Tref) - Working period	((Em1) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Tunjica	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	70	4100	6314,00
Repovac	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	30	4100	5350,50
Repovac	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	3	4100	535,05
Topić brdo	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	15	4100	2275,50
Topić brdo	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	9	4100	1365,30
Dobrile Grubor	Type as Philips BGP282 LED54-4S/730 II DM12 D9 48/60S	37,5	4	4100	615,00
Kožinac	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	29	4100	2615,80
Dom zdravlja	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	41	6	4100	1008,60
Svodna	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	59	4100	8950,30
Dobrljin	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	67	4100	10163,90
Rudice	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	45	4100	8025,75
Čulići	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	26	4100	3944,20
Vodičevo Šljok.	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	42	4100	7490,70
Donje Vodičevo	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	16	4100	2853,60

Street name	Light source type	PrefLED – Total reference power	Quantity	(Tref) - Working period	((Em1) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Ravnice Šindr.	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	19	4100	1713,80
Ravnice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	19	4100	1713,80
Ravnice Kovač.	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	16	4100	1443,20
Dobrljin-Tomašev.	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	39	4100	5916,30
Svodna-želj. stanica	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	30	4100	4551,00
Poljavnice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	24	4100	2164,80
Poljavnice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	7	4100	631,40
Petkovac	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	6	4100	910,20
-Hotel	Type as Philips BDP102 LED50/830 II DW D9 PCC GR 62P	41	17	4100	2857,70
Poljavnice-Lazići	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	34	4100	3066,80
Poljavnice 1	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	20	4100	1804,00
Karakolo	Tyep as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	22	4100	1984,40
Ravnice-Crnobrnje	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	21	4100	1894,20
Mlakve	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	21	4100	1894,20

Street name	Light source type	PrefLED – Total reference power	Quantity	(Tref) - Working period	((Em1) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Blagaj Rijeka	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	43	4100	3878,60
Blagaj Japra	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	52	4100	7888,40
Suhača-Halilov.	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	28	4100	4993,80
Blag. Japra-Troske	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	28	4100	4247,60
D.Rakani-Astor	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	36	4100	5461,20
Rudice	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	10	4100	1783,50
D.Rakani-motel	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	20	4100	3034,00
Kršlje	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	16	4100	1443,20
S.grad-kasl. Ograde	Type as Philips BGP282 LED54-4S/730 II DM12 D9 48/60S	37,5	4	4100	615,00
Hozići	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	18	4100	2730,60
Suhača	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	30	4100	5350,50
Vitasovci	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	14	4100	1262,80
Čelopek	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	23	4100	3489,10
Radišići-Rudice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	33	4100	2976,60

Street name	Light source type	PrefLED – Total reference power	Quantity	(Tref) - Working period	((Em1) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
Radišići-Rudice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	3	4100	270,60
Stadion Mlakve	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	18	4100	3210,30
Vitasovci 3	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	22	4100	3923,70
Vitasovci 3	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	18	4100	3210,30
Izbj. naselje-Rudice	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	15	4100	1353,00
Maslovare	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	9	4100	1365,30
Maslovare	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	1	4100	151,70
Šuća brdo	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	11	4100	992,20
Gornji Agići 1	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	5	4100	758,50
Asf. baza Poljavnice	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	5	4100	758,50
Donji Hozići	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	17	4100	1533,40
Donji Hozići	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	3	4100	270,60
M. Novska Rujiška	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	8	4100	721,60
Donje Vodičevo-lug	Type as Philips BGP307 LED69-4S/730 II DN10 D9 48/60S	43,5	54	4100	9630,90

Street name	Light source type	PrefLED – Total reference power	Quantity	(Tref) - Working period	((Em1) - Total standardized annual consumption
		(W)	(pcs)	(h/annually)	(kWh/annually)
V. Žuljevica-Gajići	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	17	4100	1533,40
Silos-pijaca	Type as Philips BGP283 LED100-4S/730 II DM12 D9 48/60S	62	8	4100	2033,60
Gornji Agići 2	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	30	4100	4551,00
Poljavnice Radišići 1	Type as Philips BGP307 LED30-4S/730 II DN10 D9 48/60S	22	1	4100	90,20
Blatna 1 poligon	Type as Philips BGP307 LED54-4S/730 II DN10 D9 48/60S	37	36	4100	5461,20
Total (kWh/annually)					259888,75
Number of light sources (pcs)					1846
Specific annual consumption (kWh/light source annual)					140,78

Table 14: Total electricity consumption for public lighting after implementing measures

Imagemetry analysis confirmed that replacing existing lamps will achieve significant savings, but also that brightness will demand values accordant to BAS CEN/TR 13201-1:2016 standard – Traffic roads lighting – Part 1: Lighting class selection. Therefore, it can be concluded that with this way of lighting, as it's intensity, it will fulfill issued values as issued values by standards for degree of mechanical protection accordant to BAS EN 60598 – 1:2016 standard (or BAS EN 60529:2007) and for degree of impact resistance of the safeguard accordant to BAS EN 62262:2010 standard.

9.2 Public lighting management analysis

Lighting management plays an important role in electric lighting system providing turning lights on and off function with switches and/or setting light intensity with light intensity regulator. Managing lighting system can be managed manually or automatically. Manual management cannot complete all requested lighting system functions. Considering a decision on turning on/off lights depends on a man, from a perspective of energyefficiency, this way of managing is especially inconvenient.

In the last decades these functions are automatized and integrated into greater, more flexible systems. Accomplished results significantly expand possibilities of energy savings, flexibility, reliability, interoperability among devices of different manufacturers. In the Study there will be presented a possibility of electricitysavings through lighting system automatization. In the following, measures of automatic lighting management will be analyzed and in two ways:

- Replacement of existing lamps with LED lamps with a possibility of dimming – where dimming is possible and will not have any effect on functionality and safety.
- Replacement of existing lamps with LED lamps with a possibility of dimming – where dimming is possible and will not have any effect on functionality and safety with built in central technical survilance.

9.2.1 Replacement of existing lamps with LED lamps with a possibility of dimming – where dimming is possible and will not have any effect on functionality and safety

Replacement of existing lamps with LED lamps with a possibility of dimming – where dimming is possible and will not have any effect on functionality and safety is considered with built in autonomous dimmer (Dynadimmer). Dynadimmer (image 57) is a managing device which provides dimming luminous flux to 5 levels, in intervals set by an investor. It is designed for internal and external use. Optimized for built in box for public lighting which provides great energy savings with minor installation efforts. It can be mounted in any postion if the box has IP43 protection or higher. Wiring has to be accordant to BAS EN 60598 – 1:2016 standard.

Image 57: Autonomous dimmer overview (Dynadimmer)

Main advantages of using Dynadimmer are:

- Energy savings by dimming,
- Lighting lowered interferences,
- Very small sizes,
- Fits almost into any lamp,
- Software provides energy savings prognosis,
- Software easy to use,
- Possession of programmed regimes.

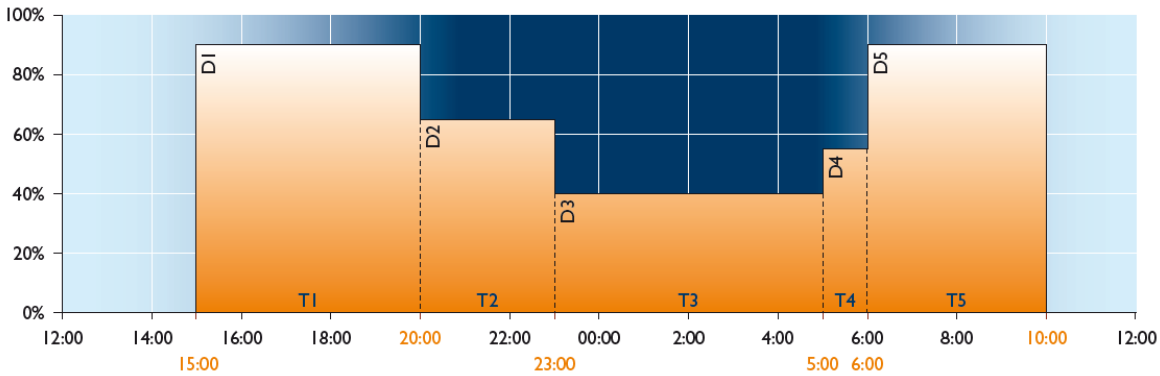

Image 58: Example of dimming luminous flux into 5 levels

For electricity consumption budget by applying replacement measures of existing lamps with LED lamps with a possibility of dimming – where dimming is possible and will not have any effect on funcionality and safety, practice during winter and summer period system is implemented. Standardized annual electricity consumption was done by equation:

$$E_{m2}=E_{m1} * k_{m2} \quad (7.)$$

Where the following is:
E_{m2} – standardized annual electricity consumption for considered M2 – measure 2 (kWh/annually);
E_{m1} – standardized annual electricity consumption from M1 – measure 1 (kWh/annually);
k_{m2} – coefficient applied from practice during winter and summer period – 0,223929

Used model can be ordered programmed and built in a lamp. Due to low price, architects usually order lamp with dynadimmer. These systems are most commonly used in an outside part of the city due to possibility of bad influence on functionality and safety. However, if taken into consideration if dimming luminous flux is always possible to reprogramme, these systems are also use din urban parts of the city.

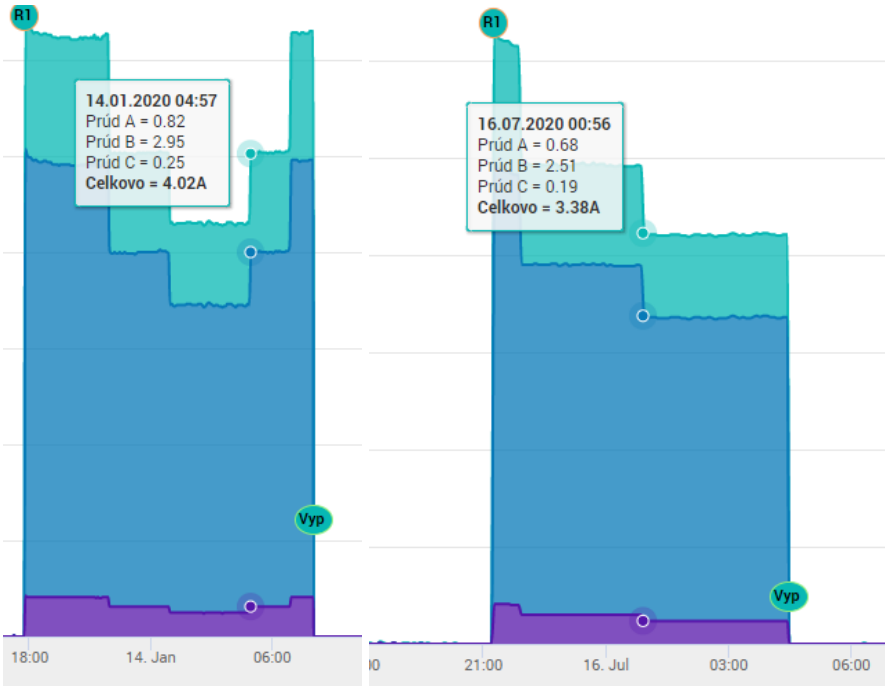

Image 59: Used model for dimming luminous flux for considered measure (left – diagram example for winter period, right – diagram example for summer period)

Table shows a total electricity consumption applying measures based on a considered model.

