Checklist for LED lighting systems

**GEAR@SME: G**enerate **E**nergy-efficient **A**cting and **R**esults at **S**mall and **M**edium-size **E**nterprises

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# Introduction

The following checklist is designed to support the procurement of high quality energy efficient LED lighting systems. It can be used both from individual SME or from Trusted Partner in charge of procurement for a group of SMEs.

The checklist consists mainly of two parts. In the first part, entitled "Situation description", the information to be provided when requesting a quote is listed. This information allows the supplier to adapt his answer to the specificity of the project.

In the second part "Specification and valuation of the offer", the specific information related to LED Lighting System that could be included in the supplier's quote is listed. Other more general information is listed in the [GEAR@SME Example Tender document].

# Situation description

This section indicates the technical specifications and what kind of information the buyer needs to provide in order for suppliers to make a quote.  
Documents related to the analysis of the actual state of the installations and any planned energy efficiency measures should be acquired. Typically this information can be gathered during an energy audit.  
In general, if an energy audit has not been performed, a feasibility study for the retrofit project should be conducted before the quote is prepared. The feasibility study may involve several levels of detail.

The minimum information to be collected in order to prepare a quote is, for example:

* surface (m²) of the areas to be subjected to energy renovation;
* destination of use of the spaces to be retrofitted;
* specific lighting needs defined by the client (e.g. need for spot lighting, etc.);
* number and type of lighting elements to be replaced;
* operational hours

Other useful information that can be collected and will allow the supplier to further detail the offer is as follows:

* information regarding the possibility of installing a lighting control system (presence sensors, dimming sensors, etc.);
* presence or absence of an existing electricity consumption monitoring system that should possibly be integrated;
* cost of current electricity use (necessary to draw up the business plan of the intervention)

The feasibility study and therefore the new lighting system shall comply with relevant national norms and standards.

# Specification and evaluation of the offer

Specific information regarding the LED lighting system is listed in this chapter.

* For more general information on supplier selection we refer to the [Gear@SME Tool supplier selection tool]
* For an example of a contract we refer to the [Gear@SME Example contract with supplier]

When requesting the offer, the client may decide to set minimum mandatory and award criteria for the technical-economic specifications.

* minimum mandatory: Example: The minimum amount off light on desks in an office must be 500 lux.
* award criterium: Example: The supplier that can offer the highest amount of lumen per Watt will score best on the award criterium for luminaire efficiency

For the award criteria a score is applied to rank the tender offers. In order to calculate the score of the various offers - and then compare them to find the best offer - a weighting of the different types of criteria is mostly desirable.

## Technical criteria

Luminaire efficiency

The amount of light that a luminaire produces per unit of energy (measured in lm/W)

Luminance

The European norm 12464-1 specifies the minimum required illuminance levels for the task area and its surroundings.

|  |  |  |
| --- | --- | --- |
| **Space description** | **Illuminance (lx)** | ***R*aindex** |
| Areas with traffic and corridors | 100 | 40 |
| Stairways, escalators, and travelators | 100 | 40 |
| Lifts | 100 | 40 |
| Loading bays | 150 | 40 |
| Coffee-break rooms | 200 | 80 |
| Technical facilities | 200 | 60 |
| Storage spaces | 100 | 60 |
| Electronics workshops, testing, and adjustments | 1500 | 80 |
| Ball-mill areas and pulp plants | 200 | 80 |
| Offices and writing | 500 | 80 |
| Check-out areas | 500 | 80 |
| Waiting rooms | 200 | 80 |
| Kitchens | 500 | 80 |
| Parking areas | 75 | 40 |
| Classrooms | 300 | 80 |
| Auditoriums | 500 | 80 |

LED module energy efficiency

A minimum efficacy value for LEDs must be observed (for example ≥ 160lm/W).

The contractual target values may be revised periodically.

