Cooperative Procurement of Lighting Systems: Stockholm Shows The Way

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ABSTRACT

This paper takes a recent European Commission study on international cooperative procurement aimed at increasing the dissemination of efficient lighting systems and other technologies as the starting point for a discussion on the various procurement methods for efficient technologies. The paper defines technology procurement as a method aimed at pulling out technologies from the labs to the market, and cooperative procurement as a method aimed at increasing the market shares of already existing efficient technologies. It concludes that for such a complex product as a lighting system, it is difficult to formulate performance requirements even if all the components needed already are available on the market. This complexity increases as the procurement activity becomes international.

However, with a recently started in-house energy management lighting service for the city of Stockholm, the paper finds that cooperative procurement for lighting systems still could be possible. Such a process requires that several institutional barriers regarding, for instance, financing and the design and installation process, have to be overcome before the procurement process can be initiated. This is easier to do on a local scale, as is illustrated by the example of Stockholm. When a local project has been successfully established, it could be expanded to other buyers and users, even internationally.

1. Cooperative Procurement: A Matter of Technology and Volumes

Procurement programs are rather new tools for transforming the market for energy-efficient technologies. Different terms are being used to describe variants of what is basically the same tool. The two major variants, here called *cooperative procurement* and *technology procurement* respectively, have many features in common. Both methods aim to bridge the gap between supply and demand in a market. By focusing on the demand side they initiate a demand pull meant to inspire manufacturers to answer to specified demands and thereby start a transformation of the market.

The basic idea of both processes is the same: A group of buyers are brought together by an independent organization (for instance an energy agency). The buyer group shares a common need for a product, and a performance-based technical specification is developed by the group. The aim is to specify a product with good environmental and energy efficiency qualities. However, to gain user acceptance for the product in question these features often have to be coupled with other so called non-energy benefits like user friendliness, easy maintenance and design. With the specification as the basis, the group will issue a call for tenders where certain awards like for example an initial order for the specified product is guaranteed. Manufacturers are then free to send in tenders, where technical solutions chosen to fulfill the functional requirements are stated. If the buyers are big or otherwise influential

(e.g., trendsetters) they will encourage the manufacturers to take up the challenge and enter the competition. When the process is finalized, activities to reinforce and secure demand is needed.

In spite of these resemblances regarding the processes, the two procurement variants differ on a number of important points. They can in short be distinguished as follows: *Technology procurement* is a process with the explicit aim of promoting development. Its use is intended to stimulate the commercialization of products or systems that better correspond to the needs of the buyers than those existing when the process is initiated. *Cooperative procurement* is a process intended to, by aggregated purchasing power, create significant markets for already existing products with good environmental and energy efficiency qualities. However, cooperative procurement is a more loosely defined term, which sometimes incorporates technology procurement, but for the purpose of this paper we will limit ourselves to use it for the process aimed at increasing dissemination of existing products. With "increasing dissemination" we mean that a given product type shall become available from more manufacturers and that the product shall be a feasible choice for more customers. Cooperative procurement thus aims at creating a more uniform market on a higher energy efficiency level.

Since a technology procurement involves developing a functional specification for a new product with features that are not fulfilled by the existing ones on the market, these specifications need to be more elaborate than with a cooperative procurement process. This means harder work for the buyer group who also has to be more motivated and patient to endure the longer development period this incurs. The fact that we are dealing with a product that does not exist and therefore never has been tried means less security for the buyers. It is more difficult to interest them and especially to have them commit themselves to buy this future product. More effort is also required from the manufacturers who also have to be strongly motivated to engage themselves in the process. In a cooperative procurement process, these problems are reduced. The functional specifications are easier to elaborate, involve less guessing, and the feeling of security among the buyers is higher. The process is less complex and therefore faster to implement and realize.

One can imagine many situations where these two instruments interact. The different roles of technology procurement and cooperative procurement in a market transformation process can be illustrated by Figure 1.