Street name	Lighting source type with built in dimming device	(Em2) - Total standardized annual consumption (kWh/annually)
Ive Andrića - Rasavci	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1660,95
Ive Andrića - Urije - Zidana	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1295,03
Ive Andrića - Urije "Crpna"	Type as PhilipsBGP282 LED85-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	5167,39
Roga	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3710,09
Želj. stanica	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1050,02
Jablanica	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	4550,10
Jablanica	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1260,03
Silos	Type as PhilipsBGP282 LED85-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	4613,74
Prekosanje	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3500,08
Karađorđa Petrovića	Type as PhilipsBGP282 LED85-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	11442,08
Karađorđa Petrovića	Type as PhilipsBDP102 LED50/830 II DW D9 PCC GR 62P– Dynadimmer DDR2 built into the lamp	1435,03
Petra Kočića	Type as PhilipsBGP282 LED85-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	369,10
Nadežde Petrović	Type as PhilipsBDP102 LED50/830 II DW D9 PCC GR 62P– Dynadimmer DDR2 built into the lamp	1304,58
Kej Vojvode Stepe	Type as PhilipsBDP102 LED50/830 II DW D9 PCC GR 62P– Dynadimmer DDR2 built into the lamp	8218,82
Njegoševa	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	420,01
Njegoševa	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	490,01
Njegoševa	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	350,01
Miloša Obilića	Type as PhilipsBGP282 LED54-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	2028,46
Caprag	Type as PhilipsBGP282 LED85-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	2768,25
Caprag	Type as PhilipsBGP282 LED85-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	553,65
Gavrila Principa	Type as PhilipsBGP282 LED54-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	1909,13
Tunjica	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	4900,11
Repovac	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	4152,37

Street name	Lighting source type with built in dimming device	(Em2) - Total standardized annual consumption (kWh/annually)
Repovac	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	415,24
Topić brdo	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1765,95
Topić brdo	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1059,57
Dobrile Grubor	Type as PhilipsBGP282 LED54-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	477,28
Kožinac	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2030,05
Dom zdravlja	Type as PhilipsBDP102 LED50/830 II DW D9 PCC GR 62P– Dynadimmer DDR2 built into the lamp	782,75
Svodna	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	6946,07
Dobrljin	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	7887,91
Rudice	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	6228,55
Čulići	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3060,98
Vodičevo Šljok.	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	5813,32
Donje Vodičevo	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2214,60
Ravnice Šindr.	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1330,03
Ravnice	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1330,03
Ravnice Kovač.	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1120,03
Dobrljin-Tomašev.	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	4591,47
Svodna-želj. stanica	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3531,90
Poljavnice	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1680,04
Poljavnice	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	490,01
Petkovac	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	706,38
-Hotel	Type as PhilipsBDP102 LED50/830 II DW D9 PCC GR 62P– Dynadimmer DDR2 built into the lamp	2217,78
Poljavnice-Lazići	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2380,05
Poljavnice 1	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1400,03

Street name	Lighting source type with built in dimming device	(Em2) - Total standardized annual consumption (kWh/annually)
Karakolo	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1540,04
Ravnice-Crnobrnje	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1470,03
Mlakve	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1470,03
Blagaj Rijeka	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3010,07
Blagaj Japra	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	6121,96
Suhača-Halilov.	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3875,54
Blag. Japra-Troske	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3296,44
D.Rakani-Astor	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	4238,28
Rudice	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1384,12
D.Rakani-motel	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2354,60
Kršlje	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp i	1120,03
S.grad-kasl. Ograde	Type as PhilipsBGP282 LED54-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	477,28
Hozići	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2119,14
Suhača	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	4152,37
Vitasovci	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	980,02
Čelopek	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2707,79
Radišići-Rudice	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2310,05
Radišići-Rudice	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	210,00
Stadion Mlakve	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2491,42
Vitasovci 3	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3045,07
Vitasovci 3	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	2491,42
Izbj. naselje-Rudice	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1050,02
Maslovare	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1059,57

Street name	Lighting source type with built in dimming device	(Em2) - Total standardized annual consumption (kWh/annually)
Maslovare	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	117,73
Šuća brdo	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	770,02
Gornji Agići 1	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	588,65
Asf. baza Poljavnice	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	588,65
Donji Hozići	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1190,03
Donji Hozići	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	210,00
M. Novska Rujiška	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	560,01
Donje Vodičevo-lug	Type as PhilipsBGP307 LED69-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp i	7474,26
V. Žuljevica-Gajići	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	1190,03
Silos-pijaca	Type as PhilipsBGP283 LED100-4S/730 II DM12 D9 48/60S– Dynadimmer DDR2 built into the lamp	1578,22
Gornji Agići 2	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	3531,90
Poljavnice Radišići 1	Type as PhilipsBGP307 LED30-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	70,00
Blatna 1 poligon	Type as PhilipsBGP307 LED54-4S/730 II DN10 D9 48/60S– Dynadimmer DDR2 built into the lamp	4238,28
Total (kWh/annually)		201692,12
Lighting sources (pcs)		1846,00
Specific annual consumption (kWh/per lighting source annually)		109,26

Table 15: Total electricity consumption for public lighting after applying measures with LED lighting and autonomous dimmer

9.2.2 Replacement of existing lamps with LED lamps with a possibility of dimming – where dimming is possible and will not have any effect on functionality and safety with built in central technical survilance

Building techincal survilance known as ''telemanagement'' is an automatized digital management system consisting of few subsystems. Telemanagement is a system which provides remote diagnostics, collecting and processing data for each lamp or a full circle of lamps (exp. to 200 lamps), as use of the same ones with purpose of further regulation (turning lamps on/off, dimming and other). Telemanagement provides malfunction detection on a lamp, powering problems and etc.,

two-way communication between a lamp and management module where exists a feedback on a particular lamp status. A system consists of 3 main elements:
- gateway,
- controller,
- management software, recently ''Cloud''.

Remote management and control system of public lighting (telemanagement) is concieved as a network system with a few command levels. User interface is accessable using mobile phone with GPRS connection and correct IP address, also using Internet accessing on a correct Web address and registration (WAN or LAN address). Server ha san applicating software in charge of whole management system, collecting, analyzing and processing data. From this management centre is possible to simultaneously manage more public lighting systems using segment controllers which is most commonly found on poles. Communication is two-way operative and it is done through TCP/IP protocol (GPS, GPRS, Edge, 3G, DSČ, ADSL, technologies, as existing LAN). This system presents general system ''Smart city'' in which is possible not to only control every lamp and consumption but to also collect remaining informations as number of traffic participants based on regulating traffic lights and other traffic electronic signs and other. Image 60, Image 61, Image 54 and Image 62 show an interface overview, using software with possibilities and settings.

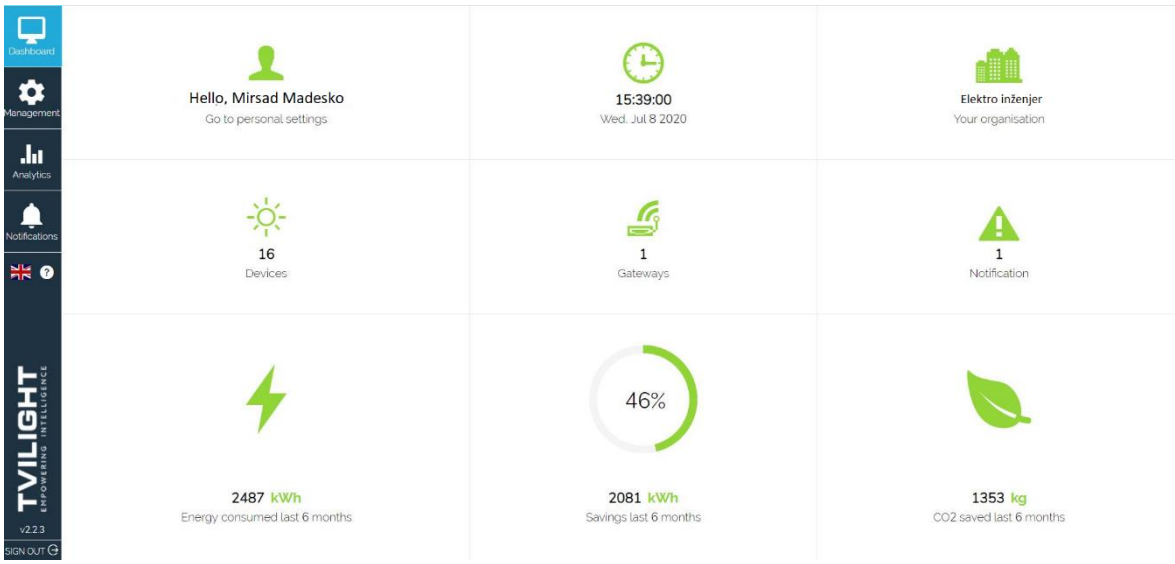

Image 60: Software interface overview

Image 61: Conducting analysis for electricity consumption example

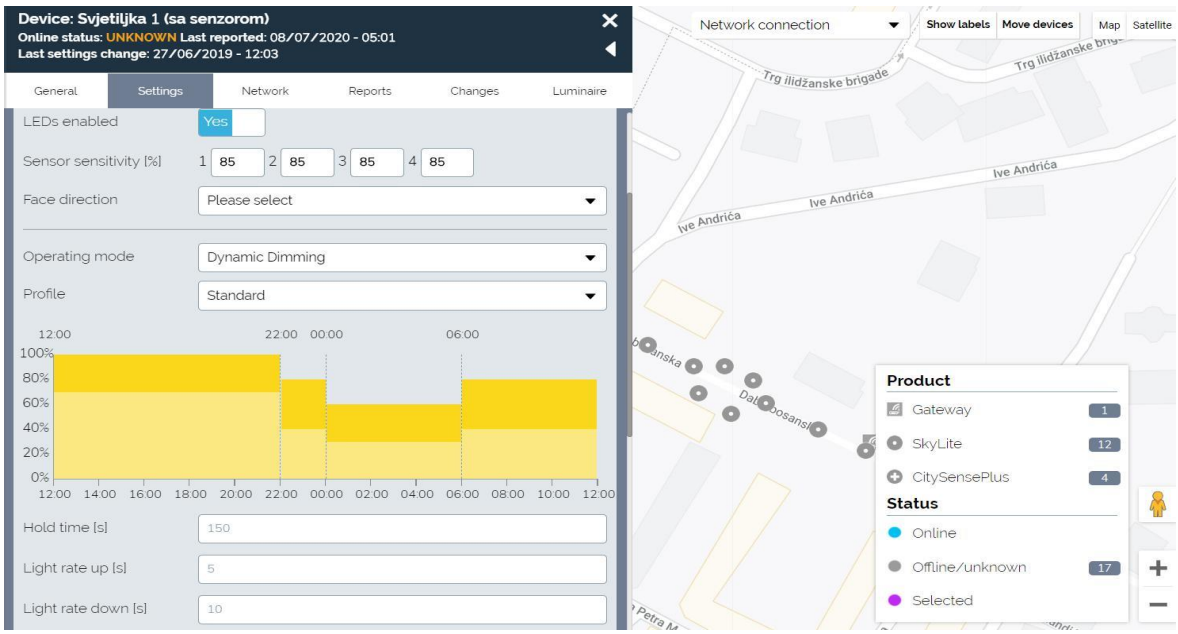

Image 62: Software settings example

For electricity consumption budget by applying replacement measures of existing lamps with LED lamps with a possibility of dimming – where dimming is possible and will not have any effect on funcionality and safety with built in techincal survilance is an applied practice system. Standardized annual electricity consumption was made by:

$$E_{m3}=E_{m1} * k_{m3} \quad (8.)$$

where the following is:

E_{m3} – standardized annual electricity consumption for considered M2 – measure 2 (kWh/annually);

E_{m1} – standardized annual electricity consumption from M1 – measure 1 (kWh/annually);
k_{m3} – coefficient applied from winter and summer period practice – 0,374

Table gives a description of a decision with automatized lighting way of work. Electricitysavings move up to 40% - achieved by combination of 3 mentioned principles:
1. maintaining constant luminous flux installation level – savings up to 10%,
2. lighting power source regulation – savings up to 25%,
3. regulation depends on traffic density – savings up to 40%.

