CSS Street Lighting Project SL2/2007

Invest to save – sustainable street lighting

P Fox

Foreword

In pursuing its goals of providing advice and guidance to lighting practitioners, the CSS Lighting Group, in partnership with SCOTS, Transport Scotland, ILE, and TfL has commissioned five research projects to advance some major lighting issues.

Recent significant fluctuation in electrical energy prices have prompted many lighting authorities to review their policies on the provision, operation and maintenance of street lighting in an attempt to minimise the impact of escalating costs. Authorities are also aware of both the nuisance potential from light pollution and the global impact of CO2 emissions. The effect of street lighting on the environment in the form of greenhouse gases and the increase in light pollution are sometimes cited as reasons to turn off street lighting. These decisions must be balanced against the significant community benefits which accrue from the provision and operation of appropriate and well maintained street lighting.

This research project is the second in the current series, it quantifies and expands on the advice contained in LB1, published jointly by UKLB and ILE in 2006 and should assist with reasoned and well informed decisions on local lighting policies.

Mouchel was commissioned to undertake the work which was managed on behalf of CSS-LG by Stuart Bulmer URS Corp and Bob Willmott Jacobs / Kent CC.

The efforts of numerous individuals from lighting authorities throughout the UK must be acknowledged for their invaluable support in assembling the background data for this work, but specifically those from Cardiff City Council, Gloucestershire County Council, Staffordshire County Council and Westminster City Council for supporting the case studies.

CSS-LG hopes that the document proves to be valuable in assisting lighting engineers and decision makers by providing useful reference material.

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FOREWORD

Recent increases in the cost of electrical energy have caused Authorities to review their policy on the provision, operation and maintenance of street lighting in an attempt to minimise the impact of these increased costs. In addition there is also an increased awareness of both light pollution and CO_2 emissions. The effect of street lighting on the environment in the form of greenhouse gases and the increase in light pollution are often cited as reasons to switch off street lighting, however, this takes no account of the major benefits that accrue from the provision and operation of appropriate well maintained street lighting.

The major benefits to the community are:

- preventing night-time personal injury accidents
- reducing street crime
- reducing the fear of street crime
- promoting sustainable transport by promoting the use of public transport, cycling and walking
- facilitating social inclusion by providing the freedom to walk along and using the streets after dark
- promoting economic development by supporting the 24-hour leisure economy and distribution
- facilitating lifelong learning by providing after dark access to educational facilities
- assisting the emergency services to identify locations and carry out their duties (without modern street lighting the time taken to attend an incident could be increased)

Many of our towns and cities now have a 24-hour culture that, whilst focused in the town/city centre, it does not stop there but extends to the suburbs and residential areas with people travelling home after work or an evening out.

EXECUTIVE SUMMARY

There are many ways in which the use and thus the cost of electrical energy for street lighting can be reduced; however, these will generally require the Authority to "Invest to Save".

It is recognised that the cost of converting lighting to part night lighting is less than fitting variable level (dimming) control gear, however, the benefits of lighting are lost when the lights are switched off, whereas if the lighting is reduced to a lower level it will still provide appropriate illumination giving security and safety to all road users particularly pedestrians and cyclists.

The careful choice of lamp type and lighting class can also provide lower energy consumption which will further reducing costs. It is recommended that each Authority review its lighting policies in accordance with the procedures specified in the British and European Standards to determine the correct level of illumination for different road types, use and location and that the minimum lighting level that meets these requirements be provided.

When reviewing their lighting policies Authorities should take care not just to replicate or provide a lighting class to the same levels and quality as the previous used, without carefully considering all the requirements of the current British and European Standards. More information can be found in CSS Research Project SL1 2007 – Review of the Class and Quality of Street Lighting.

It is recommended that when setting policies and procedures as well as replacing existing street lighting an appropriate cost benefit analysis be undertaken to accurately determine the costs and benefits of the different options.

It is recommended that all illuminated traffic signs and illuminated traffic bollards be illuminated only when required and then only at night and that existing units that operate 24-hours per day be converted to photo electric cell control as soon as possible.

It is considered that the many benefits street lighting provides the community far outweigh the limited returns that can be achieved by switching off or removing lighting. However, there are a number of potential situations where the removal of lighting can be demonstrated as a safe and practical. When applying these principles the Authority should ensure that there is no longer a need for the lighting, and the authority is mindful of the duties imposed by section 17 of the Crime and Disorder Act of 1998, and that proper consultation with the adjacent community and road users has been carried out.

Where the provision of street lighting has established a speed limit care should be taken to ensure that this speed limit is maintained by applying a traffic order when the lighting is removed.

The following table shows typical annual savings at 2008 prices that can be made by installing a fully dimmable scheme per kilometre of road type, the calculated savings include those for variable light levels, dimming to maintenance factor and dimming to reduce over lighting as well as the savings made from installing electronic control gear compared to electro magnetic control gear.

Typical savings per km of Road through installing a variable lighting system				
	Energy (kWh/p/year)	Cost (£ p/year)	CO_2 (t CO_2 p/year)	
			Short Term	Long Term
Motorway	34,430	2,926*	18.45	14.80
Traffic Route	18,311	1,556	9.81	7.87
Residential Area S2 (Option 1)	5,785	492	3.10	2.49
Residential Area to BS 5489-1: 2003 (S4 & S5) (Option 2A)	5,666	482	3.04	2.44

* at 0.65 p/kWh

From the above it can be seen that the greatest savings can be made from roads with the highest lighting class and lamp wattages

Typical Costs for a Km of Residential Lighting				
	Energy (kWh)	Cost (£)	*CO_2 (Tonnes)	
			Short Term	Long Term
Residential Area S2 (Option 1)	15068	1280.74	8.08	6.48
Residential Area S2 (Option 1) with Variable lighting levels	9283	789.01	4.98	3.99
Residential Area S2 (Option 1) with Part Night Lighting	6367	541.15	3.41	2.74
Residential Area to BS 5489-1: 2003 (S4 & S5) (Option 2A) Option 2A	10148	862.54	5.44	4.36
Residential Area to BS 5489-1: 2003 (S4 & S5) (Option 2A) with Variable Lighting Levels	6914	587.65	3.71	2.97
Residential Area to BS 5489-1: 2003 (S4 & S5) (Option 2A) with Part Night Lighting	4482	380.93	2.40	1.93

The above table shows the annual energy consumption, energy cost and CO_2 consumption for a Km of typical residential lighting on various operating regimes

The CO_2 consumption figures show values for both short term and long term consumption, the short term figure is derived using the Carbon Trust's recommended conversation factor DEFRA's 5 year rolling average (0.537 kg CO_2 per kWh) and the long term is based on DEFRA's long term marginal factor (0.43 kg CO_2 per kWh) which is the DEFRA recommended value for long term evaluation and Climate Change reporting.

CHAPTER 1

1. INTRODUCTION

This report is intended to expand on the Street Lighting - Invest to Save interim advice note LB1 published by the UK Lighting Board in 2006.

Recent increases in the cost of electrical energy have caused local Authorities to review their policy on the provision, operation and maintenance of street lighting in an attempt to minimise the impact of these increased costs there as also been an increased awareness of both light pollution and CO_2 emissions. The reduction of CO_2 emissions is seen by many as more important than the cost of electricity with the following all trying to impose reductions in CO_2 emissions on the Local Authorities and the country as a whole:

- **Kyoto Protocol:** (1997) Reduce carbon emissions to 1990 levels;
- **Stern Report:** Reduce carbon emissions & develop a sustainable future;
- **Gershon Report:** Sustainability, Best Value, Efficiency, Systems etc.; and
- **Eddington Report:** Carbon emissions should play a part in the decision making process (Transport and Infrastructure – look for efficiencies and reductions).

The initial view of some is that street lighting should be switched off either at midnight or all together. Whilst this may provide short term relief in reduced energy costs and a perceived reduction in CO_2 emission, no account has been taken of the hidden energy and CO_2 increases that society as a whole will have to bear.

