

INDICATORS PROPOSAL FOR THE SUSTAINABLE MANAGEMENT OF OUTDOOR LIGHTING

ALBERTO BAÑUELOS IRUSTA & SUSANA MALÓN GIMÉNEZ
AAC Centro de Acústica Aplicada S.L.

Street lighting is one of the main causes of energy consumption for local authorities and therefore, must be one of the main objectives in their energy efficiency plans, adapting the lighting design to comply with the illumination needs established in international recommendations.

Having specific indicators for lighting in the sustainability indicators will help to increase the citizen awareness necessary to assume the changes, which are often drastic, and modify habits and priorities in the design and use of street lighting, justified by their influence on climate change and sustainable development.

With the proposal of 6 indicators for light pollution, based on AAC's 5 years experience in this field, the aim is that the sustainable management of outdoor lighting becomes a priority, which will lead to a progressive increase in energy efficiency and environmental improvement and, therefore, an increase in the quality of the night sky.

Introduction

Economic development has influenced that economic aspects of lighting installations have moved to the background and also aspects such as efficiency have become contingent upon objectives that have been considered as priorities.

Therefore, in Spain at least, safety has been combined with a greater demand for lighting, which has justified a growing increase in the levels of lighting in many installations, identifying the amount of light with the quality of the nocturnal atmosphere and increasing the parameters of the design objectives way above the recommended levels.

This has meant that in our towns we have arrived at situations that are clearly unsustainable due to the excess consumption caused by the outdoor lighting installations which have furthermore led to a new type of pollution: light pollution, which although it initially originated as a demand against the loss of nocturnal atmosphere which prevents people from seeing the night sky, its effects have increased to include aspects such as disturbance for the actual citizens due to intrusive light, the effects on the environment as it effects on different species and also negative effects such as glare and lack of uniformity, because excessive lighting does not necessarily mean good quality lighting.

Due to its polluting effects on suitable environmental quality, as well as the excessive energy consumption, street lighting should be included in the evaluations of sustainability plans, especially considering the current priorities for reducing energy consumption and increasing efficiency, within the objectives to stop climate change.

Outdoor lighting is the main installation in energy consumption of local councils and therefore, it should be a primary objective to reduce consumption down to what is

strictly necessary to achieve adequate lighting, that respects the necessary minimums, but avoids an excess that goes beyond the design technical margin.

It is clear that this approach should definitely be included in what should be the sustainability objectives and, to do this, it is necessary to establish evaluation criteria that allows for an objective diagnosis and monitors the evolution of the operations, for which indicators should be defined that are included in the bank of sustainability indicators of a town; since due to its environmental effects as well as its value in saving energy, the sustainable management of outdoor lighting should be specifically included among the main variables to control within the sustainability plans of towns.

The 5 years experience of AAC Centro de Acústica Aplicada, working on the development of methodologies for the evaluation and management of outdoor lighting from an environmental and sustainable approach, allows us to make a proposal of sustainability indicators for street lighting.

Experience

In 2002 AAC started to put into practise a methodology to evaluate light pollution, with the aim of transferring the experience in the evaluation and management of environmental noise in urban areas to the environmental management of outdoor lighting.

The first project was developed for the town council of Las Palmas de Gran Canaria (Spain) – Environmental Service, within the project of “Design and implementation of a system to evaluate environmental quality: atmospheric, acoustic and lighting in the town of Las Palmas de Gran Canaria”, carried out between 2002 and 2004.

The system was developed from a sustainable perspective, proposing a first bank of sustainability indicators of the town, based specifically on the three environmental variables considered.

Because there are no indicator references in Local Agendas 21 that allow light pollution to be assessed specifically and considering that the light pollution caused by outdoor lighting comes under direct municipal management, which also allows for adopting relatively simple solutions and which, contrary to other operations, are paid off in a short period of time, it was agreed that within the bank of basic indicators for the city, within the field of the study, it was necessary to establish specific indicators for this pollution.

This is why a first proposal was designed, together with the technical team of the project, with 5 specific indicators for this pollution.

In the case of light pollution the study was developed in a zone that was selected as a pilot zone in the city, the district of Triana, where a methodology was developed that allowed for the evaluation of the main parameters that allow the system to be assessed and, as a consequence of this assessment, the definition of the indicators.

This initial proposal has served as a reference to establish methodologies aimed at assessing light pollution and the quality of lighting in other towns and has helped in the search for improvements in the definition of indicators, that allow the assessment of the town to be summarised and serve as a reference for the objectives of action plans.

