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Application of luminous flux regulator for energy savings in a LEDs adapted streetlight system in Tirana

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ABOUT The study

Knowing the possibilities to have a more efficient street lighting systems in Albania, the efforts for achieving the targets in that public sector are focused in two main directions:

- 1) to scale-up programs applied on intelligent technologies for SLS like Remote Control and Management System, based on project' s results undertaken with incentive of Municipality of Tirana in 2009.
- 2) To apply results of study made with request of Ministry of Infrastructure and Energy in the two biggest municipalities of Albania, Tirana and Durrës, in order to demonstrate reductions of energy in selected municipalities through street lamp retrofits using the relatively new energy-efficient LEDs technology.

Study's Findings

This study have a great potential energy savings and environment benefits: 53.3% energy savings to extend the remote control and management system with LED adaption on whole lighting network in Tirana.

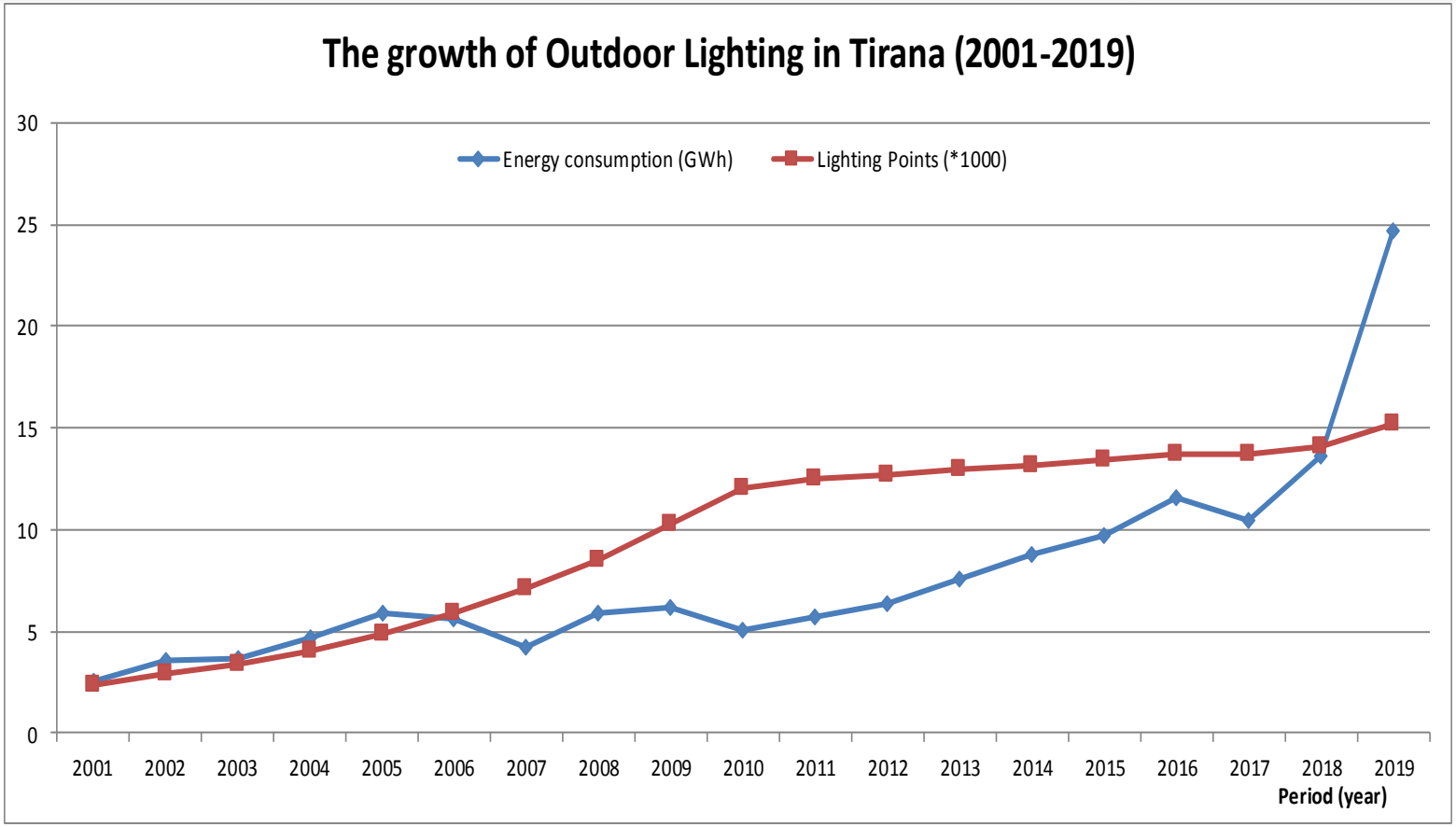
- Reduced costs for maintenance, CO2 emissions, light pollution.
- manage and control entire public lighting infrastructure and possibilities integration with other Smart City applications.
- Saving time and achieving faster services, better electrical infrastructure extends asset lifetime, improved public safety perception as streetlights illuminate automatically to a higher level upon hours with high human presence.
- The RCM System adopted in a LEDs technology luminaries SLS boost city's aesthetics through better lighting quality. Except this, predicted energy savings and expected cost reductions will be achieved when the project is scaled upwards.