Light Output Ratio (LOR, η)

The light output ratio of a combination of lamp and fixture indicates the part of the lumens that are produced that are emitted in the desired direction. For traditional TL lighting part of the light in ceiling lighting is directed upwards and therefore not contributing to illuminating the work area. Typical TL fixtures have a LOR of 75% whereas LED TL fixtures can attain 100%.

Power factor

Checking the Power Factor (PF or cosφ) is necessary. The PF must assume minimum values typically greater than 0.9 and, if necessary, also be evaluated at partial loads, in the event of the system being dimmed.

In the case of a lighting retrofit using LED lamps, imagine having to light a large area with a line of LED fixtures, e.g. with a unit power of 20 Watts, using two similar products but with very different PF. The electrical absorption (Amps) of the individual LEDs will be higher for the lower PF LED fixtures, so fewer fixtures can be installed without having to replace the line switch. Choosing LEDs with different PFs can therefore also affect plant design, resulting in higher installation costs.

Application-specific energy criteria

For example, in the case of industrial and technical lighting:

* Especially where working hours extend to 24 hours, often with little daylight; maximum daylight, maximum efficiency technologies are needed.
* Make primary use of daylight, not least to provide greater well-being for occupants.
* Monitor presence to switch lighting in secondary or less frequented areas.
* etc.

Lighting control features

Options for lighting control features should be evaluated and it should be specified whether the requirements are suitable.

The most common types of lighting control systems on the market are as follows:

* Basic lighting controls: manual on/off switch
* Pre-set lighting controls
* Daylighting control systems
* Occupancy sensors
* Motion sensor controls: for utility and security lighting
* Dimming: in combination with LED bulbs, dimmer switches can help control your building's energy costs.
* Networked lighting control systems: can be part of a Building Automation System (BAS) package or designed as a stand-alone system

A qualified professional can help you decide which configurations are most suitable.

Energy measurement system

The evaluation of a lighting system in terms of optimised maintenance and operation requires appropriate energy measurement systems.

The measurement enables rapid detection of faults and the need for maintenance. Appropriate measurement options must be considered and compared.

Tenderers may provide options for metering and state the costs and benefits within the tender.

List of the additional mandatory requirements

To be specified depending on the application.

For example:

* colour temperature
* colour rendering and consistency
* uniformity of light distribution (according to the standards)
* glare protection (assessment of discomfort and/or disability thresholds)
* Mark of conformity for all components
* Lifetime (in number of hours).
* IEC protection classes for power supplies
* water resistance (ingress protection rating, IP)
* etc.

## Execution and handover

Compliance with EN standards and relevant standards for the field of application

Compliance of the tender/project with national and application specific standards must be provided by the tenderer.

Compliance with project timelines

The tenderer's capacity must meet the specific timeline of the lighting retrofitting project.

Technical documentation

* Technical report
* Electrical system drawings
* Graphic works
* Maintenance plan
* Safety and Coordination plan
* Price analysis
* Test certificate of relevant components
* etc.

## Maintenance and warranty

Retrofit projects involving only the replacement of lamps and/or luminaires

The following criteria are suggested:

* Luminaire lifetime (in thousands of hours)
* LED module lifetime (in thousands of hours)
* Failure rate (% per 1,000 hours)

Other specific requirements to be assessed

* Availability of spare parts for lighting system components must be available for a minimum number of years.
* Ease of repair and recycling: easy access, replacement of light sources (lamp or LED module) and auxiliary devices.
* Design criteria .

Warranty

The warranty and/or service agreement period shall cover a minimum set number of years.

For example:

* Any defective light source, control gear and/or luminaire shall be replaced at no cost.
* If the luminaire provides a lower lumen output than originally specified, it shall be considered defective.
* Each batch of lamps or luminaires shall be completely replaced if the number of defective units in the batch exceeds a specified percentage of the batch.

Conditions typically not covered by warranty:

* Luminaires defective due to accidents.
* Lamps and luminaires which have been operated for a significant time under abnormal conditions (e.g. operated under an incorrect main voltage) insofar as this can be proven by the manufacturer.

