Research and Library Services

Northern Ireland Assembly

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ENERGY EFFICIENCY IN STREET LIGHTING

There are approximately 250,000 street lights in Northern Ireland accounting for an annual electricity bill of £11.1m. This paper identifies technologies available for improving energy efficiency in street lighting and outlines a number of best practice case studies.

SUMMARY OF KEY POINTS

There are approximately 250,000 street lights in Northern Ireland and the electricity bill for these amounts to around £11.1m (excluding VAT). This is equivalent to the total electricity typically used by all homes in Carrickfergus or Newry over the course of one year.

Whilst there are a number of areas where energy saving initiatives can be implemented, these must be considered in parallel with the range of community benefits that street lighting provides.

Energy saving initiatives can broadly be categorised into the following areas:

- **The lamp**: can be converted to a more efficient model such as High Pressure Sodium, Metal Halaide, or LED;
- **The luminary**: can be replaced to direct light more efficiently;
- **The ballast**: can offer greater efficiencies and opportunity for dimming lights;
- **Telemangement**: can allow lighting to respond to individual conditions;
- **Better use of existing infrastructure**: by adjusting colour, lighting class, hours of operation; or complete removal.

Oslo – Introduction of High Pressure Sodium Lamps and Intelligent Street Lighting System	
The Project	Replacement of 10,000 old style fixtures with new high pressure, high performance sodium lights and 'intelligent' lighting systems.
Costs	Initial outlay of €12m (£11.1m) for 10,000 units / £1,110 per fixture.
Economic Savings	Running cost savings of £450,000 per year which include a 70% reduction in energy costs
Environmental Savings	A 70% reduction in the energy used for street lighting per year. (Emissions equivalent to flying around the world 120 times) [1]

An Arbor – Replacement of street light fixtures with LED units.	
The Project	Introduction of LEDs for street lighting purposes.
Costs	Initial investment of $3.3m (£2.4m) / $472 (£340) per fixture for 1,400 fixtures.
Economic Savings	Running cost savings of £71,000 per year which include a 50% reduction in energy costs.
Environmental Savings	Reduction of CO_2e by 267 tonnes / year. (Emissions equivalent to flying around the world 21 times)

Los Angeles – Replacement of street light fixtures with LED units	
The Project	Replacement of 140,000 street light fixtures with LED units.
Costs	Private / Public Venture – total amount unconfirmed.
Economic Savings	Estimated that it will save the city £34m over the first seven years and £7.1m thereafter which includes a 40% reduction in energy costs.
Environmental Savings	Designed to cut energy use by 40% or approximately 28,000 tonnes per year. (Emissions equivalent to flying around the world 2,240 times)

[1] Assuming that 1 tonne of CO_2 is equivalent to flying 2000 miles.

CONTENTS

1. INTRODUCTION AND BACKGROUND

There are approximately 250,000 street lights in Northern Ireland[2] and the electricity bill for these amounts to around £11.1m (excluding VAT).[3]

This year, 108 GigaWatt hours (GWh) of electricity will be used to provide street lighting in Northern Ireland. This is equivalent to the total electricity typically used by all homes in Carrickfergus or Newry over the course of one year. [4]

There has been much emphasis on the cost and environmental impact of electrical energy and this paper outlines a range of energy saving options available within the sector. However, these must be considered in parallel with the range of community benefits that street lighting provides. These are outlined by the Institution of Street Lighting Engineers as follows: [5]

- Prevention of night time personal injury accidents;
- Reduction in street crime;
- Reduction of fear of street crime;
- Promotion of sustainable transport such as public transport and walking and cycling;
- Facilitation of social inclusion;
- Promotion of economic development; and
- Assisting emergency services in identifying locations.

This briefing paper considers the following:

- Energy saving technologies available within the street lighting sector;
- Energy Saving Measures completed in Northern Ireland; and
- Best practice case studies.