The Eddington report states that:

"The policy process needs to be rigorous and systematic: start with the three strategic economic priorities, define the problems, consider the full range of options using appraisal techniques that include full environmental and social costs and benefits, and ensure that spending is focused on the best policies" (Eddington Report)

This report will enable Authorities to develop sustainable lighting policies by quantifying the general advice given in the UK Lighting Board's Invest to Save advice note.

CHAPTER 2

2. OBJECTIVES AND DEFINITIONS

OBJECTIVES

To review the concerns and current pressures on Authorities with regard to operating their road lighting network and to investigate further the Authorities with current Invest to Save schemes.

To encourage and assist in the development of an Invest to Save approach to energy saving in street lighting in order reduce costs whilst maintaining the benefits provided by good well maintained street lighting.

To encourage a systematic review of existing policies and procedures, both for new works and maintenance, with a view to maximising the savings available from an Invest to Save scheme, in conjunction with the requirements of BS 5489-1: 2003 (+A2: 2008 and Corrigendum No.1 – Code of practice for the design of road lighting – Part 1: lighting of roads and public amenity areas) and recent advances in new technology.

To encourage the use of cost benefit analysis and modelling when reviewing policies and procedures to ensure that the most efficient option is identified and informed reasoned decisions made.

DEFINITIONS

For the purpose of this report the following definitions are used:

Authority means all forms of national and local authority having a responsibility for public lighting.

Client means the person or organisation responsible for the operation and management of the public lighting system in a defined area.

Contractor means the person or organisation employed by the client to undertake the maintenance of the public lighting system in a defined area.

CMS means a Central Management System containing a street lighting inventory capable of 2 way communication with the luminaire.

DNO means the Distribution Network Operator of a public electricity distribution system within a defined licensed area.

Highways power supply means an electrical installation comprising an assembly of associated highway distribution circuits, highways distribution boards and street furniture supplied from a common origin.

Initial lamp flux means the output of the lamp when new, in lumens.

LLMF the Lamp Lumen Maintenance Factor means the depreciation factor for a specific lamp type at the lamp replacement period.

LMF the Luminaire Maintenance Factor means the maintenance factor for a specific luminaire, cleaning interval, the ingress protection (IP) rating of the luminaire and the pollution category of the area in which the lighting is installed.

Public lighting means a system of street lighting and any associated illuminated traffic signs and illuminated traffic bollards owned by the Authority

Illuminated traffic bollard means transilluminated bollards lit by internal or base mounted lighting units carrying one or more diagrams from the TRS&GD, or the same type of unit with all plain aspects.

Illuminated traffic sign means internally or externally illuminated signs carrying a diagram or legend as required by the TSRGD, flashing school crossing warning signs centre island beacons and pedestrian crossing Belisha beacons

TSRGD the Traffic Signs Regulations and General Directions

Street lighting means a system of lighting illuminating streets, footways, footpaths, cycle tracks and pedestrian subways open to public access.

CHAPTER 3

3. REASONS FOR LIGHTING

This section looks at the requirements for lighting roads, the standards to be applied and the current supporting guidance.

3.1 BENEFITS

Modern well designed, installed and maintained street lighting provides many community benefits, by:

- preventing night time personal injury accidents
- reducing street crime
- reducing the fear of street crime
- promoting sustainable transport, public transport, cycling and walking
- facilitating social inclusion by providing the freedom to use our streets after dark
- promoting economic development by supporting a 24-hour leisure economy
- promoting 24-hour use of the existing road infrastructure, night time distribution and travel
- facilitating lifelong learning by encouraging after dark access to educational facilities
- assisting the emergency services to identify locations and carry out their duties (without modern street lighting the time taken to attend an incident could be increased)
- allowing the effective use of CCTV systems at night

3.2 POWERS AND DUTIES

When reviewing the provision, maintenance and operation of street lighting systems the authority should take account of the following items:

- A Highway Authority has a power, not a duty, under the Highways Act 1980 (or in Scotland the Roads (Scotland) Act 1984) to provide and maintain road lighting. Similarly, the local Lighting Authority, usually the Parish, Town, District or Borough Council has the power to provide and maintain Footway Lighting.

- In exercising its powers with regard to the extent, operation and maintenance of its road lighting, a Highway Authority should act reasonably. If it acts in a way that no reasonable authority would act then the decision of that authority could be subject to review in the courts.

- Road lighting has many community benefits – e.g. the prevention of night time road accidents, the reduction of street crime and the fear of crime. In exercising the Highways Act powers, the Highway Authority is required under s.17 of the Crime and Disorder Act 1998 to have regard to the effect on crime and disorder in the exercise of those powers and to have regard to the need to do all it reasonably can to prevent crime and disorder. However, there is no overriding duty on a local authority to provide or keep lit systems of street lighting to prevent crime.

- In England and Wales unless provided by separate order, restricted roads and their associated 30mph speed limits are established by the presence of a “system of street lighting furnished by means of lamps placed not more than 200 yards apart” and in Scotland “a system of carriageway lighting furnished by means of lamps placed not more than 185metres apart and the road is of a classification or type specified for the purposes of this regulation” (s81 and 82 of the Road Traffic Regulation Act 1984).

CHAPTER 4

4. SUMMARY OF SURVEY AND INTERVIEWS

An initial questionnaire was sent out to 43 Authorities in order to establish their current concerns and the pressures they are under in delivering the local Authorities lighting provision

4.1 INITIAL RESPONSES

From the completed initial questionnaires:

- 53% of the Authorities said they were currently undertaking invest to save initiatives; and
- All of the Authorities (100%) are looking to undertake invest to save initiatives in the future.

The main concerns for the Authorities were:

- Energy reduction - 100%;
- Reduced maintenance costs - 100%;
- Service Improvements - 53%; and
- Reduced maintenance costs (excluding energy) - 40%.

In addition 20% of the Authorities stated that a reduction in CO_2 emissions was a significant factor in deciding their own invest to save strategy.

One Authority stated that they have justified an invest to save scheme on Health and Safety grounds as there will be less time spent on the highway by maintenance operatives.

4.2 SUMMARY OF RESPONSES TO INITIAL QUESTIONNAIRES

What areas are Authorities looking at as part of an invest to save project?

Table 4.1 - The areas Authorities are considering for Invest to Save schemes.			
Option	**Now* %**	**Future* %**	**Not at all* %**
Lamp Source	67	40	0
Electronic control gear	73	27	0
Remote monitoring	33	40	27
Central Control and Management System	47	33	20
Changes to existing policies	67	33	7
Re-classifying roads (lighting levels)	33	60	7
Dimming	47	47	7

* the %'s do not add up to 100% because some Authorities stated that they are considering the option both now and in the future

What payback periods the Authority feels is acceptable?

Acceptable pay back period   % of Authorities**

Table 4.2 – Authorities Acceptable payback periods	
Acceptable pay back period	**% of Authorities****
0-5 years	33
5-10 years	67
10-15 years	13
15-20 years	7

** the %'s do not add up to 100% because some Authorities stated that more than one payback period is acceptable

From these initial replies it was decided to undertake follow up interviews with the following Authorities:

- Cardiff City Council
- Dudley Metropolitan Borough Council
- Gloucestershire County Council
- Staffordshire County Council
- Westminster City Council

Individual case studies are contained in the Appendix A.

CHAPTER 5

5. BARRIERS TO INVEST TO SAVE

Whilst all Authorities are under pressure to reduce the cost of their energy consumption some of the potential barriers to reducing these costs are detailed below

5.1 LACK OF FUNDING

There has been a consistent lack of funding and investment by many Authorities in replacing and upgrading their existing lighting stock, and in some cases the recent increase in energy costs has only reduced this funding even further, with some Authorities diverting funds from replacement schemes to cover the increased energy costs.