Study's DATA collection

The requested DATA for the study:

- **Lighting standards** for classification of streets.
- **Lighting master plan** or any similar document.
- Complete street **lighting projects** of the main streets, considered as pilot roads in the study.
- **Current state** of the lighting system of the roads .
- **Structure and characteristics** of SLS.
- **Energy consumption** in last three years.
- **Visits and interviews** with managers in charge for investments and maintenance costs for SLS.

Tirana problem background



Illumination point's number : 7 times

Energy consumption: 8 times

ENERGY SAVING TECHNOLOGIES AVAILABLE FOR STREET LIGHTING

There are three areas where energy saving initiatives can be implemented in SLSs. These can be categorized as :

1) **using more efficient lamps and luminaries**,

- use of **LED technologies in replacement of the traditional lighting lamps** can result in energy savings of 50% or more
- **last generation's luminaries with improved optical characteristics** , equipped with modern lamps can guarantee various advantages 25-30% higher efficiency
- **electronic ballast can contribute on reduction of upkeep costs** by extension of lamp life with 30%, and reduce consumption by 7%.
- the electronic ballast enable **the possibility of gradual dimming which improves energy performance** further.

2) **installing intelligent control system,**

3) more efficient use of existing street light infrastructure and resources.

Actual state of SLS in Tirana

Traditionally, road lighting in Tirana, is switched on/off automatically by photocells and/or timers.

Lamps are burning at full power during the whole night and lighting intensity is often excessive when traffic density is low.

On January 2009, 25% of public lighting system of Tirana has been funded to use RCMS.

The heart of the system is the flux regulator, which permits the control and the regulation of the power rates in lighting system. It allows the reduction of power required with sub sequential reduction of costs, optimize the lighting flux of the lamps during all the night, uniform level of light.

ADVANTAGES OF RCMS

The main functionalities of the RCMS, through the application software are:

