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RENEWAL OF STREET AND ROAD LIGHTING IN SWEDISH MUNICIPALITIES

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Abstract

We studied planning, responsibilities, and stakeholder's involvement in 12 Swedish municipalities of different size to identify factors that could constitute barriers for developing more energy efficient street and road lighting (SRL). In this study, small municipalities had the most energy efficient lighting and all stated that energy savings were the main reason for their substitution of mercury lamps. In medium-sized and large municipalities the ecodesign directive was given as the main motive for renewal of the SRL by four municipalities, and the remaining four municipalities stated that their main motive was the need to replace old SRL. Outsourcing of management, operation and maintenance may constitute a barrier for renewal whereas lack of knowledge and costs for renewal does not seem to be any significant barriers. Integration of SRL planning with other strategies, such as energy and economy strategies, seems to be an important factor for a proactive SRL development.

Keywords: street and road lighting, energy efficiency, local planning

1 Introduction

Energy consumption for street and road lighting (SRL) is often high due to the use of high wattage lights and long operating hours. Of the global electricity consumption, public lighting is responsible for 2.3% (Reusel, 2008), and in Sweden, approximately 1.6% of the total energy consumption is consumed by public lighting (Belysningsbranschen, 2008; SEA, 2009). Also, as shown in an example from Tuscany, USA, street lighting used 60% of the total electricity consumption for the municipality (Fiaschi et al. 2012). In addition, the costs for maintaining outdoor lighting can be substantial. For example, approximately 25% of the total costs for management and maintenance in Swedish municipalities were attributed to outdoor lighting making it the second largest expense in the municipal budget for management and maintenance (MSR, 2011).

Since a high proportion of the public lighting in Swedish municipalities is mercury vapour (Hg) lighting and a common wattage is around 120 W, there may be several reasons for renewal. One reason is the need to minimize the energy consumption of public lighting, with the motive to reduce costs as well as energy use and greenhouse gas emissions. It has been demonstrated that the depreciation time for new SRL can be relatively short (approximately 5-10 years) so it is possible to cut the costs by renewal of SRL with new, more energy-efficient alternatives (e.g. USAID INDIA, 2010; CEN, 2003). In some cases the wattage can be reduced by as much as 50% (Kostic and Djokic, 2009) and still maintain good, or even improved, lighting (EnLight, 2012). It has also been demonstrated that investments in energy management of public lighting can result in lower emissions of carbon dioxide (Radulovic et al. 2011).

In addition, the adoption and implementation of the EU directive on ecodesign requires a phase-out of Hg lighting in 2015 (EC No 245/2009). This has put pressure on Swedish municipalities to substitute their remaining Hg lighting. Also, the SRL infrastructure may be obsolete so that substitution to more efficient lighting is driven by an urgent necessity for renewal. Although new lighting technologies have been available for several years, Swedish municipalities have acted slowly in replacing their old mercury vapour lights. The underlying reasons for their passivity towards more energy efficient lighting are unknown, but may be due to financial constraints, organisational ineffectiveness, lack of knowledge, lack of integration or because of unknown factors (Ling et al. 2009).

In Sweden, local energy planning is mandatory by law (SFS, 1977) including the promotion of energy efficiency. However, inclusion of SRL in local energy planning is voluntarily. A survey conducted by
the Swedish Energy Agency shows that 32 out of 53 municipalities have not discussed lighting from a climate- or environmental perspective (Belysningsbranschen, 2008). There are examples of municipal lighting programs in Swedish municipalities but the main objectives of the lighting programs are primarily e.g. planning, safety, gender equality and esthetic purpose and are generally not focussed on improving the energy efficiency of the municipal lighting (e.g. Botkyrka, 2009; Jönköping, 2011; Malmö, 2008; Österåker, 2010). As indicated there are several incentives for municipalities to renew SRL to more energy efficient alternatives, but the frequency of renewal is low. The only recommendations or regulations regarding SRL of concern for Swedish municipalities concerns minimum lighting levels for traffic safety reasons (VGU, 2004), which may be one possible barrier for renewal to more energy efficient alternatives. Better knowledge on municipal barriers for improving energy efficiency in SRL may provide valuable insight on how to speed up the process of introducing more energy efficient SRL, but is also important for more efficient management and decision-making within the municipal organization. The objective of this study was therefore to identify factors that constitute possible barriers and incentives for new or reinvestments in more energy efficient SRL in Swedish municipalities focusing on planning and decision-making processes.