5.2 EXISTING COUNCIL POLICY – NOT FULLY USING BS 5489-1: 2003

Many Authorities do not have written, published Councillor agreed policies regarding the application of lighting within their authority and some of the agreed policies are very restrictive being based on the historical applications of the old BS 5489: 1992 and have not been fully updated to include the recommendations contained in BS 5489-1: 2003. It is important that due consideration is given to developing or updating the policy and that a policy is produced by a competent lighting engineer as defined by the ILE designer competency requirements. This policy should consider all the key aspects contained within BS 5489-1: 2003 and BS EN 13201-2: 2003 – Road Lighting – Part 2: Performance requirements and ensure they are applied correctly

In order to gain the maximum benefit and energy saving from BS 5489-1: 2003 the lighting policy for the local Authorities needs to ensure that the appropriate lighting class for each road is determined by applying the selection criteria found in BS 5489-1: 2003.

A common misinterpretation of BS 5489-1: 2003 relates to the choice of 'S Class' when considering crime. Crime rates are relative to the local area, not national. Therefore the crime assessments should only relate to the local areas, normally within the Authority.

Quite often engineers hear of Authorities describing them selves as high crime and applying a class of S1 across the board, this is a misapplication of the requirements of the standards and whilst it may make the life of the lighting engineer easier it wastes money and energy as the application of this one high lighting class across the authority, requires higher installation costs and higher maintenance costs and does not produce an appropriate lighting scheme for all of the roads within the Authority.
An evaluation of crime figures across the Authority should be made and each road rated as low, normal or high. Each road should then be assessed to determine the base lighting class and then the crime level applied to arrive at the final lighting class.

The map below shows the density of all street crime in the City of Westminster between January and June 2007.

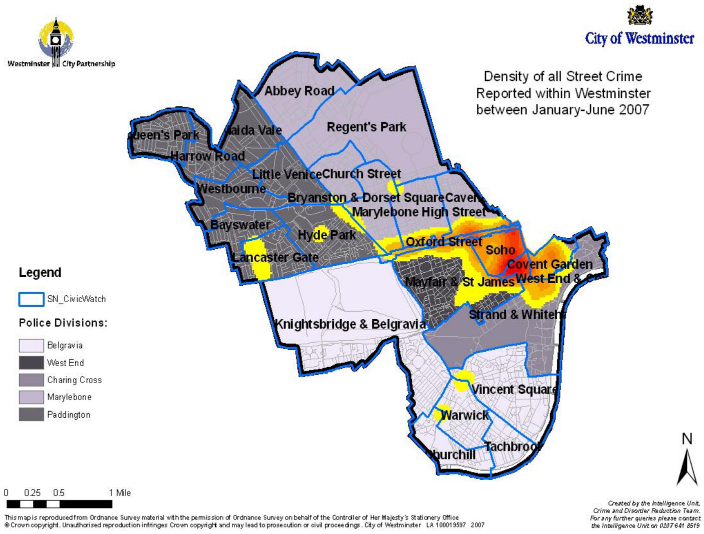


Figure 5.1 - Map of crime levels in Westminster City Council

From the above map the crime levels for the City of Westminster have been assessed as:

- Low crime <50 incidents per street
- Medium crime 50 to 100 incidents per street
- High crime > 100 incidents per street

This has allowed the appropriate lighting class to be assigned to each road.

The impact on energy and maintenance costs of applying lighting classes higher than those required by BS 5489-1: 2003 can be seen from the options produced for the typical residential area relighting scheme - Appendix B

The typical small residential area consists of a main estate road and several small side roads and cul-de-sacs, the existing lighting is approximately 35 years old and consists of 39 No. 5m tubular steel columns with post top mounted 80W Mercury Vapour (MBFU) deep refractor bowl luminaires.

The evaluated options for relighting the trial area were:

Option 1 – All roads lit to S2 with 6m mounting height 70W Son luminaires

Option 2A – Main estate road lit to S4 with 6m mounting height 50W Son luminaires
Other estate road lit to S5 with 6m mounting height 50W Son luminaires

Option 2B – Main estate road lit to S4 with 6m mounting height 70W Son luminaires
Other estate road lit to S5 with 6m mounting height 50W Son luminaires

Option 3 – Main estate road lit to S5 with 6m mounting height 45W Cosmopolis luminaires
Other estate road lit to S6 with 6m mounting height 36W PLL luminaires

The following cost benefit analysis for the proposed options shows the differences in Installation, energy and operating costs and highlights the savings that can be made from the correct application of BS 5489-1: 2003 when selecting lighting classes and lighting equipment.

From Appendix B: Typical Residential Re-Lighting scheme

Table 5.1 – Typical Costs for Residential Lighting Scheme					
	Option 1	**Option 2A**	**Option 2B**	**Option 3**	**Existing**
Installation Costs	£41,220	£39,720	£37,020	£38,080	N/A
1st Year Energy Costs	£1,025	£690	£673	£456	£1,278
1st Year Operating costs	£594	£583	£507	£574	£1,165
Total 1st Year Running Costs	£1,618	£1,273	£1,180	£1,030	£2,443

From the above table it can be seen that all of the proposed options reduce not only the existing energy costs but also the existing operating costs.

It can also be seen that by installing a scheme to the correct lighting class as determined by BS 5489-1: 2003 compared to a blanket S2 scheme an energy saving of between 33% and 55% can be made.

5.3 STANDARDISED MAINTENANCE EQUIPMENT

Restrictions placed on the designer and the scheme due to standardising equipment, limiting the luminaire type, lamp type and wattage and mounting heights will ease future maintenance issues by keeping replacement stocks to a minimum, however unless all of the roads in the Authority have a uniform width and lighting class this will lead to inefficient lighting schemes. In reality the Authorities roads will not have standard geometry and the use of different luminaires, or those with variable optics along with different lamp types and wattages at different mounting heights on different roads will maximise the return on invest to save investments.

The increased maintenance requirements, ensuring the correct replacement of lamps, luminaires and columns can be mitigated by improved inventories and also controlling maintenance operations through a central management system.

The Authorities maintenance policy should also be constantly reviewed in order to maximise all savings available, such as ensuring that all bulk changes are done at the appropriate time for the lamp, i.e. if the lamp has a life of 4 years then do not change it at 3 years. It is also recommended that the choice of light source should maximise the lamp life whilst maintaining the required quality characteristics.

5.4 POOR INVENTORY

Poor inventories can lead to punitive energy charges, It has been stated by some meter administrators that some suppliers include a percentage within un-metered tariffs which takes account of inaccurate inventories, where the inventory can be shown to be accurate this charge can be removed.

A poorly maintained inventory can also result in over payments to the energy supplier as not all of the savings accrued through investment are reflected in the charges. For example, new schemes that reduce the overall energy consumption may not have been put on to the inventory and so the Authority is still paying for the energy consumed by the old scheme.

A poor inventory will also lead to inaccurate modelling and cost benefit analysis, if your current inventory is poor you will not be able to determine the accurate costs and potential savings of proposed schemes and changes to the existing specification.

5.5 POOR MAINTENANCE

Poorly maintained equipment will not be performing at its optimum and so will be wasting money and CO_2 by not getting the best value out of the equipment already installed.

In particular lamps that not been regularly replaced will have very poor lumen output but the Authority will still be paying the full electricity costs.

Poorly maintained schemes will also contain a large proportion of outages compared to well maintained schemes with the Authority still be paying the full electricity costs.

In both of the above cases the Authority will be getting less light for their money.

Not having a planned power factor capacitor replacement programme will apparently not cost the Authority money but can still lead to increased energy consumption. A poor power factor will increase the power consumption of the lighting equipment and increase the CO_2 emissions from the electricity generating company. In addition when the energy companies undertake site checks to verify the energy consumption of the different types of lighting equipment, those Authorities with poor power factor correction may suffer increased charges when compared to those paid by others.

