



ENERGY EFFICIENCY IMPROVEMENT OF THE PUBLIC LIGHTING

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Abstract: *In this paper, it is proposed a solution for improvement of public lighting energy efficiency by the use of light dimmer devices. The analysis of power consumption was made on basis of measurements on one distribution cabinet which provided power supply for 140 sodium vapor high pressure lamps.*

Key Words: *Public Lighting/Efficiency/Light Dimmers*

1. INTRODUCTION

System of public lighting is one of the areas of power consumption where significant reduction could be made. Expenses which are made by public system of lighting in the city of Banja Luka are participating with more than 40% in total power consumption [1]. This shows that public lighting represents a significant factor in the system of public power consumption. Based on research presented in [2] which have covered several cities in Republic of Srpska (Laktaši, Prijedor and Zvornik), the conclusion can be made that 0.17-0.63% of total annual consumption of electrical energy goes to public lighting, therefore it represents a notable percentage, especially when it is known that such power consumption is participating with 20-42% in total power consumption in the mentioned cities. There are several ways for reduction of such costs. One possible solution is the use of light dimmer system, in other words system for light regulation (also known as dimmable drivers), which could be used in period of days when traffic density is lowered and when the most of population is at home. The second way is a replacement of existing street lamps with new, more efficient and more lasting street lamps which are based on LED technologies. Also, some reduction could be made with usage of conventional NaVt (Sodium Vapor High Pressure) lamps, under presumption that the electronic ballast is used instead of an electromagnetic [3]. Moreover, with the use of electronically ballast, reduction of noise, which is produced by electromagnetic ballast working on audible range frequencies, is accomplished too. It is important to emphasize that the use of electronic ballast could significantly prolong lifetime of NaVt lamps. However, the latest research in this area, which are made in the public lighting systems, has shown that improved techniques of light regulation with electromagnetic ballasts provide better results in the aspects of energy efficiency, reduction of greenhouse gases emission and prevention of environment pollution which is not the case with electronic ballasts use [4]-[6]. It is shown that

electronic ballast have shorter lifetime and lower reliability comparing with electromagnetic ballasts, and also it cannot be completely recycled, which leads to environment pollution. Also, bearing in mind lower reliability and shorter lifetime expectancy, costs of maintained are increased indirectly.

The aim of this paper is to publish the results of research made with public lighting in the city of Banja Luka. Disadvantages and possible improvements on existing system were proposed, and also possible reduction of power consumption with the use of light dimmers was analyzed.

2. ANALYSIS OF PUBLIC LIGHTING POWER CONSUMPTION

For the purpose of analysis of power consumption in Banja Luka public lighting, in cooperation with Department of Public Utilities, Housing and Traffic, different electrical parameters were measured on the level of one distribution cabinet. Distribution cabinet which was connected with measurement unit is used for power supply by 140 70W NaVt-type street lamps. For logging of information about measured parameters, system described in [7] was used. All results represented and analyzed in this paper, are from one 11-day period. On Fig. 1 is shown a change of the grid voltage level on all three phase.

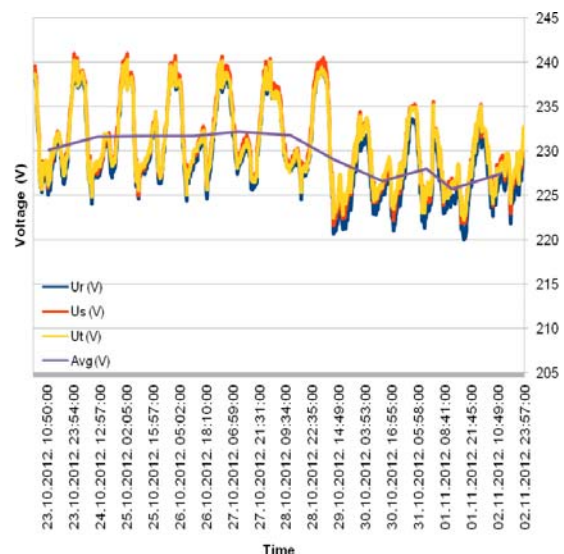


Fig. 1. *Effective value of grid voltage (three phase)*

As it could be seen, the effective voltage value was changing in range between 220 and 240 V. Variation of voltage is consequence of overloaded grid. From Fig. 1, is clearly visible that over the night, when the grid was not so loaded, an increase of voltage has occurred, comparing with values measured near the dawn when the grid load was increased. Also, it can be seen that average value of grid voltage varied over the day. This variation depends on the environment temperature, because the network is more loaded on winter days when electrical energy is used for heating purposes. From Fig. 2, it is clearly seen that grid load is correlated with a mean value of air temperature over the day.