The reference for the definition of the indicators is the compliance with the specifications that are necessary for a lighting system to fulfil its function, avoiding the effects that may be considered as light pollution.

The variables to respond to the indicators are identified, the methodologies that allow for their evaluation are established and the proposal for sustainability indicators for outdoor lighting is defined.

Based on the proposal carried out for the local council of Las Palmas de Gran Canaria, the same approach was applied to smaller towns, of between 500 and 15,000 inhabitants, all of them in the Basque Country, with a different assessment scope, which allowed for the initial proposal to be improved and the viability of applying the indicators to different fields to be checked. The municipalities analysed up to now are:

- Alegría-Dulantzi, Arrazua-Ibarrundia and Agurain-Salvatierra (Álava)
- Mungia and Arrankudiaga (Bizkaia)
- Aretxabaleta and Bergara (Gipuzkoa)

Indicators Proposal

The indicators to be considered with this objective must cover the different aspects related to the sustainability and environmental quality of outdoor lighting. This means they must cover the sections of energy consumption, points of light that are environmentally unsuitable and the evaluation of the installation, regarding both the energy efficiency and the levels of lighting in the different plans of analysis: ground, façade and sky. With regards to the levels of lighting, understanding unsuitable lighting to be pollution, due to excess or deficiency in the zones that should be lit and those areas that do not need to be lit.

The indicators should be applied to any municipality offering results that allow for comparison between different municipalities, therefore the specific data of a municipality should be related to parameters that allow for generalisation.

This initial approach does not include other types of lighting, that should also be included in the future: ornamental, publicity, industrial, private, ...

From the experience of AAC Centro de Acústica Aplicada S.L. the proposal is for 6 indicators for the sustainable and environmental evaluation of street lighting, that are described below:

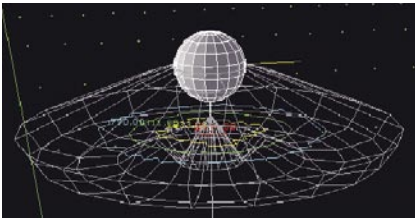
Indicator CL1: Energy consumption

Definition	Annual amount cost? per inhabitant paid for the outdoor lighting of the municipality.
Unit	Euros / Inhabitant
Calculation	Annual invoices for electric consumption paid by the council for the outdoor lighting installations, plus the maintenance costs.
Objective	Minimum consumption

This indicator aims to give an overall evaluation of all the aspects that may influence a suitable design for the lighting system, taking into account that there are a lot of factors that can affect the results. But it groups together useful aspects such as the efficiency of the installation, the urbanistic dispersion, the large tendency to light areas that do not necessarily need it or the adequate economic management in the local council, taking advantage of the best rates.

Indicator CL2: Pollutant points of light

Definition	Percentage of points of light of outdoor lighting that exceed the limits admissible for the FHS or that contain dangerous residues, such as mercury.
Unit	% of the points of light
Calculation	All the points of light will be counted that have: <ul style="list-style-type: none"> a) Fittings that involve an FHS above the admissible one for the zone where they are located, in accordance with the zonification by admissible glare, or b) Lights with especially dangerous residues (mercury, ...) <p>The indicator is obtained as the percentage that these points of light represent with regards to the total formed by the street lighting of the municipality.</p>
Objective	Zero



It assesses if the lighting fittings in their entirety can be considered as pollutant, whether because of inadequate design of the fittings, because of their excessive flux emitted above the horizontal or because they are fitted with a light that has dangerous residues at the end of its useful life.

Indicator CL3: Energy Efficiency

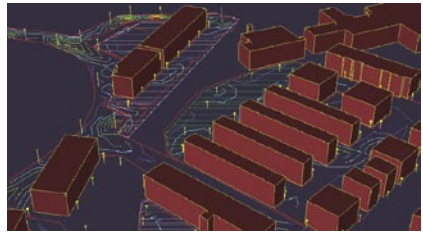
Definition	Total energy efficiency of the outdoor lighting installation of the municipality.
Unit	m ² x lux / W
Calculation	Assessment by zones of the average lighting in service per the surface area to be lit. Sum for the whole surface area to be lit of the municipality of the partial values obtained, which is divided by the total active power installed in the municipality.
Objective	Maximum

Overall assessment of the energy efficiency for the entire installations of the municipality, including in the efficiency concept the actual effect of the urban design on the lighting needs.

