

A Swedish technology procurement competition for public outdoor lighting

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ABSTRACT

A technology procurement competition for residential street and park luminaires is currently being arranged by the City of Stockholm's Council for the Local Investment Programme (LIP Council), which has a mission to create environmentally sustainable solutions. The project is still ongoing. Submitted luminaries have been tested and evaluated.

Technology procurement is an important market transformation tool in the effort to stimulate development and commercialisation of resource-efficient technology in collaboration with purchasers organisations in and outside Stockholm. In order to achieve maximum market impact, the City of Stockholm has formed a purchaser's consortium (buyer group) with other Swedish cities, and the consortium is also supported by the City of Copenhagen.

Technical specifications were developed and manufacturers invited to tender. The specifications set very strict optical requirements for luminaires, and the tenders are evaluated based on technical performance and their ability to provide low LCC costs. More than 40 proposals were submitted. The competition jury has evaluated the proposed solutions, from which a number were selected for testing. Testing took place in May 2002, and winners are expected to be announced in July 2002.

To our knowledge, this is the first ever attempt to apply technology procurement on luminaires for public lighting.

The technical requirements are unorthodox, compared to current European practices.

INTRODUCTION

Lighting of public spaces is a large cost item in municipal budgets. When calculated as total life-cycle costs for a public outdoor lighting facility, electric energy is a very large line item cost. Many facilities installed in the 1960s are in grave need of new investment today, and it is important to choose a technology with low life-cycle costs, and low environmental impact.

Lighting of public streets and parks concerns everyone. At the same time that lighting shall create a dependable, secure and attractive environment for pedestrians, it must also provide optimal lighting conditions for those driving on the streets. Lighting shall also be provided by using a minimum of natural resources and energy, and the lighting's life-cycle costs must be as low as possible. In addition, all of these requirements shall be provided without disturbing residents with intrusive light from poorly shaded luminaires. More and more people are concerned that street lighting contributes to sky glow. This phenomenon means that the night sky is being illuminated by light, which consequently makes it increasingly difficult for city residents to see the stars.

Despite larger savings from more efficient and better lighting, there are very few luminaires for street lighting that meet all or even a few of the above-named requirements.

The purpose of this technology procurement competition was to stimulate the market introduction of highly efficient, environmentally compatible and well-shaded

luminaires for municipal purchasing organisations. The luminaires shall provide their owners with low life-cycle costs.

This technology procurement competition is searching for luminaires for two principal areas of use: residential streets and public parks. The competition includes three classes: two classes concern luminaires for residential streets, and one luminaire for park lighting.

WHO'S BEHIND THE COMPETITION

The LIP Council, as commissioned by the City of Stockholm, initiated this project and is the principal financier. The Swedish Energy Administration (STEM) has contributed to the project with expertise and has funded the development of luminaire prototypes in a demonstration project, which serves as the background for most of the technical and functional requirements. Along with the above experts, a purchasers' consortium, consisting of representatives from city and municipal street lighting departments, have worked out the requirements and framework for the competition. The members of the purchasers' consortium come from the City of Stockholm, Borlänge Energi (municipal utility of Borlänge), the City of Malmö, Örebro Municipality, the City of Västerås, Sundsvall Municipality, and a group of West Swedish municipalities working together in the "LIP Klarälven" project. This competition is also being supported by the City of Copenhagen, Denmark.

During the whole competition period, new purchasers are welcome to participate in the technology procurement programme. In order to be part of the blanket contract (framework arrangement), which is intended to be signed with the winner of each class, new purchasers must announce their interest before the results of the competition are made public. New purchasers have been reported on the LIP Council's web site as they join¹.

COMPETITION SPECIFICS

The competition has three classes. Two classes concern street lighting, one class concerns luminaires intended for high pressure sodium lamps or the equivalent, and the other concerns luminaires intended as white lamps. The third class concerns luminaires for public park lighting. The requirements are written such that the luminaires optical properties are similar between the classes. The purpose was to encourage manufacturers to develop "families" of luminaires in order to maximise the number of available products.