Poor maintenance will also mean that the condition of the installed equipment is not fully known and this will lead to a lack of scheme identification and prioritisation for remedial works.

Day burners whilst at present not costing the Authority money may do so in the future, if the Authority pays for the energy consumed, through a CMS system. In addition day burners will have a detrimental effect on the perception of the Authorities lighting provision from elected members and members of the public.

In summary poor maintenance will result in the Authority paying for electricity but not getting the full benefit from the lighting installation.

Figure 5.2 – Example of a poorly maintained Lighting Column

CHAPTER 6

6. Cost Benefit Analysis

A cost benefit analysis is required in order to accurately determine the true costs and potential savings of invest to save schemes, a good cost benefit analysis allows a considered decision to be made when evaluating different scheme options or when setting policies and standards.

6.1 THE HIGHWAYS AGENCY APPROACH

The Highways Agency requires the production of a project appraisal report (PAR) which includes a cost benefit analysis when proposing any new or replacement work on the Highways Agency road network. A PAR is produced and used to asses the benefits of different options, including the appraising of new and replacement lighting on the strategic motorway and all purpose trunk road networks.

TA 49/07 – Appraisal of New and Replacement Lighting on the Strategic Motorway and Trunk Road Network provides guidance on the completion of a road lighting PAR. The appraisal for a road lighting scheme is recommended to be over a 30 year period as this is the anticipated design life of a lighting scheme.

There are 3 main areas of information required too complete the cost benefit analysis

1 The expected benefit in terms of PIA savings for a road lighting scheme.
2 The expected costs
3 Other benefits and disbenefits, both quantifiable and non quantifiable

6.1.1 Benefit of Road Lighting

The main benefit to the highways agency of installing road lighting is the reduction in night time accidents. Every personal injury accident (PIA), has a cost to society this cost is dependant on the severity of the injury and the type of road it occurs on. The PAR process for appraising road lighting proposals and options uses the average cost for night time personal injury accident for different road categories and for different years of opening, examples of these costs are given in the table below:

Table 6.1 – Typical costs of Night time PIA's

Opening Year	All Purpose Roads 30/40 mph Speed Limit		All Purpose roads 50/60/70 mph Speed Limit		Motorways
	Single	Dual	Single	Dual	
2008	88,660	88,7370	157,880	104;530	105,660
2009	89,520	88,260	158,480	104,270	105,910

All of the above prices are in £ at 2002 Market prices

Guidance to determine the number of night time PIA's saved due to installing road lighting is found in TA 49/07. The guidance states that unless an independent road safety engineer advises differently then the percentage savings of night time accidents shall be taken from the table below:

Table 6.2 – Darkness PIA Savings on Link road due to Road Lighting

Type of Link	A[1]
Motorway and motorway standard All Purpose Dual Carriageway	10%
All Purpose Dual Carriageway	10%
All Purpose Single Carriageway	12.5%

[1] Percentage darkness PIA savings due to road lighting

The savings are then calculated from existing accident statistics for that road and the number of night time accidents saved per year is obtained

The number of accidents saved is then multiplied by the cost of the accidents in order to obtain a yearly saving. This annual cost is then multiplied by the evaluation period to obtain the total savings.

6.1.2 Cost of Road Lighting

The costs are made up of 4 elements:

- design and construction;
- maintenance over the appraisal period;
- energy charges over the appraisal period; and
- decommissioning and disposal at end of life.

Design and Construction cost

The works cost should include all the costs that are incurred whilst preparing and installing the proposed scheme.

Typical costs to be included are:

- Costs of overheads such as design and site supervision;
- Cost of supplying and installing all of the lighting equipment;
- Cost of alterations or new vehicle restraint system required solely for the protection of lighting equipment;
- Cost of electricity supplies including feeder pillars and Distribution Network Operator charges;
- Cost of cable network, including all ducting, trenching and draw pits;
- Cost of any temporary lighting required;
- Cost of illumination of signs made necessary by installing the lighting;
- Cost of reinstatement;
- Cost of traffic management; and
- Cost of impact mitigation measures (compensation).

Maintenance costs

The maintenance costs should calculated for a period that covers a whole number of lamp replacement and electrical testing cycles, an allowance should be made for less frequent maintenance activities, painting and luminaire replacement. All these costs need to be considered when calculating the maintenance costs.

Typical costs to be included are:

- Cost of lamp replacement;
- Cost of luminaire cleaning;
- Cost of routine column inspection (including brackets and any fixings);
- Cost of any column inspection and testing, especially after expiry of fatigue design life;
- Cost for the inspection and maintenance of vehicle restraint system provided solely for the protection of lighting equipment;
- Cost of electrical testing;
- Cost of painting;
- Cost of luminaire replacement;
- Cost of Specialised access equipment for any of the above; and
- Cost of traffic management.

Energy Cost

The opening year energy cost should be calculated using the currently applicable rates negotiated with the Highways Agency's or other Overseeing Organisation's energy supplier. It is expected that energy charges will outstrip the Retail Prices Index (RPI) for the foreseeable future, although it is impossible to predict the likely difference between the two over the appraisal period. To take account of this, the annual energy cost should be multiplied by a factor for the energy inflation rate above RPI. Guidance on this calculation is given in TA 49/07.

Decommissioning costs

It should be assumed that the lighting will be decommissioned at the end of the appraisal period, whether or not a replacement scheme would be implemented. The cost of decommissioning (which should include disposal) should be allowed for in the appraisal and should cover all site works. However if an accurate estimate cannot be determined then it can be assumed that the decommissioning cost of lighting equals 20% of the works cost.

Typical costs to be included are:

- Cost of removal of lighting equipment;
- Cost of removal of vehicle restraint system (where provided solely for the protection of lighting equipment);
- Cost of recycling and disposal in accordance with legislation;
- Cost of reinstatement;
- Cost of Specialised access equipment for any of the above; and
- Cost of traffic management.

6.1.3 The PAR process

All of the above costs are then entered into the PAR worksheet and various other factors are then applied in the worksheet to allow for changes in road use, inflation and various other factors.

The PAR then produces a Benefits Cost Ratio (BCR) which is the ratio of the Present Value of Costs (PVC) over the Present Value of Benefits (PVB) if the ratio is greater than 1 then there is a positive cost benefit and the scheme will then be approved. If the ratio is less than 1 then either the scheme will not be approved or the non-monetised benefits will need to be considered.

It must be noted that there may be other benefits and disbenefits, both quantifiable and non-quantifiable that need to be considered.

The following items are also addressed, but are not included within the financial model:

- Landscape;
- Townscape;
- Heritage; and
- Biodiversity.

A formalised impact assessment is needed for each of the following topics. This should be carried out in accordance with the recommendations of TA 96/xx: Whole Life Cycle Code of Practice for Lighting on the Strategic Road Network. (Once TA 96 has been published by the Highways Agency.):

- Physical Fitness

This refers to the encouragement of walking and cycling activities. Where the road to be lit has provision for walking and/or cycling an estimate should be made of the likely increase in walking and cycling journeys after dark resulting from lighting.

- Journey Ambience

A journey in darkness may be less stressful if the road is lit and a comment to this effect should be made. However, in the daytime the presence of lighting columns can detract from views of the surrounding area if the landscape is of reasonable quality.

- Security

Road lighting will generally make little difference to the security of road users and should normally be assessed as having a neutral impact.

- Severance

In situations where a road passes through a settlement, road lighting can be very beneficial after dark. It can restore the connection between the two sides visually and it can encourage the movement of inhabitants from one side to the other. However, this should not be considered without public consultation as alternatives to road lighting may be preferred.

- Government Policy

All impacts on Government policy should be reported. For example, road lighting would contribute to meeting casualty reduction targets. On the other hand, road lighting would consume energy, thus working against the Government's long-term strategy to reduce greenhouse gas emissions. Other policies where road lighting would have a non-neutral impact should also be mentioned.

