Energy Saving activities in Public Lighting of Slovak Republic

SMOLA Alfonz - GASPAROVSKY Dionyz

Abstract
The paper deals with technical and economic problems of energy saving possible achievements in public lighting, according to special conditions of Slovakian energy market. Essence of new „puzzle“ method on public lighting design and reconstruction ellaborated at SUT is described, some first realized projects and practical application of puzzle method are presented.

Introduction

Aimed to find out possible areas of energy market of Slovak Republic with significant potentials in energy saving, a huge investigation has been carried out within the programme DSM Slovakia. Results of investigation performed in the frame of the DSM programme Slovakia showed that 16% of energy consumption takes the lighting. Especially, public lighting seems to be an important item having big reserves in energy efficiency of installed light sources and in lighting control as well. In many cases, lighting system is not designed to be optimal in means of luminous flux distribution and geometry of lighting system. Therefore, additional research has been done in cooperation between Slovak University of Technology (SUT) and Slovak Electric Company, oriented towards ellaboration of methodology for optimized reconstruction of existing public lighting systems applicable for technical and economic conditions of Slovak Republic.

Energy saving options for public lighting

Efficient light sources

If common incandescent bulbs are used, it is necessary to replace them by either compact fluorescent lamps (CFLs) or sodium high-pressure discharge lamps. Due to big number of mercury high-pressure lamps used in public lighting in Slovak republic, there exists a big potential of energy saving when replacing these light sources of efficacy about 80 lm/W by sodium lamps with efficacy up to 150 lm/W. The problem is that common sodium lamps require a device called starter which in some cases may lead to installation of new luminaires and the price of reconstruction increases. The use of more efficient luminare but may reach additional savings as it will be explained further. There also exist a special kind of sodium lamps that do not require a starter and can directly exchange mercury lamps. Price of such sodium lamps is higher than of normal sodium lamps.

Efficient luminaires

Modern luminaires have cover made of unbreakable polycarbonate which prevents this device from damage. Covering class exceeding IP 65 prevents from penetration of dust and dirt into body of luminaire and deposition of dust onto optical system. Reflector made of high-reflectace aluminium mirror contributes to increase the efficiency and to form an optimal light intensity distribution curve (LIDC) of luminaire. Maintanence of luminaire can be reduced then to time when light sources are usually exchanged (once in three years).

Efficient lighting system

Complete re-build of lighting system requires a huge investments including replacement of light sources, luminaires, poles, installations and distribution boxes. Only by this complete reconstruction it is possible to reach maximum savings, but investments cannot be effectively covered only by savings, according to life expectacy of lighting system (approx. 20 years). In spite of this, such reconstruction is very needed in existing lighting system in Slovakia, because most of installed systems are in very bad condition. Additional financial sources are expected to be found.

Lighting controls

Control of public lighting means regulating the luminous flux of sources to decrease the energy consumption in time, when there is no heavy traffic (from 11pm to 4am). Luminous flux is possible to decrease by switching or dimming. Switching of groups (e.g. each second luminaire) is not the best solution due to deterioration of uniformity. Double sourced luminaires provide a better way to decrease the luminous flux (one of two sources within luminaire is switched off) but the main disadvantage is in higher price of such luminaires and LIDC differs from the usual used. Moreover, in both cases an additional control cable is necessary to be installed. Dimming the light seems to be the best way how to lower energy consumption. For sodium high pressure lamps, voltage can be ranged 180 - 230V, below the 180 V discharge disappears. Decrease of voltage to 180 V causes decrease in luminous flux to 50% (non linear dependance on voltage). Our investigations showed that just the dimming the light can bring big energy savings.

Investigation of present state in public lighting of Slovak Republic

Investigation has been focused on structure of light sources and other important aspects of present state in existing public lighting installations. Questionaire, which have been sent to mayors of selected towns and villages in all regions of Slovakia, contained following points: Plans of electrical installations, Structure of light sources, Data about luminaires used, Mounting height and distance between poles, Public lighting switching mode, Public lighting control mode, Electricity consumption and costs for public lighting, Maintanance, Funcionality of lighting system, Data about number of inhabitants, total length of illuminated roads, etc.