The technology procurement competition has two primary stages. In the first stage, the submitted, written tenders report and/or present how the luminaires fulfil the Specification of Requirements. The tender had to report which lamp and ballast accompany the luminaire, the sub-order price on which the life-cycle costs are based, as well as the luminaire's appearance and construction. In the sec-

ond stage, the luminaires that the jury decides have met the requirements were invited in for testing and evaluation. The initial testing took place in an indoor sports centre without daylight, where luminaires were mounted on real lamp poles. Illumination, luminance and easy of mounting the luminaires as well as easy of lamp replacement were tested and evaluated.

The winners of each class will be selected by how well they fill the technical requirements, how they place in the life-cycle cost analysis, and whether the jury believes the products are commercially viable (i.e. whether they jury itself believes in purchasing them).

Tendering manufacturers shall be able to deliver a first series for field testing in Autumn 2002 and be prepared to deliver the luminaires to the purchasers at the suborder price quoted in the tender from early Autumn 2002 up to the period settled on in the finalised blanket contract (i.e. for at least one year).

How will the jury decide?

A jury consisting of representatives from the purchasers' consortium, to which independent experts may be called in, will evaluate the tenders and announce a winner.

The tenders are being evaluated based on: the general considerations presented below; *obligatory* and desired requirements according to the weighting found in the competition requirements (see section technical and functional requirements)²; and the luminaire's life-cycle costs according to a calculation guide enclosed in the competition documents.

Should the jury decide that no single entry meets the above-stated evaluation criteria, the jury reserves the right to call off the competition without declaring a winner.

The jury's decision cannot be appealed.

Investment costs

Concerning free standing luminaires outdoors, it is generally true that the major part of the installation costs, normally 80%, are attributable to on-site work. Cables and light poles represent a small part of the costs. The luminaire itself is usually the smallest part of the total investment costs.

In evaluating the entries, the costs for on-site work, cables and poles will **not** be factored in. These installations are assumed to already exist, and in those cases where they do not, it is still assumed to be unrelated to the luminaires.

Operations costs

Concerning investments in general, a life-cycle cost (LCC) analysis will be performed by the purchasers' consortium. Here, costs for operation and maintenance (electricity, lamp replacement, necessary repairs) are seen as an important part of the total cost for the facility's total service life. For example, if a light source's power is halved, the total life-cycle cost generally goes down by a third. There-

1. www.stockholm.se/lip

2. Technology Procurement For Lighting of Public Spaces (English translation). Competition instructions May, 2001. Available at www.stockholm.se/lip.

fore, in order to make a fair comparison among the various entries, entrants were instructed to use the service life and replacement price information found with a list of light sources located on the LCC calculation form.

Climate Conditions

Entries to this competition were asked to show that the proposed luminaires are suited for Nordic winter conditions.

Environmental aspects

The luminaire's electricity consumption constitutes its largest environmental impact during its service life. Since all luminaires have a service life of approximately 30 years, it is important to choose an energy-efficient luminaire. However, in evaluating the tender, the jury will not consider the electric energy's environmental impact. The electricity consumption during the luminaire's service life will only be considered as an economic factor, for which a monetary value can be assigned.

It is, however, a more difficult task to evaluate fairly the weight of other environmental aspects in relation to the life-cycle cost, because these generally do not correspond to a cost item for the owner. In certain cases *obligatory* requirements have been established, which serve as minimum requirements that the luminaire shall fulfil. In other cases *desired* requirements have been established. In this case, the jury will evaluate these desired requirements according to a weighting scheme. *Desired* requirements only concern factors that can be evaluated by studying the luminaire itself and its properties. Accordingly, for example, energy consumption during production and the production process' possible environmental impact will *not* affect the evaluation.