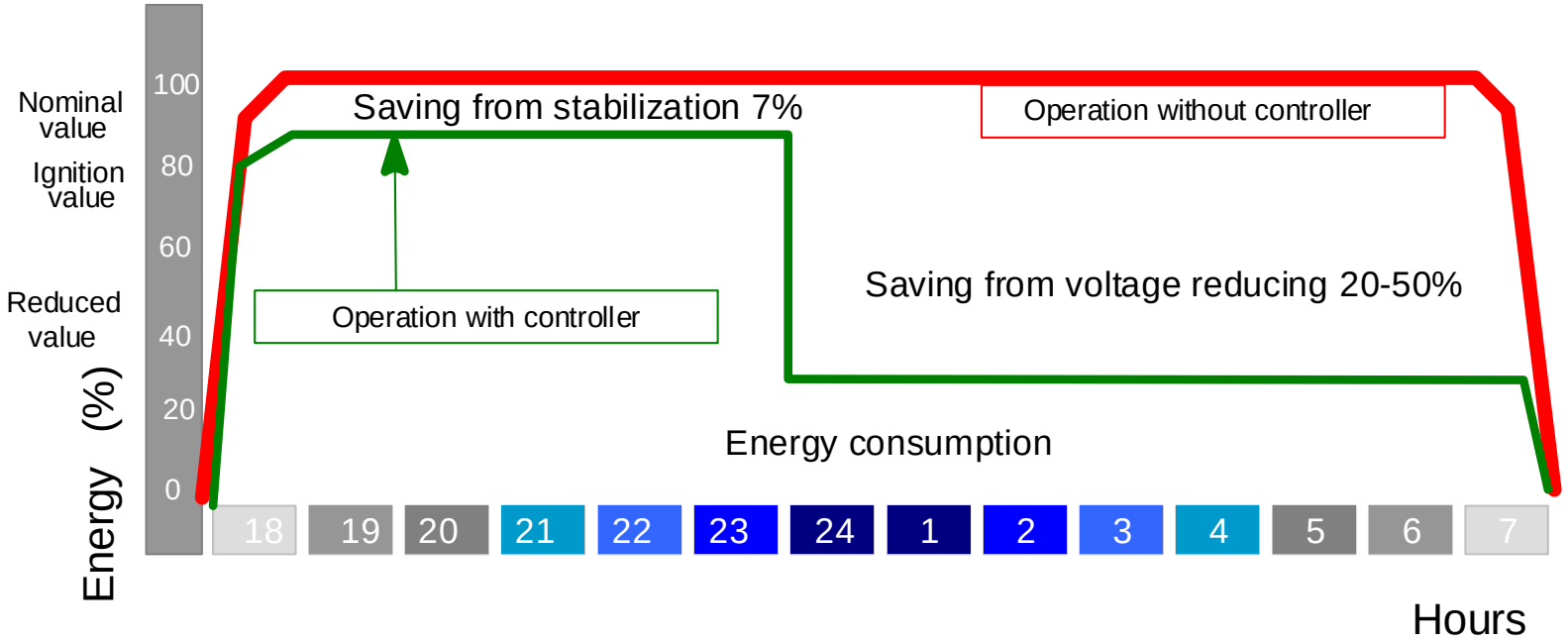
- remote monitoring and control of road lighting lamps operation and consumption parameters,
- data acquisition of electrical consumption, assisting of operators and energy managers in diagnosing consumption patterns that might be indicative of excessive electrical energy consumption allowing potential savings to be accurately quantified.
- the trend analysis functions of electrical energy consumption, trend on any measured parameter of electrical supply system: voltage, current, active and reactive power, power factor, demand, predicted demand, energy, harmonics, temperature, etc.,

ADVANTAGES OF RCMS

- graph aggregate electrical load profiles from each metering points, create usage profiles to reveal demand peaks, dangerous trends, or unused capacity and track electrical energy-related costs for each user.
- It offers also electrical power quality analysis such as: continuous monitoring and data capture and reporting for power quality and reliability conditions,
- IEC 61000-4-30 and EN50160 compliance reports, quickly review of power quality as numeric charts or graphic profiles, display harmonic histograms, odd/even harmonics, THD, K-factor, crest factor, phase diagrams and symmetrical components.

Results from “pilot” project with RCMS

The system is tested for one year, operated at two luminance levels, depending on the amount of traffic and weather conditions. The lighting system operates at 20% and 100% of normal lighting levels (0.4 cd/m2, and 2.0 cd/m2). No negative safety effects at the 20% light level were found and it was concluded that 20% of light level is sufficient for low traffic volume at night when the weather is fine.



Methodology for Calculating the Savings

The calculation of the achievable savings from the implementation of RCMS are worked out using the following methodology, as Eqs. [1-4]. Analytical calculation is done individually for each factor that contributes on energy saving. The amortization period is taken in account.

$$E_{as}=E_{rs}+E_{ms}+E_{ss} \quad (1)$$

$$E_{rs}=P_a\, N_r\, E_{\%}\, C \quad (2)$$

$$E_{ms}=(C_l+C_{lr})[(1/8000)-(1/16000)]N_t \quad (3)$$

$$E_{ss}=P_a\, N_t\, E_{(ss\%)}\, C \quad (4)$$

Where: E_{as}= overall annual energy saving; E_{rs}= electrical energy saving from working underpowered; E_{ms}= maintenance saving (increasing lamp life); E_{ss}= energy savings due to voltage stabilization; P_a= Active power absorbed by the lighting network; N_r= Number of hours per year in underpowered operation; $E_{\%}$= Electrical energy saving as a percentage; C= Cost of kWh (is taken 0.114 €/kWh); C_l = total cost of the lamps; C_{lr} = Total cost for replacement of the lamps; N_t=Total number of operation; 8000 = Number of lamp's hours before implementation; 16000 = Number of lamp's hours life after implementation; $E_{ss\%}$ = Electrical energy saving as a percentage due to stabilization (7%).