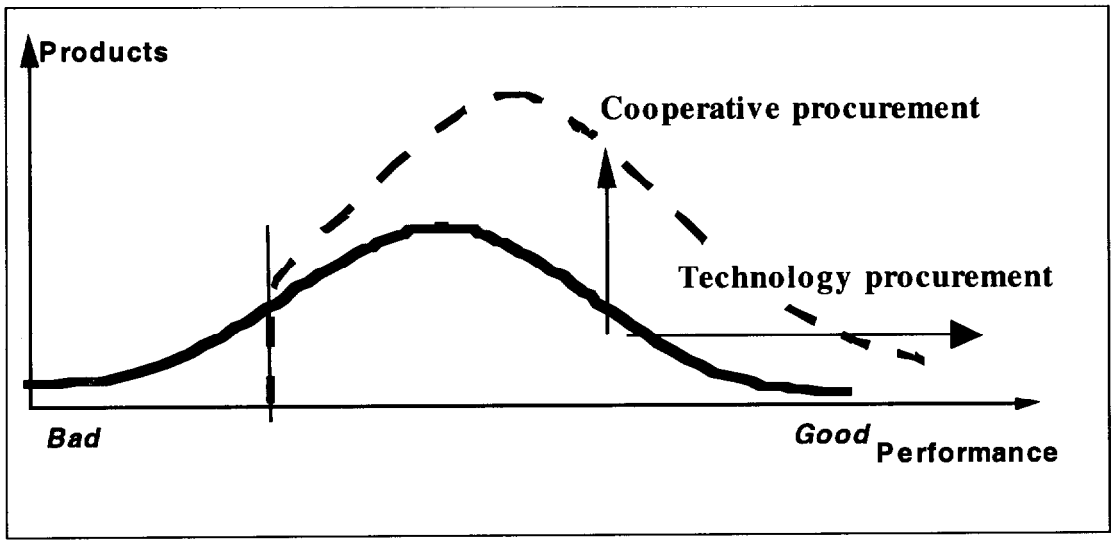

Figure 1. Market transformation.

Before any action is taken the market is represented by the unbroken line, a normal distribution curve. A technology procurement process brings new products to the marketplace. Once tried by a small and committed buyer group and available on the high end of the market, a cooperative procurement action can be used to continue the market transformation and make the market more uniform on a higher level than before. The new, transformed market is represented by the broken line. When there is a need for another step upwards on the technology ladder, a technology procurement once again does the job of commercializing a new technology that has been cooked up or refined in the research labs of the manufacturers.

A cooperative procurement process has similarities with the *Procurement Challenge* under the US Federal Energy Management Program (FEMP), but important differences are to be noted. While FEMP targets governmental actors, the cooperative procurement process also involves private buyers. And while the procurement challenge under FEMP is an ongoing process which helps federal buyers by pointing at buyer guidelines and up-to-date catalogues of recommended products (for instance, ACEEE's guidelines and the USEPA EnergyStar guidelines), the cooperative procurement process is to be seen more like an ad hoc measure meant to provide a significant kick to a market. Moreover, cooperative procurement is a targeted measure carried out over a limited period in time rather than a long-term procurement policy (Borg et al 1997, McKane & Harris 1996, Westling 1996). However, the involvement of a FEMP-type procurement challenge program in a cooperative procurement process would add significant strength to the buyer group.

2. Cooperative Procurement on a European Scale

The technology level of energy consuming products, and the spreading of efficient products on the markets in the European countries sometimes differ significantly from region to region. A more uniform European market would highly facilitate the Union's continued work with energy efficiency. For example, EU-wide minimum efficiency standards and other regulation will be easier to introduce. The requirements can be set higher since the consideration that normally has to be taken for weaker markets will be diminished.

A number of initiatives have shown that procurement processes are possible and also effective within one country, or a limited number of countries (Nutek 1994a, Lund et al 1997). During recent years, initiatives have been launched to scale these efforts up for international collaboration. Within the International Energy Agency's (IEA) Implementing Agreement on Demand-Side Management, *Annex III*, a number of technology procurement pilot projects are presently running. As of Spring 1998, four projects are presently running: motors, copiers, improved incandescent lamps, and heat-pump clothes dryers. Each of these projects involves at a maximum buyers from five countries. These countries all have well developed institutions, a relatively strong governmental sector and a high technology level, factors that often mean more experience in working methods like procurement processes and therefore facilitates participation. Further, the differences in economic situation and demographics are small between the participating countries (all projects are European, except for the copier project which is transtlantic, but led by the United States). (EM 1998, Annex III 1998)

Extending the cooperative procurement concept to take the whole European Union into consideration would mean a strong market pull, but also new challenges. To join forces from the whole of the EU would give a stronger signal to the market parties, and we would be able to influence markets where purchasing power from only one or few countries would not be enough to move the specific market.

However, the countries in Europe are rather different not only in terms of climate, culture and therefore usage of different products, but also in terms of market structures and political aspects. This complicates the process. (EM 1998)

During one year a study team consisting of nine EU countries, ranging form north to south, have studied cooperative procurement in a European context. Four different market situations were investigated and the implications for European-wide aggregated purchases were assessed. The products covered by the study were: Induction motors, systems for office lighting, medium-sized solar systems for water heating, and (residential) fridge/freezer units. This paper will only discuss the findings from the study of the office lighting systems.[1]

2.1 The European Markets for Office Lighting Systems

When the European study team investigated the possibilities to use cooperative procurement for lighting systems, they targeted office rooms for which a complex system design was conceived comprising visual performance requirements, light sources, ballasts, optical devices, luminaries, and daylighting. After having investigated the national markets for such complex systems it could be concluded that lighting is responsible for an important share of energy consumption in office buildings in all European countries. According to the countries where more detailed information was available, lighting energy use represents about 15% of total energy use in office buildings and between 30 and 50% of electricity consumption.[2]

