SOLUTION FOR MODERNIZING THE PUBLIC STREET LIGHTING SYSTEM WITH LED TYPE LAMPS AND REMOTE MANAGEMENT

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Abstract - The paper aims at the analysis to the establishment of the optimal solution regarding the efficiency and modernization of the rural public lighting. Thus, two possible scenarios are analyzed in which it is considered to replace the current lighting system with a lighting system with LEDs equipped or not, with remote control modules, equipping the ignition points with remote management modules and the realization of a lighting system remote management for lighting.

Keywords: lighting, modernization, led lamps, remote management.

1. INTRODUCTION

Public lighting is one of the quality criteria of modern civilization. Its role is to ensure both the safe orientation and movement of pedestrians and vehicles at night, and to create a proper environment in the hours without natural light, [1]. Achieving adequate lighting in particular reduces indirect costs, reduces unwanted events, and improves the social and cultural climate by increasing the safety of activities during the night.

Sources with high or low pressure discharge in existing sodium vapor have very good light efficiency, producing a yellow monochrome light (color rendering index Ra = 20), they are recommended in street lighting.

LED luminaires, compared to luminaires with high pressure discharge sources, have high light and energy efficiency (minimum 150 lm / W, including optical and source losses), an index of color rendering Ra> 70 and a nominal service life of at least 100,000 hours.

The depreciation of the parameters of LED luminaires is much lower than that of luminaires with sodium sources. Another major advantage of LED luminaires is the possibility of easy control of the luminous flux, without extinguishing the lamp, by adjusting the parameters of the power supply (dimming) and respectively the possibility of lighting, reducing the flow or selective switching off, individually or in logically organized groups, luminaires (telemanagement) depending on the place of use or needs.

Thus it can order the reduction of light flux between certain hours with low traffic on some parts of the street while in intersections, pedestrian crossings or risk areas the lighting works at maximum parameters, or you can order the reduction or even complete extinction of lighting in areas in which there is no activity during the night (dedicated parking lots). This leads, by changing the power supply, to reducing the power consumed and finally to reducing the consumption of electricity for lighting, [4].

LED luminaires, through the above characteristics, are a modern alternative for eliminating the disadvantages of sources with high pressure discharge in mercury or sodium vapor and the achievement of an efficient lighting system with low operating and maintenance costs.

2. USE OF PHOTOVOLTAIC INSTALLATIONS TO ENSURE URBAN STREET PUBLIC LIGHTING. CASE STUDY.

2.1. Analysis of the existing situation

Some of the lighting networks and equipment in the locality under analysis are obsolete, with an advanced degree of wear, which leads to high maintenance costs and high energy consumption. For the modernization and efficiency of public lighting in the locality, parts were studied of public lighting installations: public lighting network, lighting fixtures, lighting points and network poles. Currently, the public lighting in the locality are as follows:

- The distribution networks are overhead and mostly classic type with non-insulated conductors and with no common with the supply network of private consumers.
- The existing pillars are made of concrete (type SE4, SE I 0, SE II, SC 10002 or SC 10005);
- Existing luminaires are mostly equipped with energy-saving lamps, and partly with sodium vapor discharge lamps.
- The installed power of the luminaires is about 14.72 kW.

The general condition of the local lighting system in the locality is worrying, having outdated, inefficient equipment and an advanced degree of wear; unjustifiably high electricity costs compared to light efficiency; very high maintenance / upkeep costs generated by the poor condition of the system; the unfair and inefficient distribution of light points in the territory, so that while in some areas the lighting is missing or poor, in others there is a high density; uneven light distribution with the standards in force and which creates difficulties for traffic participants.

It is found that the streets have, for the most part, a good distribution of lighting poles, arranged at distances between them of about 35-37 m on the secondary streets and 36-37 m on the main streets. The control of the current lighting system is centralized from 12 existing ignition points powered by 20/0.4 kV overhead substations.