Table 1: Structure of light sources in public lighting in Slovakia

mercury lamps	41,64 %	234 164 pcs
sodium lamps	54,74 %	307 833 pcs
incandescent lamps	3,62 %	20 357 pcs
total		562 354 pcs

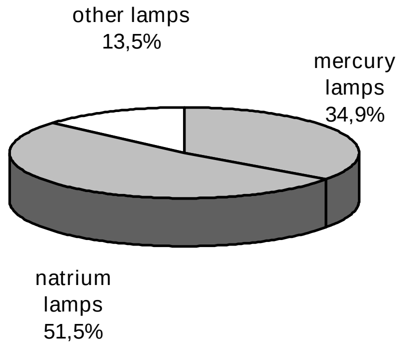

Fig. 1 Structure of light sources in public lighting in Slovakia

Collected data have been statistically evaluated and analysed. From our investigation followed that in public lighting of any town or village in Slovak republic is number of installed luminaires given by

1 luminaire per 10 inhabitants

and this is valid approximately for all towns. Other important results of investigation are shown above.

In public lighting of Slovak Republic, mercury and sodium vapour high-pressure lamps are widely used, only small amount of incandescent lamps and compact fluorescent lamps (CFL) is used for lighting of parks or in special cases. Low pressure mercury nor sodium lamps are not used at all. Hence low pressure sodium lamps can reach the maximum possible efficacy (about 180 lm/W) but these lamps have the worst colour rendering because the spectrum contains only two narrow lines in the yellow part of spectrum.

Table 2: Total and average consumption and costs for electricity in slovakian public lighting

total consumption of electrical energy per year	342,151 GWh/year
total costs for electricity	19,66 mil USD
total costs for maintanance	5,86 mil USD
total costs pro year	25,54 mil USD
average consumption of electricity for 1 luminaire	616,777 kWh/year
average energy costs for 1 luminaire	24,79 USD/year
average maintanance costs for 1 luminaire	10,42 USD
total costs for 1 luminaire	35,21 USD

The „puzzle“ method

From lighting technology point-of-view, there is no difference between design of absolutely new roadlighting system or reconstruction of existing system. From electrical installations point-of-view is suitable to keep the existing poles wherever it is possible. Costs for reconstruction of poles or cables are too high to be covered by energy savings.

The so called „puzzle method“ is a set of methodical procedures for reconstruction of public lighting systems under conditions of Slovak republic, oriented toward energy savings. Principle of the method reside in creating variable steps and procedures for ellaborating a project of reconstruction of lighting system usable not only for experts but also for laymen. Puzzle method is based on Slovak national standards, namely STN 36 0410 „Illuminating of local communications“. Technical possibilities of public lighting reconstruction are detailly analysed. In frame of method, energy saving options have been analysed from technical and economical point-of-view.

Puzzle method also contains ellaborated sample projects of lighting systems for all types and categories of roads, crossings, places, road arcs, etc. These samples can be used directly for simple projecting of public lighting by simple assembling of puzzle elements into complete document. Using of samples suppose to use the same or similar luminaires used for calculating the samples. Third, relative self-standing part of puzzle method is dedicated to elementar economic procedures of analysis of public lighting reconstruction for each selected energy saving options, particularly for three cases: village, town and a city.

From the practical point-of-view, the application of puzzle method is possible to be divided into following parts, that corenspond with the chronology of project ellaborating process: 1. Data collection, 2. Lighting project, 3. Economic project.

Pilot projects of energy-efficient lighting systems

From energy saving options, following three have been selected in the frame of introductory phase of project, where economic aspects of these have been studied: 1. complete replacement of mercury lamps to sodium lamps, 2. replacement of luminaires, 3. lighting control. Two pilot projects proposed and realised in towns Trencianske Teplice and Nemsova are presented below. Abbreviation RVL is used for mercury and SHC for sodium high pressure lamps.

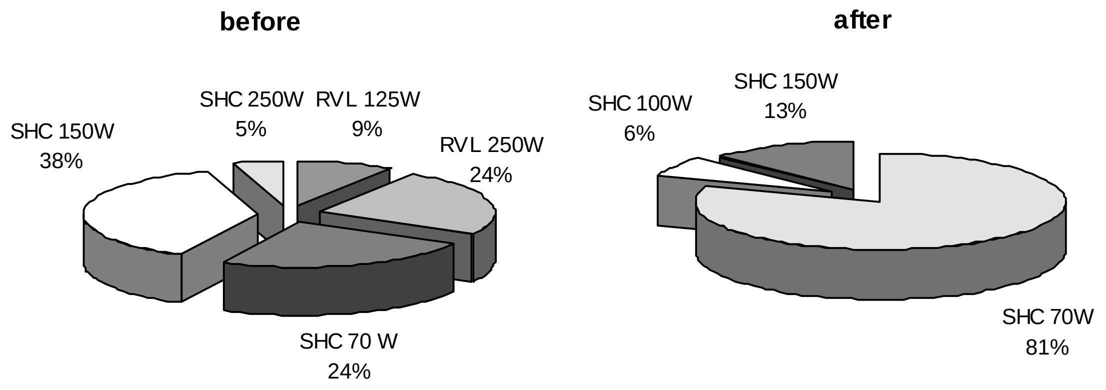

Fig. 2 Structure of light sources before and after reconstruction in Trencianske Teplice