6.2 RECOMMENDED LOCAL AUTHORITY APPROACH TO COST BENEFIT ANALYSIS

It is suggested that local Authorities concentrate on evaluating the costs that they are incurring and not those that society as a whole incur. In addition, when evaluating different options then the common benefits provided by all of the schemes do not need to be included in the analysis. i.e. reduction in night time accidents need not be included if all of the options provide the same level of savings.

Only those costs requiring evaluation should be included if the installation costs are not important due to the budget already being secured for the scheme then the cost benefit analysis can concentrate on the future operating costs to see which of the options is more efficient.

It is also recommended that decommissioning costs are not included as the majority of local authority equipment once installed is only removed when it is replaced and so the decommissioning costs will be included within the replacement scheme cost benefit analysis.

A cost benefit analysis should be undertaken for all of the proposed lighting options and where applicable for the existing lighting scheme.

The appraisal should be relevant for assisting in the making an informed decision on the proposed options. The appraisal can also be used to justify funding where appropriate.

If the scheme appraisal requires the costs for the existing scheme to be include then all of the future maintenance costs should be included i.e. the additional structural inspection and testing costs, any column painting, an estimate of the remedial maintenance costs i.e. costs for replacing columns that fail the structural test, essentially all costs that will be required in order to enable the existing equipment to be functional and safe at the end of the chosen appraisal period should be included.

It is also recommended that in order to fully assess the impact of future operating and energy costs then an estimate of future price increases due to inflation are included. The values can be obtained from government figures on predicted inflation rates in addition it is recommended to make an allowance for the future increase in energy costs over and above the inflation figure

From Appendix B: Typical Residential Re-Lighting scheme

Table 6.3 – Typical Costs for Residential Lighting Schemes - Appendix B					
	Option 1	**Option 2A**	**Option 2B**	**Option 3**	**Existing**
Installation Costs	£41,220	£39,720	£37,020	£38,080	N/A
1st Year Energy Costs	£1,025	£690	£673	£456	£1,278
1st Year Operating costs	£594	£583	£507	£574	£1,165
Total 1st Year Operating Costs	£1,618	£1,273	£1,180	£1,030	£2,443
Total 1st Year Cost	£42,838	£40,993	£38,200	£39,110	£2,443

From the above costs it can be seen that all of the proposed options reduce the annual operating costs and will provide a positive return on the money invested.

From Appendix B: Typical Residential Re-Lighting scheme

Table 6.4 – Results of Cost Benefit Analysis from Typical residential lighting schemes – Appendix B					
	Option 1	**Option 2A**	**Option 2B**	**Option 3**	**Existing**
Total Costs 12 years - No Inflation	£60,638	£54,995	£51,179	£50,438	£29,317
Total Costs 12 years - Inflation Only	£67,224	£58,958	£54,852	£53,644	£36,922
Total Costs for 12 years with inflation & Energy increases	£66,721	£59,306	£55,192	£53,874	£37,567
Total Costs 30 years - No Inflation	£89,766	£77,908	£72,417	£68,975	£73,292
Total Costs 30 years - Inflation Only	£133,153	£107,731	£100,062	£93,103	£130,531
Total Costs for 30 years with inflation & Energy increases	£139,170	£111,418	£103,659	£95,541	£137,357

Inflation assumed to be 3.5% per annum
Additional Energy increase assumed to be 10% over 30 years on Energy Prices

From the table above the effect of adding annual inflation to the operating costs and an additional increase above inflation for energy costs can be seen, whilst the none of the options for replacing the lighting produces a positive cost benefit over 12 years compared to maintaining the existing lighting scheme, however after 30 years only option 1 does not produce a positive cost benefit and option 3 produces a cost benefit, saving, of £41,816 over the 30 years period, allowing for inflation and future energy increases.

It is also recommended that all of the intangible benefits should also be stated in the final report .i.e. appropriate lighting levels, improved light source, reduced maintenance requirements, improved electrical safety, improved structural safety of columns, improved safety due to the use of passively safe equipment, improved aesthetic appearance, less remedial maintenance, etc., and due consideration given to them.

CHAPTER 7

7. REDUCING THE COST OF ELECTRICAL ENERGY

The main area of concern for the majority of all of the Authorities surveyed was the rapidly increasing cost of electricity as can be seen from the graph below:

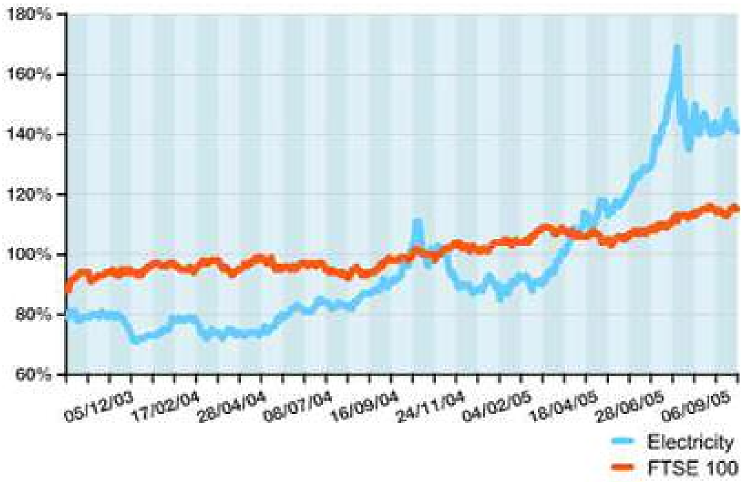


Figure 7.1 Graph showing the Increase in the cost of electricity compared to the FTSE 100

From the surveys and interviews completed it is apparent that there is not a standard price for electricity charged to local Authorities current prices being paid are between 5.84 and 11.50 p/kWh, the price paid is dependant on when the agreement is reached, the percentage of “green” energy purchased, the length of the agreement and the purchasing power of the authority or buying group.

Reducing the cost of electricity will obviously reduce the Authorities energy bill.

7.1 TRADING ARRANGEMENTS

It is recommended that Authorities looking to minimise costs move to half hourly trading agreements (HH) rather then non-half hourly trading agreements (NHH).

NHH trading was originally intended for small Authorities such as Parish Councils and requires a simple level of administration and energy usage is based upon profiles of energy use.
HH trading accounts for energy is more accurate, but requires the use of a Meter Administrator (MA) and photocell arrays. The photocell array is used to replicate the Authorities lighting stock and switching regimes.

Currently under NHH trading there is no benefit through the application of trimming as all switching regimes are assigned the same burning hours. This is however being reviewed by UMSUG and the review is based on the data from photocell arrays. Under HH trading the photocell array takes account of the trimming hours and as such a benefit can be obtained.

It must also be noted that the use of a central management systems (CMS) as equivalence meters was approved in Feb 08 and so at least part of the Authorities energy bill can be calculated from the CMS. The authority will pay only for the energy that is consumed. This is however dependent on the Authority having an accurate inventory and being on HH trading.

HH trading also provides the best energy price and Energy budget savings of 12% plus have been obtained through Authorities changing from NHH to HH which is an easy win situation but will require an accurate auditable inventory. A 12% energy bill saving for most Authorities would quickly cover the costs required of developing an accurate inventory.

7.2 ACCURATE INVENTORIES

Inaccurate inventories can lead to punitive energy charges It has been stated by some meter administrators that some suppliers include a percentage within un-metered tariffs which takes account of inaccurate inventories, where the inventory can be shown to be accurate this charge can be removed.

An accurate, up to date and maintained inventory will not only save money but is also the key to the 'Invest to Save' approach without an accurate inventory accurate modelling can not be achieved and reasoned decisions taken.

A poor inventory costs the authority money as well as leaving them open for future claims for back dated payments.