2.2. Possible scenarios for the evolution and development of the lighting system

Scenario 0

Scenario 0, of continuity, consists in maintaining the current situation of the public street lighting system involving only maintenance-maintenance expenses. However, it is necessary to replace defective equipment, power cables and conductors, mains clamps, CDD type; destroyed dispersers; defective or damaged metal fittings; electrical switchboards of public lighting points depending on their state of degradation; protections and components of the ignition points; periodic verification of the dispersion resistance of the earthling sockets at the ignition points and those related to the power supply network of public lighting system.

Scenario1

For the public lighting system, works are required to dismantle the current old luminaires and to install LED street lighting fixtures on all existing poles with 0.44kV OHL network - 24W public lighting on secondary streets and 55W on main roads.

The designed installed power is: 25.97 kW. There is approximately a doubling of the value of the installed power and at the same time a better lighting, by installing lighting fixtures on all existing poles, compared to the existing arrangement of luminaires on 44% of the number of poles. It is also possible to reduce the installed power on the light point from about 55.1 W to about 43.5 W and increase the light efficiency 40-80 lm / W to over 150 lm / W.

Scenario 2

In this scenario, the public lighting system requires the dismantling of the current old lighting fixtures and the installation of LED street lighting fixtures equipped with remote management modules on all existing poles with 0.4 k V OHL public lighting 24W on secondary streets and 55W on main roads, equipping the ignition points with remote management modules and creating a remote management system for lighting.

The recommended scenario is scenario 2 which ensures a modern lighting system, with high light and energy efficiency, with a long lifespan (minimum 100,000 hours) applying modern standards on lighting on main and secondary roads.

The scenario provides for the installation of an LED luminaire, a luminaire with a very good color rendering index. At the same time, it ensures the solution of the major problems of the public lighting system and contributes to the reduction of electricity expenses, to the reduction of carbon dioxide emissions by using efficient lighting fixtures and modernizing the existing lighting point.

The telemanagement system also includes a dimming program to increase the energy efficiency of the street lighting system and reduce electricity costs. This reduces the luminous flux of the lamps in hourly intervals with low traffic and the absence, almost entirely, of pedestrian traffic.

Table 1 - Comparative analysis of possible evolution scenarios

Nr. crt.	Comparation element	Measure unit	Possibile scenarios		
			0	1	2
1	AIL life time	h	20,000	100,000	100,000
2	Lighting objects	buc.	0	608	608
3	Remote management modules for existing ignition points	buc	0	0	12
4	Remote management modules for lighting fixtures	buc.	0	0	608
5	Estimated work costs	RON	0	524,029.56	1,023,874.53

The objectives to be achieved by the implementation of the new street lighting system are:

- Energy saving - the efficiency of LED lighting systems is superior to incandescent and gas discharge lamps, thus saving energy and reducing the electricity bill;
- Light efficiency - LED systems produce more light per watt consumed than other types of lamps. Strict control of light scattering achieved through the optical system with lenses for focusing the rectangular light beam ensures light pollution; the lens has the role of reducing light loss, eliminating the risk of blindness;
- Color - LED systems can emit the shade of light - the desired color without the use of color filters. The warm, neutral or cold light obtained is very close to natural light, shows the true color of objects and increases comfort and visibility at night;
- On-off time - from the moment of powering, the LED luminaires light practically instantaneously at maximum intensity, without any delays, supporting very well the on-off regimes;
- Luminous intensity - each module has a constant light intensity regardless of the fluctuations of the mains voltage;

Power factor - LED systems have a power factor greater than 0.98 which substantially reduces additional network losses;

When choosing the luminaires from the point of view of the constructive criteria, the results of the lighting calculations were taken into account, the framing of the roads in accordance with SR EN 13201: 2015 and the location on the poles, respectively their arrangement. The selection and location criteria of the bodies took into account the traffic density in different areas, the traffic participants, as well as the risk areas for traffic safety (we use public transport stations, intersections).The sizing of the construction elements of the installations and technical solutions was performed according to the regulations in the field and the results of the lighting calculations. In order to establish the solutions of the lighting systems, the following standards were observed: SR EN 13201: 2015 “Public lighting”, CIE 115/2010 “Light of roads for motor and pedestrian traffic” and NP

062-2002 “Norm for the design of road lighting systems and pedestrian ”, [7], [8], [9].

