

ENERGY EFFICIENCY IN STREET LIGHTING – CITIZENS POINT OF VIEW

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ABSTRACT

Energy-efficiency has been gaining more and more importance in the past few years, and today it is considered essential, in order to optimize the use of energy resources and to assure environmental and economic sustainability. Regarding street lighting, there are several solutions for achieving energy efficiency, raising opportunities for improvement and innovation, and allowing a rationalization in consumption. Although these benefits are clear and significant, a specific challenge arises, namely the acceptance of these solutions by citizens, as many of them affect their perceptions and feelings regarding their own security and their quality of life in the public spaces of cities. To better understand the citizens' attitudes towards public street lighting, a study was conducted in 2014, with the following objectives: 1) understand the assessments about streetlight; 2) measure citizen knowledge about energy efficiency; 3) develop hypothesis on how can streetlight consumption become more efficient without interfering in the citizens security. Over 2000 interviews were conducted, covering three stages of assessment: attitudes, expectations and scenarios receptivity (always in the citizen perspective). From this study interesting conclusions can be taken, which will support the implementation of energy efficiency measures in public lighting. The high importance citizens attribute to street lighting is reinforced, particularly regarding their sense of security and day-to-day habits. We conclude that citizens are willing to accept changes in street lighting, aiming at achieving gains in energy efficiency, mainly through the elimination of what they consider to be a waste in consumption.

INTRODUCTION

The Distribution System Operators (DSO) have a significant role in promoting energy efficiency. EDP Distribution is the most relevant operator of street lighting in Portugal, and as so, has an increased responsibility in this domain, promoting and implementing innovative technology solutions to achieve efficient Smart Cities. However, challenges arise, as street lighting is an issue of special importance to everyday life of citizens, and their acceptance of these technologies is crucial for both Municipalities and DSO's. Aiming to address the main issues regarding citizens acceptance of energy efficiency technological solutions for street lighting, a study was conducted by EDP and "Instituto de Marketing Research". In this study, the best practices in energy efficiency for

streetlight were identified and the main opportunities for improvement, taking in account the citizen's feedback, are presented. The study had the purpose of answering three main research questions: what do citizens think about street lighting (their attitudes towards street lighting); how do citizens react to streetlight solutions (their receptivity to new concepts and innovative solutions); and finally how do they evaluate the different solutions. These main blocks correspond to three sequential phases of the research (Figure 1). First, there is the assessment of the attitudes towards streetlight in everyday life situations (first phase). Then their receptivity to new streetlight solutions is measured (second phase), considering the energy efficiency. Finally, the different relevant scenarios, were evaluated and tested (third phase): light intensity, operating periods (switch on/ switch off) and change in lighting colour. [2]

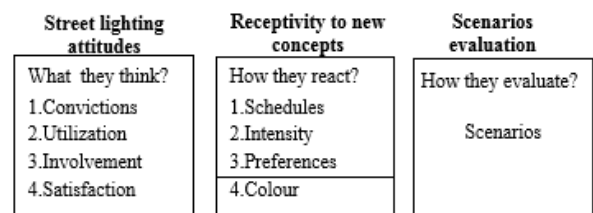


Figure 1 - Study Phases

METHODOLOGY

The study took place in three regions, each one with specific characteristics: urban (Évora); suburban (Leiria); nearby rural environment (Azaruja) and eco track (Ecopista). In Évora and Leiria, citizens and shopkeepers were interviewed, in the other regions, just citizens. Given the heterogeneity of the populations, different techniques were used. In Évora qualitative and quantitative techniques were used. In Azaruja, Ecopista and Leiria only the quantitative approach was used. [1] In Figure 2, it is the calendar for the fieldwork. In the evaluation phase, three scenarios were designed (S1, s2, and S3) for Évora, Azaruja and Ecopista. In Leiria, a fourth scenario, unique from others, was designed (S4).