Calculations of energy savings with RCMS

Item No	*Calculations of energy savings*		
	Item Description	***Unit***	***Total***
9	Energy consumption without control system (kWh/year)	kWh	2,586,615
10	Energy consumption after intervention (kWh/year)	kWh	1,664,844
11	Energy saving	%	35.6
12	Energy saving (kWh/year)	kWh	921,771
13	Energy saving (€/year)	EUR	105,081
14	Energy saving due to life lengthening of lamps (€/year)	EUR	26,280
15	Energy saving from stabilisation of voltage (€/year)	EUR	21,141
16	OVERALL SAVING (€/year)	EUR	152,502
17	Cost of Control system and its Installation	EUR	308,355
18	Simple payback	Year	2.02

Old technology lamp's replacement with LEDs

The study to accelerate LED's adoption for street lighting in municipality of Tirana is undertaken with request of Ministry of Infrastructure and Energy of Albania.

The aims of the study:

- **to analyze the current lighting level** of Tirana's streets, **compared with EU Standards** ,
- **to check the possibilities for improving**
- based on results **to give the proper recommendations** to responsible people of Tirana Municipality.

In order to do full analysis about actual illumination of street lighting in Tirana **conform standard EN 13201-2, the classification of roads** is made. **The photometric calculations are made with DIALux software**. The objective is **to find the adequate retrofit LED lamp** for different cases as: street type, pole distance, pole height, etc., which fulfill lighting performance requirements as minimum luminance L and illuminance E, average uniformity of the luminance U0, longitudinal uniformity U1, surround ratio SR and maximum threshold increment T1, which is a parameter designed to control glare.

Some problems of SLS in Tirana

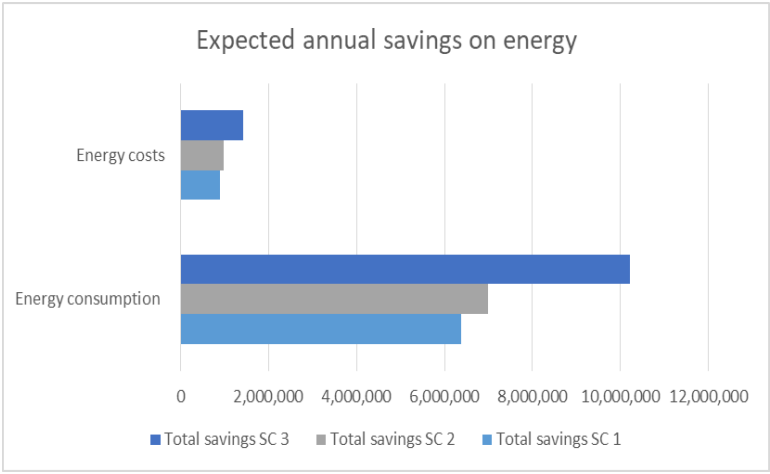
The SLS in Tirana suffers some problems :

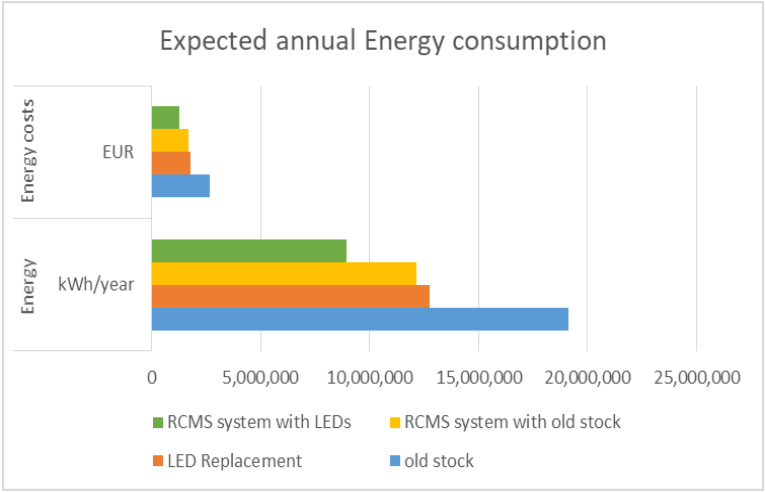
- most of streets are over illuminated, some of them have not uniformity in lighting distribution. So, replacement with LED lamps will be accompanied by additional costs, that should be calculated on a case by case basis.
- In order to maintain the luminance continuity parameter is often required to intervene at the height of the column and there are cases when this parameter cannot be achieved only by LED replacement.
- illuminated places that have no need, causing light pollution.
- Potential energy savings are noticed by replacement of traditional lamps with LED ones because a considerable power reduction is evident. Based on calculations for typical roads, the energy saving from replacement of old inefficient lamps with efficient ones are calculated and the results are summarized on Table .