Measure name	Quantity	Wireless	Control room operable	(Em3) - Total standardized annual consumption
Telemanagement system installation	set	DA	DA - Cloud	162690,36
Total (kWh/annually)				162690,36
Lighting sources (pcs)				1846
Specific annual consumption (kWh/per lighting source annually)				88,13

Table 16: Total electricity consumption for public lighting after implementing measures with technical survilance

10 ANALYSIS OF ENERGY AND ECONOMIC EFFECTS OF THE SUGGESTED MEASURES

10.1 Quantitative analysis of energy and economizing

In this chapter, an analysis of the economic savings of the measures suggested in the previous chapter is performed.

10.1.1 Energy savings analysis

10.1.1.1 Analysis of energy savings by replacing existing lighting with LED

The calculation of electricity that would be needed after the implementation of this measure was performed, and the results are found in table 21 for each individual roadway. The annual number of working hours is 4100 according to the standard BAS CEN / TR 13201-1: 2016.

Ordinal number	Street Name	(Em) - Total standardized annual consumption	(Em1) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually	(pcs)	(KM/annually)
1	Ive Andrića - Rasavci	7072,50	2140,20	4932,30	12	411,03
2	Ive Andrića - Urije - Zidana	6483,13	1668,70	4814,43	11	437,68
3	Ive Andrića - Urije "Crpna"	16502,50	6658,40	9844,10	28	351,58
4	Roga	31236,88	4780,60	26456,28	53	499,18
5	Želj. stanica	8840,63	1353,00	7487,63	15	499,18
6	Jablanica	38309,38	5863,00	32446,38	65	499,18
7	Jablanica	8487,00	1623,60	6863,40	18	381,30
8	Silos	11787,50	5945,00	5842,50	25	233,70
9	Prekosanje	29468,75	4510,00	24958,75	50	499,18
10	Karađorđa Petrovića	20463,10	14743,60	5719,50	62	92,25
11	Karađorđa Petrovića	6483,13	1849,10	4634,03	11	421,28
12	Petra Kočića	1886,00	475,60	1410,40	2	705,20
13	Nadežde Petrović	5893,75	1681,00	4212,75	10	421,28
14	Kej Vojvode Stepe	37130,63	10590,30	26540,33	63	421,28
15	Njegoševa	3536,25	541,20	2995,05	6	499,18

Ordinal number	Street Name	(Em) - Total standardized annual consumption	(Em1) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually	(pcs)	(KM/annually)
16	Njegoševa	2310,35	631,40	1678,95	7	239,85
17	Njegoševa	2357,50	451,00	1906,50	5	381,30
18	Miloša Obilića	10019,38	2613,75	7405,63	17	435,63
19	Caprag	7072,50	3567,00	3505,50	15	233,70
20	Caprag	1768,13	713,40	1054,73	3	351,58
21	Gavrila Principa	9430,00	2460,00	6970,00	16	435,63
22	Tunjica	41256,25	6314,00	34942,25	70	499,18
23	Repovac	14145,00	5350,50	8794,50	30	293,15
24	Repovac	1768,13	535,05	1233,08	3	411,03
25	Topić brdo	7072,50	2275,50	4797,00	15	319,80
26	Topić brdo	5304,38	1365,30	3939,08	9	437,68
27	Dobrile Grubor	1886,00	615,00	1271,00	4	317,75
28	Kožinac	17091,88	2615,80	14476,08	29	499,18
29	Dom zdravlja	3536,25	1008,60	2527,65	6	421,28
30	Svodna	34773,13	8950,30	25822,83	59	437,68
31	Dobrljin	39488,13	10163,90	29324,23	67	437,68
32	Rudice	26521,88	8025,75	18496,13	45	411,03
33	Čulići	15323,75	3944,20	11379,55	26	437,68
34	Vodičevo Šljok.	24753,75	7490,70	17263,05	42	411,03
35	Donje Vodičevo	9430,00	2853,60	6576,40	16	411,03
36	Ravnice Šindr.	11198,13	1713,80	9484,33	19	499,18
37	Ravnice	11198,13	1713,80	9484,33	19	499,18
38	Ravnice Kovač.	9430,00	1443,20	7986,80	16	499,18
39	Dobrljin-Tomašev.	22985,63	5916,30	17069,33	39	437,68
40	Svodna-želj. stanica	17681,25	4551,00	13130,25	30	437,68
41	Poljavnice	7921,20	2164,80	5756,40	24	239,85
42	Poljavnice	4125,63	631,40	3494,23	7	499,18
43	Petkovac	3536,25	910,20	2626,05	6	437,68
44	-Hotel	10019,38	2857,70	7161,68	17	421,28
45	Poljavnice-Lazići	20038,75	3066,80	16971,95	34	499,18
46	Poljavnice 1	11787,50	1804,00	9983,50	20	499,18

Ordinal number	Street Name	(Em) - Total standardized annual consumption	(Em1) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually	(pcs)	(KM/annually)
47	Karakolo	12966,25	1984,40	10981,85	22	499,18
48	Ravnice-Crnobrnje	12376,88	1894,20	10482,68	21	499,18
49	Mlakve	12376,88	1894,20	10482,68	21	499,18
50	Blagaj Rijeka	25343,13	3878,60	21464,53	43	499,18
51	Blagaj Japra	30647,50	7888,40	22759,10	52	437,68
52	Suhača-Halilov.	16502,50	4993,80	11508,70	28	411,03
53	Blag. Japra-Troske	16502,50	4247,60	12254,90	28	437,68
54	D.Rakani-Astor	21217,50	5461,20	15756,30	36	437,68
55	Rudice	5893,75	1783,50	4110,25	10	411,03
56	D.Rakani-motel	11787,50	3034,00	8753,50	20	437,68
57	Kršlje	9430,00	1443,20	7986,80	16	499,18
58	S.grad-kasl. Ograde	2357,50	615,00	1742,50	4	435,63
59	Hozići	10608,75	2730,60	7878,15	18	437,68
60	Suhača	17681,25	5350,50	12330,75	30	411,03
61	Vitasovci	6601,00	1262,80	5338,20	14	381,30
62	Čelopek	13555,63	3489,10	10066,53	23	437,68
63	Radišići-Rudice	19449,38	2976,60	16472,78	33	499,18
64	Radišići-Rudice	2829,00	270,60	2558,40	3	852,80
65	Stadion Mlakve	10608,75	3210,30	7398,45	18	411,03
66	Vitasovci 3	12966,25	3923,70	9042,55	22	411,03
67	Vitasovci 3	8487,00	3210,30	5276,70	18	293,15
68	Izbj. naselje-Rudice	8840,63	1353,00	7487,63	15	499,18
69	Maslovare	2970,45	1365,30	1605,15	9	178,35
70	Maslovare	103,73	151,70	-47,97	1	-47,97
71	Šuća brdo	6483,13	992,20	5490,93	11	499,18
72	Gornji Agići 1	2946,88	758,50	2188,38	5	437,68
73	Asf. baza Poljavnice	1650,25	758,50	891,75	5	178,35
74	Donji Hozići	10019,38	1533,40	8485,98	17	499,18
75	Donji Hozići	990,15	270,60	719,55	3	239,85

Ordinal number	Street Name	(Em) - Total standardized annual consumption	(Em1) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually	(pcs)	(KM/annually)
76	M. Novska Rujiška	4715,00	721,60	3993,40	8	499,18
77	Donje Vodičevo-lug	31826,25	9630,90	22195,35	54	411,03
78	V. Žuljevica-Gajići	10019,38	1533,40	8485,98	17	499,18
79	Silos-pijaca	2640,40	2033,60	606,80	8	75,85
80	Gornji Agići 2	17681,25	4551,00	13130,25	30	437,68
81	Poljavnice Radišići 1	589,38	90,20	499,18	1	499,18
82	Blatna 1 poligon	21217,50	5461,20	15756,30	36	437,68
TOTAL		**1041694,38**	**259888,75**	**781805,63**	**1846**	**423,51**

Table 17: Energy savings for lighting after replacing existing lighting with LED

10.1.1.2 Energy savings analysis by replacing existing lamps with dimmable LED lamps - where dimming is possible and will not affect functionality and safety

The calculation of electricity that would be needed after the implementation of this measure was performed, and the results are found in table 18.