2 Methods

2.1 Case studies

Municipalities that we included as case studies were either successful or unsuccessful in switching to more energy efficient SRL. This was considered important for comparisons in the study since the objective was to analyse differences in e.g. management, planning, and organisation between municipalities. We choose municipalities after discussions with lighting professionals at the Swedish road administration, one energy company dealing much with lighting issues, and one large municipality in Sweden. Also municipalities of different sizes were included in the study since we had reason to believe the size of the municipality would affect the renewal of SRL. Three different size classes, representative for the majority of municipalities in Sweden, were included, i.e. small municipalities with around 10 000 inhabitants (Tingsryd, Torsby, Vännäs, Strömstad), medium-sized municipalities with 30 - 40 000 inhabitants (Lerum, Katrineholm, Piteå, Växjö) and large municipalities with 110 - 140 000 inhabitants (Umeå, Jönköping, Linköping, Västerås). A total of twelve municipalities from different geographical locations in Sweden were thus included, four from each size class.

2.2 Questionnaire study

To identify potential barriers and incentives for new investments and renewal of SRL in Swedish municipalities a questionnaire study with a number of semi-structured questions was carried out in twelve municipalities. The main focus of the questionnaire was the planning and decision making processes, responsibilities, stakeholders and organisational structure of relevance for decisions about SRL. The questionnaire also included a number of questions regarding the technical status of the current SRL, such as numbers, types, and energy consumption of SRL, and future plans for exchanges and renewal of the SRL.

Interviews were executed either by telephone or by distributing the questionnaire by email to the official responsible for the management and maintenance of the SRL in the municipalities. In some cases additional clarifications of both written and oral answers were done by telephone. Normally, the official responding belonged to the traffic department, under the technical services committee, but there were some exceptions. In one case the person with knowledge of the public lighting was employed by the local energy company. This paper will not reveal information about the municipal identity of the answers.

3 Results

All included municipalities had some type of database of the SRL, at least including number and type of SRL. The larger municipalities had or were developing map-based systems. This data indicated, as expected, that the number of SRL increased with the size of the municipality and the number of inhabitants (Figure 1) and that the number of lights per 100 inhabitants was somewhat lower in the medium and larger municipalities compared with the smaller municipalities. The total annual energy consumption in each municipality was, also as expected, strongly correlated with the number of SRL lights.
Figure 1 – Graph showing the number of lightings in relation to inhabitants. Data from twelve municipalities of different sizes in Sweden, small = around 10 000 inhabitants, medium = 30-40 000 inhabitants, large = 110-140 000 inhabitants.

Annual energy consumption per light, however, was more variable. It generally ranged between 240 – 442 kWh (Table 1), with one exception in one of the medium-sized municipalities which declared 650 kWh/light and year. The small municipalities declared SRL with comparatively low energy consumption (< 300 kWh/light/year), whereas the medium sized (except the one extreme) and large municipalities declared significantly higher energy consumption ranging between of 325 - 442 (650) kWh/light/year for their SRL.

Table 1 – Annual energy consumption per light per year (kWh) for the twelve municipalities included in the study, including average values ± 95% confidence interval.

<table>
<thead>
<tr>
<th>Municipality size class</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
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<td>281</td>
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<td>238</td>
<td>325</td>
<td>357</td>
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<td></td>
<td>285</td>
<td>442</td>
<td>404</td>
</tr>
<tr>
<td>Mean annual energy consumption (kWh)</td>
<td>268 ± 34</td>
<td>395 ± 99</td>
<td>386 ± 72</td>
</tr>
<tr>
<td>Total mean annual energy consumption (kWh)</td>
<td></td>
<td></td>
<td>390 ± 77</td>
</tr>
</tbody>
</table>

*Not included in the calculation of mean values.

The percentage of Hg lamps in the surveyed municipalities ranged between 0-75%, and a more detailed analysis showed that the annual energy consumption/light was significantly correlated with the percentage of Hg lamps remaining, confirming the potential to save energy by renewing the SRL (Figure 2). In consistence with the results above, the small municipalities had the lowest percentage of Hg lamps remaining (0-12 %) whereas the large and medium sized municipalities, with one exception, had the highest percentages. High pressure sodium lamps were generally the most common light source type, ranging from 25-100% of the total SRL in the surveyed municipalities and also the most common lamp type to replace the Hg lamps. In some cases ceramic metal halide lamps and other types of light sources were found in small amounts. Four municipalities planned to replace Hg lamps with ceramic metal halide lamps and one small municipality had a strategy to substitute all SRL to ceramic metal halide lamps.
Three of these municipalities stated that the reason for choosing ceramic metal halide lamps was that they desired more white light, for example in parks, playgrounds, or in central city locations. Both alternatives would generally lead to lower energy consumption in comparison with Hg lamps since a common wattage for high pressure sodium lamps used in streets in residential areas is about 50 W and for ceramic metal halide lamps about 70 W, both significantly lower than the 120 W Hg lamps.