## Cost criteria

Total costs of ownership (TCO) or Life cycle costs (LCC)  
Ideally, the supplier shall provide a detailed calculation based on a total cost and/or life cycle cost approach.

Investment costs   
This can be an award criterion for projects where LCC respectively TCO cannot be assessed.

## Contractual criteria

For general criteria, please refer to [GEAR@SME Example Tender document]

Correct installation

* correct installation of the lighting system as per requirements/specifications   
  (for example installation according to NEN 1010 specifications in the Netherlands)
* deliver a schedule of the installed lighting equipment with manufacturers' invoices or delivery notes attached
* certificate of conformity of the installed equipment

Putting into service of lighting systems and controls

KPI monitoring

Identify appropriate Key Performance Indicators (KPIs) to be measured and monitored before and after the implementation of energy efficiency measures.

Indicators may constitute evaluation criteria where the investment is financed through an incentive mechanism or scheme and monitoring of KPIs after the implementation of the measure is required.

Waste reduction and recovery

The Tenderer shall implement appropriate measures to reduce and recover waste generated during the installation of the new lighting system or the refurbishment of the lighting system.

All replaced lamps, luminaires and electronic parts shall be separated and recovered in line with the applicable directives.

Know-how and expertise of the tenderer

The requirement to be submitted will concern a minimum number of relevant lighting projects carried out in the last years (to be specified) with a project size similar to the specific tender.

Proof of expertise also can include previous projects in other companies/SMEs similar to the company under consideration.

In order to ensure the quality and correct execution of the work, the implementation team will require the presence of qualified technical staff, e.g. an electrician.

Proposed weighting of award criteria

A weighting approach is often helpful for the evaluation of award criteria.

Below is an example of a possible weighting criterion for the various elements of the offer:

|  |  |
| --- | --- |
| **Award criterion** | **Proposed weighting (%)\*** |
| Investment costs | 30 |
| Technical criteria | 30 |
| Execution and handover | 20 |
| Maintenance | 10 |
| Supplier know-how & expertise | 10 |
| TOTAL | **100** |

(\*) The weighting of criteria must typically be adapted to local needs and requirements. Therefore, the approach recommended here is only one possible option.

# Abbreviations and definitions

Luminous flux (lumens) [4]

The light emitted by a source such as a lamp or received by a surface, irrespective of direction. Lumen (abbreviation lm): The SI unit of luminous flux used in describing the total light emitted by a source or received by a surface. (A 100-watt incandescent lamp emits about 1200 lumens).

Illuminance (lux or lumens/m2) [5]

The quantity of illumination. The illuminance is measured in lux, where 1 lx = 1 lm/m2.  
Illuminance is readily measured by a light-meter held at the point of measurement.

Luminous efficacy (lumens/W) [6]

is the ratio of luminous flux (light) in lumens to radiant flux (total radiation) in watts in a beam of radiation. It is an important concept for converting between [radiometric](https://www.sciencedirect.com/topics/chemistry/radiometry) and photometric quantities. Its units are the [lumen](https://www.sciencedirect.com/topics/physics-and-astronomy/lumens) per watt, lm/W.  
[Luminous efficacy](https://www.sciencedirect.com/topics/engineering/luminous-efficacy) is not an efficiency since it is not a [dimensionless ratio](https://www.sciencedirect.com/topics/engineering/dimensionless-ratio) of energy input to energy output—it is a measure of the effectiveness of a beam of radiation in stimulating the perception of light in the human eye.

Colour temperature (K) [7]

The colour temperature of a light source is the temperature of an ideal [black-body](https://www.sciencedirect.com/topics/engineering/blackbody) radiator that radiates light of comparable hue to that of the light source. Colour temperature is conventionally stated in the unit of absolute temperature, the kelvin (K). Colour temperature is a characteristic of visible light that has important applications in lighting, photography, videography, publishing, manufacturing, astrophysics, and other fields.

When the temperature of an incandescent source is increased, more light is produced. The colour of the material changes from red at low temperature to yellow and finally to nearly white as the temperature is increased.