For the realization of the lighting projects, the specialized software DIALux was used, establishing the number of necessary lighting devices, their power, the lighting levels related to the roads.

Figures from 1 to 4 presents the results of the lighting calculation performed in DIALux for the main street,[6], included according to the standard SR EN 13201: 2015 „Public lighting. Part 1: Selection of lighting classes”, in the lighting class for motorized traffic, M5.

In figure 1 were defined observers for each lane, positioned in the middle of them, for each observer checking the minimum required lighting parameters.

For the sizing of the lighting system, control situations were used for each road class, taking into account the location constraints.

The lighting project is based on the following data: average distance between poles, 37m; height of the light point, 8 m; the exit of the light point in the console (-3,105 m); tilt the console 15.0o; console length, 0.900 m; the location of the pillars, unilateral; reflection coefficient 0.07 - R3 corresponding to asphalt road pavement; the poles are placed at the edge of the road surface at a distance that does not influence the various existing utility networks, annual number of operating hours, 4,150h; consumption of 1444.5 W / km. For maintenance, a maintenance factor of 0.80 was taken into account, see figure 1.

DJ M5: Alternative 1 / Roadway 1 (M5) / Table

Roadway 1 (M5)

Horizontal illuminance [lx]

5.958	11.6	10.2	8.14	6.71	5.30	4.34	4.03	4.34	5.21	6.49	8.02	10.2	11.8
4.875	14.9	12.6	9.72	7.67	5.87	4.73	4.31	4.70	5.77	7.27	9.41	12.6	15.1
3.792	18.6	15.1	11.2	8.59	6.44	5.08	4.54	5.01	6.23	7.99	10.7	15.0	18.9
2.708	22.6	17.6	12.4	9.22	6.87	5.28	4.69	5.17	6.51	8.42	11.8	17.3	22.8
1.625	25.8	19.2	13.0	9.52	7.07	5.31	4.73	5.17	6.63	8.52	12.3	19.0	26.0
0.542	27.2	19.5	12.9	9.36	6.99	5.15	4.66	5.01	6.50	8.21	12.0	19.2	27.5
m	1.423	4.269	7.115	9.962	12.808	15.654	18.500	21.346	24.192	27.038	29.885	32.731	35.577

Grid: 13 x 6 Points

Em [lx]	Emin [lx]	Emax [lx]	g1	g2
10.5	4.03	27.5	0.382	0.147

Fig.1 - Lighting calculation main road [6]

In figure 2 it is presented the table of values, generated in DIALux, for the maintenance value of the horizontal lighting intensity.

DJ M5: Alternative 1 / Roadway 1 (M5) / Results summary

Roadway 1 (M5)

Light loss factor: 0.80
Grid: 13 x 6 Points

Lm [cd/m²] ≥ 0.50	Uo ≥ 0.35	Ul ≥ 0.40	TI [%] ≤ 15	EIR ≥ 0.30
✓ 0.56	✓ 0.45	✓ 0.46	✓ 11	✓ 0.57

Assigned observer (2):

Observer	Position [m]	Lm [cd/m²] ≥ 0.50	Uo ≥ 0.35
Observer 1	(-60.000, 1.625, 1.500)	0.56	0.47
Observer 2	(-60.000, 4.875, 1.500)	0.61	0.45

Fig. 2 - Horizontal illumination calculation [6]

Figure 3 shows the maintenance value for the light density with the dry road, respectively with the new lighting installation.