A far as light sources are concerned the national markets are quite similar. Fluorescent lighting is largely predominant, mainly with linear lamps and for a small part with CFLs. The remaining sources are standard GLS lamps and low-voltage halogen lamps. The share of HID lamps is still negligible in indoor commercial applications. Regarding fluorescent lighting, triphosphor lamps are slowly replacing former standard halophosphor lamps, but the precise market shares are not known. The same is true for old T12 tubes which are only used for replacement. T8 is currently the most popular fluorescent lamp in Europe (over 90% of the market in Germany). Dissemination of the much newer T5 technology seems generally to be very limited.

Electronic ballasts are slowly gaining increased market shares in all countries but are still far from the leading position held by conventional magnetic ballasts. In some countries like Austria, Germany or Sweden, the dissemination of HF ballasts is quite good (between 30 and 40% of the market for new luminaires) while the penetration seems to be lower in other countries (often below 10%). However, in the countries with a fairly good penetration of ballasts we still find inefficient luminaires and lighting system solutions.

The lamp manufacturers are strong and their technical capacities important. Energy efficiency improvement of light sources has been one of their main R&D topics for almost 20 years, along with light quality improvements and light source miniaturization. The introduction of the new T5 fluorescent

[1] The co-author Engleryd was co-ordinating the European study team. Most of the information on the possibilities for European wide actions as well as the information regarding the European market for lighting systems originates form the findings of the study team.

[2] The following two sections (2.1 and 2.2) describing the lighting market in Europe is based on the report prepared for the study (Ademe 1997) unless other references are stated.

tube, or smaller and more efficient ceramic metal-halide lamps are examples of this technical evolution. The light source industry is highly internationalized with a dominance of three multinational manufacturers in Europe; Philips, Osram and General Electric. They are all present in all European countries together with the two other multinational players SLI, which is much smaller, and Matsushita / Panasonic, which is large but has a weak presence in Europe. There are also smaller, often national companies active. The three dominant manufacturers mentioned above also sell ballasts, and in certain countries luminaries.

The ballast industry is more fragmented with large producers independent from the large light source producers, such as Motorola, Magnetek, Helvar and Tridonic active on the market.

The luminaire industry is yet more fragmented than the ballast industry. Manufacturers are generally numerous with a higher proportion of smaller firms. In some countries, only a few ones represent a great part of the market (as in Portugal or Germany for example), while elsewhere the market is split on a large number of companies (in Sweden for example, 27 manufacturers are sharing 67 % of the market). The main difference compared to the lamp industry is the existence of smaller manufacturers. They may be specialized in niche markets but their innovation capacities should not be neglected, particularly in the countries in which the context is favorable to the development of new more efficient lighting products (Sweden and Germany, mainly). In these countries, due to a greater market demand, the luminaire manufacturers are active in developing energy efficient products, notably for incorporating the new T5 lamps. New developments are slower in other countries where manufacturers meet an apparent lack of interest from the market.

2.2 Product Flow and Decision Making

In order to assess the possibilities for cooperative procurement regarding a certain product, the product's way from manufacturer to user has to be traced and the decision making path at different levels of the chain mapped out. In the case of lighting systems the product flow follows a complicated route from manufacturer to end user. The general path, as seen in the picture below, goes from the manufacturer to the wholesaler and then to the installer and the end-user. But some large users/purchasers purchase large quantities directly from the manufacturers.

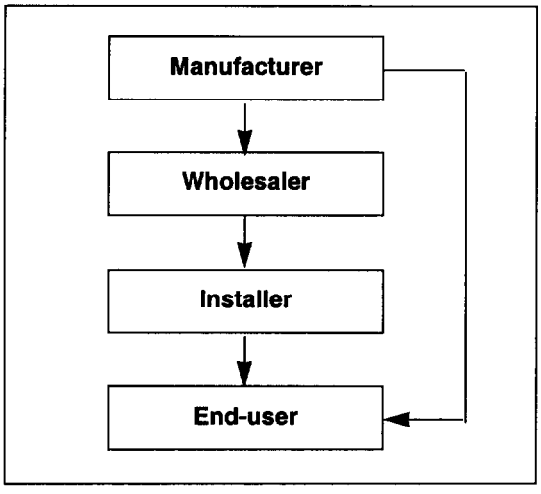

Figure 2. Product flow lighting systems

The decision making process may involve a large number of different actors depending on who the owner of the premises is (real estate developer or owner/user), what the purpose of the building is (to be sold, rented or owner occupied), the size or the nature of the project (new building or retrofitting). Owners, tenants, developers, architects, lighting engineers, contractors/installers, wholesalers and manufacturers are some of the actors which may take part in the decision when a new lighting system is to be installed.