Table 3: Comparison of the state before and after reconstruction with savings evaluation

		before*	after	savings	savings %
installed power	P_i (kW)	102,1	53,53	48,57	47,6 %
energy consumption	A_i (MWh)	408,4	145,74 **	262,66	64,3 %
energy costs	N_e (USD/year)	18 257,8	6 515,4	11 742,4	
	N_e (USD/20years)			234 848,8	
exchange of sources	(USD/year)	2 941,2	811,1	2 130,0	72,4 %

* present state according to installed power of sources ** for light dimming

Table 4: Costs for reconstruction in Trencianske Teplice

device	costs (USD)
luminaires	80 591,2
light sources	7 771,2
distribution boxes	12 104,7
work	25 808,8
project	2 941,2
total	129 217,1

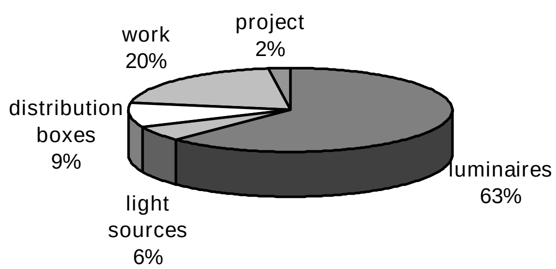

Fig.3: Structure of costs for re-construction in Trencianske Teplice

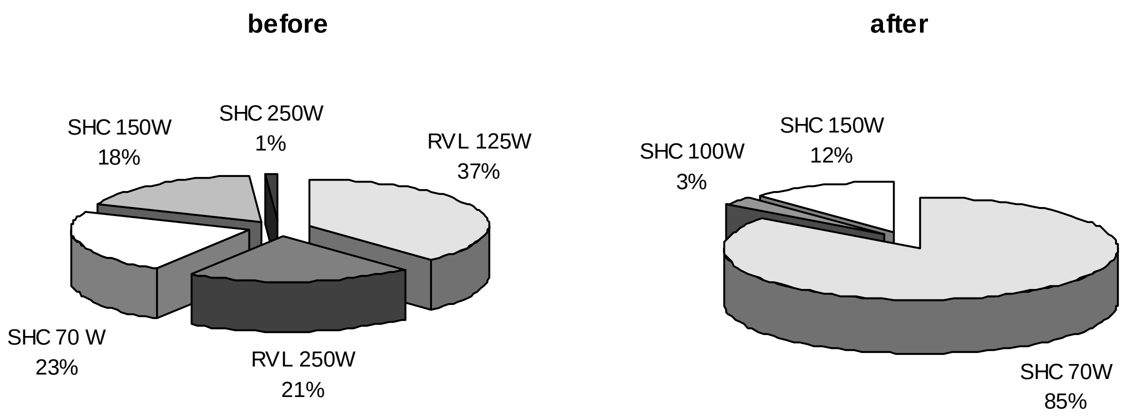

Fig. 4 Structure of light sources before and after reconstruction in Nemsova

Table 5: Costs for reconstruction in Nemsova

device	costs (USD)
luminaires	65 803,2
light sources	4 841,2
distribution boxes	8 274,4
work	16 120,6
project	
total	95 039,4

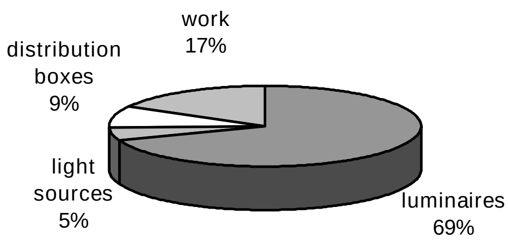

Fig. 5 Structure of costs for reconstruction in Nemsova

Table 6: Comparison of the state before and after reconstruction with savings evaluation

		before*	after	savings	savings %
installed power	P_i (kW)	56,9	32,70	24,20	42,5 %
energy consumption	A_i (MWh)	227,6	89,02 **	138,58	60,9 %
energy costs	N_e (USD/year)	10 175,0	3 979,7	6 195,4	
	N_e (USD/20 years)			123 907,0	
exchange of sources	(USD/year)	1 434,8	505,4	929,4	72,4 %