Another kind of environmental impact concerns the luminaire's light distribution. Luminaires in outdoor environments that spill light skywards contribute to a phenomenon sometimes referred to as sky glow — stray light that illuminates the night sky and reduces the possibility of seeing stars. Luminaires that spill light into homes can also annoy residents.

Creating security

Luminaires in public spaces must also contribute to creating security. Glaring luminaires make it difficult for motorists to see even if they fulfil the standards for horizontal illuminance. This also applies to pedestrians when light levels increase. Spill light and anti-blinding requirements are included as obligatory requirements in the specified technical and functional requirements.

Consideration of appearance

The luminaire's appearance ought to reflect its function. For this competition, this means that function has a pre-dominant importance, yet the purchasers behind these programme requirements still consider appearance to be very important. Even though the evaluation will be based on the items given in the competition documentation, primarily technical and economic, the purchasers' consorti-

um nonetheless presumes that the submitted entries represent good aesthetic design. The possibility exists that the purchasers, in collaboration with city architects and others, will ultimately declare the winning entry under much consideration of the creative design.

Ability to deliver, etc.

The winning suppliers in each class shall have the capacity to deliver luminaires to pilot installations, and at an even larger volume afterwards. A winning producer must be active in the Swedish market and have a Swedish service organisation, either through their own production and marketing organisation, or via a retailer.

Award and publicity

No financial awards will be given to winners, but winning manufacturers have the opportunity to deliver luminaires according to the blanket contract (framework arrangement).

The LIP Council will help winners to attract attention, through publication of winners and through publishing information about pilot installations, etc. Information about the competition results and testing will be disseminated to all municipalities and the public via the LIP Council and the Swedish National Energy Administration. It should be noted that not only winners will be published. All submitted luminaries that fulfil the technical and functional requirements will be published.

TECHNICAL AND FUNCTIONAL REQUIREMENTS

The technology procurement competition covers 3 classes:

Class 1	Luminaires for residential streets, equipped with light sources $Ra \leq 79$.
Class 2	Luminaires for residential streets, equipped with light sources $Ra \geq 80$.
Class 3	Park luminaires equipped with light sources $Ra \geq 80$.

The technical requirements for classes 1 and 2 are identical. However, light sources with different Ra indexes can produce very different outcomes in a LCC analysis. The luminaires' scattering angle is also affected by the various lamp shapes, so if identical luminaries were submitted for both class 1 and 2, for example, it was tested and evaluated with each light source as an independent submission.