This decision-making process typically creates split incentives between investors and users. When constructing an office building, the end-user and the developer are generally different, except for large companies like banks or insurance companies who invest for their own use. The investors are often real estate developers whose aim is to rent or sell the new or retrofitted buildings. In that case, the developer, who is choosing the lighting system, will not pay the energy bill, wherefore he or she is unlikely to be interested in energy efficiency. As a consequence, energy saving initiatives only start when the buyers preferences take energy efficiency into consideration or when the tenant has influence. Long lasting renting contracts have been mentioned as a possibility for reinforcing the power of tenants and introducing concern about future running energy costs at the construction stage.

Based on interviews carried out during the EU study, energy efficiency doesn't seem to be a dominant criteria anywhere in Europe when a new lighting system is chosen. The most common criteria is a low purchasing price in a large number of countries like Finland, Portugal, Sweden and France. When the buyers express preferences regarding the characteristics of the lighting systems, the main concern is to raise the productivity of the workers by improving the visual comfort, which means sufficient lighting level, low glare, good contrast, etc. Low and easy maintenance is sometimes considered while life cycle costs are seldom used by end-users as a purchase criteria for lighting systems.

At present this is the general situation, but in some countries the picture is slightly different or is slowly changing with the increasing importance of environmental issues. Market research in the UK shows a greater concern for environmental questions among developers and occupying companies (Ademe 1997). The same is true for Sweden where sustainability, recycling and energy efficiency are becoming more important to the end-users. Pleasant and ergonomic working conditions and more flexible office solutions is also increasingly important. In Sweden, Nutek ran a 9-month national tour with a mock-up office in four train cars around Sweden. The tour stopped in major cities for a couple of weeks to demonstrate environmentally friendly and energy-efficient office solutions in combination with seminars. Tens of thousands of people from local companies visited the exhibition. Nutek also cooperated with the union of office workes and the Swedish Society for the Protection of Nature in this project, in which also purchasing guidelines were developed. These have been currently updated and cover energy efficiency as well as other environmental and ergonomic issues. The demand for these guidelines have been rising steadily. (Engström 1998) These "green trends" could also be noted by one of the authors (Borg) at the Hannover World Light Fair in April 1998 where the number of energy-efficient and ergonomic solutions was significant.

2.3 Possibilities for European-Wide Actions

After having investigated the European markets for lighting systems, the European study team concluded that a fully European-wide cooperative procurement of lighting systems would be very difficult to realize.

There are two important factors influencing the feasibility to carry out actions on a European

scale. First, the process is easier to carry through among a large group of countries the more standardized the product is and the more similar the usage is throughout the countries in question. The more standardization, the easier it is to formulate and use the same functional specifications, testing procedures, labels etc. It is also easier to form a buyer group when the usage is similar. Second, the more international the market is, with international companies and large import and export flows taking place between the countries, the easier it is to make an international aggregated purchase work (EM 1998). Obviously, internationally operating companies will be easier to attract if the buyers are present in many of their markets. It is also more likely that the procurement will meet less protectionistic opposition if the prospective tenderers are used to tough international competition. People may be afraid that a small national producer will loose its safe domestic market to foreign competitors, but no one will feel sorry about a global actor who doesn't win a competition.

Systems are in general very difficult to standardize, especially such complicated systems as lighting systems. Related to the low level of standardization is the need for having the product made-to-fit for the specific premises. This means that it will probably be difficult to aggregate buyers that can agree upon common specifications. The geographical distance between the supplier and the end-user becomes important. However, the systems can be divided into components and whole systems, for which different conditions apply. The market for whole systems is certainly more national than international, while the market for some parts or components are highly international. (EM 1998)

Even if the needs for lighting are similar, the preferences differ between different cultures providing another constraint to the formulation of a buyer group and the elaboration of common specifications. The difficulties in defining a system can be illustrated by the Nutek program requirements for office lighting that would be difficult to use as specification even if the procurement would limit itself to Sweden only: The Nutek office lighting requirements have become close to a de facto standard design guideline in Sweden. The design requirements define the lighting solution from the user perspective, that is, they define what sort of lit environment to be created by the installation. For instance, the maximum luminance (surface brightness) of room surfaces and light source to be perceived by the user from various angles is defined, and nothing is said about what type of luminaire that can achieve a proper illumination level without exceeding the glare recommendations and the specified energy requirements. In short, the energy requirements allow a maximum power density of $10W/m^2$. (Nutek 1994b/1997)