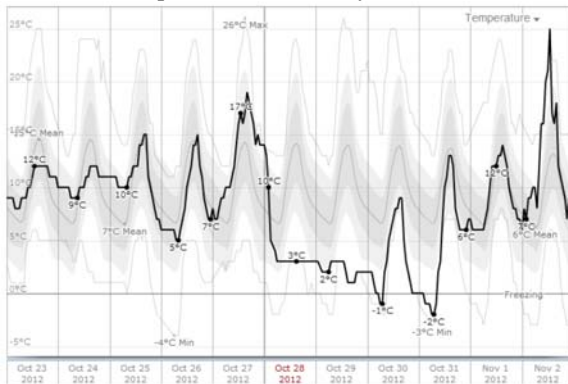


Fig. 2. Change of air temperature in the period of measurement [8]

Increase of voltage during the night, when the light system is on, results in shorter values of lamps lifetime, because in that case they are working on higher power voltage than nominal. Higher voltage leads to increasing in power consumption too, which deflects negative in the aspect of power efficiency. Systems for light dimming, used for enhancement of efficiency, are based on constant-voltage preservation. From the previous observation, conclusion can be made that this system can be used for maintenance of constant voltage without influence of grid load, which prolongs lifetime of lamps along with better power efficiency.

On Fig. 3, measured parameters of electrical current for all three phases are shown.

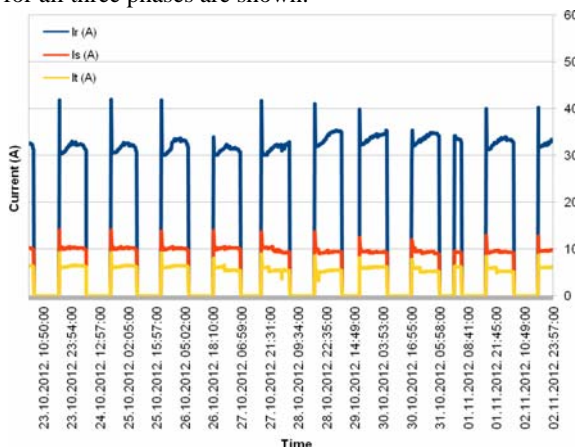


Fig. 3. Effective value of current (three phase)

NaVt lamp has low impedance when cold. That is the reason why current spike appears when light is switched

on. Duration of warming period is about 30-60s. As it can be seen from Fig. 4, increased value of current is much more significant for apparent power, so reactive power consumption is slightly higher in the period of lamp initial warming.

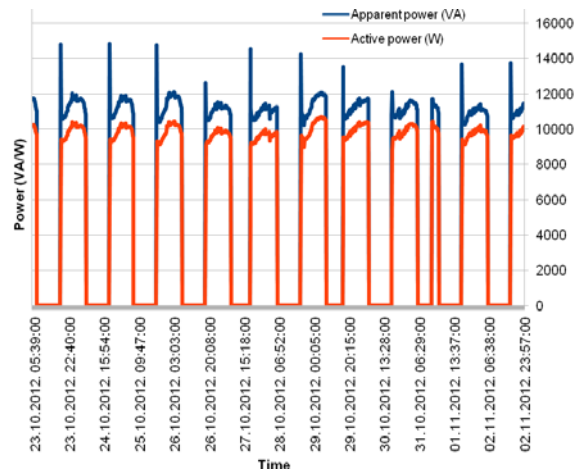


Fig. 4. Total apparent and active power

Power factor change (Fig. 5) is corresponding with change of apparent and active power which is shown on Fig. 4. Total power factor of public lighting is 0.9, as it is visible from Fig. 5. Beside of the previous mentioned parameters, power consumption was measured too. For a period of 11 days, 1344 KWh was consumed, in other words 122 KWh per day.