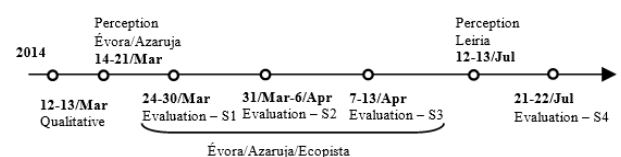


Figure 2 - Study chronology

Another important factor to stress out is that in Évora the interviews were made to a test group (goers of the area, and they tested all scenarios), and a control group (non-goers, with different people in each scenario). These groups were formed by citizens and shopkeepers, in order to generalize the conclusions to the whole city. In the other areas, only a test group was used. The purpose of having a control group in Évora was to compare the perceptions of citizens on the test area, with the perception of the whole city. The study involved more than 2000 interviews (test group in Évora and in Leiria, the same citizens tested all scenarios; Évora's control group was always different along the several phases).

WHAT CITIZENS THINK ABOUT ?

Qualitative research identified **four dimensions** that characterize the **attitudes and behaviour** of citizens towards the public street lighting. The **first dimension** is related to their **convictions**. Citizens have both positive and negative beliefs about public street lighting, but the positive are the strongest. They attribute high importance to Public Street Lighting and are well aware of the issues related to sustainability and environmental protection. For this reason, they accept changes that make the street lighting consumption more energy efficient, provided that it won't affect their safety, or their everyday lives. Citizens are receptive to savings but, in their perception, technological innovation initially entails increased costs, and for this reason, they defend the need to identify in a clear way the benefits associated with the change. The implementation of new street lighting technology solutions, can easily generate a rejection phenomenon, so it is advisable to have a communication plan to engage the population in decision making, stressing out the challenges addressed, the changes that will occur, and the goals and benefits to achieve.

The **second dimension** is related to how citizens **use** public street lighting, which depends on: 1) whether it is summer or winter; 2) if it is weekday or weekend; 3) the home departure and arrival schedules. The quantitative part of the study found that: 1) mostly in summer, citizens go out after dinner (> 60% the interviewed); 2) regarding home departure times, there is a difference between weekdays (over 60% leave until 9:00 am) and weekends (60% have no fixed hours for leaving); 3) in the case of home arrival times, during the week, ≥60% of interviewed citizens need public street lighting (they arrive between 18:00 and 21:00 p.m) but on weekends, many of them stated they do not have fixed time (50% in Évora and 80% in Leiria).

Qualitative research has identified four factors underlying **the third dimension**, linked to the **citizens' involvement** with public street lighting:

1) Expected benefits, with special emphasis on personal safety (the quantitative research revealed that this is the

most important indicator, pointed out by >95% of citizens), the possibility to walk safely on the streets, (referred by ~ 60% in the quantitative study), and the protection of private and public property and monuments;

2) Street Lighting Quality Perception, mainly associated with light intensity (80% of interviews), but also with the lack of cuts and the colour of light (cited by more than 35% of citizens);

3) Sensitivity Indicators, where Costs associated with lighting is the most important issue (indicated by more than 80% of the interviewed), followed by Wasteful consumption in public lighting, reported by 50% of the respondents (eg: lights on during the day and space optimization between poles and power luminaires) and Environmental Protection (eg: we only need public lighting when we don't have enough sunlight, Off-Set could be sensitive to light shifting according to the time of day) reported by 15% of the citizens — shopkeepers also value faults;

4) Energy Efficiency - the majority of citizens correctly understand the concept of energy efficiency (to take advantage of natural sunlight, avoid waste of energy, save in consumption but maintain the comfort, and reduce the environmental impact). Citizens are receptive to the best fit between operation hours, light intensity responsiveness to the existing traffic flow, optimization of the lighting poles distribution and the optimization of the technical characteristics of luminaires.

The **fourth dimension** is related to the **experience** enjoyed and perceived by individuals, towards the public lighting, and it has three factors:

1) Importance attached to public lighting (>85% of the interviewed citizens give great importance to public lighting - rating 8/10, on a scale from 0 to 10);

2) Main perceived/witnessed problems (1° lighting imbalance between zones, either in Évora and in Leiria, more intense among shopkeepers - mentioned by 80% vs. ~30% in Évora and 15% in Azaruja; 2° existence of light bulbs turned on and off frequently - 75% shopkeepers and 20% in other places), noted that ~30% of interviewed citizens did not identify problems;

3) Global satisfaction, citizens are satisfied with the public street lighting (average satisfaction level close to 8/10) but shopkeepers reveal some discontent (average satisfaction level close to 5/10) especially regarding light intensity and quantity of the working streetlight poles. The analysis of attitudes and behaviour, in Évora and Leiria, allowed to conclude that there are no objections to the implementation of improvements in Public Lighting.