In Nutek's office lighting project, a test room was built to reflect the most common type of single-person office module in Sweden. As of December 1997, about 50 luminaire solutions had passed the tests in this room and are listed in the Nutek catalogue (Nutek 1994b/1997). If the user has such an office module, practically no professional design is needed: The user can simply choose the luminaire he or she wants and place it according to the plan (which specifies, for instance where the luminaire should be oriented according to the desk). The major *disadvantage* with such a list is that not all persons understand that these luminaires are part of a system and they will only perform to fulfill the requirements if the conditions of the model office room are fulfilled. For instance, many of the most efficient solutions in this project with T5 lamps and a power density of 7-9 W/M^2 must be oriented rather exactly to the desk. If the desk is moved as little as 10-20 cm, the desk will become underlit. Moreover, if a solution for a one-person office is used in a room with many occupants the luminaire may still work on one person's desk but cause glare for another person. A skilled lighting designer will know when a luminaire will work and when not, but even if an installation is perfectly designed, the end-result may be corrupted by the installer or by the user him or herself who decides that the desk should be placed differently.

The split incentives between landlords and tenants is another factor that negatively influences the possibilities for aggregated purchases, and so does the lack of testing methods in this case. In Europe there are today no internationally recognized testing methods for such complex lighting systems as have been investigated in the study. To define such methods will be a very complex, and therefore most likely expensive process.

2.4 A Large Potential for Improvements

The European study team did not only find problems for actions within this area, but also a potential for improvements. The widespread use of conventional lighting technologies on all markets leaves room for significant technical possibilities for energy savings using existing efficient technologies. Most of the countries consider that energy savings of 25% compared to the present electricity consumption for lighting in offices are realistic (Ademe 1997). This may represent savings of 50% compared to old existing installations from the end of 70's, by using the current most efficient technologies such as high efficiency luminaries, electronic ballasts, and new fluorescent tubes. Techniques like control units and the active use of dayligthing promises even higher savings.

The possibilities of making the lighting systems more ergonomic and create pleasant working conditions are also significant, since most of the existing systems rarely respect these needs. Even if the real importance of integrated energy efficient lighting designs still seem limited, the increasing importance of daylighting in Germany, the development of user friendlier controls in the UK, and ergonomic lighting in Sweden, shows a growing interest for global approaches in office lighting design.

Recognizing these possibilities makes it worthwhile to seek solutions to capture them. One example of how one can work within this area is a lighting service project presently carried out by the City of Stockholm.

3. The City of Stockholm Lighting Service Project

In September 1997 the city of Stockholm's procurement office decided to launch a pilot project aimed at introducing an in-house full-service lighting contracting package in the cities' premises. Stockholm is the capital of Sweden with a population of about 700 000, and it employs about 55 000 people. Moreover, the city also procures much goods and services for the county council which is in charge of most health care for the county's almost 2 million inhabitants. In early 1997 the procurement office opened an environmental division, which got the mission to start several concepts to actively help the city go green. Three environmental service concepts were conceived and the planning started immediately so the services could be launched by mid-1998. Apart from lighting, the procurement office has started a car sharing project for the city's departments and a packaging materials take-back and recycling service which will utilize the return trips of empty trucks that have delivered goods. In the case of lighting, the procurement office decided to combine its purchasing power with the design, installation and financing of lighting systems. The purpose is to boost efficiency investments and bring down the city's energy consumption while at the same time improve working conditions for the city's employees.[3]

[3] The co-author Borg is involved in the pilot design of the Stockholm City lighting contracting project. Most of the information on the Stockholm project is based on the direct hands-on experience of the project.

Like many other public administrations all over the world, Stockholm's various offices and departments have problems to bear even moderate investments for energy-efficiency, even if these investments would yield only a few years' payback time. The reason is that most public administrations don't allow their units to "borrow" money from current or future operations and maintenance budgets to be spent on efficiency investments so that money can be saved over time (Borg et al 1997). At times, separate ad hoc funds in the city are made available for such investments, but these are insufficient. Moreover, even if funds are available, various ad hoc measures may yield sub-optimal solutions since the city will not build up enough in-house competence. The lack of continuity and steady investment volumes also leads to the city failing to use its purchasing power to its full extent in order to obtain lowest possible costs for efficient systems.

In spite of these obstacles, the general efficiency level of the city has nevertheless continuously been improved. Every time the city is refurbishing a building or renting a new office space, these spaces will typically be modern and thus as a rule more energy-efficient than the older ones. Moreover, even if efficiency has not been placed high on the agenda, the city's procurement office is experienced and has a tradition of setting tough requirements on the products and services they procure, and will often recognize the value of low life-cycle costs. This has probably had positive impacts on the general efficiency of equipment procured over the years, but no systematic evaluation from that perspective has been carried out. Despite this slow increase in efficiency, the city has failed to capture its full efficiency potential that the NUTEK office lighting experiences suggest are possible. (Camitz 1998)