[2] DRD Roads Service, *Street Lighting,* http://www.roadsni.gov.uk/streetlightingleaflet.pdf
[3] DRD DALO, *Street Lighting in Northern Ireland,* 2nd March 2009.
[4] Assuming that 1 GWh is equivalent to the energy used per 250 homes for one year. http://www.esru.strath.ac.uk/EandE/Web_sites/03-04/marine/glossary.htm
[5] Institution of Lighting Engineers, *Street Lighting – Invest to Save – Reduction or removal of street lighting – Interim Advice note LB1,* 2006, pg 2.

2. Energy Saving Technologies Available for Street Lighting

There are a number of areas where energy saving initiatives can be implemented in street lighting. These can broadly be categorised into the following areas:

- The lamp;
- The luminary;
- The ballast;
- Telemanagement or 'Intelligent' systems; and
- More efficient use of existing street light infrastructure.

Each of these is considered in further detail below.

Lamps

Lamps are a generic term for a man-made source of light.

The efficiency of lamps has improved significantly in recent years and the type used can have significant impact on the amount of energy required to run them.

Table 1 below considers the most common types of lamps available and provides a summary their success in terms of cost, energy efficiency and lighting performance.

Table 1: Lamp Type Descriptions

Lamp Type	Description
High-pressure mercury vapour lamp	- One of the most common types of lamp used in Europe. - Contains mercury and gives out white light. - Inexpensive to install and has a life span of 3 years. - Extremely energy in-efficient.
Low-pressure sodium	- Used in **older street lighting systems in Northern Ireland**. - Commonly used in the UK. - Contains no mercury. - Life span of 3 years. - Energy efficient. - Unable to direct the lamps light, therefore energy wasted. - Light is not immediate – must be switched on earlier than needed. - Provides orange light which lowers the quality of light for the road user.
High-pressure sodium	- **Used in new lighting installations in Northern Ireland**. - Very energy efficient. - Lifespan of 4 years. - Optically efficient but light is not immediate. - Provide golden/pink light. - Provide reasonable colour/rendering identification.

Metal Halide	- Based on the latest technology in street lighting. - Very energy efficient. - Low mercury levels. - Longer lifespan so cost advantages achieved. - Provides high quality white light. - Significant environmental achievements.
LEDs	- Relatively new technology. - Extremely energy efficient. - Longer lifespan of about 10 years. - Relatively high cost to implement. - Cost savings achieved through reduced labour and maintenance costs. - Able to direct light which reduces energy needed and limits light pollution. - Instantaneous light. - Dimming capabilities. - Can produce a specific colour.

Lamp changing initiatives have taken place in a number of countries. The *E-Street Initiative* was a joint public and private sector project aimed at considering efficiency in street lighting technologies across Europe. It stated that:

> *shifting to high-pressure sodium or metal halide lamp (*from older models) *could result in an efficiency improvement in the lamp itself as high as 40%.*[6]

This type of initiative was introduced in Oslo in 2004 and Section 4 of this report provides further information.

The use of LED technology for street lighting purposes has gained considerable momentum in recent years. LED technology has been trialled in a number of towns and cities in Europe and the USA. Most recently, Los Angeles announced the refit of 140,000 street light fixtures to LED technologies. Further information on case studies are contained within Sections 5 and 6.

It has been stated that energy savings from the use of LED technologies in replacement of the traditional lighting such as high pressure mercury can result in energy savings of 50% or more.[7]

LUMINAIRES

A luminaire is a complete lighting unit which consists of a lamp or lamps together with the parts designed to distribute the light, to position the lamps and to connect the lamps to the power supply.

Luminary development over the last 30 years has focused on improving the optical performance made possible because of the characteristics of the new lamp types.

[6] E-Street, *Project Report – Intelligent Road and Street Lighting in Europe, E-Street,* pg 20.
[7] Clinton Climate Initiative, *Best Practices, Lighting,* Internet accessed: 12.03.09.
http://www.c40cities.org/bestpractices/lighting/annarbor_led.jsp

Modern luminaries, equipped with modern lamps can be far more efficient in terms of placing light where it is required.

The *E-Street Light Report* states that:

> *development in lamp size and the characteristics* in optical *design mean that the efficiency of modern luminaries can be 25-30% higher that those based on old lamps.*[8]

BALLASTS

A ballast is a device used to obtain the necessary circuit conditions for starting and operating street lighting. Technology for ballasts is changing rapidly from magnetic to electronic technology.