All municipalities included in the study were aware of the ecodesign directive and the requirement to substitute their Hg lamps in the future. Also, all municipalities had some type of plan for renewal and replacement of SRL in general and specifically Hg lamps. In some cases the plans were not documented, however. Replacement of Hg lamps was usually planned to take place within 2-3 years, but one of the large municipalities planned to use the Hg lamps until they are obsolete and paid-off in 2018. All municipalities had at least some relatively recent experiences from installing new SRL. Ten of the municipalities surveyed reported positive experiences of the replacement, but one medium sized and one large municipality were dissatisfied with the newly installed lighting due to technical problems. There had been very few reactions from residents. Only two municipalities had received complaints about the light quality of high pressure sodium lamps, and two had received complaints about excessive spacing between street lights. One municipality had received comments from the public that the SRL had become brighter (the type of lamps was, however, not specified).

The responsibility for the SRL was assigned to the technical office or a technical official in most of the municipalities. In two municipalities, the head of the traffic department was also the person responsible for decision making regarding public lighting, including planning, investments, operation and maintenance. However, there were also other solutions. In one of the medium-sized municipalities, the SRL was owned by the local energy company and in one large municipality the ownership of the SRL had recently been transferred from the local energy company to the municipality. In another large municipality, the SRL was owned by the municipality but the responsibilities of renewal, lighting investments, management and maintenance was outsourced to the local energy company. In this case the responsibility for new investments and their budget was, however, still maintained within the municipal office (at the technical service committee). Larger investments usually needed to be decided at a higher level in the municipal organizations, for example by the technical services department, the technical services committee or the municipal executive committee. Normally, decisions regarding the SRL were reported to be taken in co-operation with the immediate executive (e.g. the head of the traffic department).

The responsibility for operation and maintenance, including budget, was usually assigned to the same official or department that was responsible for investments and the investment budget for SRL. This was
the case for the small municipalities which were among the municipalities which had the most energy-efficient SRL, but also for several of the medium sized and large municipalities which had less energy-efficient SRL. Among the municipalities with least energy-efficient SRL, the responsibility for the budget for management and maintenance of the SRL was in two cases assigned to the local energy companies, and in one case to the technical committee. Eleven of the twelve municipalities employed contractors for operation and maintenance of facilities, often in the form of a specialist or general contractor. In one case the maintenance was specified as preventive maintenance, scheduled maintenance and troubleshooting. The duration of the contracts was usually 3-6 years.

On the question of whether competence is available within the organization, most municipalities answered "yes", three responded "partly", and one referred to the local energy company. In the large municipality that had outsourced the main responsibility for renewal, lighting investments, operation and maintenance to the local energy company, there was a lack of competence within the municipal organisation. About 50% of the municipalities had at some point consulted a lighting contractor.

The mechanism for the procurement of new SRL equipment varied between the municipalities, but procurement was generally carried out under the Public Procurement Act and current procurement requirements of the municipality in question. A few municipalities had used a lighting consultant for support and some had cooperated with neighbouring municipalities in developing their procurement policy. No municipality indicated that they had any problems carrying out procurement.

The main motives for renewal of the SRL stated by the municipalities were saving energy, phase-out of the Hg lamps due to the EU ecodesign directive (EC No 245/2009), and the need for substitution of obsolete lighting. All four small municipalities stated that energy savings were the main reason for substitution of the Hg lamps. In the medium sized and large municipalities the EU Directive was given as the main motive by four municipalities while the remaining four municipalities stated that their main motive was the need to replace old and obsolete SRL. The four small municipalities that stated that energy savings was the main reason for renewing the SRL also stated that reduced costs for management and maintenance was of relevance. None of these municipalities mentioned reduction of greenhouse gases as a motive, but environmental motives was stated by one.

4 Discussion

The twelve municipalities surveyed had very different levels of energy efficiency in their SRL, and variable proportions of Hg lamps still in use. The percentage of Hg lamps was lowest in the small municipalities, which is consistent with the lower annual electricity consumption for SRL per lighting point in these municipalities as compared to the medium-sized and large municipalities surveyed. Studies of decision-making processes and planning show that these are complex processes, and that there are many factors that may have crucial importance for the outcome of such processes and also for the effectiveness of management (Ling et al. 2009; Larsson and Bostedt, 2000; Jalonen, 2006; Ranhaugen, 2008). One important factor may be the approach or strategic contexts in which various issues, in this case the question of renewal of SRL, are placed. Other possible factors may be for example routines for communication and coordination between planning sectors or unclear roles and responsibilities between individuals, between different parts of organizations or between organizations. Such ambiguities can also be related to technical and economic aspects, but in this case also to unclear boundaries between infrastructure investment and operation and maintenance.