HOW TO BE MORE EFFICIENT?

The second part of the study (qualitative and quantitative methodology), allowed to measure, both in Évora and in Leiria, the potential receptivity by citizens and shopkeepers towards the tested solutions, particularly

relative to operation hours, light flux regulation, reduction of the number of working poles, and colour change. The study leads to the following conclusions:

1) Citizens reveal some disappointment about switch on and switch off, for them, sunset and sunrise are the reference points for offset, and any further time of operation of public lighting is considered useless; **switch on and switch off dependent on seasonality** - in summer 85% of interviewed citizens are willing to save 20min in both periods, and during winter a maximum of 10min is accepted, but this is not consensual; also it is worth mentioning that shopkeepers know better the periods;

2) There is **general acceptance** (~90% of citizens and shopkeepers) to **light flux regulation**, if the main objectives are to reduce cost and allow for greater environmental protection - the majority of citizens want to have more intensity in the initial period, 18:00-22:00 and less intensity in the last period, 02:00-06:45 (> 70%), in the period from 22:00-02:00 opinions are divided more (~50% of citizens accept an intermediate intensity but shopkeepers want equal intensity in period 18:00-22:00); interviewed refuse reducing the number of operating poles;

3) In Leiria, it was tested the responsiveness of citizens and shopkeepers to color change (substitution of sodium vapor lamps for lighting fixtures LED); being the current color of the items with lower satisfaction evaluation, respondents were **receptive to change**, that will allow increase in their perceived safety and visibility, 62% of citizens and 80% of shopkeepers validated the idea, associating to it a cost reduction.

HOW DO CITIZENS EVALUATE?

In the last phase of the study, the citizens were exposed to several different scenarios, depending on the operation area.

Évora

In Évora, **light flux regulation** systems coupled with movement sensors, were the focus. These scenarios involved a test group and a control group. In each group, there were 180 citizens and shopkeepers.

Scenario 1 a light flux regulation was set (Figure 3), for the several time periods, that was the opposite of the *Actual scenario*. In the first period (sunset + 15 min), the light had a lower intensity, and a higher intensity in the last period. The evaluation by citizens of this scenario was very low, only 28% validated the adjustment. The shopkeepers have identified some difficulties resulting from less security, and less visibility on the streets. This change was perceived to be by economic reasons but the majority did not accept it.

Scenario 2, the light intensity began at 80% and was decreased to 60% in the last period, with traffic. Without traffic, the light intensity began at 50% and ended at 30%. The scenario had 52% of citizens' acceptance and

shopkeepers were less receptive to change.

Scenario 3, for periods without traffic, the light flow regulation was less than 10% compared to scenario 2. The acceptance rate was 76% for citizens. This scenario was the most consensual and confirms the perception that, citizens want the strongest light intensity in the first period.

Along the several scenarios, it was found that the test group became aware of the difference that existed, and the control group didn't.

In brief, whatever the scenario that we implement, we can make some adjustments, to optimize costs and for the assurance of efficiency and environmental protection, because small differences aren't detected by the population.

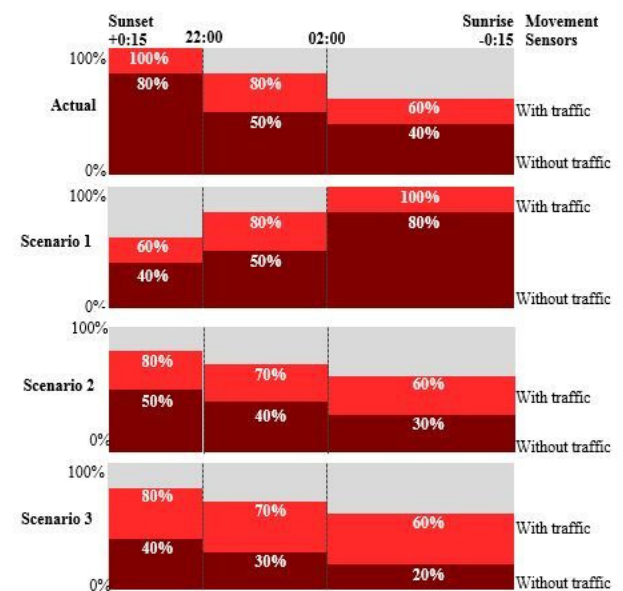


Figure 3 – Scenarios evaluation: Évora

Azaruja/Ecopista

In this area the main objective of the test was on **operating periods** (switch on /switch off) and light intensity (flow controller). In these scenarios were involved 126 citizens in Azaruja and 24 in Ecopista/Eco track (recreation area), belonging to the test group.