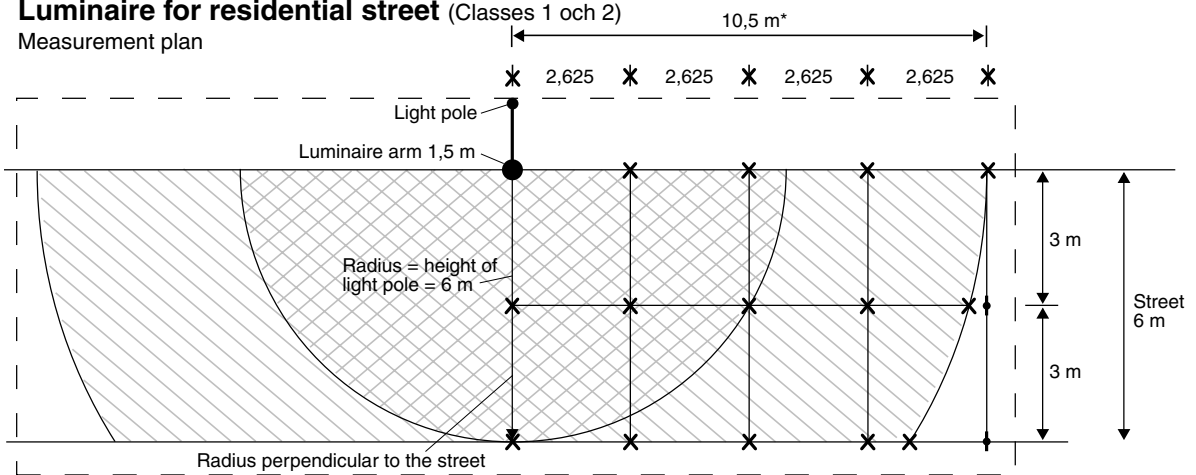
Light sources

Light sources shall have a long service life in order to reach a low life-cycle cost—for example, 16,000 hours gives a replacement interval of four years. It is currently difficult to reach such a long service life using white light sources. However, because white light is desired in several areas, this contest also has a class based on the lamp's Ra index. The lamp shall be energy-efficient, i.e. have a high light output in relationship to the electrical power.

Requirements for residential street lighting luminaires

Luminaire for residential street (Classes 1 och 2)

Measurement plan



*10,5 m corresponds to half the light pole spacing, with the spacing at 3,5 times the pole's height

x measurement points

It is assumed that the measurement surface, as well as the light distribution, is symmetrical on both sides of the radius perpendicular to the street's direction

The lowest allowable measurement value in this area is $E_H \geq 10$ lux

The lowest allowable measurement value in this area is $E_H \geq 2,5$ lux

For other measurement points $E_H \geq 1$ lux

Fig 1 shows the minimum illumination that has to be provided by a luminaire for street lighting. The same illumination was required for both classes 1 and 2 (luminaires for residential streets, equipped with light sources $R_a \leq 79$ and $R_a \geq 80$ respectively). This plan was also used as the measurement plan when the luminaires were evaluated.

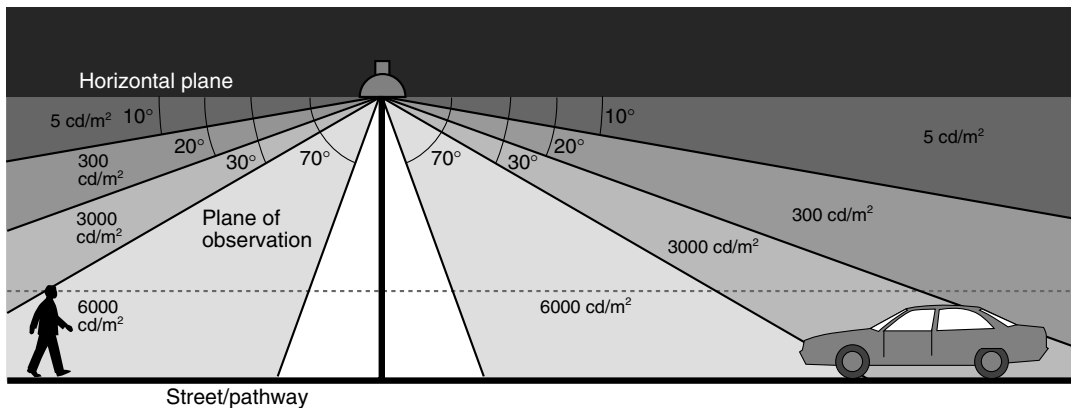


Fig 2 shows the requirements for the luminaire's maximum luminance for a number of given distribution angles along the street. (both class 1 and 2)

For lamps, obligatory requirements were set:

- for lamps less than 45W, the light output shall be at least 50 lm/W.
- for lamps 45W and over, the light output shall be at least 70 lm/W.

