SMART LED LIGHTING SYSTEMS IMPLEMENTATION IN LISBON METROPOLITAN AREA

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ABSTRACT

EDP Distribuição (EDPD), the Portuguese DSO is implementing in Portugal an ambitious Smartgrid program (InovGrid). The main key drivers for this program are: Energy efficiency, distributed energy resources integration, and new customer value added services.

The ambition is to build intelligent networks and intelligent cities by improving energy networks and energy supply. Lisbon Clients and Networks Direction (DRCL) has a close engagement with this project and one of the many initiatives driven is the improvement of smart public Lighting management, together with municipalities head offices, innovation clusters and lighting manufacture companies. The project is being developed by EDPD, LED lighting solutions, management systems suppliers, and R&D companies. The objective is the implementation of test scenarios comprehending traditional street lamps and lanterns replacement by LED light, energy efficiency measures, and ultimately the reduction of public lighting energy consumption.

The project also includes the installation of sensors and the development of management system that can be remotely controlled with added features of flux reduction, associated with street movement, either by cars or people passing on the street, and a supervision center that can establish energy consumption profiles for each LED lamp.

Picture 1 – Praça do Município (Lisbon City Hall).

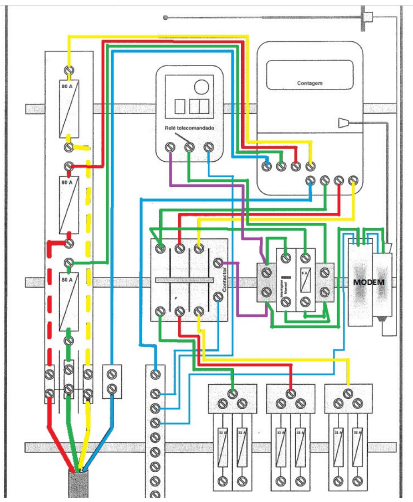
INTRODUCTION

The public lighting system has extreme value to Lisbon municipality, representing the energy cost and maintenance an essential annual budget piece, and an important factor to Lisbon inhabitants and tourist's satisfaction and safety, as Lisbon is being considered one of the best places to visit.

Lisbon has a public lighting infrastructure with 68.188 lighting points installed, of which 60.291 are lamp posts and 7.897 are building wall lanterns. Construction and maintenance is done by Lisbon city Hall and EDPD together, being registered in 2015 around 7.000 malfunctions reported by citizens.

LISBON PUBLIC LIGHTING CONTROL

Lisbon public lighting is controlled by a remote central system through the injection of a frequency based signal on the HV/MV Sub-stations in to MV network. This signal than propagates to LV, on to Ripple Control Receivers (RCR) located on street electricity box that turn on and off the circuits regarding public lighting. The working frequencies of the RCR are between 200Hz e 750 Hz, and the schematic for the power connections is as shown on picture 2.



Picture 2 – Schematic for public lighting boxes.

In order to define a standard, register all energy flux, properly calculate losses, and to stimulate the retail B2C energy market, the Portuguese regulator established that all public Lighting installation should be treated as a regular LV client installation, with special licencing processes as this installations and networks are developed, constructed and managed by the DSO respecting concessions contracts signed with municipalities.

So together with the command and control equipment's, all public lighting installations have necessarily a meter instated.

SMART GRID INTEGRATION

EDP D, is currently expanding remote metering solutions, mainly to allow detection of commercial losses through energy balance, and maintaining the control of public lighting such as it is. With the introduction to specially designed smart meters, that are able to remotely control public lighting trough GSM or GPRS telecommunications based systems, and have an internal astronomic clock as a backup, the RCR will fall into disused, giving way to this new technology, and allowing the desired offsets for controlling their city lighting, with daily application, but also for special activities such as Christmas lighting, special holidays, etc. Other Smart meters functionalities include fault detections, daily energy consumption charts, and power monitoring peaks for public lighting billing services.

There are currently 2.452 lighting connections for Lisbon, of which about 1.000 have already a smart meter installed as showed on picture 2. Once all public lighting connections are equipped with a smart meter (expected June 2016), Lisbon County will have real time information of the energy costs associated with this service.

Picture 3 – Public lighting box with a smart meter.

PRAÇA DO MUNICIPIO STUDY CASE

"Praça do Munícipio" (Lisbon city Hall) is an emblematic place in the city, with a large flow of pedestrian (many of them tourists), and a stage for municipal and national events.
The square has 26 Arquihistoric street lights of three different types, has showed on table 1. Before the intervention, all the street lamps had 164W (total power) of high pressure sodium (HPS).

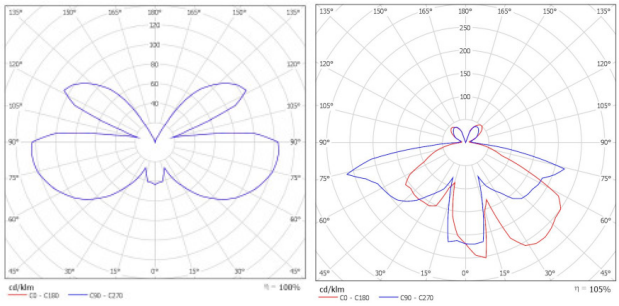
quantity	Format	Previous power	New power	New light flux
10	**Octogonal**	**164W**	**81W**	**6.900lm**
12	**"Nabo"**	**164W**	**71W**	**5.600lm**
4	**Hexagonal**	**164W**	**91W**	**6.200lm**

Table 1 – Street lights types.

The main project assumptions was to maintain similar levels of color temperature, and light flux, decreasing the power consumption.