For several years, the city council has asked its various offices and departments to work actively with energy efficiency, and especially with electricity savings, but this requirement was never defined in terms of activities or as a savings goal. However, the city finally decided that each administrative unit within the city must reduce its electricity consumption by 5 percent annually, starting in 1998. In parallel, the city is introducing an environmental management system which requires, among other things, that each department must declare in detail what has been done to reach various environmental goals and if the goals has not been reached, why this was the case. As part of the lighting services package, the procurement office will offer each customer in the city a certificate that declares how much electricity that has been saved. The procurement office will make sure that the city council accepts the certificate so it can be used as part of the annual report. Since the new environmental management system is perceived as a large, and partly difficult mission for each of the administrative units (they can be large hospitals with staff dedicated to energy management, but also very small children's daycare centers, schools, etc.) the procurement office believes that the certificate will be an important tool for marketing the lighting service: The departments in the city are not only offered a service that can help them save money, this service also helps them to get rid of the time-consuming task to explain what they are doing about energy efficiency, a task they are poorly prepared to solve.

3.1 Specifying the room, finding the luminaires

The typical process of installing a new lighting installation in the city has been that an electrical consultant or the installers themselves have planned and procured the lighting systems. The large electrical contractors often get good discounts for large installations. However, the lighting design is seldom careful and typically a professional lighting designer is not involved. For smaller projects, the city may use its own installers. The city has had two- or three-year call-off agreements (or basic ordering agreements) with a limited number of luminaire manufacturers. Such agreements are common in

the public sector: There is no commitment to order any units at all but the agreement is a framework that offers a good discount on a number of defined products or services. The agreement secures better prices than would be achieved if each single order was procured on an ad hoc basis, but it is also a practical and time-saving arrangement to avoid starting the complicated public procurement process each time goods or services above a certain value is to be purchased. In the case of Stockholm, the city had discount arrangements on the whole catalogue from a small number of manufacturers. No analysis were done whether the luminaires were appropriate or not for the city's needs. Since the overall volumes have been small, the discounts have not been great. At times, the discounts have in fact been perceived so small that even the city's own installers have bypassed the city's call-off agreements (which they are obliged to use) since they could buy luminaires at better conditions from other sources (Camitz 1998).

For the new lighting service in Stockholm, the volumes had to be increased and the design, installation and verification stages simplified. However, the quality of the design process also needed to be improved far above the average, not only to assure energy savings, but also because the procurement office plans to use the improved ergonomics as an important sales pitch. The city had call-off agreements with luminaire manufacturers that ended in May 1998. When manufacturers were invited to tender for a new two-year period, it was decided that there would be agreements on the whole range of luminaires from a number of manufactures just as before. But on top of that, the city decided to identify a limited number of luminaires that could be used in the lighting-service project in order to get better discounts. When defining what luminaires to be used in the project, Stockholm faced a similar problem as the one identified in the European study described above: How should the city write a specification for a lighting system where so many components were unknown? The luminaire is a unit, but once installed it will become part of a system where factors such as room size and layout, the color and reflectance of walls and ceiling, the tasks to be performed, the furniture plan, etc., will influence its performance.

The project management decided to accept the ergonomic and energy efficiency design requirements developed within Nutek's office lighting project described above. However, there were no guarantee that the luminaires from the Nutek project would perform to achieve the lit environment specified expect for rooms with a similar plan, surface color and type, etc, as the room used in the Nutek project. Instead, the visual requirements of the Nutek project had to be applied to the needs and the reality of the city.

Flexibility is a key word. The city has defined the following four elements as key factors for a flexible solution: It is flexible if:

1. it can be used in as many small room types as possible (but the luminaire may differ in size, no. of lamps and lumen output, etc.),
2. it works for large rooms with many occupants,
3. it will work over time in the same room even if the furniture plan is changed, and
4. it is accepted by users with varying preferences.

It was concluded that not all of these requirements could be fulfilled by one single luminaire, but the city took this as the starting point for defining their needs and foster clarity of thought. Following this rough definition, a matrix was developed that would help to facilitate the decision-making process. The matrix (Table 1) consists of two broad categories: *Single-person (cellular) office rooms* and *open-space offices and other large rooms* with many occupants. Each of these two categories were divided into three subcategories, where factors such as flexibility, energy consumption, and the speed

Table 1 Decision-making matrix for procuring luminaires for the Stockholm Lighting service Project.

Low Flexibility

A1. Single-person office space (cellular)

Fixed to building fabric and the work area. (Nutek's office lighting project list of luminaires.)
Standard office room. "point and choose".

+ Very little, if any, design/planning needed. Contractor can follow installation plan provided by the luminaire manufacturer.
+ Most of these luminaire solutions provide task lighting and ambient lighting in one. (Majority of solutions in the Nutek project were direct/indirect solutions)
+ Optimal efficiency
– Fixed installation/low flexibility. Minor adjustments in furniture plan will require that the user understands how to change the installation. Often, contractor is needed to do the changes.