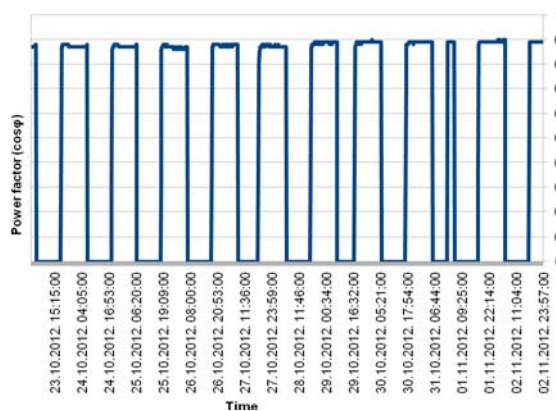


Fig. 5. Total power factor (cosφ)

3. EFFICIENCY IMPROVEMENT WITH LIGHT DIMMERS

For the purpose of measurement of consumption reduction effect with use of light dimmer, in cooperation with Department of Public Utilities, Housing and Traffic of the city of Banja Luka, parameter analysis was made in the case when light dimmer M-BOX *Intelight* was installed in the system. More information about this device can be found on manufacturer website [9].

The measurements were covered two distribution cabinets which are used for light control in two different streets. Two programs for reduction of power consumption were used as it is shown if Table 1.

Table 1. *Light regulation program in two distribution cabinets*

| Regulation program for I cabinet | | | Regulation program for II cabinet | | |
|----------------------------------|--------|-------|-----------------------------------|--------|-------|
| Interval I | 15-22h | 205 V | Interval I | 15-22h | 205 V |
| Interval II | 22-24h | 195 V | Interval II | 22-24h | 197 V |
| Interval III | 24-05h | 170 V | Interval III | 24-05h | 187 V |
| Interval IV | 05-15h | 170 V | Interval IV | 05-15h | 187 V |

The measurement was performed in period of one week for two cases: 1) with decrease of network voltage according with programs which leads to light diming, and 2) with constant network voltage. The results for two distribution cabinets are shown in Table 2.

Table 2. *Program of light regulation for two cabinets*

| I Cabinet | | | II Cabinet | | |
|---|-------------------|--------------------------|---------------------|-------------------|--------------------------|
| Energy consumption when light control is used | | | | | |
| Initial state (kWh) | Final state (kWh) | Energy consumption (kWh) | Initial state (kWh) | Final state (kWh) | Energy consumption (kWh) |
| 87876 | 88281 | 405 | 592556 | 593365 | 809 |
| Energy consumption when light control is not used | | | | | |
| 88281 | 88901 | 620 | 591204 | 592537 | 1333 |
| Energy saving: | | 215 kWh (35%) | Energy saving: | | 524 kWh (39%) |

As it could be seen from previous table, light dimmer use could lead up to 30% of power consumption reduction. With the fact that the price of reduction system is about 2500€ (incl. VAT), and with the data about possible power savings from previous table and the price of kWh (0.897€), we come to the estimated pay-off period of about 3 years. It is necessary to emphasize that during the time-interval when voltage regulation was used, some of the lamps in light system which were on long distance from distribution cabinet, due to voltage drop, were not able to work in regular and expected way, more precisely, they were switching on and off, due to a lack of minimum required voltage (170V). This leads to shorten lifetime of lamp, so it is of high importance to keep in mind this phenomenon when installation and calibration of voltage regulation system is in place.

4. CONSLUSION

In the city major part of public power consumption goes to the public light system. With the improvement of energy efficiency it is possible to significantly reduce

greenhouse gases emission, in other words to improve environment protection. Power consumption reduction in public lighting could be achieved by introduction of adequate light dimmers and energy efficient lamps. In next phase of research, special attention should go to development of regulators for conventional and LED lamps, as well to consumption analysis of implemented solutions.

5. REFERENCES

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