In addition in order to use a CMS system as an equivalent meter the Authority must have an accurate inventory, to the Meter Administrator's satisfaction, and be on HH trading

7.3 BUYING POLICY

It is recommended that Authorities join a buying group or look to purchase all of the energy for the Authority including offices, schools, libraries etc in one agreement in order to maximise buying power. The Authority should also make the councillors aware of the implications of enforcing a green policy on to the trading conditions.

CHAPTER 8

8. REDUCING THE USE OF ELECTRICAL ENERGY

Whilst reducing the cost of energy is a quick win solution to increasing energy bills the only long term solution to reduced energy bills is to reduce the amount of electricity consumed
There are a number of methods of reducing the use of electrical energy whilst still maintaining the benefits of street lighting, which should be considered before switching off or removing street lighting.

8.1 THE CORRECT APPLICATION OF BS 5489-1: 2003

From the typical residential area lighting design in Appendix A it can be seen that the correct application of BS 5489-1: 2003 in selecting the lighting class can have a significant impact on the amount of electricity consumed.

From Appendix B: Typical Residential Re-Lighting scheme

Table 8.1 – Energy consumption figures from Typical residential lighting schemes – Appendix B					
	Option 1	**Option 2A**	**Option 2B**	**Option 3**	**Existing**
Total Energy Consumption per Option per annum	12,054kWh	8,118kWh	7,921kWh	5,367kWh	15,031kWh
Total Saving in Energy Consumption per annum compared to the Existing	2,977kWh	6,913kWh	7,109kWh	9,664kWh	0kWh
Total Saving in Energy Consumption per annum compared to Option 1	0kWh	3,936kWh	4,133kWh	6,687kWh	-2,977kWh

Option 1 All roads lit to a blanket level of S2.
Option 2 (A and B) All roads lit to the correct levels as required by BS 5489-1: 2003 using SON.
Option 3 All roads lit to the correct levels as required by BS 5489-1: 2003 using a white light source..

From the table above it can be seen that all of the proposed options result in an energy saving compared to the existing lighting installation.

Also from the above table it can be seen that an energy saving of up to 55% can be achieved by installing lighting to the correct lighting class as required in BS 5489-1: 2003 rather than the blanket S2 class.

8.2 REDUCING THE AMOUNT OF LIT AREAS

Whilst the need for lighting in our towns and cities is understandable and accepted, Lighting may not be acceptable or desirable in remote rural locations especially where the lighting has not been provided due to the local communities need or request but purely as part of a developers desire to make his development “special” or to comply with the blanket planning conditions. How many times do we see a new housing development lit in an otherwise unlit village, normally to a level that is totally out of keeping with the surroundings. The future energy and maintenance costs for these lighting installations are then passed on to the Authority through the adoption process, putting a considerable strain on Authority budgets for very limited localised benefits.

It is imperative to in order to avoid unnecessary future costs that the Authority has a lighting plan and this plan considers new developments in previously unlit areas and only allows the provision of lighting where there is a positive benefit to the community as a whole and not just for a handful of local residents.

Lighting on existing lit areas should be evaluated if that area changes use or character, a new school or housing estate will change the traffic flow on existing roads and the lighting class should be recalculated, similarly a change in use can reduce traffic flow i.e. there are a number of inner city footpaths being blocked up and gated to prevent escape routes for criminals, if these are currently lit then there is not only a potential maintenance and safety issue due to restricted or no access, but the existing lighting is providing a very limited benefit, and should be assessed to see if it can be removed.

It is important when assessing if an area is to be lit that we consider what we are trying to achieve if it is to reduce crime and the fear of crime then in order to deter criminals they have to be made to feel vulnerable by the proposed lighting scheme i.e. they have to think that they are going to be seen when they commit the crime either by CCTV or local residents, so that when the lighting is installed the criminals are deterred from operating in that area through the fear of being caught, if there are no observers then the provision of light just makes the criminals life easier

Figure 8.1 - A photograph showing a well lit area with a high level crime due to a lack of observers.

8.3 CENTRAL MANAGEMENT SYSTEMS

As of February 2008 the use of Central Management Systems (CMS) as equivalence meters became viable and Authorities energy bills can therefore be accurately calculated and they will only pay for what they consume. As mentioned above the Authority must have an accurate inventory and be on HH trading.

CMS can also be used to control the lighting levels through dimming and trimming, as well as providing valuable live maintenance information about the condition, even predicting future lamp failures, and type of equipment on the street.

When assessing the use of CMS all of the costs need to be assessed including energy costs, communication costs and those costs incurred for data hosting either by the supplier or the Authority.

8.4 TRIMMING

Photo electric cells because of their low cost and reliability have become the accepted means of controlling modern street lighting systems resulting in the almost universal all night operation. Currently it is almost standard to fit photo electric cells which switch on at 70 lux and off at 35 lux.

These settings having been established to mimic those of time switches, to allow for the wide tolerances and inaccuracies of early photo cells and to take account of the time required for discharge lamps to reach their maximum output. The actual settings of modern photo electric cells should be carefully considered as modern discharge lamps, especially those operated on electronic control gear, have a quicker run up period than older lamp types operated on conventional electro magnetic control gear and therefore reach full output quicker.

The actual average level of light on traffic roads can be determined from table B.1 in BS 5489-1: 2003

Table 8.2 – Table B.1 Lighting classes of comparable levels BS 5489-1: 2003

ME class	CE class	S Class	Average Lux
--	CE0	--	50
ME1	CE1	--	30
ME2	CE2	--	20
ME3	CE3	S1	15
ME4	CE4	S2	10
ME5	CE5	S3	7.5
ME6	--	S4	5
--	--	S5	3
--	--	S6	2

NOTE: The data in this table is taken from CEN/TR 13201-1

From the above table the average illuminance level for all roads can be established.

The improved (known) start up time and the known average illumination of the road allows the switching levels of photo electric cells to be reconsidered.

The installed street lighting needs to be fully run up, giving maximum lumen output when the natural lighting levels fall below the average illuminance level required by the lighting class.
The installed street lighting can be switched off when the natural lighting levels have risen to meet the levels of the required lighting class

From the above it can be seen that for most Authorities the most onerous situations will be for residential streets classified as S1 having an average of 15 Lux and traffic routes classified as ME2, having an average of 20 Lux

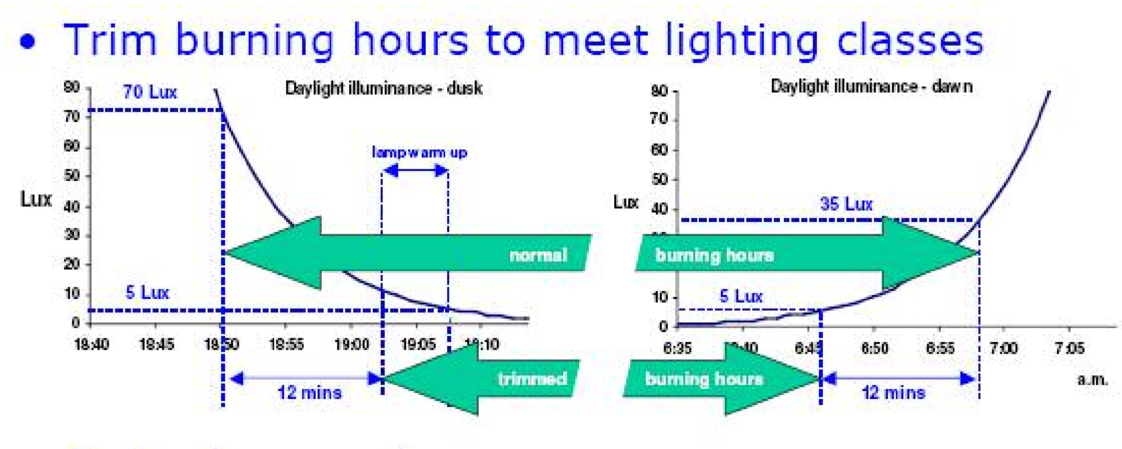


Figure 8.1 A diagram showing trimming savings

Whilst the above diagram shows the typical savings of 24 minutes a day, 146 hours per annum, from a switching regime of 15 lux on and 5 lux off, the resulting minimum level of 5 lux is not suitable for all areas, changing to a switching level of 35 lux on and 16 lux off will provide a more acceptable minimum lighting level for all areas whilst still providing a saving of 50 hours per annum (approximately 1-2%).