Energy savings

CALCULATION OF EXPECTED PROFITABILITY PER YEAR (RELATED TO 2018)

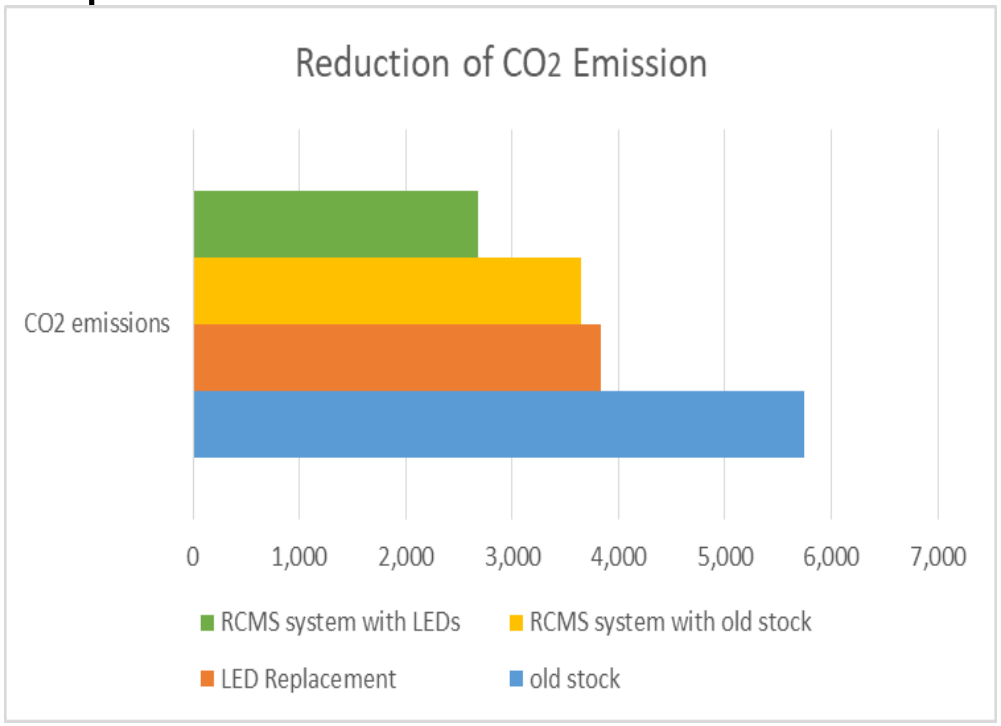
		Power	Energy	Energy costs	CO2 emissions
		kW	kWh/year	EUR	T
	old stock	3,450	19,147,500	2,680,650	5,744
SC1	LED Replacement	2,300	12,765,000	1,787,100	3,830
SC2	RCMS system with old stock	2191	12,158,663	1,702,213	3,648
SC3	RCMS system with LEDs	1610	8,935,500	1,250,970	2,681
	Total savings SC 1	1,150	6,382,500	893,550	1,915
	Total savings SC 2	1,259	6,988,838	978,437	2,097
	Total savings SC 3	1,840	10,212,000	1,429,680	3,064





Environment and Energy Efficiencies

Switching to LEDs is beneficial in terms of **energy savings** and **reduction of gas CO2 emissions**, additional **socio-economic benefits**. Light quality improvements result in better visibility and reductions in road accidents. LED street lights provide **opportunities for new commercial investment and enhancement** of regions which benefit from the improved infrastructure.



CONCLUSIONS

- Energy saving using luminous flux regulators through voltage reducers, combined with replacement of old technology lamps with new and efficient technology LEDs , give a very good result on energy savings.
- The expected aims conform EU directive become achievable.
- The costly equipment including an integration of power reducing technology with metering and remote control for overall street lighting system and new technology lamps, leads to a large financing burden to Municipality of Tirana.
- The cost of these measures is repaid by savings and lighting quality is maintained or improved after the project have been running for 2-3 years.
- A lot of benefits are evidenced: 53.3% energy savings for combined scenario, and thereby reduced costs, CO2 emissions and light pollution.
- Better maintenance, remotely monitoring, manage and control entire public lighting infrastructure and possibilities integration with other Smart City applications.
- The automatic reports and diagnosis help tracking luminaire health and performance, thus saving time and achieving faster services, better electrical infrastructure extends asset lifetime.

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Thank you for attention!
Any question ?