CRI (Colour Rendering Index)

Color rendering index (CRI) is a measure that shows the light source's ability to reproduce the object's color compared to daylight. CRI is measured on a scale of 0-100, with 100 representing the maximum value with the highest color rendering. So a high CRI makes that colors are represented more similar to daylight. Applications where a high CRI might be of significant value are clothing and food retail. Normally a CRI of 80 or higher is considered good.

Text from Wikipedia: “The value often quoted as "CRI" on commercially available lighting products is properly called the CIE Ra value, "CRI" being a general term and CIE Ra being the international standard color rendering index.

Numerically, the highest possible CIE Ra value is 100 and would only be given to a source whose [spectrum](https://en.wikipedia.org/wiki/Spectrum) is identical to [the spectrum of daylight](https://en.wikipedia.org/wiki/Solar_spectrum), very close to that of a [black body](https://en.wikipedia.org/wiki/Black_body) (incandescent lamps are effectively black bodies), dropping to negative values for some light sources. [Low-pressure sodium lighting](https://en.wikipedia.org/wiki/Low-pressure_sodium_light) has a negative CRI; [fluorescent lights](https://en.wikipedia.org/wiki/Fluorescent_light) range from about 50 for the basic types, up to about 98 for the best multi-phosphor type. Typical white-color [LEDs](https://en.wikipedia.org/wiki/LEDs) have a CRI of 80 or more, while some manufacturers claim that their LEDs achieve a CRI of up to 98.

CRI Ra's ability to predict color appearance has been criticized in favor of measures based on [color appearance models](https://en.wikipedia.org/wiki/Color_appearance_model), such as [CIECAM02](https://en.wikipedia.org/wiki/CIECAM02) and for [daylight](https://en.wikipedia.org/wiki/Daylight) simulators, the CIE [metamerism index](https://en.wikipedia.org/wiki/Metamerism_index). CRI is not a good indicator for use in visual assessment of light sources, especially for sources below 5000 [kelvin](https://en.wikipedia.org/wiki/Kelvin) (K). New standards, such as the [IES TM-30](https://en.wikipedia.org/wiki/IES_TM-30), resolve these issues and have begun replacing the usage of CRI among professional lighting designers However, CRI is still common among household lighting products.”

Power factor (cosφ) [8]

Power factor (PF) is defined as the ratio of true power in watts (W) to apparent power volt–amperes (VA). A pure resistive load has a PF of 1. But in active loads, such as light-emitting diodes (LED) drivers, the mains supply current passes through a bridge rectifier and then the DC voltage is smoothed using a large-electrolytic capacitor. As the capacitor only charges during the peaks in the AC supply cycle, the current is pulsed and nowhere near sinusoidal. Simple rectified supplies tend to have PFs close to 0.5.

Special measures can be taken to “correct” a poor PF. Power factor correction, or PFC, is a term used with AC mains–powered circuits. Techniques are used to create a good PF, so that the AC current is sinusoidal and in phase with the AC voltage.

There are regulations in many countries that require a good PF. In Europe, regulations demand that residential lighting have a PF of greater than 0.7 and commercial lighting have a PF greater than 0.9. In any case, lighting products with a power rating of greater than 25 W must have a good PF of 0.95 or higher, regardless of the end use.

Water resistance (IP 65 / IP 67 / IP 68 )

These alphanumeric terminologies represent LED’s water resistance. Listed below are their definitions along with water resistance and waterproofing limits.

**IP65** = These LED lights are water resistant. These LED lights are not meant to be submerged. IP65 LED lights  are not waterproof.

**IP67** = These modern LED lights are called water resistant plus.  IP67 LED lights should not be submerged in water for more than 10 minutes.

**IP68** = These are the lights that can be fully submerged permanently. The maximum depth that they can survive  is 3 meters.  
Above are some of the most important LED terminologies that you must consider while choosing an indoor or outdoor LED light system.

# Sources

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[9] European norm 12464-1 (finalised 2011)