Optical and visual requirements

The optical and visual requirements are the most controversial part of the competition requirements. This is mainly because of the strict luminance requirements, that mean that light poles need to be placed closer than is normally the case in Sweden and elsewhere. Given the choice among requirements for optimal light distribution on the ground, wide (i.e., economical) spacing between light

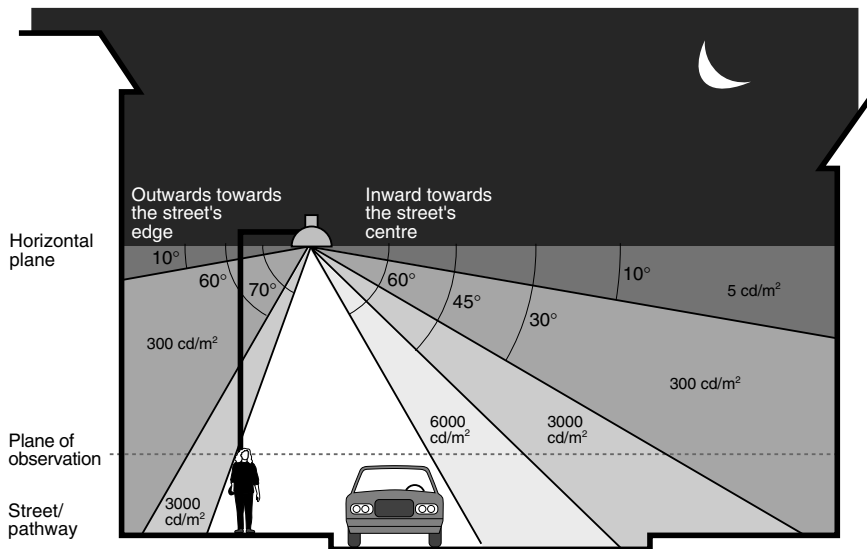


Fig 3. shows the requirements for the luminaire's maximum luminance for a number of given distribution angles across the street. (both class 1 and 2)

