

Energy Efficient Modernization of Road Lighting in the Town of Dobrich, Bulgaria

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Abstract – The paper presents the approaches to introducing modern energy efficient road lighting in an average Bulgarian town and the results of the implemented project.

Keywords – high-pressure sodium lamp, luminaire, street lighting, lighting design, energy efficiency.

I. INTRODUCTION

The town of Dobrich is situated in the North-East of Bulgaria, at a distance of 50 km from Varna and 30 km from the Black Sea resort Albena. The population of Dobrich with its satellite villages is 104 000 inhabitants.

The paper presents the approaches to introducing modern energy efficient road lighting in an average Bulgarian town and the results of the implemented project.

The major goals and objectives of the project are: improving the quality of road lighting in accordance with the recommendations of Bulgarian and European standards; increasing the energy efficiency of road lighting; reducing the power consumption and the costs incurred by the Municipality on road lighting; providing secure passage and safety in the streets.

The most significant results of the project are as follows:

- a) Introducing road categories in accordance with:
 - Bulgarian State Standard 5504-82 "Lighting of Streets and Pedestrian Zones", [1];
 - New European Recommended Values EN 13201 - Road Lighting, [2].

According to the New European Recommended Values, the percentage of minor streets is increased in proportion to the decrease in major roads and highways. This brings about a reduction in the required power installed and annual power consumption. The system of road categories proposed is very comprehensive and precise, which is a prerequisite for determining the actual road category exactly.

- b) Replacement of high-pressure mercury lamps of 250 W and 125 W by high-pressure sodium lamps of 150 W, 100 W, 70 W, 50 W and compact fluorescent lamps of 36 W and 55 W, as well as reduction in the overall road lighting power installed.

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- c) Modern control of road lighting. The road lighting of Dobrich is "all-night" and the system of "all-night" and "half-night" lighting requires 50 % or 33 % of the light sources to be switched off after 10 p.m. or after midnight. In this way the power consumption is reduced by 30÷35 %. This measure should not be applied for local and collector roads, as this would result in an increased crime rate and less safety for pedestrians.

- d) Environment Protection. The decrease in the power consumed for road lighting leads to a corresponding decrease in the power produced and, indirectly, to a drop in the harmful emissions in the atmosphere.

One of the main objectives of road lighting is to provide for the safe passage of vehicles and pedestrians in the evening and at night and to establish conditions for increasing the traffic capacity of the road network.

Road accidents present one of the major communication problems nowadays. It is interesting to note that a great number of road accidents happen in the evenings or at night, when an average of 25 % of the overall road traffic takes place. The number of casualties during this period is approximately equal to the number of casualties in the daytime, when 75 % of the road traffic takes place.

II. ENERGY AUDIT

Energy research has been carried out and the following problems have been studied:

- Examining the position and the number of transformers supplying the road lighting network in the neighbourhoods, as well as the available electric meters;
- Studying the number, type and power of road-lighting luminaries supplied by each transformer;
- Taking the existing position of posts in cadastre plan;
- Measuring the illuminance level of road lighting.

The territory of the town is being studied and developed in its graphic part, based on the town cadastre plan, presented on paper or in digital model.

The road lighting in the town is supplied by 180 transformers and boards for road lighting with an open circuit. The power supply of the specific luminaries from the respective road lighting board have been studied.

The energy research has shown that 3 855 road lighting luminaries all together comprising 1 143 luminaries of 110 W, 1 911 of 210 W and 801 of 250 W. the number of decorative luminaries is 3 430, among them 356 of 50 W, 3 032 of 110 W and 42 of 250 W. The total number of luminaries is 7 285.

TABLE I
MULTI-VERSION LIGHT ENGINEERING CALCULATIONS – MAJOR ROAD CATEGORY, BUL. “DOBRUDJA”, DOBRICH

Company and Brand of the Luminaire Type and Power of the Light Source	Calculated Qualitative and Quantitative Light Engineering Indicators						
	L_{cp}	$\frac{L_{min}}{L_{cp}}$	U_l	TI	G	E_{cp}	$\frac{E_{min}}{E_{cp}}$
	[cd/m ²]	-	-	[%]	-	[lx]	-
PHILIPS SGS 102/150T SON-T+ 150W	0.94	0.86	0.84	7.70	5.30	17.60	0.54
PHILIPS SGS 305/150T SON-T+ 150W	1.32	0.73	0.83	10.10	5.90	20.00	0.62
СВЕТЛИНА Ст. 3. 900.188 SON-T+ 150W	1.26	0.54	0.51	11.00	-	18.30	0.54
DIMOV 00730 I57 HJIBH-T 150W	1.03	0.50	0.30	8.00	-	17.10	0.74
HIT JOTA SHP-TS 150W	0.86	0.45	0.57	7.30	-	13.50	0.54
HIT PRIMO SHP-TS 150W	1.03	0.72	0.66	8.10	5.60	19.80	0.55
LUMINEX LUM 5 - 150 W I36 HJIBH-T 150W	1.21	0.68	0.55	11	4.6	14.2	0.46
ITALMODALUCE ASTRA 2 HJIBH-E 150W	1.1	0.57	0.56	13.6	4.5	15.9	0.49