Ordinal No.	Street name	(Em1) - Total standardized annual consumption	(Em2) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
1	Ive Andrića - Rasavci	2140,20	1690,76	449,44	12	37,45
2	Ive Andrića - Urije - Zidana	1668,70	1318,27	350,43	11	31,86
3	Ive Andrića - Urije "Crpna"	6658,40	5260,14	1398,26	28	49,94
4	Roga	4780,60	3776,67	1003,93	53	18,94
5	Želj. stanica	1353,00	1068,87	284,13	15	18,94
6	Jablanica	5863,00	4631,77	1231,23	65	18,94
7	Jablanica	1623,60	1282,64	340,96	18	18,94

Ordinal No.	Street name	(Em1) - Total standardized annual consumption	(Em2) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
8	Silos	5945,00	4696,55	1248,45	25	49,94
9	Prekosanje	4510,00	3562,90	947,10	50	18,94
10	Karađorđa Petrovića	14743,60	11647,44	3096,16	62	49,94
11	Karađorđa Petrovića	1849,10	1460,79	388,31	11	35,30
12	Petra Kočića	475,60	375,72	99,88	2	49,94
13	Nadežde Petrović	1681,00	1327,99	353,01	10	35,30
14	Kej Vojvode Stepe	10590,30	8366,34	2223,96	63	35,30
15	Njegoševa	541,20	427,55	113,65	6	18,94
16	Njegoševa	631,40	498,81	132,59	7	18,94
17	Njegoševa	451,00	356,29	94,71	5	18,94
18	Miloša Obilića	2613,75	2064,86	548,89	17	32,29
19	Caprag	3567,00	2817,93	749,07	15	49,94
20	Caprag	713,40	563,59	149,81	3	49,94
21	Gavrila Principa	2460,00	1943,40	516,60	16	32,29
22	Tunjica	6314,00	4988,06	1325,94	70	18,94
23	Repovac	5350,50	4226,90	1123,61	30	37,45
24	Repovac	535,05	422,69	112,36	3	37,45
25	Topić brdo	2275,50	1797,65	477,86	15	31,86
26	Topić brdo	1365,30	1078,59	286,71	9	31,86
27	Dobrile Grubor	615,00	485,85	129,15	4	32,29
28	Kožinac	2615,80	2066,48	549,32	29	18,94
29	Dom zdravlja	1008,60	796,79	211,81	6	35,30
30	Svodna	8950,30	7070,74	1879,56	59	31,86
31	Dobrljin	10163,90	8029,48	2134,42	67	31,86
32	Rudice	8025,75	6340,34	1685,41	45	37,45
33	Čulići	3944,20	3115,92	828,28	26	31,86
34	Vodičevo Šljok.	7490,70	5917,65	1573,05	42	37,45
35	Donje Vodičevo	2853,60	2254,34	599,26	16	37,45
36	Ravnice Šindr.	1713,80	1353,90	359,90	19	18,94
37	Ravnice	1713,80	1353,90	359,90	19	18,94

Ordinal No.	Street name	(Em1) - Total standardized annual consumption	(Em2) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
38	Ravnice Kovač.	1443,20	1140,13	303,07	16	18,94
39	Dobrljin-Tomašev.	5916,30	4673,88	1242,42	39	31,86
40	Svodna-želj. stanica	4551,00	3595,29	955,71	30	31,86
41	Poljavnice	2164,80	1710,19	454,61	24	18,94
42	Poljavnice	631,40	498,81	132,59	7	18,94
43	Petkovac	910,20	719,06	191,14	6	31,86
44	-Hotel	2857,70	2257,58	600,12	17	35,30
45	Poljavnice-Lazići	3066,80	2422,77	644,03	34	18,94
46	Poljavnice 1	1804,00	1425,16	378,84	20	18,94
47	Karakolo	1984,40	1567,68	416,72	22	18,94
48	Ravnice-Crnobrnje	1894,20	1496,42	397,78	21	18,94
49	Mlakve	1894,20	1496,42	397,78	21	18,94
50	Blagaj Rijeka	3878,60	3064,09	814,51	43	18,94
51	Blagaj Japra	7888,40	6231,84	1656,56	52	31,86
52	Suhača-Halilov.	4993,80	3945,10	1048,70	28	37,45
53	Blag. Japra-Troske	4247,60	3355,60	892,00	28	31,86
54	D.Rakani-Astor	5461,20	4314,35	1146,85	36	31,86
55	Rudice	1783,50	1408,97	374,54	10	37,45
56	D.Rakani-motel	3034,00	2396,86	637,14	20	31,86
57	Kršlje	1443,20	1140,13	303,07	16	18,94
58	S.grad-kasl. Ograde	615,00	485,85	129,15	4	32,29
59	Hozići	2730,60	2157,17	573,43	18	31,86
60	Suhača	5350,50	4226,90	1123,61	30	37,45
61	Vitasovci	1262,80	997,61	265,19	14	18,94
62	Čelopek	3489,10	2756,39	732,71	23	31,86
63	Radišići-Rudice	2976,60	2351,51	625,09	33	18,94
64	Radišići-Rudice	270,60	213,77	56,83	3	18,94
65	Stadion Mlakve	3210,30	2536,14	674,16	18	37,45

Ordinal No.	Street name	(Em1) - Total standardized annual consumption	(Em2) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
66	Vitasovci 3	3923,70	3099,72	823,98	22	37,45
67	Vitasovci 3	3210,30	2536,14	674,16	18	37,45
68	Izbj. naselje-Rudice	1353,00	1068,87	284,13	15	18,94
69	Maslovare	1365,30	1078,59	286,71	9	31,86
70	Maslovare	151,70	119,84	31,86	1	31,86
71	Šuća brdo	992,20	783,84	208,36	11	18,94
72	Gornji Agići 1	758,50	599,22	159,29	5	31,86
73	Asf. baza Poljavnice	758,50	599,22	159,29	5	31,86
74	Donji Hozići	1533,40	1211,39	322,01	17	18,94
75	Donji Hozići	270,60	213,77	56,83	3	18,94
76	M. Novska Rujiška	721,60	570,06	151,54	8	18,94
77	Donje Vodičevo-lug	9630,90	7608,41	2022,49	54	37,45
78	V. Žuljevica-Gajići	1533,40	1211,39	322,01	17	18,94
79	Silos-pijaca	2033,60	1606,54	427,06	8	53,38
80	Gornji Agići 2	4551,00	3595,29	955,71	30	31,86
81	Poljavnice Radišići 1	90,20	71,26	18,94	1	18,94
82	Blatna 1 poligon	5461,20	4314,35	1146,85	36	31,86
TOTAL		**259888,75**	**205312,11**	**54576,64**	**1846**	**29,56**

Table 18: Energy savings for lighting after replacing existing LED lighting with Dynadimmer

10.1.1.3 Analysis of energy savings by replacing existing lamps with dimmable LED lamps - where dimming is possible and will not affect functionality and safety with the installation of central technical supervision

Table 19 shows the total realized electricitysavings by installing a telemanagement systems.

Measure name	(Em1) - Total standardized annual consumption	(Em3) - Total standardized annual consumption	Annual savings	Quantity	Annual savings per lamp
	(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
Installation of telemanagement system	259888,75	162690,36	97198,39	1846	52,65

Table 19: Calculation of potential electricity savings by installing a telemanagement system

10.1.2 Economic analysis

10.1.2.1 Analysis of economic savings of replacing exisiting lighting with LED

The calculation of electricity Expenses that would be after the implementation of this measure has been performed, and the results are found in table 20.

Ordinal No.	Street name	Expenses according to energy consumption Em	Expenses according to energy consumption Em1	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
1	Ive Andrića - Rasavci	1164,84	352,49	812,35	12	67,70
2	Ive Andrića - Urije - Zidana	1067,77	274,83	792,94	11	72,09
3	Ive Andrića - Urije "Crpna"	2717,96	1096,64	1621,32	28	57,90
4	Roga	5144,71	787,36	4357,35	53	82,21
5	Želj. stanica	1456,05	222,84	1233,21	15	82,21
6	Jablanica	6309,55	965,64	5343,92	65	82,21
7	Jablanica	1397,81	267,41	1130,40	18	62,80
8	Silos	1941,40	979,14	962,26	25	38,49
9	Prekosanje	4853,50	742,80	4110,71	50	82,21
10	Karađorđa Petrovića	3370,27	2428,27	942,00	62	15,19
11	Karađorđa Petrovića	1067,77	304,55	763,22	11	69,38
12	Petra Kočića	310,62	78,33	232,29	2	116,15
13	Nadežde Petrović	970,70	276,86	693,84	10	69,38

Ordinal No.	Street name	Expenses according to energy consumption Em	Expenses according to energy consumption Em1	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
14	Kej Vojvode Stepe	6115,41	1744,22	4371,19	63	69,38
15	Njegoševa	582,42	89,14	493,28	6	82,21
16	Njegoševa	380,51	103,99	276,52	7	39,50
17	Njegoševa	388,28	74,28	314,00	5	62,80
18	Miloša Obilića	1650,19	430,48	1219,71	17	71,75
19	Caprag	1164,84	587,48	577,36	15	38,49
20	Caprag	291,21	117,50	173,71	3	57,90
21	Gavrila Principa	1553,12	405,16	1147,96	16	71,75
22	Tunjica	6794,90	1039,92	5754,99	70	82,21
23	Repovac	2329,68	881,23	1448,45	30	48,28
24	Repovac	291,21	88,12	203,09	3	67,70
25	Topić brdo	1164,84	374,77	790,07	15	52,67
26	Topić brdo	873,63	224,86	648,77	9	72,09
27	Dobrile Grubor	310,62	101,29	209,33	4	52,33
28	Kožinac	2815,03	430,82	2384,21	29	82,21
29	Dom zdravlja	582,42	166,12	416,30	6	69,38
30	Svodna	5727,13	1474,11	4253,02	59	72,09
31	Dobrljin	6503,69	1673,99	4829,70	67	72,09
32	Rudice	4368,15	1321,84	3046,31	45	67,70
33	Čulići	2523,82	649,61	1874,21	26	72,09
34	Vodičevo Šljok.	4076,94	1233,72	2843,22	42	67,70
35	Donje Vodičevo	1553,12	469,99	1083,13	16	67,70
36	Ravnice Šindr.	1844,33	282,26	1562,07	19	82,21
37	Ravnice	1844,33	282,26	1562,07	19	82,21
38	Ravnice Kovač.	1553,12	237,70	1315,43	16	82,21
39	Dobrljin-Tomašev.	3785,73	974,41	2811,32	39	72,09
40	Svodna-želj. stanica	2912,10	749,55	2162,55	30	72,09
41	Poljavnice	1304,62	356,54	948,08	24	39,50
42	Poljavnice	679,49	103,99	575,50	7	82,21

Ordinal No.	Street name	Expenses according to energy consumption Em	Expenses according to energy consumption Em1	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
43	Petkovac	582,42	149,91	432,51	6	72,09
44	-Hotel	1650,19	470,66	1179,53	17	69,38
45	Poljavnice-Lazići	3300,38	505,10	2795,28	34	82,21
46	Poljavnice 1	1941,40	297,12	1644,28	20	82,21
47	Karakolo	2135,54	326,83	1808,71	22	82,21
48	Ravnice-Crnobrnje	2038,47	311,97	1726,50	21	82,21
49	Mlakve	2038,47	311,97	1726,50	21	82,21
50	Blagaj Rijeka	4174,01	638,81	3535,21	43	82,21
51	Blagaj Japra	5047,64	1299,22	3748,42	52	72,09
52	Suhača-Halilov.	2717,96	822,48	1895,48	28	67,70
53	Blag. Japra-Troske	2717,96	699,58	2018,38	28	72,09
54	D.Rakani-Astor	3494,52	899,46	2595,06	36	72,09
55	Rudice	970,70	293,74	676,96	10	67,70
56	D.Rakani-motel	1941,40	499,70	1441,70	20	72,09
57	Kršlje	1553,12	237,70	1315,43	16	82,21
58	S.grad-kasl. Ograde	388,28	101,29	286,99	4	71,75
59	Hozići	1747,26	449,73	1297,53	18	72,09
60	Suhača	2912,10	881,23	2030,87	30	67,70
61	Vitasovci	1087,18	207,98	879,20	14	62,80
62	Čelopek	2232,61	574,65	1657,96	23	72,09
63	Radišići-Rudice	3203,31	490,25	2713,07	33	82,21
64	Radišići-Rudice	465,94	44,57	421,37	3	140,46
65	Stadion Mlakve	1747,26	528,74	1218,52	18	67,70
66	Vitasovci 3	2135,54	646,23	1489,31	22	67,70
67	Vitasovci 3	1397,81	528,74	869,07	18	48,28
68	Izbj. naselje-Rudice	1456,05	222,84	1233,21	15	82,21