B1. Open-plan office/multi-usage room

Fixed to building and work area.
Luminaires like Nutek-project (direct/indirect) possible to use.

+ Most of these luminaire solutions provide task light ing and ambient lighting in one. (Majority of solutions in the Nutek project were direct/indirect solutions)
(+?) Optimal efficiency
– Needs design/planning and installation.
– Fixed installation/low flexibility. Minor adjustments in furniture plan will require that the user understands how to change the installation. Often, contractor is needed to do the changes.

A2. Cellular — **Two-component lighting** — **B2.** Open-Plan

Indirect fixed lighting component and desk-mounted task lighting.

(–/+) Design and planning needed, but this process is simplified since only the indirect lighting component needs to be planned.
(–/+) Potentially slightly less efficient
+ Flexible solution. Even if the indirect component is fixed, the task luminaire can easily be moved and adjusted by the user.
(–) Two luminaires needed. More capital investment typically required.

A3. Cellular — **Two-component in one luminaire** — **B3.** Open-Plan

Not very common luminaire type but few exist. This luminaire will provide an indirect component as an uplighter and part of this light directed towards the desk as a direct component. The luminaire is free-standing or fixed to the desk (but can still be moved).

+ Little or no design/planning needed.
+ Extremely flexible solution. The user can easily move it around and adjust it to his or her own needs
+ Cheap installation, it can simply be plugged into the wall.
(+) Optimal efficiency.
– Few luminaries/few lumen package configurations available on the market. If the room is too big for one and too small for two units, additional luminaires will be needed. This may affect the possibility to achieve optimal efficiency.

High Flexibility

Note: The matrix is a simplified illustration of the criteria for procuring a set of luminaires to fill variuos needs. Commissioning is needed to verify the installation in any of the solutions above. Many of the cases specify similar criteria, buy may differ on an important point. The lighting solutions in box A2 and A3 are similar, for example, but differ on the crucial point of flexibility.

and costs at which a lighting installation could be designed, were used to categorize the room. It was decided that a maximum of three luminaires from each category in Table 1 would be selected for use in the lighting service project, but since some of the six subcategories were found to represent an identical need, fewer luminaires are in fact needed. The specification for the open-space office rooms are in principle applicable for any open-space working area such as schools and daycare centers.

3.2 The Leasing and Marketing Process: Identifying Actors and Key Tools

When the luminaires have been specified and procured, the problem to get them used in the city still has to be solved. This is very much a marketing task, but since the city will offer its own premises a full-service concept the following key areas in the service were identified and the role of an actor or the function of a tool were identified.

Installers

The services from a number of contractors will be procured. Together with the electrical contractors' trade association, the city is defining the contents of a one-day training course in lighting design and ergonomics to alert the contractors for the need to be careful when installing the lighting systems. The course takes the luminaires procured by the city as the point of vantage to make the course less abstract. The city requires that site managers from the contractors must go through the course if the contractor wishes to tender for an installation.

Working description

The general technical guidelines for the project is written extremely simple. It is believed that a more complex and detailed technical guideline will drive up the sums of the tenders.

Legal issues

In practice, the luminaires used in each project will be purchased by the contractor, who will quote a code for Stockholm's call-off agreement when they order the luminaires from the manufacturer. If the luminaires were to be purchased by the procurement office and delivered to the site, it would be unclear who is responsible for taking care of the luminaire. Since the installer purchases the luminaire, they will be legally responsible for it until it is installed and the whole project is delivered to the city. This procedure follows the normal market procedure, since any other procedure is believed to drive up the costs for the installations.

A tool for verification, energy calculations and cost estimates

The city has developed a computer-based tool for calculating the energy savings and the costs for each installation. The tool is linked to a database which contains information on the Nordic countries electricity fuel/emission mix. Thus, each kWh can easily be converted into reduced emissions of CO_2, NO_X, and even into reduced production of plutonium, that truly reflects the power mix of the city's electricity use.

This tool will not only be used a means for the procurement to calculate the profitability of the project. It will also be used as a marketing tool to help the prospective customer get an idea of the possible savings, the pay-back time at a given leasing fee, and the environmental benefits. The computer tool also describes the energy-efficient alternative's ergonomic benefits. In small check-boxes, flicker

free lighting, low glare, etc. is checked by default. It is then up to the prospective customer to click the equivalent boxes for their current installation.

Since many projects are likely to have long payback periods (or result in monthly payments that are much higher than the reduced energy costs), the ability to convince the customer about the ergonomic benefits is crucial. There is no solid research data upon which ergonomic improvements can be connected to quantitative productivity investments. However, solid research has linked isolated factors to some specific symptoms. For instance, flicker has been linked to symptoms of "electric allergy", headaches etc. (Lundberg 1996). No one knows the exact costs of these symptoms, but if one person is absent for long periods because of real — or perceived — problems, this will cost the employer a lot of money. The efficient lighting solution is marketed as a solution that can help insure the employer from many of these problems. A large forestry and paper company (Södra) has taken a decision to assume a one-percent productivity increase as the result of lighting upgrades. This will have drastic effects on the economics of an installation (Lundberg 1995).