Typical savings from made by trimming to 35/16 Lux per lamp (50 Hours per annum).

Table 8.3 – Typical savings from made by trimming to 35/16 Lux per lamp

Lamp Type	Typical Total Circuit Wattage	Energy Saving per Annum for Saving of 50 hours per Annum	Cost saving per Annum at an Energy Cost of 8.5p kWh	CO_2 Emissions Reduction per Annum at 0.43 kg CO_2 per kWh*	
				Short Term	Long Term
400W SON	430W	21.500kWh	£1.83	11.546kg	9.245kg
250W SON	280W	14.000Wh	£1.19	7.518kg	6.020kg
150W SON	165W	8.250kWh	£0.70	4.430kg	3.548kg
140W Cosmopolis	153.5W	7.675kWh	£0.65	3.813kg	3.300kg
100W SON	110W	5.500kWh	£0.47	2.954kg	2.365kg
70W SON	88W	4.400kWh	£0.37	2.363kg	1.892kg
60W Cosmopolis	67.5W	3.375kWh	£0.33	1.812kg	1.398kg
50W SON	60W	3.000kWh	£0.26	1.611kg	1.290kg

*Short Term - DEFRA 5 year rolling average factor, 0.537 kg CO_2 per kWh
Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh

The reduction in the operational hours of the lamp would also reduce the chances of premature failure of the lamps towards the end of their life. On an average group replacement period of four years the lamps would have operated 200 hours less (approximately one months operation) than lamps switching at 70 lux on 35 lux off.

The use of lower switch on/off lighting levels is not recommended for older lamp types such as low pressure sodium lamps (SOX) and mercury vapour lamps (MBF/U) operated on conventional electro magnetic control gear. Such installations should be operated at 70 lux on and 35 lux off as a minimum to allow the lamps to fully run up by the time the lighting is required.

8.5 VARIABLE ROAD LIGHTNG LEVELS

The current lighting standards BS 5489-1: 2003 - Code of Practice for the Design of Road Lighting – Part 1: Lighting of Roads and Public Amenity Areas and BS EN 13201-2: 2003 - Road Lighting – Part 2: Performance Requirements allow the use of variable lighting levels based on traffic flows.

The performance requirements for road lighting given in BS EN 13201-2: 2003 introduces a greater range of road lighting classes than the old BS 5489-1 to 10: 1992 and the advice given in BS 5489-1: 2003 and in the CEN technical report PD CEN/TR 13201-1: 2004 further influence good practice in road lighting.

This permits and encourages a flexible approach to the selection of road lighting classes and in specific circumstances variable road lighting levels, during the hours of darkness, can be applied.

8.5.1 Criteria for Variable Road Lighting Levels

The criteria for variable road lighting levels are laid down in the new road lighting standards as follows:

PD CEN/TR 13201-1, clause 6.1.3 states, "Significant variation of parameter values can apply at different periods of the night, particularly in respect of ambient luminance and traffic flow. The application of the Tables in Annex A can therefore indicate different lighting classes appropriate to these different periods. For this purpose a more detailed analysis of traffic flow than that provided by ADT can be necessary."

BS 5489-1: 2003 in clause 10.13 discusses variable road lighting systems as follows, "In some areas where user demands can vary during the course of the night, lighting provision can be varied by arranging multiple luminaires, lamp switching sequences, or dimming. This should be considered where traffic usage varies, for security and energy saving purposes, and where a higher level of lighting is required that can be obtained without detracting from the visual appearance."

BS 5489-1: 2003, clause 5.4 Note 3 states, "In PD CEN/TR 13201-1 parameters relevant to lighting are used in the selection of lighting classes and in PD CEN/TR 13201-1 6.1.3 it is explained that these parameters can vary during the night, and thus within the hours of operation the lighting class may be varied. This can be achieved by dimming or switching techniques."

BS 5489-1: 2003, clause 10.4.1 states, "… when the selected lighting class provides high lighting levels related to periods of major traffic movement, a reduction to a lower class should be considered at other times. This can be achieved by the "variable lighting" approach discussed in 10.13, by switching lamps in multi-lamp luminaires or by dimming."

Annex B of BS 5489-1: 2003, Table B.2, Notes 3 and 4, state, "Traffic flow can vary significantly during the night, and the use of different lighting levels at some periods may be considered. For this purpose a detailed analysis of traffic flow is carried out, considering hourly flow through the night." and "Where lighting levels are reduced for certain periods, any lower levels can use the average luminance values from the appropriate lower ME class, but retain the Uo and Ul values of the ME class selected for the peak period."

8.5.2 Variable Road Lighting Systems

The road lighting classes for traffic route lighting can be varied for the following reasons:

- variations of traffic flow; and
- change in use.

Variation due to Traffic Flow

The parameters for selecting road lighting classes for the road lighting on traffic routes are detailed in Table B.2 of BS 5489-1: 2003. The selection process parameters are as follows:

- Hierarchy description;
- Type of road;
- Description;
- Presence of conflict areas; and
- Traffic flow (average daily traffic flow, ADT).

All of these parameters are fixed and are unlikely to change except ADT.

In the Note 2 in Table B.2 in Annex B of BS 5489-1: 2003 advice on the application of ADT in selecting the appropriate road lighting class is given as follows:

"The guidance on lighting class application for motorways and traffic routes uses average daily traffic flow (ADT), which is the normal concept in traffic planning, and is usually known. Peak traffic is generally taken to be 10% and 12% of ADT in rural and urban areas respectively. If hourly flows are known, and the peak hour traffic is greater than 12%, the peak traffic should be taken into account when selecting the lighting class."

The value for ADT is required for the initial selection of the road lighting class. In order to use variable road lighting levels through the night the hourly traffic flows are required. The value of ADT for each lighting class needs to be converted to hourly traffic flows using the advice above. The relevant hourly traffic flows for each lighting classes is shown in the table below
.

Table 8.4 - Traffic Flow Transition Levels for Determining Road Lighting Classes

Traffic Flow Transition Levels for Determining Road Lighting Classes		
ADT	Equivalent Hourly Traffic Flow	
	Rural (10% of ADT)	Urban (12% of ADT)
40,000	4,000	4,800
15,000	1,500	1,800
7,000	700	840

From an analysis of the hourly traffic flow it can quickly be established when the road lighting can be switched between classes.

It must be noted that there is also a morning peak flow.

Variation due to change in use

Variable lighting levels can be used on roads and areas where there is a known change in use that would require a change in lighting class i.e. quite low traffic residential roads around sporting venues and exhibition halls can become car parks and areas of high traffic when there is an event on. Whilst it may be both out of character and costly to provide the enhanced levels all of the time a variable lighting system would provide the appropriate lighting at the appropriate time.

In addition it may be possible to charge the event managers for the extra energy consumed for the safe operation of their event.

8.5.3 Control of Variable Road lighting levels

Variable road lighting levels can be controlled in the following ways:

- statically
- dynamically

Static Systems

A static system uses historical traffic flow data to predetermine when the transition level between the different road lighting classes is reached.

In order to ensure that the road lighting levels are varied correctly, accurate hourly traffic flow data is required.

A detailed analysis of this data is then required in order to establish when the transition between road lighting classes should occur.

Schemes that vary the road lighting levels using historical traffic flow data should be regularly checked and undergo continuous evaluation throughout their lifetime to ensure that the switching regime is still valid.

Dynamic Systems

A dynamic system uses live traffic flow data to determine when the transition level between the different road lighting classes is reached. The traffic flow data would be obtained from automatic traffic counters. Arrangements would need to be made for accessing the live information.

