

# Energy efficiency in public lighting systems

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## ABSTRACT

The public lighting systems sector is at the beginning of important technological changes, due to economic and environmental sustainability reasons.

It is quite easy to operate, thanks to a considerable installation uniformity. It is therefore programmable and the public decision makers have to make choices involving energy and maintenance savings, environmental sustainability, public security and safety, aesthetic improvement of the cities, relationships with citizens.

The main technical matters are the light sources (efficient lamps and modern LEDs) and automatic light control systems. The implementation can be retro-fitted on the existing installations. It is easy to reach the necessary compromise between the conservation requirements of historical urban sections and the sustainable development.

The main purpose of this kind of enterprises is the complete requalification of the whole city lighting plants, or of a large amount of them such as the historical sections. The financial instruments are promoted from the Directive 2006/32/EC on energy end-use efficiency and energy services, using private capitals (Energy Service Companies - ESCo).

## KEYWORDS

Energy and maintenance savings  
Electrical and mechanical safety  
Retro-fit installation  
Light pollution  
Light plan  
Directive 2006/32/EC  
Energy Service Company (ESCo)

## **ENERGY AND MAINTENANCE SAVINGS**

In the requalification of the whole city lighting systems, or of a large amount of them, the energy saving can be about or more than 50%.

The power consumption reduction is obtained with two main operations:

1. power reduction
2. light control

The power reduction can be usually around 20-25% (sometime more). It is reached through the replacement of old light fittings - often mounting mercury lamps (now forbidden from the EU) or overpowered lamps - with modern light fittings, retro-fitted on the same pole and plant. The new light fittings have efficient cut-off optics with high-efficiency and long-life sodium / iodide lamps. For relevant applications, can be used ultimate LED fittings, characterized by extremely high-efficiency and long-life.

The light control reduces the light level during the night time, when the street traffic is lower. It produces 25-30% energy saving and permits a high performance installation management thanks to a complete supervision system on all the city light points.

The maintenance saving is about 30%, with long-life lamps and fittings, and with automation and supervision systems.

## **ENVIRONMENTAL SUSTAINABILITY - LIGHT POLLUTION**

Another environmental problem is the light pollution. This is a very important topic for many Environmental Associations, because it causes the disappearance of the vision of starry sky and difficulty for astronomical observations.

The problem is solved through a retro-fit change of the old light fittings, with modern fittings having efficient cut-off optics.

In Italy many Regions have issued local laws in order to indicate the way to design and make new lighting plants, according to technical criteria to reduce or eliminate the light pollution.

## **PLANNING**

The public decision makers can make medium-long term planning with an urban planning and illumination instrument called "Light Plan".

The Light Plan allows to follow appropriate sustainable development programs, for the whole town but with specific actions fitted for protected city centres, urban sections, small settlements, etc.

The Light Plan purpose is to harmonize the external lighting with the transformation and development of the town, optimizing present and future choices and operations, in order to avoid fractional and not-coordinated operations with consequent waste of public and environmental resources.

## **FINANCING**

The Local Government units are facing economic difficulties, so the intervention ways are oriented to financial instruments that use private capitals, as Project Financing or Third Party Financing, where an ESCo (Energy Service Company) develops an appropriate business-plan, making the initial investment in plants requalification and financing all or part of the operation with energy and maintenance savings.

This kind of financial instruments are promoted from the European Community with the Directive 2006/32/EC on energy end-use efficiency and energy services.

The Local Government has to issue a tender for running the maintenance and energy service for several years, together with the initial lighting systems requalification. The

Local Government pays a fee to the ESCo that is equal to or often lower than the historical energy and maintenance costs, with the advantage of having renewed, safe and efficient plants.

In order to have a business-plan that allows to make the total initial requalification of the city lighting systems, it is generally necessary to run an energy and maintenance contract with a period from 10 to 30 years.

### LATEST PUBLIC LIGHTING TECHNOLOGIES

The topics of a public lighting system requalification, that uses the latest technologies, are:

- 1. Electrical and mechanical safety with renewed plants;
- 2. Modern light fittings with efficient cut-off optics;
- 3. High-efficiency and long-life lamps or LEDs;
- 4. Light-point control with PLC / Power Line Communication technology;
- 5. Retro-fit installations (no civil works);

**Electrical and mechanical safety with renewed plants** The lighting plants have often a strong lack of maintenance and require important operations or replacement of parts as electrical boards, electrical lines, poles and brackets.



Figure 1. Renewed or new electrical boards



Figure 2. Renewed or new poles

**Modern light fittings with efficient cut-off optics** The old light fittings, with obsolete optics and with mercury lamps or overpowered sodium lamps, are replaced with new modern fittings, with cut-off optics and high-pressure limited-power sodium lamps.