Ordinal No.	Street name	Expenses according to energy consumption Em	Expenses according to energy consumption Em1	Annual savings	Quantity	Annual savings per lamp
		(kWh/annually)	(kWh/annually)	(kWh/annually)	(pcs)	(KM/annually)
69	Maslovare	489,23	224,86	264,37	9	29,37
70	Maslovare	17,08	24,98	-7,90	1	-7,90
71	Šuća brdo	1067,77	163,42	904,36	11	82,21
72	Gornji Agići 1	485,35	124,92	360,43	5	72,09
73	Asf. baza Poljavnice	271,80	124,92	146,87	5	29,37
74	Donji Hozići	1650,19	252,55	1397,64	17	82,21
75	Donji Hozići	163,08	44,57	118,51	3	39,50
76	M. Novska Rujiška	776,56	118,85	657,71	8	82,21
77	Donje Vodičevo-lug	5241,78	1586,21	3655,57	54	67,70
78	V. Žuljevica-Gajići	1650,19	252,55	1397,64	17	82,21
79	Silos-pijaca	434,87	334,93	99,94	8	12,49
80	Gornji Agići 2	2912,10	749,55	2162,55	30	72,09
81	Poljavnice Radišići 1	97,07	14,86	82,21	1	82,21
82	Blatna 1 poligon	3494,52	899,46	2595,06	36	72,09
TOTAL		**171567,06**	**42803,68**	**128763,39**	**1846**	**69,75**
TOTAL (EUR/anually)		**87720,84**	**21885,17**	**65835,68**		**35,66**

Table 20: Expenses calculation after replacing existing lighting with LED

10.1.2.2 Analysis of economic savings by replacing existing lamps with dimmable LED lamps - where dimming is possible and will not affect functionality and safety

The calculation of electricity Expenses that would be after the implementation of this measure has been performed, and the results are found in table 21.

Ordinal No.	Street name	Expenses according to energy consumption Em1	Expenses according to energy consumption Em2	Annual savings	Quantity	Annual savings per lamp
		(KM/annually)	(KM/annually)	(KM/annually)	(pcs)	(KM/annually)
1	Ive Andrića - Rasavci	352,49	273,56	78,93	12	6,58
2	Ive Andrića - Urije - Zidana	274,83	213,29	61,54	11	5,59
3	Ive Andrića - Urije "Crpna"	1096,64	851,07	245,57	28	8,77
4	Roga	787,36	611,05	176,31	53	3,33
5	Želj. stanica	222,84	172,94	49,90	15	3,33
6	Jablanica	965,64	749,40	216,23	65	3,33
7	Jablanica	267,41	207,53	59,88	18	3,33
8	Silos	979,14	759,88	219,26	25	8,77
9	Prekosanje	742,80	576,46	166,33	50	3,33
10	Karađorđa Petrovića	2428,27	1884,51	543,76	62	8,77
11	Karađorđa Petrovića	304,55	236,35	68,20	11	6,20
12	Petra Kočića	78,33	60,79	17,54	2	8,77
13	Nadežde Petrović	276,86	214,86	62,00	10	6,20
14	Kej Vojvode Stepe	1744,22	1353,64	390,58	63	6,20
15	Njegoševa	89,14	69,18	19,96	6	3,33
16	Njegoševa	103,99	80,70	23,29	7	3,33
17	Njegoševa	74,28	57,65	16,63	5	3,33
18	Miloša Obilića	430,48	334,09	96,40	17	5,67
19	Caprag	587,48	455,93	131,55	15	8,77
20	Caprag	117,50	91,19	26,31	3	8,77
21	Gavrila Principa	405,16	314,43	90,73	16	5,67
22	Tunjica	1039,92	807,05	232,87	70	3,33
23	Repovac	881,23	683,89	197,33	30	6,58
24	Repovac	88,12	68,39	19,73	3	6,58
25	Topić brdo	374,77	290,85	83,92	15	5,59
26	Topić brdo	224,86	174,51	50,35	9	5,59
27	Dobrile Grubor	101,29	78,61	22,68	4	5,67
28	Kožinac	430,82	334,35	96,47	29	3,33
29	Dom zdravlja	166,12	128,92	37,20	6	6,20
30	Svodna	1474,11	1144,02	330,10	59	5,59
31	Dobrljin	1673,99	1299,14	374,86	67	5,59
32	Rudice	1321,84	1025,84	296,00	45	6,58
33	Čulići	649,61	504,14	145,47	26	5,59

Ordinal No.	Street name	Expenses according to energy consumption Em1	Expenses according to energy consumption Em2	Annual savings	Quantity	Annual savings per lamp
		(KM/annually)	(KM/annually)	(KM/annually)	(pcs)	(KM/annually)
34	Vodičevo Šljok.	1233,72	957,45	276,27	42	6,58
35	Donje Vodičevo	469,99	364,74	105,24	16	6,58
36	Ravnice Šindr.	282,26	219,06	63,21	19	3,33
37	Ravnice	282,26	219,06	63,21	19	3,33
38	Ravnice Kovač.	237,70	184,47	53,23	16	3,33
39	Dobrljin-Tomašev.	974,41	756,21	218,20	39	5,59
40	Svodna-želj. stanica	749,55	581,70	167,85	30	5,59
41	Poljavnice	356,54	276,70	79,84	24	3,33
42	Poljavnice	103,99	80,70	23,29	7	3,33
43	Petkovac	149,91	116,34	33,57	6	5,59
44	-Hotel	470,66	365,27	105,40	17	6,20
45	Poljavnice-Lazići	505,10	391,99	113,11	34	3,33
46	Poljavnice 1	297,12	230,59	66,53	20	3,33
47	Karakolo	326,83	253,64	73,19	22	3,33
48	Ravnice-Crnobrnje	311,97	242,11	69,86	21	3,33
49	Mlakve	311,97	242,11	69,86	21	3,33
50	Blagaj Rijeka	638,81	495,76	143,05	43	3,33
51	Blagaj Japra	1299,22	1008,29	290,93	52	5,59
52	Suhača-Halilov.	822,48	638,30	184,18	28	6,58
53	Blag. Japra-Troske	699,58	542,92	156,66	28	5,59
54	D.Rakani-Astor	899,46	698,04	201,42	36	5,59
55	Rudice	293,74	227,96	65,78	10	6,58
56	D.Rakani-motel	499,70	387,80	111,90	20	5,59
57	Kršlje	237,70	184,47	53,23	16	3,33
58	S.grad-kasl. Ograde	101,29	78,61	22,68	4	5,67
59	Hozići	449,73	349,02	100,71	18	5,59
60	Suhača	881,23	683,89	197,33	30	6,58
61	Vitasovci	207,98	161,41	46,57	14	3,33
62	Čelopek	574,65	445,97	128,68	23	5,59
63	Radišići-Rudice	490,25	380,47	109,78	33	3,33
64	Radišići-Rudice	44,57	34,59	9,98	3	3,33

Ordinal No.	Street name	Expenses according to energy consumption Em1	Expenses according to energy consumption Em2	Annual savings	Quantity	Annual savings per lamp
		(KM/annually)	(KM/annually)	(KM/annually)	(pcs)	(KM/annually)
65	Stadion Mlakve	528,74	410,34	118,40	18	6,58
66	Vitasovci 3	646,23	501,52	144,71	22	6,58
67	Vitasovci 3	528,74	410,34	118,40	18	6,58
68	Izbj. naselje-Rudice	222,84	172,94	49,90	15	3,33
69	Maslovare	224,86	174,51	50,35	9	5,59
70	Maslovare	24,98	19,39	5,59	1	5,59
71	Šuća brdo	163,42	126,82	36,59	11	3,33
72	Gornji Agići 1	124,92	96,95	27,97	5	5,59
73	Asf. baza Poljavnice	124,92	96,95	27,97	5	5,59
74	Donji Hozići	252,55	196,00	56,55	17	3,33
75	Donji Hozići	44,57	34,59	9,98	3	3,33
76	M. Novska Rujiška	118,85	92,23	26,61	8	3,33
77	Donje Vodičevo-lug	1586,21	1231,01	355,20	54	6,58
78	V. Žuljevica-Gajići	252,55	196,00	56,55	17	3,33
79	Silos-pijaca	334,93	259,93	75,00	8	9,38
80	Gornji Agići 2	749,55	581,70	167,85	30	5,59
81	Poljavnice Radišići 1	14,86	11,53	3,33	1	3,33
82	Blatna 1 poligon	899,46	698,04	201,42	36	5,59
TOTAL		**42803,68**	**33218,69**	**9584,98**	**1846**	**5,19**
TOTAL (EUR/annually)		**21885,17**	**16984,45**	**4900,72**		**2,65**

Tabela 21: Expenses calculation after installing the Dynadimmer system

10.1.2.3 Analysis of economic savings by replacing existing lamps with dimmable LED lamps - where dimming is possible and will not affect functionality and safety with the installation of central technical supervision

The calculation of electricity Expenses that would be after the implementation of this measure was performed, and the results are found in table 22.

Measure name	Expenses according to energy consumption Em1	Expenses according to energy consumption Em3	Annual savings	Quantity	Annual savings per lamp
	(KM/annually)	(KM/annually)	(KM/annually)	(pcs)	(KM/annually)
Installation of telemanagement system	42803,68	26795,1	16008,58	1846	8,67
	(€/annually)	(€/annually)	(€/annually)	(pcs)	(€/annually)
	21885,17	13700,12	8185,06	1846	4,43

Table 22: Calculation of Expenses after installing a telemanagement system

11 FINANCIAL ANALYSIS

In general, the implementation of EE measures on public lighting systems leads to the realization of various positive effects. In technical terms, there is an optimization of lighting capacities, a reduction in electricity consumption, the release of capacity for further expansion of public lighting systems, and a number of other positive effects.

These technical improvements, consequently, lead to improvements of the financial situation in the companies that manage public lighting systems as well as on the side of their users. Within the technical analysis, which was done with the aim of finding the optimal way to improve the public lighting system in the city of Novi Grad, the implementation of 4 EE measures was considered:

- Measure 0 - Preparatory works / dismantling of existing lighting fixtures
- Measure 1 Procurement and installation of new LED lamps;
- Measure 2 Procurement and installation of a ballast for autonomous wireless attenuation of light flux;
- Measure 3 Procurement and installation of telemanagement.

The financial effects of the implementation differ both for each of the above measures individually and for a combination of 2 or more measures. In order to select a measure or combination of measures that will lead to the greatest financial effects, 3 EE scenarios have been defined, as follows:

- Scenario 1 - includes procurement and installation of new LED lamps;
- Scenario 2 includes the procurement and installation of new LED lamps and the procurement and installation of a ballast for autonomous wireless attenuation of light flux;
- Scenario 3 includes the procurement and installation of new LED lamps and the procurement and installation of telemanagement.

The analysis of the financial justification of the above scenarios was done on the basis of cash flow projections for each scenario for a period of 15 years (2020 -2035), which served as a basis for calculating financial indicators: (i) internal rate of return (internal rate of return(IRR)), (ii) Net Present Value (NPV), (iii) Simple Payback Period, and (iv) Discounted Payback Period.