DJ M5: Alternative 1 / Roadway 1 (M5) / Table

Observer 1

Luminance with dry roadway [cd/m²]

5.958	0.46	0.41	0.35	0.32	0.28	0.27	0.27	0.30	0.32	0.36	0.40	0.44	0.48
4.875	0.56	0.50	0.41	0.37	0.32	0.30	0.30	0.34	0.38	0.43	0.49	0.56	0.60
3.792	0.70	0.58	0.46	0.41	0.36	0.34	0.34	0.40	0.46	0.51	0.57	0.68	0.75
2.708	0.82	0.69	0.54	0.47	0.41	0.40	0.41	0.47	0.55	0.60	0.69	0.83	0.91
1.625	0.95	0.77	0.60	0.52	0.49	0.49	0.51	0.57	0.67	0.70	0.78	0.93	1.06
0.542	1.01	0.81	0.67	0.62	0.61	0.62	0.68	0.73	0.83	0.81	0.85	1.00	1.12
m	1.423	4.269	7.115	9.962	12.808	15.654	18.500	21.346	24.192	27.038	29.885	32.731	35.577

Grid: 13 x 6 Points

Lm [cd/m²]	Lmin [cd/m²]	Lmax [cd/m²]	g1	g2
0.56	0.27	1.12	0.472	0.237

Luminance with new lamp [cd/m²]

5.958	0.58	0.51	0.43	0.40	0.35	0.33	0.33	0.37	0.40	0.45	0.50	0.55	0.60
4.875	0.71	0.62	0.51	0.46	0.39	0.38	0.37	0.43	0.47	0.54	0.61	0.71	0.75
3.792	0.87	0.73	0.58	0.52	0.45	0.43	0.43	0.50	0.58	0.64	0.71	0.85	0.94
2.708	1.02	0.86	0.68	0.59	0.51	0.50	0.52	0.59	0.69	0.75	0.86	1.04	1.14
1.625	1.19	0.97	0.76	0.65	0.61	0.62	0.64	0.71	0.84	0.87	0.97	1.17	1.32
0.542	1.26	1.01	0.83	0.78	0.76	0.77	0.85	0.91	1.03	1.01	1.06	1.25	1.40
m	1.423	4.269	7.115	9.962	12.808	15.654	18.500	21.346	24.192	27.038	29.885	32.731	35.577

Grid: 13 x 6 Points

Lm [cd/m²]	Lmin [cd/m²]	Lmax [cd/m²]	g1	g2
0.70	0.33	1.40	0.472	0.237

Fig. 3 - Values table of luminance with dry roadway and new system [6]

Figure 4 presents the isolux lines for the maintenance value for the light density with the dry road, respectively with the new lighting installation.