Total power installed of 1 209 354 W is distributed according to the power of the lamps used as follows: 50W lamps – 21 182 W, 110 W lamps – 521 875 W, 210 W lamps – 439 530 W, 250 W lamps – 226 767 W.

The road lighting level in the Dobrich areas studied is determined by measuring the value of the average illuminance of the road surface between two lamps posts. The average illuminance studied varies over a broad range according to the different road categories and the lighting uniformity is inadmissibly low.

III. LIGHTING DESIGN

Based on the light engineering classification of road categories and in accordance with the Bulgarian and the new European standards requirements have been accepted for the average road surface luminance L_{ave} , the overall uniformity ratio U_0 , the lengthwise uniformity ratio U_l , threshold increment TI and glare control mark G.

The light engineering calculation present the decisions for the choice of the most suitable light source and luminaire for modernizing the road lighting in Dobrich. The calculations have been carried out using specialized software product CalcuLuX Road 4.5b – Philips. The characteristics of luminaries manufactured by eight Bulgarian and foreign companies have been used – Table I, and multi-version comparative calculations have been performed with them for each of the 224 streets. The differences in the calculated results obtained are due to the different optical system and different luminous intensity diagrams of luminaries of different manufacturers, having equal power – Table I.

IV. ENERGY EFFICIENCY

Table II and Fig. 1 present the energy and technical indicators of the road lighting modernization in Dobrich after the replacement of 7 285 luminaries with high-pressure mercury lamps by 5 310 luminaries with high-pressure sodium lamps. The existing power installed 1 209 354 W is reduced to 437 384 W, i.e. by 64 % or 2.8 times, thus proving the expediency and energy efficiency of the implemented project.

TABLE II
ENERGY AND TECHNICAL INDICATORS OF THE ROAD LIGHTING
MODERNIZATION IN DOBRICH

Road Category	Existing Lighting with Mercury lamps		Modernized Lighting with high-pressure Sodium Lamps		Economy
	Number of Luminaires	Total Power, W	Number of Luminaires	Total Power, W	Installed Power, W
Major	1 487	349 510	725	111 054	238 456
Radial	631	105 659	599	56 554	49 105
Collector	1 396	269 064	1 145	95 416	173 648
Local	3 081	412 814	2 232	132 804	280 010
Pedestrian	690	72 307	609	41 556	30 751
Total	7 285	1 209 354	5 310	437 384	771 970

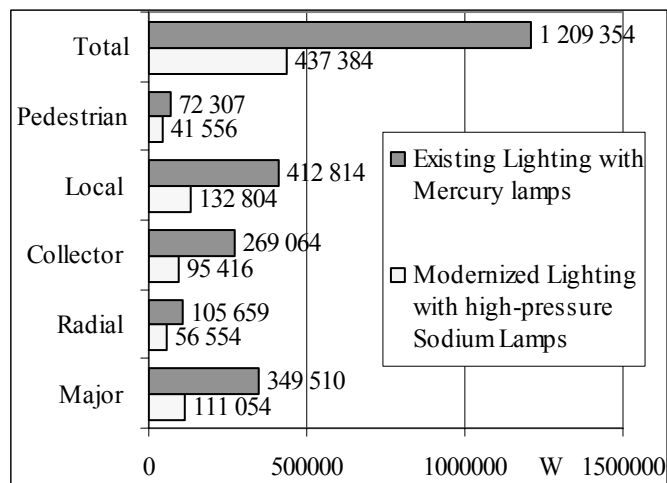


Fig. 1. Installed Power

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- [1] Bulgarian State Standard 5504-82 “Lighting of Streets and Pedestrian Zones”.
- [2] European Recommended Values EN 13201 - Road Lighting.
- [3] Baer, R., M. Eckert, D. Gall, Beleuchtungstechnik, Anwendungen, Verlag Technik GmbH Berlin-München, 1993