One key question was therefore whether the renewal of SRL in the municipalities was handled within a priority strategic context for the municipality. In the case of SRL such a strategic context could be targets on energy efficiency and emissions of greenhouse gases. Alternatively, economic incentives and safety issues could provide this context. The results obtained in this study showed that the main strategic context for the propensity to make investment decisions in the SRL seemed to be energy savings or energy efficiency, motivated either by economic incentives or possibly by a strategic energy plan. The municipalities that had entirely or to a very large extent replaced the Hg lamps with other light sources stated that energy savings was the primary reason, and context, for the substitution. These municipalities were also the smallest, indicating that integration between different policy and planning sectors is easier in a smaller organisation. Another reason for renewal of the SRL in these municipalities was economic incentives. These objectives were also referred for their future plans for continuously cutting future operation and maintenance costs of SRL.

The medium-sized and large municipalities that had the largest proportion of Hg lamps left in the SRL had not coordinated the issue of SRL with other strategic issues such as energy, environment, safety or economic objectives. These municipalities had a purely technical and functional approach to SRL and
only changed the light fixtures as the old ones wear out and it seems that strategic energy planning had only a limited effect on decisions regarding renewal of the SRL. None of the municipalities surveyed indicated that the cost for renewal of the SRL was a barrier for substitution of the SRL. Rather, it seems that renewal of the SRL is viewed as an opportunity to save money and energy by the municipalities that has been most successful in replacing their inefficient lightings. This limited study did not allow any further investigation into the causes of the proactive or reactive behaviour of different municipalities with respect to renewal of the SRL. The result, however, is an indication that coordination and cooperation between planning sectors and different organisational levels may be a factor that contributes to a more proactive planning in municipalities and that such processes are easier to accomplish in small municipalities. Possible contributing factors for this are the concentration of different responsibilities to fewer officials and offices such as for example planning for renewal and operation and maintenance of SRL. Also, fewer employees and more informal contacts between officials and offices, generally more coordination of responsibilities dealing with different issues or other organisational factors cannot be unambiguously inferred from this study, but such factors may have contributed. In order to achieve the same degree of coordination in larger municipalities where the responsibility for various planning sectors are distributed over a larger organisation and more officials, clear instructions and procedures for the coordination of different issues may be required (Jalonen, 2005; Wieck and Walter, 2009).

Different types of contracts where the responsibility for the SRL has been delegated to other organisations may also have an impeding effect on the incentives to renew the SRL. In three of the four municipalities with the highest percentage of Hg lamps still in use, different types of entrepreneurs, usually the local energy company, were contracted for operation and maintenance, for managing the infrastructure, or both. None of these municipalities had any active involvement with the local energy companies regarding the SRL. In one municipality the representative for the local energy company argued that the old Hg lights had not been paid off yet and that this was the main reason for not replacing them. Such solutions may result in situation where it is not profitable for the local energy company to invest in new SRL that would result in lower electricity costs, especially if they also deliver the electricity for the SRL. When the entire responsibility for the SRL (operations, maintenance and power consumption), or parts of it is contracted out, there therefore is a risk that the driving forces for renewal and increased efficiency is lost. Several of the less energy efficient (medium-sized and large) municipalities had still not decided what type of lighting to replace the Hg lamps with. One municipality intended to await the development of LED lamps and therefore planned to keep their Hg lamps until 2018, while other municipalities were conducting their own test of LED lights. Lack of knowledge or competence was not identified as a barrier for renewal, rather the officials considered themselves to be competent and well informed, and they also used the opportunity to consult lighting experts when required. The intensive technological development in the area, however, seemed to cause some hesitation regarding the choice if strategy and type of lighting. It is not clear from this study why this would be more pronounced in the medium-sized and large municipalities.

One main conclusion from this study is that the integration of SRL planning with other strategies, such as energy and economy strategies, seems to be an important factor for a proactive SRL development. Outsourcing of management, operation and maintenance may constitute a barrier for renewal whereas lack of knowledge and costs for renewal does not seem to be any significant barriers. A more thorough analysis of local strategic development in the energy sector in municipalities of different size organisations than could be performed in this survey, would therefore provide more valuable information about obstacles and barriers, and their causes, for the renewal of SRL.

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References

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