The *E-Street Light report* estimates that:

> *the electronic ballast can extend lamp life by 30% while reducing consumption by 7%. On top of this, the electronic ballast gives the opportunity to provide for the possibility of stepless dimming which improves energy performance further.*[9]

TELEMANAGEMENT OR 'INTELLIGENT' LIGHTING SYSTEMS

Telemanagement systems allow for individual street lights to automatically react to external conditions such as traffic density, daylight levels, road works, accidents, or weather circumstances.

The advantages of such systems include:

- operating cost savings;
- energy cost savings;
- increased reliability;
- improved quality of lighting systems;
- Monitoring of fixture performance which can reduce maintenance costs; and
- Ability to track hours of illumination which allows for validation of energy bills, warranty replacements etc.

Intelligent technology was recently introduced in Oslo. Further information can be found in Section 4.

CONCLUSIONS ON ENERGY SAVING TECHNOLOGIES

The *E-Street Light* report concludes that:

> ***it is possible to reduce the amount of energy used significantly if changed from an old to an entirely new situation*** (this research excludes the use of LEDs)***. Replacing lamp, luminaire and ballast can achieve savings of up to 37%.***[10]

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[8] E-Street, *Project Report – Intelligent Road and Street Lighting in Europe, E-Street,* pg 20.
[9] *Ibid.*
[10] *Ibid,* pg 27. Note the use of LED lamps were not considered within this report.

> ***Telemanagement in such an installation can be as high as 45% of this number when applied fully which can bring total energy savings to 66% of a conventional older installation.***[11]

<u>BETTER USE OF EXISTING INFRASTRUCTURE</u>

The Institution of Lighting Engineers (ILE) has published guidance on the reduction or removal of street lighting[12] and notes that any such initiative must be considered in parallel with the wide range of community benefits that street lighting provides.

The ILE outlines a number of methods for reducing the use of street lighting and thus the cost of electrical energy. These are summarised below.

Photo electric cells – are the means by which lighting systems are controlled (ie switch them on an off when exposed to light) which have resulted in all night operation. The levels of these can be carefully considered and adjusted.

Reduced residential lighting – it may be possible to reduce lighting in areas where it is not desirable to have all night lighting.

Reduced traffic route lighting – may be considered where traffic flows or the use of particular routes have changed.

Lighting class – changes in British and European standards may allow for lower lighting classes to be provided that formally used.

White light – use of white light (not provided in low pressure sodium lamps) allow for a lower lighting class to be used and therefore reduce energy consumption.

Permanent Removal – it may be possible to identify limited locations where road lighting could be removed as a result of a change of circumstances.

Driving organisations such as the AA and RAC have expressed concern over such initiatives[13] and Roads Service officials have advised that such schemes were rejected on safety grounds.[14]

There are also other issues to consider when considering the complete removal of street lighting. These include: the damage that can occur to equipment; electrical safety; cost implications; and maintenance.

Roads Service has confirmed that it has considered energy conservation measures in accordance with the ILE interim guidance and that a number of energy conserving options are currently being implemented and assessed.[15] These are outlined further in the next section.

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[11] *Ibid*.
[12] Institution of Lighting Engineers, *Street Lighting – Invest to Save; Reduction or removal of street lighting – Interim advice note LB1,* 2006*.*
[13] AA, 13.03.09. http://www.theaa.com/public_affairs/news/switching-off-street-lights.html
[14] AQW 2372/08.
[15] DALO response, *Street Lighting in Northern Ireland,* 2nd March 2009.

3. Energy Saving Measures in Street Lighting in Northern Ireland

DRD has confirmed that Road Service:

> *currently uses a range of good quality street lighting lanterns with efficient optical systems and control gear that are best suited to the circumstances of the installation. These are selected on the basis of whole life costs.*[16]

The lamp types used in street lighting installations are mostly High Pressure Sodium (SON). These lamps give off a golden/pink light and provide a reasonable colour rendering/identification.