Indicator CL4: Illuminance level

Definition	Percentage of the surface area to be lit of the municipality that complies with the objectives of international illuminance levels (CEI), without exceeding them by more than 20 %.
Unit	% of the surface area to be lit of the municipality
Calculation	Partial assessments are carried out that are compared with the corresponding average illuminance level (lux), being classed as a positive result if: CEI Level < Illuminance Level (lux) < 1.2 * CEI Level % is obtained of the total surface area of the zones which have obtained a positive result regarding the total surface area of the municipality that needs to be lit.
Objective	100 %

It aims to evaluate the compliance with illuminance levels that are suitable for the lighting needs of the municipality in accordance with the international recommendations, avoiding both insufficient systems and ones that are too large.

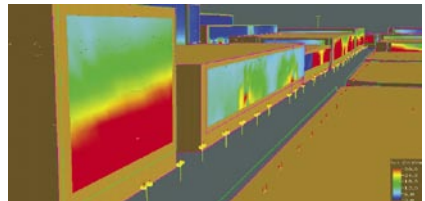


Indicator CL5: Intrusive light

Definition	Percentage of the population whose house façade is exposed to illuminance levels exceeding 2 (lx) in the period of reduction of the level of light
Unit	% of the population of the municipality.
Calculation	To evaluate the average illuminance levels in the façades of each residential building and associate it to the population of the building. To add up the population of the buildings with levels in the façades exceeding 2 lx and obtain the percentage with regards to the total population of the municipality.
Objective	Zero

NOTE: A second level of evaluation could be applied that is less restrictive, for example with 5 or 10 lx.

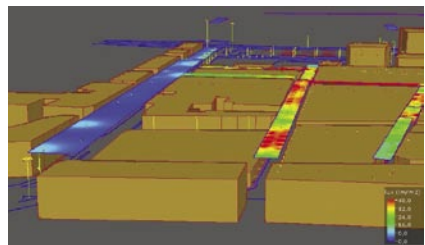
It aims to avoid unnecessary lighting on façades, which also disturbs the residents.



Indicator CL6: Sky glow

Definition	Percentage of the installed flow that is directed towards the sky.
Unit	% of Total Flow Installed
Calculation	To evaluate by zones the light flow that is directed towards the sky, taking into account the contribution of reflections. To add up the total flow towards the sky of the municipality. To calculate the percentage with regards to the total flow installed in the municipality.
Objective	Minimum

It aims to evaluate the loss of energy towards the sky and the contribution to the light glow over lit up areas, which prevents visibility of the stars. Reflections from the ground and façades must be taken into account, to incorporate the suitable selection of materials in urban design, although for an initial evaluation it can be applied without considering the reflections based on the flow emitted directly towards the sky.



Results obtained for different municipalities

The results obtained from seven studies in different municipalities with different scopes are summarised in the table below:

Indicators	Nº of Data	Unit	Results	Objective
CL1 Consumption	3	Euros/Inh.	20.6 / 30.5 / 36.7	Min.
CL2 Consumption	7	% Light Points	27 / 34 / 40 / 42 / 47 / 83 / 84	0
CL3 Consumption		m ² *lux/W		Max.
CL4 Consumption	3	% Surface	12 / 35 / 39	100
CL5 Consumption	2	% Inhabitants	75 / 80	0
CL6 Consumption	2 (+5)	% Total Flow	16 / 29 (without reflec. 11 / 18 / 18 / 21 / 27)	Min.

NOTE: Energy efficiency data is not provided, since the results available in some municipalities have not been assessed comparatively nor in accordance with the proposal explained here.

Conclusions

- 6 indicators are proposed that largely cover the problems caused by light pollution.
- There are other possible indicators, but they must be assessed to see if their use is just technical or also in sustainability observatories.
- The relation of indicators must be considered as an initial proposal, that must be discussed, evaluated in municipalities with different characteristics and adjusted.
- The main objective is to inform politicians and citizens of the state of street lighting concerning sustainability objectives, that are so important currently, and to make the most of these evaluation to justify decided plans of actions.

Notes and References

1. “*European Common Indicators – Final Project Report*”. Ambiente Italia Research Institute. 2003
2. “*Modelo de Ordenanza Municipal de Alumbrado Exterior*”. Instituto para la Diversificación y Ahorro de Energía, IDAE.
3. “*Guía Técnica de Eficiencia Energética en Iluminación: Alumbrado Público*”. Instituto para la Diversificación y Ahorro de Energía, IDAE.
4. Documents International Lighting Committee (CIE)

Contact

Alberto Bañuelos Irusta y Susana Malón Giménez, AAC Centro de Acústica Aplicada S.L., Parque Tecnológico de Álava, 01510 Miñano (VITORIA-GASTEIZ) - Spain. E-mail: aac@aacacustica.com; Tel: +34 945 298 233.