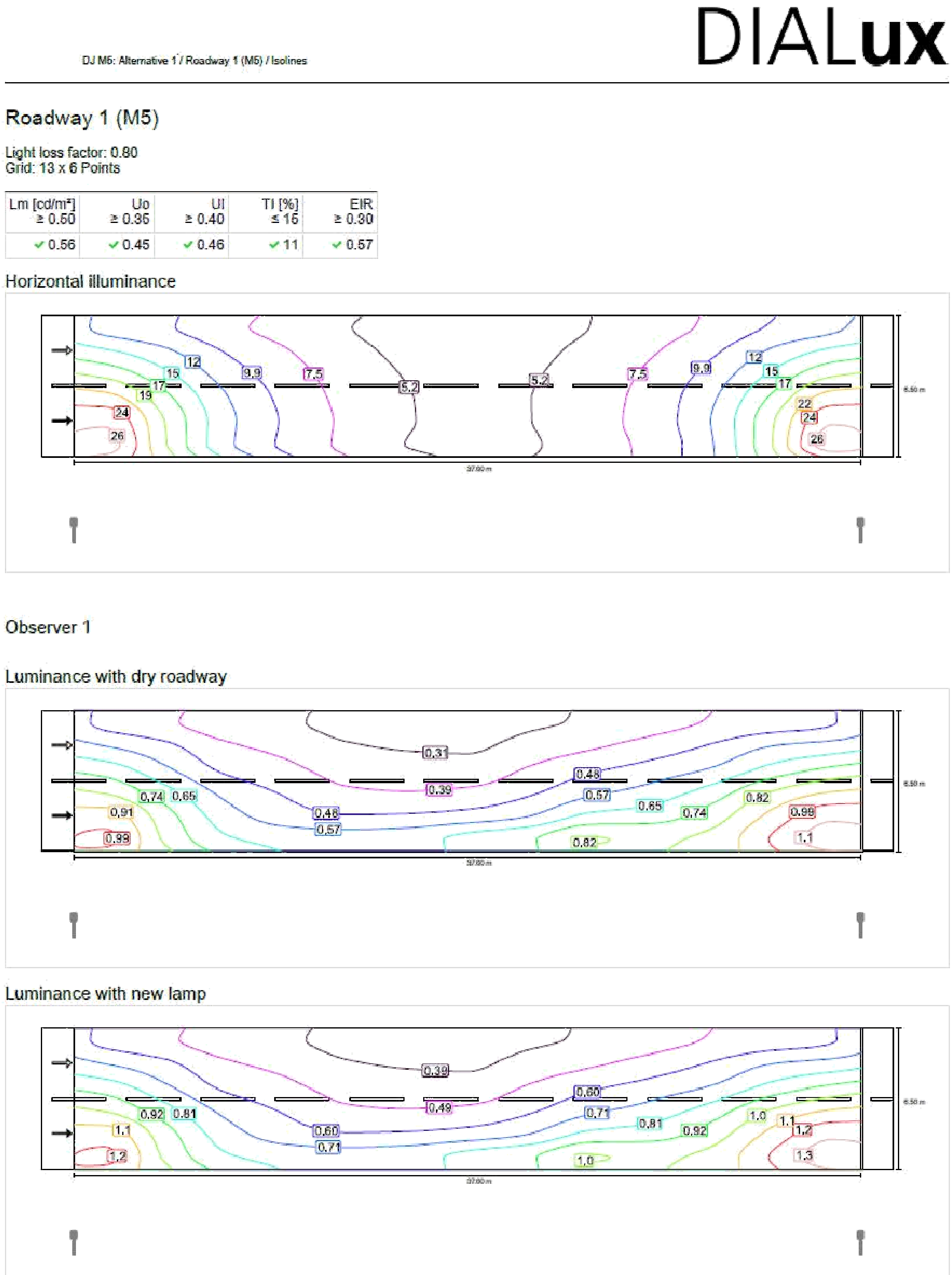

Fig.4 - Isolines for horizontal luminance and luminance with dry roadway and new system [6]

3. CONCLUSION

By framing the main roads in the M5 lighting standard, a better lighting is ensured, this being the street with the highest traffic. The use of longer brackets, which bring the mounting height of the bodies to 8 m leads to better lighting of the area with a much higher uniformity of light.

The installation of LED luminaires with a high degree of protection and impact resistance (IKIO, JP66) ensures conditions for maintaining the initial characteristics over time and reducing maintenance costs.

The estimated cost of energy per year, considering that the operating time of the lamps 4180 hours / year is 130Euro / MWh.

The implementation of the new system reduces the number of systematic inspections for checking lamps, the time for cleaning the optical system, the duration of interventions and downtime and reduces maintenance costs and electricity for lighting due to the high efficiency of lighting fixtures.

Due to the operating period of 100,000 operating hours and the average annual operating time of the system of 4,150 hours, then it turns out that this new system will be in operation for about 24 years. The efficiency of the remote management system is given by the operating costs related to the lifetime. Thus, the remote control system at the flash point will use the LoRa communication protocol or equivalent. The equivalence lies in the lack of costs with data transmission through the technology used.

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