Older street lighting systems are of the Lower Pressure Sodium (SOX) variety and produce an orange light output. Although the light output per watt is very high, the poor colour rendering/identification of SOX lamps has led to their reduced use of over recent years.

DRD have implemented a number of energy conservation measures:

- where possible, replacing the highest wattage street lights with more energy efficient lanterns that still maintain lighting standards;
- high efficiency electronic control gear is now specified in the majority of street lighting installations;
- Ensuring that the appropriate minimum lighting levels are used for new lighting schemes, therefore avoiding over lighting;
- Reducing burning hours by turning lights on slightly later and off slightly earlier;
- Use of white lamps, which allow lower lighting output levels; and
- Use of variable lighting levels through dimming systems.

DRD has advised that in 2006, an independent energy report on public lighting, noted that Roads Service had already carried out many of the most effective energy saving measures.[17]

[16] DRD DALO, *Street Lighting in Northern Ireland,* 2nd March 2009.
[17] *Ibid.*

4. Oslo, Norway – Introduction of High Pressure Sodium Lamps and Intelligent Street Lighting System

Summary

The Project	Replacement of 10,000 old style fixtures with new high pressure, high performance sodium lights and 'intelligent' lighting systems.
Costs	Initial outlay of €12m (£11.1m)[18] for 10,000 units / £1,110 per fixture.
Economic Savings	Running cost savings of £450,000 per year.
Environmental Savings	Annul CO_2 reduction of 1,500 tonnes equivalent for 10,000 units which equals a 70% reduction in the amount of energy used for street lighting. Emissions equivalent to flying around the world 120 times.

The Project

The initiative was a joint venture between the City of Oslo authority and a major electricity distributor in the area. The project involved the replacement of existing features which contained mercury and other chemicals[19] with high pressure, high performance, sodium lights and an advanced data communication system.

The data communication system allowed for the level of light being transmitted by individual fixtures to be adjusted according to local conditions.

The Results

Benefits of the project were stated by the Clinton Climate Change Initiative as follows:[20]

- increased life expectancy of lamps and equipment;
- economic savings in the form of reduced maintenance and energy costs;
- environmental benefits such as energy and CO_2 reductions;
- easier identification of units that required maintenance; and
- estimated technology efficiency improvements of 30%.

Furthermore, the new street lights included gears which measured accurate rates of consumption by difference consumers. For example: private cars, private companies, public parks etc. This meant that consumption could be accurately measured and taxed and users would be billed not on actual volume of use which created incentives to influence consumer demand.

After the project had been running for 2-3 years, the providers noted that it had performed well in terms of customer satisfaction. A number of problems were however documented which related to the failure in the communication units. Despite this, predicted energy savings were achieved and it is expected that cost reductions will be achieved when the project is scaled upwards.

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[18] Currency Converted using 12.03.09 prices €1 = 0.93 GBP.
[19] Other chemicals refer to PCBs or polychlorinated biphenyls.
[20] Clinton Climate Initiative, *Lighting Best Practices – Oslo Norway,* Website accessed 23.02.09. http://www.c40cities.org/bestpractices/lighting/oslo_streetlight.jsp

Environment and Energy Efficiencies

It is important to note that lighting in Norway is 100% hydropower generated. Therefore, environmental and energy efficiencies are hypothetical.

If oil had have been used to generate the power for lighting, the initiative would have resulted in reductions of 1,440 tonnes equivalent of CO_2. In real terms, this would have resulted in a 70% reduction in the amount of electricity used compared to the old system or 4.5 Gigawatt hours -

Financial Efficiencies

The project involved the replacement of 10,000 units which was 15% of street lighting in the Oslo area.

This involved an initial investment of €12m (£11.1)[21] which was made up of €6m (£5.5m) for the luminaries; €3m (£2.78m) for the intelligence technology; and €3m (£2.78m) installation costs.[22]

The project notes running cost savings of €450,000 per year (£417,000). However, scaling up the scheme could provide much more.