* present state according to installed power of sources
** for light dimming

Problem of optimisation

It is clear that factors influencing to the design of public lighting systems are contradictory and in present time there do not exist any program allowing to design the lighting system optimally:
1. Mounting height - should be as low as possible. Low poles are cheaper than high poles and the luminous flux of sources is utlilised better. For low poles the uniformity is lower (at given distance between poles) or distance between poles becomes to be too small (at given level of unoformity). This causes then the rise of number of poles per 1 km of road and this means higher initial costs to the lighting system. Glare risk increases, too.
2. Distance between poles - should be as much as possible. Then, number of poles per 1 km of road is small. It is necessary to keep the longitudal uniformity.
3. Installed power of light sources - should be as low as possible, because the value of power determines the installed power of whole roadlighting system per 1 km. In some cases it is more suitable to use sources with higher power due to higher efficacy (sources with higher power usually have higher efficacy in lm/W).
Problems of public lighting in Slovak republic
The age of most of lighting systems is very high and is quite equal, because these have been projected cca 20 - 30 years ago
Technical stuff and equipment used within existing lighting systems are obsolete. In present time there are available energy efficient and modern in design and function new and improved types of light sources, luminaires and other elements of lighting systems on uncomparable higher level than in time of realisation of existing systems. For example, modern light sources are characterized by higher efficacy, lower power, lifetime, etc.

Technical standards for public lighting have been novelised. It is necessary, in the near future, also suppose the application of the european standards for the public lighting.
Financial sources for public lighting are insufficient and lighting systems are actually badly maintaned
Price for electricity is low (actually 0,0447 USD/kWh) and does not correspond with prices for lighting systems and devices and does not create sufficient pressure to domiciles to increase the quality of maintanance nor reconstruction of public lighting
Present state in public lighting does not correspond with increase of traffic on roads in Slovak republic
Present state in public lighting influences to increase of criminality

Conclusions

Public lighting in Slovak republic can be characterized by balanced structure of light sources (altmost equal percentage of high pressure mercury and sodium lamps), high level of damage of luminaires, bad maintanance and lack of financial resources for lighting systems reconstruction. Big reserves of energy savings are in replacement of mercury based light sources, in efficiency and technical performance of luminaires and in lighting control. Two first projected and realised pilot projects in towns Trencianske Teplice and Nemsova showed that savings in installed power (depend on the improved structure of light sources) are about 40%, energy consumption savings (differ from savings in installed power due to light dimming) are about 60% and savings in maintanance are about 70% in both cases. These results express the possibility of covering the costs for reconstruction by energy savings gained during the lifetime of lighting system. Using the new „puzzle“ method, similar projects in other towns in Slovakia may lead to significant decrease of energy needs for public lighting, and in lighting generally.

References

Gasparovsky, D.: Public Lighting Designs. ETM Journal No. 3/98, pp. 32-37, (in Slovak)
Gasparovsky, D.: Energy Saving Potentials in Public Lighting of Slovak Republic. In Proc.: 17th Congress of the World Energy Council, Houston 1998
Gasparovsky, D.: The Puzzle Method for Public Lighting Reconstruction. In Proc.: Lighting Technology Workshop XV - Exterior lighting. Ostrava 1997, pp. 19-26, (in Slovak)
Gasparovsky, D.: Energy Savings in Public lighting: Experience with realisation of energy - saving technics in Slovakia. In Proc.: EEBW: Energy Savings 1998, Praha 1998, (in Slovak)
Smola, A., „Public Lighting Reconstruction under Conditions of Slovak Republic“, proc. Lighting Technology Course XV, Ostrava, Czech republic, 9-10 October, 1997, (in Slovak)
Smola, A., „Development Trends of Lighting Technology“, pub. TZB Haustechnik, Vol.5, No. 5, 1997, (in Slovak)
Smola, A.- Gasparovsky, D.: Recent problems of public Lighting in Slovak Republic. In Proc.: Light '98, Bratislava 1998, pp. 60-67, (in Slovak)

Doc. Ing. Alfonz Smola, PhD.
FEE&IT, Slovak University of Technology
Ilkovicova 3, 812 19 Bratislava
phone: ++421 7 602 91 774
fax: ++421 7 654 25 826
e-mail: smola@elf.stuba.sk

Ing. Dionyz Gasparovsky, PhD.
FEE&IT, Slovak University of Technology
Ilkovicova 3, 812 19 Bratislava
phone: ++421 7 602 91 485, ++421 903 455 035
fax: ++421 7 654 25 826
e-mail: hung@elf.stuba.sk