Scenario 1, street light switch on, 30 minutes after sunset (*current situation* is 15 min), and switch off 60 minutes before sunrise (*current situation* is 15 min), with a light intensity of 78%. About 55% of the citizens accepted the scenario.

Scenario 2, a more radical scenario. The street light switch on was configured with a 60 minutes delay comparing to the *current situation* and the switch off occurred 120 minutes before sunrise. Light intensity was adjusted to 100%. This scenario was rejected by the

majority of interviewed citizens, (Azaruja: 88% of citizens, 65% of shopkeepers and Ecopista 89% of citizens), alleging loss of security and lower quality of life. **Scenario 3**, the operating periods (switch on /switch off) were set up to be equal to the *Current situation*, but with light intensity adjusted to 78%. In reaction to scenario 2, that was very radical in terms of operation hour, citizens accepted in majority this scenario (Azaruja: 97% of citizens and 85% of shopkeepers and Ecopista 45% of citizens) because it didn't cause insecurity.

Given this results, we confirm that users do not accept solutions that put into risk their safety and cause disruption in their daily lives. Therefore, radical solutions generate an hostile reaction phenomena in users. Assessing the different scenarios, we conclude that there isn't significant scope for changes in operating periods.

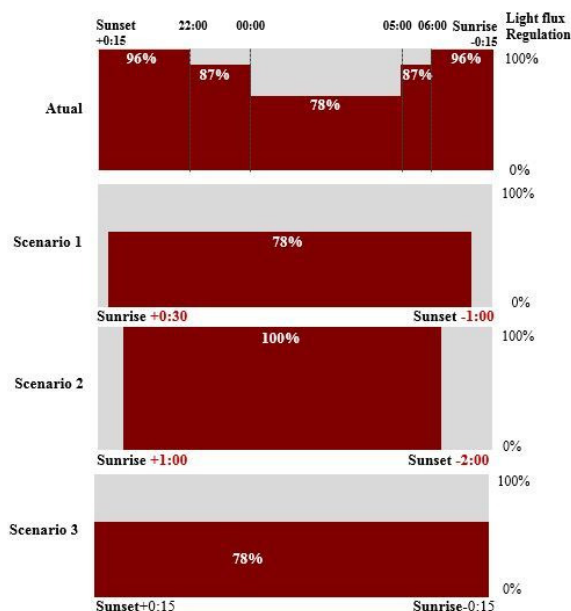


Figure 4 – Scenarios evaluation: Azaruja/Ecopista

Leiria

In this area, **Scenario 4**, we tested **colour** change on public street lighting, yellow HPS (high-pressure sodium) to white LED (Light Emitting Diode). The study involved a test group of 225 citizens and shopkeepers. It took place between 21 and 22 July 2014. The assessment regarding the change of colour was positive, with an acceptance rate above 80%. The citizens were delighted with LED neutral white colour.

In this scenario, disadvantages were not identified. The main advantages were better visibility, allowing security, cost reduction and better sharpness of objects and people.



Figure 5 – Previous (yellow HPS)



Figure 6 – Now (white LED)

CONCLUSION

"The public lighting has a considerable importance in annual energy costs, it makes sense to focus here an effort to make more efficient" [3]

Considering this view, it is essential to promote energy efficiency in public lighting and this study, evaluating the different scenarios, come to support some measures and technologies solutions of energy efficiency:

- there is scope to reduce the light intensity between 20 to 30%, in particular HPS, which will allow interesting efficiency gains, existing generalized receptivity, from the citizens, to cost reduction issues;
- the colour change lighting, corresponded to the acceptance of LED technology, will provide a strong reduction in energy costs because LED is more efficient, the study support the agreement of this technology;
- the combination of light intensity adjustment and LED (with colour changing and improving the colour rendition) will allow significant gains: over 75% efficiency than the mercury vapour and more than 60% efficient than HPS;
- another aspect to consider, resulting of the study, is the use of movement sensors in streetlight, would require an economic evaluation and only used in specific areas.

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