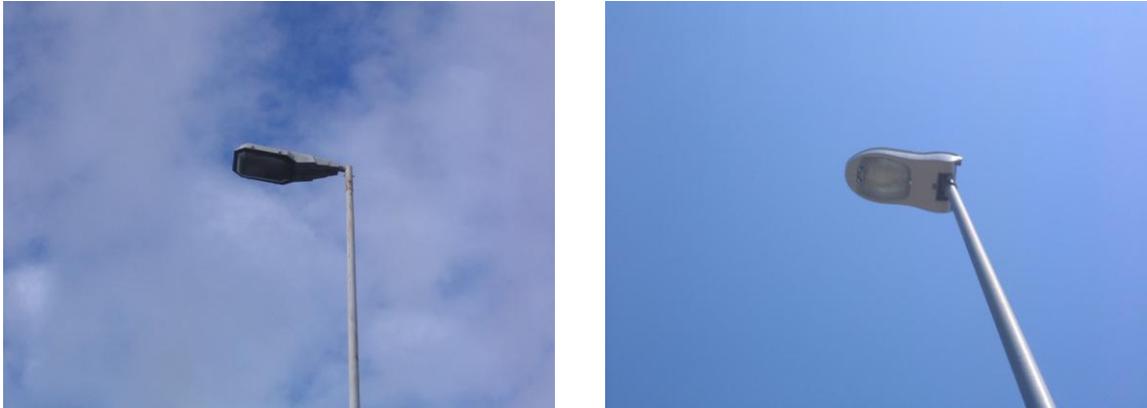


Figure 3. New retro-fitted light fittings with efficient cut-off optics

**High-efficiency and long-life lamps or LEDs** The obsolete mercury lamps, forbidden from the European Community (Directive 2002/95/CE RoHS), are replaced with high-efficiency high-pressure sodium lamps, with limited power and long-life (more than 48,000 hours).

For relevant applications, the obsolete lighting fittings are replaced with modern ultimate fittings using Light Emitting Diode (LED) as light sources. These fittings have very high efficiency and life (about 50,000 to 100,000 hours).



Figure 4. High-efficiency and long-life lamps or LEDs

**Light-point control with PLC / Power Line Communication technology** All of the city light points are controlled and regulated in light intensity with supervision systems, using Power Line Communication technology. This means the use of the existing electrical cables for power supply and no need to lay new cables.

With this system it is possible:

1. to reduce the light intensity (and then the power and the energy consumption) during the night hours with low traffic;

2. to control the whole city light systems from one or more remote control rooms, managing for example an industrial area in a different way than an historical city centre or a dangerous street cross.

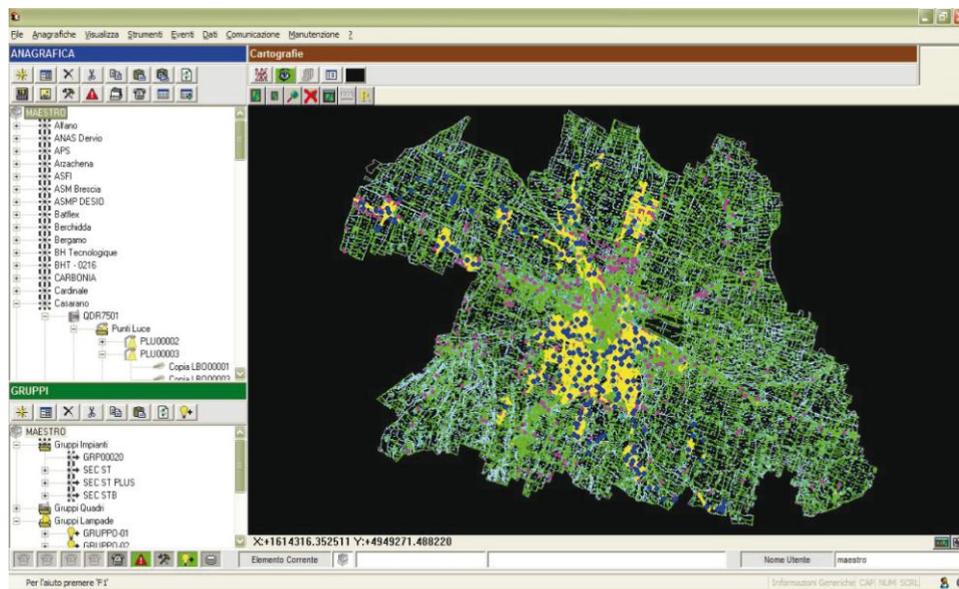


Figure 5. Punctual supervision of the whole city public lighting system

**Retro-fit installations (no civil works)** In order to reduce the economical impact for the complete requalification of the city lighting plants - or a large amount of them - the main installations are retro-fitted on the existing electrical lines, poles and brackets. This is also very good for the historical town sections, where not needing to make civil works allows to minimize the impact on cultural heritage buildings and areas.