Marketing within the city

The project "lease the light" (*Lisa Lyse*, which is an untranslatable pun) is marketed through brochures and the newsletter that is sent out regularly to all employees in the city. As soon as the first pilot installations have been completed, the city will try to get media coverage in the region's TV and daily press. However most important in a city with 55 000 employees is probably the grapevine: Already half a half a year before the project was mentioned in a newsletter or other public information source, various key persons in the city contacted the procurement office to hear more about how they could get this "environmentally friendly new lighting"!

Reference objects

During the planning stage, the city's procurement office has kept track of office renovation projects in the city and offered lighting design consultancy expertise so these projects are turned into high-quality, low-energy installations. These offices are not financed through leasing agreements but through normal refurbishment ad-hoc funds, but technically and design-wise they can be used as reference objects. The procurement office's headquarters have also been upgraded to state-of-the-art lighting.

3.3 Marketing and Placing the Luminaires by the City's Offices: Step by Step

In short, each site-specific project will go through the following stages (assuming that the marketing has been successful):

1. First contact: Someone from a city department contacts the city's procurement office.
2. A person from the procurement office with very basic training in lighting visits the potential customer's location and performs an initial survey. Data is gathered on the number of rooms, number of employees, basic floor plans, current installations (including installed power and the number of luminaires), surface colors, room height, floor area etc.
3. Back home, the procurement office staff will do a first basic calculation using the computer tool. A preliminary environmental certificate will be produced. It is a "see-but-not-touch" document that is used as a teaser.
4. The prospective customer is invited to the procurement office or to any other of the reference

sites. There, the results from the computer model are presented, including preliminary cost estimates. The preliminary certificate is shown. At this stage, the customers are asked if they want to proceed. If they do, they must sign a Letter of Intent which obliges them to pay the costs of the detailed design and planning stage. These costs are based on approximately three days of work per project, but they will only sign up for a fixed sum. This cost will be different depending on the size of the prospective customer's office, and number of employees.

5. When the customer has signed the letter of intent, the design and planning stage starts. After the lighting design consultant is ready, the electrical contractors are asked to provide tenders. When they do so, the city will not accept alternative luminaire solutions (it is very common that the contractor proposes a luminaire on which they have better profit margins). A detailed list describes what is included and not included in the work.
6. The contractor's tender is used as the basis for the final offer from the procurement office to the prospective customer department. A detailed savings estimate is done, monthly or quarterly payments fixed and the contract is signed. If the customers pulls out at this stage, they must pay the fixed design and planning cost stated in the letter of intent.
7. The installation is completed and the certificate is handed over.

3.4 Stockholm Project Status

The Stockholm lighting service concept is still in an initial pilot stage. The step-by-step process described above, for example still has to be tried in larger scale. A number of pilot projects are planned for the summer and autumn of 1998. These pilots will be evaluated before the project is scaled up to full-scale. The evaluation will focus on the process and how well the design criteria can be applied without costly consulting services. The technology as such hardly need to be demonstrated since it is well-known off-the-shelf technology that will be used. The city hopes that the lighting service can be a full-scale project by spring 1999.

4. Conclusions: Where Do We Go From Here?

Even if the initial studies of the EU cooperative procurement project concluded that lighting systems are too complex to start procure on an international basis, the Stockholm project illustrates that it is not impossible to define the criteria. However, the project illustrates the importance to have a lot of crucial institutional factors in place before the procurement work can start. For instance, Stockholm has a solution to financing and the tenant-landlord problem. But even with a first market in place, several luminaire solutions are needed, and it is very difficult for the city to give safe estimates about the possible volumes for each luminaire selected for the project. Thus, both the city and the manufacturers are forced to guess quite a bit, and the prices for each luminaire will thus be higher than if the volumes were known in greater detail. In the future, when the city has more experience of the volumes to be expected, fewer luminaire solutions may be procured and the prices possibly pressed considerably.

An important lesson to learn is that where the system and the specifications are complex, the buyer's own learning process is difficult. This leaves little room for coordination with other buyers. However, the process will generate experience and knowledge on which more precisely defined requirements can be based. Once several reference installations are at hand, the city can place more efforts on

expanding its aggregate purchasing power. There are already plans to expand this service to neighboring municipalities

Experiences from the Stockholm project will hopefully be useful on a European level. For instance, some functional requirements, such as the one for a free-standing two-in-one luminaire, can be used by several buyers all over the continent.

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