It is important to note that the amounts of investment costs for the proposed measures, as well as the amounts of operating costs and revenues are shown without value added tax (VAT). Taking into account their amounts, it is expected that the implementer of measures, regardless of whether it is a local self-government unit or a third legal entity, will be a registered VAT payer and thus have the right to deduct VAT.

Cash savings that will be realized as a result of the implementation of a certain scenario are considered as cash inflows, while investment costs and maintenance costs for a given scenario are considered as cash outflows. Also, within the financial analysis of the considered scenarios, a discount rate of 5% was used.

11.1 Investment costs (CAPEX)

ITEM	AMOUNT	
Measures	KM	EUR
M0 – Preparatory works/dismantling of existing ligting fixtrues	36.920	18.877
M1 – Procurament and installation of new LED lightbulbs	792.670	405.286
M2 – Procurament and installation of a ballast for autonomus wireless atenuation of light flux	49.842	25.484
M3 – Procurament and instalaltion of telemanagement	893.500	456.839
Scenarios		
Scenario 1 (M0+M1)	829.590	424.163
Scenario2 (M0+M1+M2)	879.432	449.646
Scenario3 (M0+M1+M3)	1.723.090	881.002

gives the overview of investment costs for discussed scenarios.

ITEM	AMOUNT	
Measures	KM	EUR
M0 – Preparatory works/dismantling of existing ligting fixtrues	36.920	18.877
M1 – Procurament and installation of new LED lightbulbs	792.670	405.286
M2 – Procurament and installation of a ballast for autonomus wireless atenuation of light flux	49.842	25.484
M3 – Procurament and instalaltion of telemanagement	893.500	456.839
Scenarios		
Scenario 1 (M0+M1)	829.590	424.163
Scenario2 (M0+M1+M2)	879.432	449.646
Scenario3 (M0+M1+M3)	1.723.090	881.002

Table 23: Scenarios investment costs

The assumption is that the investments in the considered scenarios will be realized during 2020, and that Novi Grad municipality will start realizing the financial effects from the implementation of the investment in 2021.

11.2 Financial savings

Financial savings that will be the result of implementation of considered scenarios are calculated on the basis of existing consumption of electrricity for public lighting in Novi Grad municipality, and electricity consumption after implementation of considered scenarios. In the analysis was used the electricity price of 0,1647 KM/kWh or 0,084 EUR/kWh from the chapter Analysis of energy costs and estimates of future consumption.Table 28 gives the overview of financial savings per considered scenarios.

ITEM	UNIT	AMOUNT
Existing considered electricity consumption	kWh/year	1.041.694
Electricity consumption per scenarios		

Scenario 1	kWh/year	259.888,75
Scenario 2	kWh/year	201.692,12
Scenario 3	kWh/year	162.690,36
Electricity savings		
Scenario 1	kWh/year	781.805,63
Scenario 2	kWh/year	840.002,26
Scenario 3	kWh/year	879.004,02
Electricity price	KM/kWh	0,1647
	EUR/kWh	0,0842
Financial savings		
Scenario 1	KM/year	128.763,39
	EUR/god.	65.835,67
Scenario 2	KM/god.	138.348,37
	EUR/god.	70.736,40
Scenario 3	KM/year	144.771,96
	EUR/year	74.020,73

Table 24: Financial savings

11.3 Operational costs (OPEX)

11.3.1 Operating costs

The equipment that will be installed within the considered scenarios will have a warranty for a period of 5 years, which implies that there will be no maintenance costs in the period of 2020-2025. After the 2025., it is assumed that the annual maintenance costs will be 1% of the investment costs for the given scenario, which in addition to the regular maintenance costs also include the costs for the necessary licenses. Table 25 gives overview of maintenance in scenarios.

Scenario	UNIT	
	KM	EUR
Scenario 1	8.710,70	4.453,71
Scenario 2	9.234,04	4721,28
Scenario 3	18.092,45	9250,52

Table 25: operating costs

11.4 Cash flow projection

Based on the aforementioned investment costs and maintenance costs and expected financial savings, a cash flow projection was made for each scenario for the period 2020- 2035. Table 26, table 27 and table 28 provide an overview of cash flow for each scenario considered and the values of IRR, NPV, payback period and discounted payback period (DPP).

ITEM	UNIT	AMOUNT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CASH INFLOW																							
Financial savings	KM			128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32
CASH OUTFLOW																							
Maintenance costs	KM		0	0	0	0	0	0	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	
Investment costs	KM		829.590	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NET CASH FLOW	**KM**		**-829.590**	**128.763**	**128.763**	**128.763**	**128.763**	**128.763**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**128.763**
CUMULATIVE CASH FLOW	**KM**		**-829.590**	**-700.827**	**-572.063**	**-443.300**	**-314.537**	**-185.773**	**-65.306**	**55.161**	**175.629**	**296.096**	**416.564**	**537.031**	**657.499**	**777.966**	**898.433**	**1.018.901**	**1.139.368**	**1.259.836**	**1.380.303**	**1.500.771**	**1.629.534**
IRR	**%**	**12%**																					
NPV	**KM**	**456.737,58**																					
Discontinued payback period	**year**	**9**																					
Payback period	**year**	**7**																					

ITEM	UNIT	AMOUNT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CASH INFLOW																							
Financial savings	KM			128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32	128.763,32
CASH OUTFLOW																							
Maintenance costs	KM		0	0	0	0	0	0	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	8.296	
Investment costs	KM		829.590	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NET CASH FLOW	**KM**		**-829.590**	**128.763**	**128.763**	**128.763**	**128.763**	**128.763**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**120.467**	**128.763**
CUMULATIVE CASH FLOW	**KM**		**-829.590**	**-700.827**	**-572.063**	**-443.300**	**-314.537**	**-185.773**	**-65.306**	**55.161**	**175.629**	**296.096**	**416.564**	**537.031**	**657.499**	**777.966**	**898.433**	**1.018.901**	**1.139.368**	**1.259.836**	**1.380.303**	**1.500.771**	**1.629.534**
IRR	**%**	**12%**																					
NPV	**KM**	**456.737,58**																					
Discontinued payback period	**year**	**9**																					
Payback period	**year**	**7**																					

Table 26: Scenario 1 cash flow

ITEM	UNIT	AMOUNT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CASH INFLOW																							
Financial savings	KM			138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31	138.348,31
CASH OUTFLOW																							
Maintenance costs	KM		0	0	0	0	0	0	8.794	8.794	8.794	8.794	8.794	8.794	8.794	8.794	8.794	8.794	8.794	8.794	8.794	8.794	8.794
Investment costs	KM		879.432	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NET CASH FLOW	**KM**		**-879.432**	**138.348**	**138.348**	**138.348**	**138.348**	**138.348**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**	**129.554**
CUMULATIVE CASH FLOW	**KM**		**-879.432**	**-741.084**	**-602.735**	**-464.387**	**-326.039**	**-187.690**	**-58.136**	**71.418**	**200.972**	**330.526**	**460.079**	**589.633**	**719.187**	**848.741**	**978.295**	**1.107.849**	**1.237.403**	**1.366.957**	**1.496.511**	**1.626.065**	**1.755.619**
IRR	**%**	**13%**																					
NPV	**KM**	**503.368,91**																					
Discontinued payback period	**year**	**9**																					
Payback period	**year**	**7**																					

ITEM	UNIT	AMOUNT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CASH INFLOW																							
Financial savings	EUR		0	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367	70736,367
CASH OUTFLOW																							
Maintenance costs	EUR		0	0	0	0	0	0	4.496	4.496	4.496	4.496	4.496	4.496	4.496	4.496	4.496	4.496	4.496	4.496	4.496	4.496	4.496
Investment costs	EUR		449.646	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NET CASH FLOW	**EUR**		**-449.646**	**70.736**	**70.736**	**70.736**	**70.736**	**70.736**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**	**66.240**
CUMULATIVE CASH FLOW	**EUR**		**-449.646**	**-378.910**	**-308.174**	**-237.437**	**-166.701**	**-95.965**	**-29.725**	**36.515**	**102.755**	**168.995**	**235.235**	**301.475**	**367.715**	**433.955**	**500.195**	**566.434**	**632.674**	**698.914**	**765.154**	**831.394**	**897.634**
IRR	**%**	**13%**																					
NPV	**EUR**	**257.368,44**																					
Discontinued payback period	**year**	**9**																					
Payback period	**year**	**7**																					

Table 27: Scenario 2 cash flow

ITEM	UNIT	AMOUNT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CASH INFLOW																							
Financial savings	KM			144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90	144.771,90
CASH OUTFLOW																							
Maintenance costs	KM		0	0	0	0	0	0	17.231	17.231	17.231	17.231	17.231	17.231	17.231	17.231	17.231	17.231	17.231	17.231	17.231	17.231	17.231
Investment costs	KM		1.723.090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NET CASH FLOW	**KM**		**-1.723.090**	**144.772**	**144.772**	**144.772**	**144.772**	**144.772**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**	**127.541**
CUMULATIVE CASH FLOW	**KM**		**-1.723.090**	**-1.578.318**	**-1.433.546**	**-1.288.774**	**-1.144.002**	**-999.231**	**-871.690**	**-744.149**	**-616.608**	**-489.067**	**-361.526**	**-233.985**	**-106.444**	**21.097**	**148.638**	**276.179**	**403.720**	**531.261**	**658.802**	**786.343**	**913.884**
IRR	**%**	**2%**																					
NPV	**KM**	**-324.657,26**																					
Discontinued payback period	**year**	**14**																					
Paybac period	**year**	**13**																					

ITEM	UNIT	AMOUNT	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
CASH INFLOW																							
Financial savings	EUR		0	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697	74020,697
CASH OUTFLOW																							
Maintenance costs	EUR		0	0	0	0	0	0	8.810	8.810	8.810	8.810	8.810	8.810	8.810	8.810	8.810	8.810	8.810	8.810	8.810	8.810	8.810
Investment costs	EUR		881.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NET CASH FLOW	**EUR**		**-881.002**	**74.021**	**74.021**	**74.021**	**74.021**	**74.021**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**	**65.211**
CUMULATIVE CASH FLOW	**EUR**		**-881.002**	**-806.981**	**-732.961**	**-658.940**	**-584.919**	**-510.898**	**-445.688**	**-380.477**	**-315.266**	**-250.056**	**-184.845**	**-119.634**	**-54.424**	**10.787**	**75.998**	**141.208**	**206.419**	**271.630**	**336.840**	**402.051**	**467.262**
IRR	**%**	**2%**																					
NPV	**EUR**	**-165.994,62**																					
Discontinued payback period	**year**	**14**																					
Payback period	**year**	**13**																					

Table 28: Scenario 3 cash flow

Scenarios 1 and 2 have acceptable financial indicators. IRR Value for Scenario 1 and 2 is 12%.

Payback period for Scenarios 1 and 2 is the same, 7 years, as well as discounted payback period of 9 years.

NPV in Scenario 1 is 415.000 KM or 212.000 EUR,a nd in Scenario 2 459.000 KM or 234.000 EUR.

Scenario 3 value of financial indicators is significantly unfavorable compared to the first two scenarios, IRR is 1%, with payback periodof 14 years and discounted payback period of 15 years.