## MAIN STANDARDS

In order to develop an appropriate external lighting systems project, the main European and International Standards are:

CEN/TR 13201-1 : 2004	"Road lighting - Part 1: Selection of lighting classes"
EN 13201-2 : 2003	"Road lighting - Part 2: Performance requirements"
EN 13201-3 : 2003	"Road lighting - Part 3: Calculation of performance"
EN 13201-4 : 2003	"Road lighting - Part 4: Methods of measuring lighting performance"
EN 60598-1 : 2004	"Luminaires. General requirements and tests"
EN 62035 : 2000	"Discharge lamps (excluding fluorescent lamps) safety specifications"
EN 60662 : 1993	"High-pressure sodium vapour lamps"
EN 61167 : 1992	"Metal halide lamps"
EN 40-x	"Lighting columns"
IEC 60364-7-714 : 1996	"Electrical Installations of Buildings - Part 7: Requirements for Special Installations or Locations - Section 714: External Lighting Installations"

## EXAMPLES

**San Vito dei Normanni** is an historical town of about 20,000 inhabitants, in the Brindisi district of Puglia, southern Italian Region.

The Municipality of San Vito dei Normanni made a Tender on the whole town public lighting systems, for a 15 years energy and maintenance service, and for the complete energy and safety requalification.

The public lighting systems have 2,710 light points.

The expected energy saving is 58.7% and the maintenance saving is 33%.

The total economical amount of the initial requalification works, to be charged on the ESCo, is € 2,152,425.68 -

Table 1. San Vito dei Normanni (Brindisi) - Power and Energy reduction

	before	after	diff.	diff. %
Power (kW)	556	336	-220	-39.7%
Energy (MWh/year)	2,031	839	-1,192	-58.7%
TOE (tonne of oil equivalent)	508	210	-298	-58.7%

**Geovest** is an association of several towns, in Emilia Romagna, central Italian Region.

Geovest, together with the Municipalities of Sant'Agata Bolognese, Sala Bolognese, Nonantola, Crevalcore, Calderara di Reno, made a Tender on the whole 5 towns public lighting systems, for a 15 years energy and maintenance service, and for the complete energy and safety requalification.

The 5 towns public lighting systems have about 9,000 light points.

The expected energy saving is 33.3% and the maintenance saving is 27%.

The total economical amount of the initial requalification works, to be charged on the ESCo, is € 2,222,175.67 -

Table 2. Geovest (n.5 Cities in Emilia Romagna) - Power and Energy reduction

	before	after	diff.	diff. %
Power (kW)	1,028	892	-136	-13,2%
Energy (MWh/year)	4,427	2,951	-1,476	-33,3%
TOE (tonne of oil equivalent)	828	552	-276	-33,3%

**San Donato Milanese** is an industrial town of about 33,000 inhabitants, in the Milan district of Lombardia, northern Italian Region.

The Municipality of San Donato Milanese made a Tender on the whole town public lighting systems, for a 20 years energy and maintenance service, and for the complete energy and safety requalification.

The public lighting systems have 5,176 light points.

The expected energy saving is 48.4% and the maintenance saving is 30%.

The total economical amount of the initial requalification works, to be charged on the ESCo, is € 3,429,658.39 -

Table 3. San Donato Milanese (Milan) - Power and Energy reduction

	before	after	diff.	diff. %
Power (kW)	661	546	-115	-17.4%
Energy (MWh/year)	3,109	1,604	-1,504	-48.4%
TOE (tonne of oil equivalent)	581	300	-281	-48.4%

**Cosenza** is a town of about 70,000 inhabitants, in Calabria, southern Italian Region. The Municipality of Cosenza made a Tender on the whole town public lighting systems, for a 20 years energy and maintenance service, and for the complete energy and safety requalification.

The public lighting systems have about 11,000 light points.

The expected energy saving is 63.8 % and the maintenance saving is 35%.

The total economical amount of the initial requalification works, to be charged on the ESCo, is € 6,945,723.75 -

Table 4. Cosenza (Calabria) - Power and Energy reduction

	before	after	diff.	diff. %
Power (kW)	2,555	1,766	-789	-30.9%
Energy (MWh/year)	10,220	3,696	-6,524	-63.8%
TOE (tonne of oil equivalent)	1,911	691	-1,220	-63.8%