Requirements for park luminaires

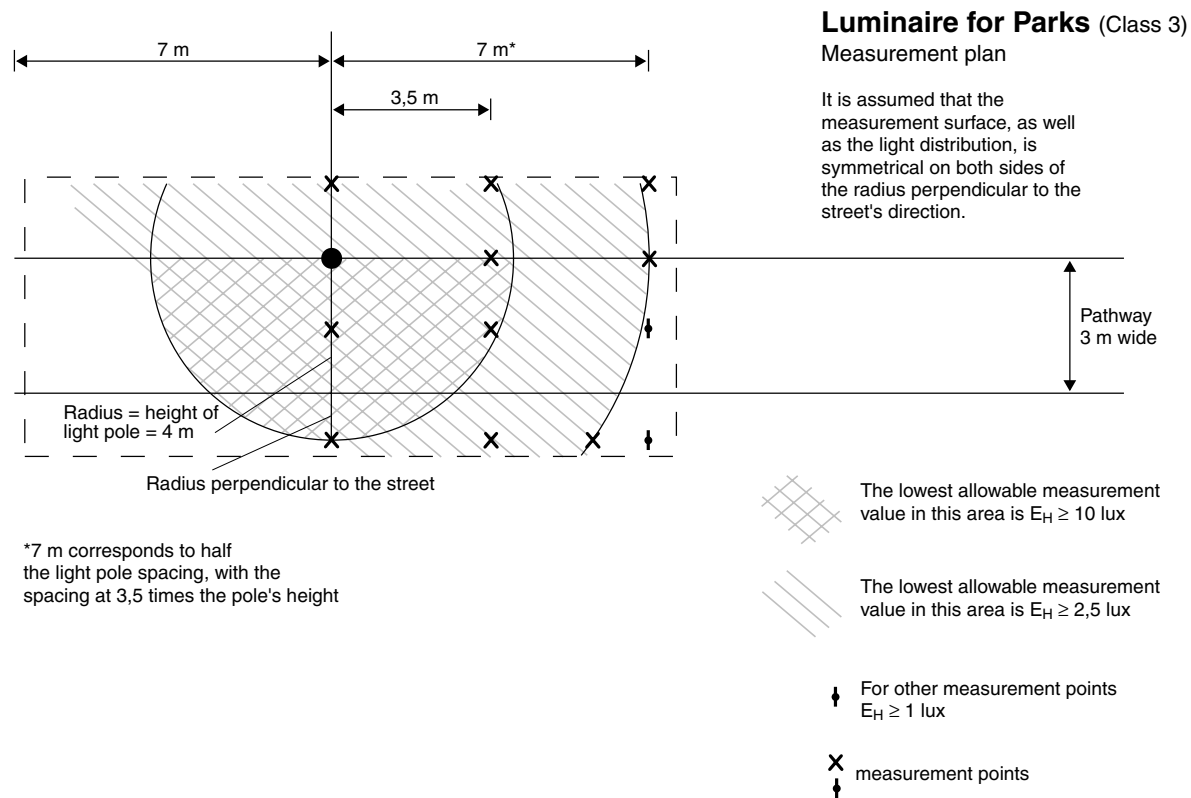


Fig 4 shows the minimum illumination that has to be provided by a luminaire for park lighting. The luminance requirements for park lighting were very similar to those of the residential street lighting luminaires.

poles and good anti-glare properties, the purchasers' consortium prioritises low glare. This means that an optimal distribution of light across the ground comes from a pole spacing of approximately 3.5 times the pole height. This corresponds to about 21 meters for street lighting and around 14 meters for park lighting. However, the purchas-

ers' consortium feels that acceptable lighting can be had from a somewhat wider spacing.

One can argue that the requirements should have specified how a tendering manufacturer would propose to lit up a road stretch long enough to get the total costs for lighting per—for instance—100 m, but the jury and the participating municipalities agreed that this would be very difficult

to evaluate. Instead, the street pole distance was agreed upon as a fact, and the increased cost for more closely placed light poles will thus not show in the economic analysis for each tender. The LCC analysis is thus only valid for a single luminaire within the given constraints.

The municipalities still chose to put more weight on glare control and reduced sky glow. In cases where this will create darker areas between poles in already existing installations where only the luminaires are retrofitted (compared to a luminaire which distributes light more in the horizontal direction), this should be weighed against the improved visibility that should come with reduced glare.

Mounting and maintenance

The requirements asked for luminaires that shall be easy to mount and maintain in order to reduce total LCC costs. In the LCC report form, the estimated time for mounting and lamp replacement and to be specified, and this was also evaluated by experienced installation and maintenance staff.

Further, the consortium asked for easy-to-understand maintenance and installation instructions in Swedish.

Environmental requirements

Most of the environmental requirements are so-called *desired* requirements. The jury will thus look favourably upon the fulfillment of those requirements, but they are no “musts”.

The following requirements were “desired”:

- A report *shall* be submitted on how the luminaire and its accompanying lamps *will* be recycled. For those parts that cannot be recycled, scrapping instructions *shall* be delivered, and where scrapping is not possible, instructions for destruction *shall* be delivered.
- Heavy metals and environmentally hazardous substances, according to the National Chemical Inspectorate’s “OBS list” (i.e. “NB!-list”), *should not* be used in either the luminaire or the accompanying lamps.
- Should environmentally hazardous substances on the National Chemical Inspectorate’s “OBS list” appear in production, they *should* be present in such manner and form that recycling is facilitated.
- Energy consumption, energy type and processes used in manufacturing luminaires *should* achieve a low environmental impact.
- Energy consumption, energy type and processes used in manufacturing the packaging materials *should* achieve a low environmental impact.

Only two environmental requirements were mandatory:

- The package materials shall be recyclable and not contain any substance on the above-mentioned “OBS list” (a Swedish official list referring to hazardous materials).
- The supplier of the luminaire shall provide for repossession of the return packaging material.

Other requirements

A number of other requirements were specified as well. These related to IP class (IP 65), that manufacturers had sufficient production capacity (to avoid “cellar-companies”), impact resistance, corrosion resistance, and the luminaires suitability to Nordic winter climate.

REFERENCES

Technology Procurement For Lighting of Public Spaces (English translation). Competition instructions May, 2001. Available at www.stockholm.se/lip.

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