Considering previously mentioned it is recommended that Novi Grad Municipality implements EE measures proposed within **Scenario 2**, as they lead to achieving the biggest financial effects compared to invested funds in their implementation.

11.5 Analysis of funding sources

Novi Grad Municipality has several different models and sources of funding available for the implementation of the proposed measures in the public lighting system.

First of all, it is necessary to consider the city's own financial capacity to implement these measures. According to the data on the budget for 2017, 2018 and 2019, Novi Grad Municipality allocated an average of 0.5 million KM for capital projects. The investment in the proposed EE measures is 878.000 KM which is 72% of the amount allocated for capital projects. Therefore, it can be concluded that there is no financial capacity of Novi Grad Municipality to implement the proposed EE measures from its own resources.
An additional possibility of financing the implementation of the proposed EE measures is through loans. The city of Novi Grad can provide credit funds with domestic commercial banks or international financial institutions (EBRD, WB, etc.).

The third possibility for financing EE measures is through public-private partnership (PPP), which is becoming an increasingly common practice in the realization of many public investments. The PPP model can be attractive to both the public and private sectors. Private financing can support increased investment in projects of social interest without additional public sector borrowing.At the same time, better private sector management systems, and their capacities leading to innovation, can lead to increased efficiency in the implementation and management of various projects of social interest.

On the other hand, the interest of the private sector exists primarily for financially viable projects that have the possibility of commercialization. Also, the involvement of the private sector through the PPP model can lead to additional benefits for the public sector, such as:

- Faster project implementation;
- Reduction of implementation and project management costs;
- Creation of added value and additional income.

In accordance with the Law on Public-Private Partnership in Republika Srpska, the municipality of Novi Grad is able to involve the private sector in improving the public lighting system through two PPP models:

- Contractual form - according to which the partnership between public and private partner is based exclusively on contractual relations;
- Institutional form - according to which the partnership of the public and private sector includes the cooperation of the economic entity formed for that purpose.

In order to consider the possible costs and benefits of implementing EE measures through PPP, and to select the most acceptable PPP model, it is necessary to perform a detailed analysis of possible models of PPP implementation, taking into account the interests of the municipality of Laktaši and potential private partners.

11.6 Least Cost analysis of public lighting system

Least cost analysis of the public lighting system implies a comparison of possible public lighting systems from the financial aspect in relation to the proposed public lighting system. All public lighting systems use electricity to produce artificial light. So there are no alternatives between public lighting systems when it comes to the energy they use.
Therefore, the only segment in which it is possible to compare different public lighting systems is by the technology and equipment they use. Taking into account the above, in Novi Grad Municipality, it is possible to identify and compare 2 public lighting systems:

- Existing system - which uses fluorescent and sodium lamps to produce artificial light;
- Proposed system - which uses LED lamps with the possibility of dimming the light.

In order to compare the mentioned systems from the financial aspect, the calculation of unit costs per lamp for both systems was performed. Table 29 provides an overview of these costs.

Item	Unit	Existing system	Proposed system
Number of lightbulbs	#	1.846	1.846
Electricity costs	KM/year	171.567	33.219
	EUR/year	87.721	16.984
Maintenance costs	KM/year	0	9.234
	EUR/year	0	4.721
Investment costs	KM	0	879.432
	EUR	0	449.646
Unit electricity costs	(KM/lightbulb)	93	18
	(EUR/lightbulb)	48	9
Unit maintenance costs	(KM/lightbulb)	0	5
	(EUR/lightbulb)	0	3
Unit investment costs	(KM/lightbulb)	0	42
	(EUR/lightbulb)	0	21
TOTAL UNIT COST	KM	93	65
	EUR	48	33

Table 29: Unit cost of public lighting system

Based on the previous table it can be concluded that the proposed public lighting system is significantly more cost-effective for Novi Grad Municiplaity, by 28 KM or 14 EUR per lightbulb annually.

11.6.1 Sensitivity analysis

Sensitivity analysis includes an analysis of the impact of variables, which can lead to a change in either project costs or revenue, on the final result of the project. In this case, the variables that may affect the ultimate cost-effectiveness of implementing the selected scenario are investment costs (CAPEX) and operating costs (OPEX). For the purpose of making the sensitivity analysis, the changes of CAPEX and OPEX by +/- 5% were assumed and their impact on IRR, NPV, payback period and discounted payback period was analyzed.Table 33 shows the results of the sensitivity analysis.

11.6.2Sensitivity analysis

Sensitivity analysis includes an analysis of the impact of variables, which can lead to a change in either project costs or revenue, on the final result of the project. In this case, the variables that may affect the ultimate cost-effectiveness of implementing the selected scenario are investment costs (CAPEX) and operating costs (OPEX). For the purpose of making the sensitivity analysis, the changes of CAPEX and OPEX by +/- 5% were assumed and their impact on IRR, NPV, payback period and discounted payback period was analyzed.Table 33 shows the results of the sensitivity analysis.

Variable	Change	Result			
		IRR	NPV (EUR)	Payback period (year)	Discontonued payback period (year)
CAPEX	-5%	14%	279.851	7	8
	0%	13%	257.368	7	9
	5%	12%	234.886	7	9
OPEX	-5%	13%	258.729	7	9
	0%	13%	257.368	7	9
	5%	13%	256.008	7	9

Table 30: Sensitivity analysis

Based on the sensibility analysis it can be concluded that:

- CAPEX reduction by 5% leads to:
  - IRR increase by 1%;
  - NPV increase by 22.000 EUR;
  - Reduction of discounted payback period by 1 year
- CAPEX increase by 5 % leads to:
  - IRR reduction by 1%;
  - NPV reduction by 22.000 EUR;
  - Increase of discontinued payback period by 1 year
- Reduction or increase of OPEX by 5% has no significant influence on final profitability of the project.

12 ENVIROMENTAL AND SOCIAL ASSESSMENT

12.1 CO_2 reduction analysis

Earth is a large greenhouse in space where instead of glass, heat is maintained by some of the gases in the atmosphere. They let in the heat of the Sun that reaches the ground, and then retain it and maintain the temperature on a planet suitable for life. On the other hand, when coal burns, carbon combines with oxygen from the air and thus forms carbon dioxide - CO_2. Carbon dioxide is a colorless and odorless gas, and in the atmosphere it is one of the greenhouse gases. Increasing its concentration causes a decrease in heat loss by radiation from the Earth's surface into space and therefore increases the temperature on Earth.

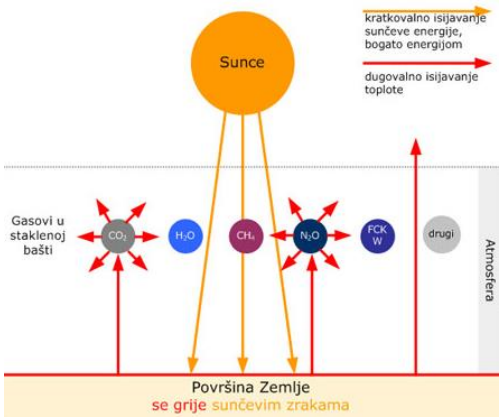

Image 63: Greenhouse effect

As CO_2 concentrations have increased over the last century the greenhouse effect is becoming more pronounced. The consequence is a global increase in average temperature which causes:

- melting of polar caps and glaciers,
- raising sea levels,
- climatic extremes,
- impact on agriculture.

According to the analysis of the current situation, at the locations in the city of Novi Grad that are the subject of this study, mostly sodium light sources are used, which are low-efficient in terms of electricity consumption, i.e. large consumers of electricity, which directly affects CO_2 greenhouse gas emissions.

CO_2 emissions from public lighting are indirect emissions from electricity consumption (emissions do not occur at the location of direct energy consumption), and data on annual electricity consumption and CO2 emission factor for electricity will be used as input data for the calculation. Emission factor for electricity according to the Ordinance on the methodology for calculating the energy performance of buildings (Official Gazette of RS No. 30/2015, 22.04.2015), which is obtained from the ratio of electricity produced from hydropower and thermal power plants depending on the structure of fossil fuels used (and other renewable sources) amounts to **0.7446 tCO2 / MWh.**

Accoridng to analyses of energy consumption and measures recommended in the chapter 7, what follows are results of CO_2 emission estimates for existing situation, scenario 1, scenario 2, sceanrio 3, reduction of electricity consumption and indirectCO_2 emissions resulting from the implementation of all mentioned measures.

Parameter	Exsiting situation	Scenario 1	Scenario 2	Scenario 3
Electricity consumption (kWh/year)	1.041.694	259.889	201.692	162.690
CO2 emission (t/year)	775,65	193,51	150,18	121,14
Savings (kWh)	-	781.806	840.002	879.004
Savings ofCO2 (t/year)	-	582,13	625,47	654,51
Reduction of emission of CO2 (%)	-	75,05%	80,64%	84,38%

Table 31: Electricity consumption for public lighting on analyzed coverage and associated CO_2 emissions

Based on results of estimates, annual indirect emission of CO_2 of public lighting of Novi Grad Municipality amount 775,65 tCO_2/year with annual consumption of electricity of 1,041,694 kWh/year. By impelmenting measures proposed by the project it is possible to achieve total emission reduction of 75,05% with the implementation of Scenario 1, 80,64% by implementing Scenario 2 and 84,38% by implementing Scenario 3. the biggest reduction of electricity consumption if achieved with the implementation of Scenario 3 and with it, indirect emission of CO_2 compared to the exisitng situation.

The reduction of harmful components into the atmosphere is in line with the tasks that BiH needs to fulfill in terms of implementing international obligations. As a signatory to a number of international agreements and conventions related to environmental protection and renewable sources (Southeast European Energy Community Treaty, Framework Convention on Climate Change, Kyoto Protocol, Espoo Convention, etc.) and the Stabilization and Association Agreement itself, Bosnia and Herzegovina is committed to respect the same. The members of the Energy Community have committed themselves to the implementation of a number of EU directives, including Directives 2001/77 / EC, 2003/30 / EC and 2009/28 / EC. The mentioned directives refer to the obligations of the EU member states, that is, the signatories, that they will work on the development and wider application of various renewable energy sources in the energy sector and transport.

In particular, Directive 2009/28 / EC provides a framework for the harmonization of activities and legislation related to the application of green technologies.[9]Adherence to the provisions of the

[9] Energy Community, Study of the Implementation of the New EU Renewables Directive in the Energy Community, juni 2010., p. 6., www.energy-community.org

2009 Directive would mean for BiH that the share of renewable sources will increase by 2% in the next two years, or by more than 6.5% in 2020 (to 33%) . By signing the Agreement on the Common Energy Market of Southeast Europe, BiH, like other members, has committed itself to transposing the acquis communautaire in the field of energy and environmental protection. The aim of establishing the Community, in addition to creating a single energy market, was to increase energy efficiency and the use of renewable energy sources.
BiH ratified the UN Framework Convention on Climate Change (UNFCCC) on December 6, 2000. As we are not a developed country (we do not belong to Annex I), we do not have a strict obligation to reduce greenhouse gases, but we have general obligations related to calculating annual greenhouse gas emissions, implementing measures to regulate anthropogenic emissions and measures to adapt to climate change, adoption and development of technologies that limit and reduce greenhouse gases.