[21] Currency Converted using 12.03.09 prices €1 = 0.93 GBP.
[22] Clinton Climate Initiative, *Lighting Best Practices – Oslo Norway,* Website accessed 23.02.09. http://www.c40cities.org/bestpractices/lighting/oslo_streetlight.jsp

5. Ann Arbor, Michigan, USA – Replacement of Existing Light Fixtures with LED Units.

Summary

The Project	Introduction of LEDs for street lighting purposes.
Costs	Initial investment of $3.3m (£2.4m) / $472 (£340) per fixture for 1,400 fixtures.[23]
Economic Savings	Savings of $100,000 (£71,000) per year in electricity.
Environmental Savings	Reduction of CO_2e by 267 tonnes / year. (Equivalent to flying round the world 21 times)[24]

The Project

Following a trial period, the City of Ann Arbor (population 115,000) has installed LED street lights in order to reduce lighting costs and green house emissions. After successfully trialling an LED replacement programme, the authority received a grant from the local Development Authority which allowed for the retrofit of 1,400 light fixtures.

The Results

Evidence suggests that the trail was very successful. Advantages included:

- The ability to direct light therefore reducing energy required and light pollution.
- Lamp life time in the region of 10 years which reduced maintenance costs.
- Reduction in energy use by 50%.

Environment and Energy Efficiencies

Testing is continuing on neighbourhood street lights and it is Ann Arbour's goal to fully replace all lighting fixtures with LED technology. It is estimated that this would cut its public lighting energy use by 50% and reduce greenhouse emissions by 2, 200 tonnes Co2e annually.[25]

Partial rollout resulted in an annual reduction of 267 tonnes of CO_2e per year.

Clinton Climate initiative reports energy use savings of 50-80%.[26]

Financial Efficiencies

The trail was achieved through an initial investment of £2.4m which included a grant from the State's Development Authority. It is estimated that the initial installation will save the City Authority over $100,000 (£72,400) per year in electricity costs.

[23] Currency converted at rate of 1 USD = 0.724014.
[24] Assuming that 1 tonne of CO_2 is equivalent to flying 2000 miles.
[25] *ICLEI Climate Innovation Invitational: Ann Arbour's LED Streetlight Programme.*
[26] Clinton Climate Initiative, *Lighting, Ann Arbour, USA.* Website accessed 23.02.09. http://www.c40cities.org/bestpractices/lighting/annarbor_led.jsp

6. Los Angeles, USA – Replacement of Existing Light Fixtures with LED Units

Summary

The Project	Replacement of 140,000 street light fixtures with LED units.
Costs	Covered through public and private sector venture.
Economic Savings	Estimated that it will save the city $48m (£34m) over seven years and $10m for each year after (£7.1m).
Environmental Savings	Designed to cut power use by 40% or 197,000 tonnes of CO_2 over seven years (approximately 28,000 tonnes per year).

The Project

In February 2009, it was announced that Los Angeles would replace 140,000 existing streetlight fixtures with LED units. This is the largest ever retrofit of a city's street lighting network. The initiative is to be under taken by the Los Angeles Bureau of Street Lighting and will be rolled out over a five year period. [27]

The new LED lamps will have a lifespan of 12 years[28] – twice that of current streetlamps – and will be fitted with remote monitoring units that report failures directly to the Bureau of Street Lighting for immediate repair.

Energy and Environmental Impacts

The initiative has been designed to cut the energy used in street lighting by 40% which amounts to 197,000 tonnes of CO_2 over seven years. This is equivalent to 28,000 tonnes per year which is equivalent to the emissions generated from flying round the world 2,200 times.

Financial Impacts

Street lighting costs represent one of the largest components of a city's utility bill, typically accounting for between 10 and 38 per cent of energy costs. It is hoped that such a move would result in an annual saving of £4.8m for the first seven years and £7.1m thereafter.

It has not been possible to confirm the total cost of the initiative as it is being undertaken as a public / private sector initiative.

[27] CTN Ecological, *LED Street Lights,* 19.02.09. http://ctngreen.com/ecologic/2009/02/led-street-lights-la-plans-to-install-140000-of-them/
[28] Note that specific LED lamps may have different lifespans as a result of technology used.