Three light fixture types were custom designed resulting in three specific modules composed by: LED lamp, power supply adapter and control board. The light fixture body has been kept replacing the interior with the custom module designed to replace the equivalent output light features. All modules have, at maximum flux operation, proximally internal unitary power correction factor avoiding significant harmonic distortion to the implemented electric distribution.

In picture 4 is showed the comparison between the HPS and LED diagrams for the hexagonal light fixture type.



Picture 4 – Hexagonal light diagram example before and after conversion.

Picture 5 – Refurbished historical building lanterns.

System Description:

Each Lamp post communicates via Power Line Communication (PLC) using a narrow data flow communication that fulfills all the requisites of the CENELEC Band B normative. The technology profiles a wide spectrum coupling with nominal carriers between 95 and 125 kHz according to EN50065 normative for signal transmission through power wires. The solution results in an innovative implementation that provides "intelligent grid" features capable of responding dynamically to usage demands.

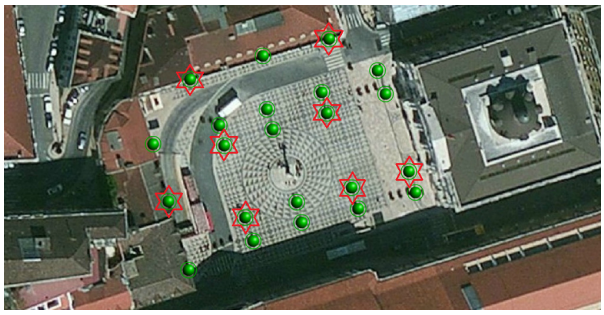
In this concept, street lights operate on a real time network, reacting to movement in the surrounding environment and according to a pre-programmed configuration. The control is mastered by a single gateway that keeps the network system alive and that provides remote access to full features through a user friendly Web application.

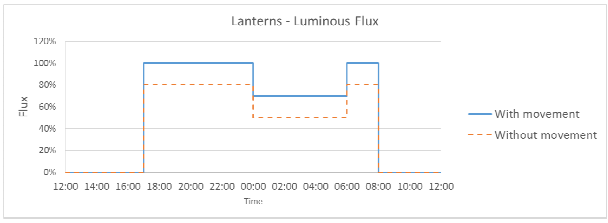
A user can simply perform real time management to each individual lamp post, retrieve data and setup pre-programmed configuration, as well as firmware upgrades upload.

Picture 6 –Web application.

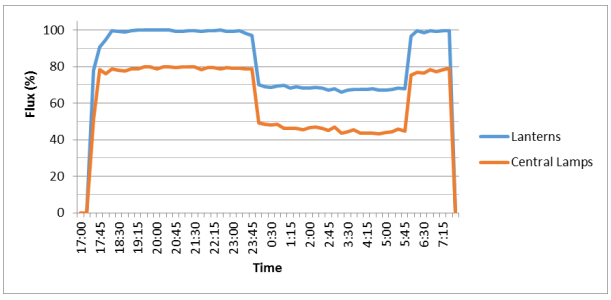
These features promote significant energy savings through setup time based light flux reduction plans, optimized maintenance activities through remote monitoring and better usage of resources when it is actually required according to movement detection inputs.

The solution used has motion detection triggered to pedestrian and control adjustment for two distinct lamp post groups: the historical lanterns by the building walls and light fixtures on poles, in central square sidewalk. Given so, each group operates seamlessly within the associated set, and according to several motion sensors distributed by some of the light fixtures. In general terms once there is a movement trigger, only the group of a set of light fixtures associated to it responds to the appropriated pre-programmed light level in a network fashion manner


Picture 7 – Ligths and movement sensor location.



Picture 8 – Lanterns flux setting.



Picture 9 – Average dimming during January.

SMART LIGHTING SYSTEM BENEFITS

The operational savings:

Remote management and monitoring – Street light management software gives a general oversight of all street lights. It's possible to see in real-time how much energy is being consumed by all lamps or each one individually, as well as its luminosity flux profile. It also allows real-time lamp control, for example promotes an action to mitigate the damage of one lamp by changing the luminosity flux of other active lamps.

Automatic fault detection – The system provides outages instant information, notification and other minor events or alarms. This feature will allow a significant reduction in the number of complaints, calls, and therefore related customer support costs. Given this, it will be possible to filter false alarms, have a more accurate knowledge of the zones malfunction and faster repair teams in fault detection and service reestablishment, leading to a higher citizen's satisfaction level.

Proactive condition based maintenance - street light management software also provides predictive information, alerting operators to lamps usage, so replacements can be scheduled proactively.

Economic savings:

Dimming: Due to their high light output, LED lamps can be dimmed as much as 20% when first installed with minimal compromise in regulatory light levels.
In addition, operators can schedule lamps to dim as circumstances allow, for example in low movement hours. By adding movement sensors to the light fluxes control system, it's possible to reduce the lamps energy consumption more than 50%.

Smart lighting systems like this one, can offer a supplementary service to similar smart city applications that can handle smart parking, traffic management, EV charging stations, etc.

CONCLUSIONS

This project adds great value for municipalities on public lighting management, making possible to delegate or share with municipalities departments the control, giving the possibility to implement special lighting profiles and the system map interface, with the detection of potential faults or malfunctions that can be reported to the DSO. It's expected that citizens' complaints will be reduced, improving life quality and the city reputation.

More than the implementation of led system this project provides an important management tool that has the capacity to reduce energy cost by 50% without compromising safety.

REFERENCES

For a Conference citation:

[1] Carreira P, Esteves P, Samora C, Sousa A, de Almeida., 2012 "Efficient and Adaptive LED Public Ligthting Integrated in Évora Smart Grid", Strategies in Light Europe 2012