12.2 Waste disposal

During the implementation of the project, the Investor is obliged, in accordance with the provisions of the Law on Environmental Protection ("Official Gazette of RS", No. 71/2012 and 79/2015) and the provisions of the Law on Waste Management ("Official Gazette of RS", Nos. 111/2013 and 106/2015), to take adequate waste management measures and provide basic measures to prevent waste generation, recycling and treatment of waste for reuse, extraction of raw materials and possible energy and safe disposal.

The project includes the dismantling of existing lamps which, according to the *Ordinance on categories, testing and classification of waste ("Official Gazette of RS", 1/15 and 79/18)* are classified as hazardous waste, i.e. any waste that has one or more characteristics that pose a danger to human health and the environment by their origin, composition or concentration, as well as that waste listed in the waste list as hazardous and regulated by an implementing regulation.
Therefore,the current legislation defines the manner of disposal of this type of waste, i.e. the operator / owner of waste is obliged to enter into a contract with an authorized company that deals with the collection and final disposal of this type of waste and with the prescribed documentation to hand it over. Also, the authorized company is obliged to give feedback to the owner of hazardous waste that the waste has been disposed of in the prescribed manner.

In order to minimize waste generation, during the implementation of project activities to replace existing lamps, it is necessary to take measures to prevent waste generation. One of the goals of waste management is controlled waste disposal, prevention of irresponsible waste management, controlled procurement of funds and education on waste management and safe disposal of waste while taking all necessary measures to protect human health and the environment.

Table 32 shows the waste flow of the Investor with a description of waste management practices, which the Investor is obliged to implement and the regulations according to which each measure is implemented.

No.	Emission	Description of the procedure of waste disposal management	Final disposal	Relevant regulation in RS that prescribe it
1.	Electronic waste from the removal of existing lamps	Proper temporary storage in a specially designated place and special containers -Removal by special vehicles by an authorized company -Handing it over to an authorized company for further management	Authorized company for this type of waste with which the Investor will enter into a contract	The Law on Waste Management (Official Gazette of RS, 111/13, 106/15, 16/18) The Rulebook on the manner of storage, packaging and labeling of hazardous waste (Official Gazette of RS, 49/15)

Table 32: Waste management procedures in accordancee with regulations in RS and EU legislation

12.3 Light pollution

Light pollution includes any unnecessary emission of artificial light in a space outside the zone that needs to be illuminated. The main causes of this type of pollution include mainly improper installation and design of lighting fixtures and therefore when installing new lighting fixtures or designing a new public lighting network, it is important to adjust the design that will have the least negative impact.

In addition, light pollution can be avoided by using environmentally friendly lighting fixtures that do not scatter light outside the space that needs to be illuminated. According to the data of the First World Atlas of Light Pollution from 2001, 82% of the population in Bosnia and Herzegovina is exposed to clear skies whose light is greater than the natural light of the night sky: threshold bp which determines that the night sky is polluted [i.e. when the light of the artificial sky is greater than 10% of the natural light of the night sky above 45 ° altitude (Smith 1979)[10]

[10] The first World Atlas of the artificial night sky brightness, P. Cinzano, F. Falchi, C.D. Elvidge, December 2001, Monthly Notices of the Royal Astronomical Society, Volume 328, Issue 3, December 2001, Pages 689 f707

Image 64: Satellite image of Europe during nighti[11]

If we take into account that light pollution cannot be completely avoided, it is necessary to minimize negative impacts by applying simple principles and measures. Also, unlike other types of pollution, the results of the application of measures to reduce light pollution are visible immediately, at least at the local level. Effective reduction measures are based on the following principles:

- Artificial light should be directed where it is needed and emissions outside the coverage area should be minimized
- Depending on the purpose, it is necessary to ensure that the illumination does not exceed the required minimum
- Whenever possible, it is necessary to use light of warm tones and continuous spectrum, and avoid sources that emit a lot of light energy in the blue, purple and near UV range of the spectrum.

If we compare the current lighting fixtures and the project proposed lightbulbs, the current lighting fixtures in Novi Grad Municipality are designed to emit light in almost all directions, and the efficiency of emitted light to illuminate the desired area is only 10- 30%. This type includes all those lighting fixtures in which the glass ball or hemisphere is "thrown" out of the luminaire housing. The use of these lighting fixtures is usually extremely energy inefficient, i.e. 30- 40% of electricity is wasted unnecessarily, which is also shown in the earlier chapters in which the comparison of electricity consumption was made.

Unlike existing lighting fixtures, the project envisaged alternative environmentally friendly lighting fixtures that are full cutoff and have the ability to control light emission and not allow light to be scattered into the environment. Such luminaries have flat glass on the underside, and the cheaper versions are without glass and illuminate only the target area, without unnecessarily emitting light to the side and towards the sky. The implementation of measures to replace inefficient lighting fixtures in the city of Novi Grad achieves a significant reduction in light pollution and reduces the risks that this type of pollution has on the health and safety of residents.

[11] http://www.savethenight.eu/Lights%20in%20Europe.html

13 COMPARATIVE ANALYSIS OF PUBLIC LIGHTING ENERGY CONSUMPTION INDICATORS

When analyzing electricity consumption, it is necessary to provide consumption indicators in order to identify and analyze energy consumption in the system, compare consumption before and after the implementation of energy efficiency measures, and ultimately make comparisons on an annual level or with similar systems of other Cities / Municipalities. Energy consumption indicators are values derived from parameters that describe or provide information on the state of energy consumption of the system. They appear as indices (a set of aggregated parameters or parameters with weight fractions), or as parameters (value measured or evaluated). Without energy consumption indicators in the field of energy, energy management is inconceivable, precisely because they provide a link between human activities, energy changes, but also the effects of measures. Indicators allow individual systems to be compared with other or to be monitored over a longer period of time. Therefore, the indicators will be used to analyze the energy consumption of the system.

Energy consumption indicators can be expressed as ratios of produced / consumed energy per lamp unit or some similar criterion.

Therefore, the indicator of annual energy consumption can be presented through the ratio of total annual energy consumption (P, kWh) of the system and e.g. by the number of light sources (Br, number), for which the following equation is used:

$$E = \frac{P}{B_r} \tag{9.}$$

Apart from the number of light bulbs, energy consumption can be expressed by the total area of the Municipality / City or the considered part of the public lighting system or by other specifics that have an impact on energy consumption, and this energy consumption indicator can be presented by the ratio of total annual electricity consumption. (City, Municipality, Street, etc.) and considered areas (City, Municipality, Street, etc.):

$$E = \frac{P}{A} \tag{10.}$$

In addition to these, there are other ways of expressing electricity consumption indicators, so in the case of this system, the indicators of actual electricity consumption are provided in earlier chapters.

13.1 Inditors of energy consumption for current situation

In order to compare and analyze the consumption of electricity for public lighting, it is necessary to provide indicators of energy consumption in the public lighting system. Electricity consumption indicators can depend on many factors such as geographical location, degree of utility of the system and the like. For the purpose of analysis of electricity consumption for public lighting, the most important indicators are given below, which will be analyzed even after the possible

implementation of the proposed energy efficiency measures, i.e. the realization of the optimal scenario. By having indicators for the current state of energy consumption, and indicators of energy consumption after the proposed energy efficiency measures, a comparative analysis of these indicators is possible.

Thus, the following energy consumption indicators will be considered:

- Number of light sources (pcs),
- Required electricity for public lighting (kWh / year),
- Specific annual consumption (kWh / light source /yr).

The most relevant and most frequently analyzed indicator is the consumption of electricity for public lighting by light source (kWh / pc per year).

The specific consumption of electricity, i.e. the need for electricity for public lighting, depends on the size of the system, i.e. the number of light sources. The listed indicators of electricity consumption for public lighting for the current situation are given in Table 33.

Indicator	Value
Number of light sources (pcs)	1846
Required electricity for public lighting (kWh/year)	1041694,38
Specific annual consumption (kWh/light source /year god)	564,30

Table 33: Overview of electricity consumption indicators for public lighting for current situation

It can be seen that required public lighting electricity for the current state is 1041694,38 kWh / year. If this value is divided by the considered number of light sources, it is obtained that the specific annual consumption is 564,30kWh / light source per year.

13.2 Indicators of energy consumption after implementation of energy efficiency measures

Following the implementation of the proposed measures to increase energy efficiency, electricity consumption for public lighting would be reduced. This reduction in electricity consumption is represented by the energy indicators provided in Table 37, according to the optimal scenario described earlier in the document.

Indicator	Value
Number of light sources (pcs)	1.846
Reguired electricity for public lighting (kWh/year)	201692,12
Specific annual consumption (kWh/light source year)	109,26

Table 34: Overview of electricity consumption indicators for public lighting after implementation of proposed measures

It can be seen from the table that the electricity needs would be reduced and amount 201692,12 kWh/ year, and thus the specific electricity consumption per light source on an annual basis would be reduced to 109,26 kWh/ light source per year.

13.3 Comparative analysis of indicators of electricity consumption and needs for electricity for current situation and after implementation of measures

The comparative analysis established the state of electricity needs for public lighting before and after the implementation of energy efficiency measures. As expected, the electricity needs after the implementation of energy efficiency measures would be reduced. An overview of indicators before and after the implementation of energy efficiency measures is given in Table 35.

Indicator	Current state	State after
Electricity needed for public lighting (kWh/year)	1041694,38	201692,12
Specific annual production (kWh/light source year)	564,30	109,26

Table 35: Overview of indicators before and after implementation of proposed EE measures

Comparing the relevant indicators before and after the implementation of energy efficiency measures (according to the optimal scenario), it is obvious that the electricity needs are reduced by 80,64%, and thus the specific annual consumption from 564,30 kWh/ light source to 109,26 kWh / light source/ yr.

14 CONCLUSION

Through the preparation of the Study for the replacement of existing lighting fixtures with LED lighting, the key aspects that are important in the implementation of such a project were considered and analyzed. The identification of the initial state of the lighting system was done, which determined the basis for further conceptual design of the system. It was determined that such solutions make sense and that the effects after the implementation of the project are positive both financially and environmentally.

The first part of the study focused on the analysis of the current state of light sources, electrical characteristics and electricity consumption. A field visit revealed that the lamps are of very low energy efficiency.

The second part of the study included an analysis of the electricity consumption of the public lighting system. It has been established that the costs for electricity in the last three years amount to 0.1647 KM / kWh.

The fourth part of the study is the one in which the cost-effectiveness analysis of all proposed measures was performed. All measures are cost-effective within acceptable deadlines. Combinations of measures (scenarios) have been proposed and it has been shown that the optimal scenario is scenario 2. In addition, the reduction of CO_2 emissions has been calculated if any of the scenarios is realized.

If the measures are carried out according to the optimal scenario, it is possible to achieve energy savings of 80,64%. The investment would pay off in 7 years according to current electricity prices.

15 APPENDICES

- Geolocation coordinates of poles and lighting fixtures
- Imagemetric calculations of new lighting with LED technology on the streets

15.1 Geolocation coordinates of poles, light fixtures and BMP

15.2 Imagemetric estimates of new lighting with LED technology per streets

15.3 Specification of equipment and overview of public lighting works