The system would react to live changes in the traffic flow. As the traffic flow decreases at night, traffic flow should be measured in three consecutive fifteen-minute periods and the road lighting level should be reduced when this is a quarter of the hourly transition traffic flow level. In the morning, when the traffic flow increases, the traffic flow should be measured in three consecutive five minute periods and the road lighting increased when this is a twelfth of the hourly transition traffic flow level.

Once the system has been triggered in the morning any subsequent drops in the traffic flow should be ignored.

This system is also capable of increasing the lighting back to its full level if the traffic flow is measured to be above the transition traffic flow level at any time, in the event of an accident, or if there are adverse weather conditions. This could be achieved by monitoring the speed of the traffic and the return to full lighting should be automatic. A manual override should also be provided

8.6 VARIABLE LIGHTING LEVELS FOR MOTORWAYS

The use of variable lighting levels on motorways has the potential for the greatest cost saving because the initial lighting class and lamp wattages are high. Additionally there could be up to three lighting levels. The control can be easily installed as most motorways are supplied via large private cable networks and the traffic flow data is readily available from the Midas detectors. There are also not many conflict areas on motorway networks and this makes the application of variable lighting levels easier.

A desktop study was undertaken to asses the viability of installing a Central Management System and variable lighting on an existing stretch of 18km of motorway:- appendix B – variable lighting levels for motorways

In this example the existing columns and electrical infrastructure are in a good condition and so can be retained.

Table 8.5 – Typical Savings for Variable lighting levels on a motorway - Appendix B

	Energy	**Cost**	**CO_2***
Existing Annual usage with Magnetic control gear	1,842,841kWh	£184,284.10	792.4 tonnes
Annual savings due to changing to electronic control gear	120,185kWh	£12,018.50	51.7 tonnes
Annual savings due to applying Variable lighting Levels	344,531kWh	£34,453.10	148.2 tonnes
Annual savings due to applying dimming to MF	155,039kWh	£15,503.90	66.7 tonnes
Total annual savings	619,755kWh	£61,975.50	266.6 tonnes
Total Annual savings per km	34,430kWh	£3,443.08	14.8 tonnes

* Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh.

The estimated payback period for installing this scheme is 6 years.

However at present there is a problem with the lack of proven and reliable fully electronic control gear for 400W and 600W SON lamps.

8.7 VARIABLE LIGHTING LEVELS FOR TRAFFIC ROUTES

The use of variable lighting levels on traffic routes is now becoming both cost effective and achievable due to the reliability of lower wattage electronic control gear and the various different communication systems available
The main problem is finding the right communication system for the road and Authority, this can be either a mains borne system, wireless, WiFi system, or a combination of systems.

A desktop study was undertaken to asses the viability of installing a Central Management System and variable lighting on a typical traffic route:- appendix B – variable lighting levels for traffic routes

Table 8.6 – Typical Savings for Variable lighting levels on traffic routes - Appendix B			
	Energy	**Cost**	**CO_2***
Annual savings due to installing electronic control gear	4,792kWh	£407.31	2.06 tonnes
Annual savings due to applying Variable lighting Levels	12,698kWh	£1,079.37	5.46 tonnes
Annual savings due to reducing Over Lighting	12,698kWh	£1,079.37	5.46 tonnes
Annual savings due to applying dimming to MF	6,434kWh	£5,46.88	2.77 tonnes
Total annual savings	36,623kWh	£3,112.93	15.75 tonnes
Total Annual savings per km	18,311kWh	£1,556.00	7.87 tonnes

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh.

The estimated payback period for the additional cost of installing a CMS system and fully dimmable electronic control gear is 4.6 years.

8.8 VARIABLE LIGHTING LEVELS FOR RESIDENTIAL AREAS

Dimming of residential lighting produces the least savings due to the smaller lamp wattages however the technology required to dim is the most proven and reliable. There are restrictions on the viable choice of communication systems, due to the majority of columns having an individual DNO supply and the DNO's being reluctant to host mains borne signalling on their network, there are various other control and communication systems that overcome this problem.

The increased cost of providing dimmable installations on new developments can be passed on to the developers with just a change of specification, the equipment can be installed and then if required the dimming can be configured and activated in the future.

The use of variable light levels should not compromise safety and increase the fear of crime however variable lighting levels can be used to improve safety and reduce the fear of crime by providing higher levels of illumination when crime and the fear of crime is at its highest, when the pubs and clubs are shutting and normal levels for all other times.

The definitions of traffic flow can be used to determine if and when the lighting level can be varied.

Traffic flow influences the lighting class chosen from BS 5489-1: 2003 table B.4 but the traffic flow for residential areas is not defined in values of ADT but as Low Normal and High traffic flow

- Low traffic flow refers to areas where the traffic usage is of a level equivalent to a residential road and solely associated with the adjacent properties.

- Normal traffic flow refers to areas where the traffic usage is of a level equivalent to a housing estate access road and can be associated with local amenities such as clubs, shopping facilities, public houses, etc.

- High traffic flow refers to areas where the traffic usage is high and can be associated with local amenities such as clubs, shopping facilities, public houses, etc.

From the above definitions Normal and High traffic flows "are associated with local amenities such as clubs, shopping facilities, public houses, etc" these local amenities are not open all night and so it could be argued that the traffic flow changes during the night and the lighting level altered when these amenities are closed.

A desktop study was undertaken to asses the viability of installing a Central Management System and variable lighting on the options for relighting a typical residential area appendix B – variable lighting levels for residential areas

Option 1 – A blanket level of S2 applied to all of the roads within the area using SON

Table 8.6 – Typical Savings for Variable lighting levels in a residential area –Option 1 – Appendix B			
	Energy	**Cost**	**CO_2***
Annual savings due to installing electronic control gear	1,292kWh	£109.78	0.56 tonnes
Annual savings due to applying Variable lighting Levels	2,368kWh	£201.26	1.02 tonnes
Annual savings due to applying dimming to MF	969kWh	£82.33	0.42 tonnes
Total annual savings	4,628kWh	£393.37	1.99 tonnes
Total Annual savings per km	5,785kWh	£492.00	2.49 tonnes

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per

Option 2A – All roads classified according to the requirements of BS 5489-1: 2003 with SON

Table 8.7 – Typical Savings for Variable lighting levels in a residential area –Option 2A - Appendix B			
	Energy	**Cost**	**CO_2***
Annual savings due to installing electronic control gear	541kWh	£46.00	0.23 tonnes
Annual savings due to applying Variable lighting Levels	1,364kWh	£115.93	0.59 tonnes
Annual savings due to applying dimming to MF	682kWh	£57.96	0.29 tonnes
Total annual savings	2,587kWh	£219.89	1.11 tonnes
Total Annual savings per km	3,234kWh	£275.00	1.39 tonnes

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh.

Whilst from the above tables it can be seen that the savings that can be made are considerably smaller than motorway and traffic route lighting and that option 1 produces more potential savings than option 2A option 1. It must be remembered that option 2A uses the least amount of energy to start with.

8.9 DIMMING TO REQUIRED LEVELS

When designing road lighting schemes, especially traffic routes, one of the quality characteristics can be the constraining factor and in order to achieve a compliant scheme the average luminance may exceeded the required levels, the lumen output of the lamp can then be reduced to ensure that the correct value is achieved thus avoiding over lighting and providing an energy saving.

8.10 DIMMING TO MAINTENANCE FACTOR

Dimming to maintenance factor can be a quick win when installing equipment that can provide continually controllable variable lighting levels, not factory preset levels.
The light level is reduced to the required lighting level from day one this stops the over lighting due to the maintenance factor.
From the luminaire maintenance factor and lamp lumen depreciation graph we can predict how the installation depreciates over time and vary the dimming level accordingly.

There are 2 options for dimming to maintenance factor

- Continual dimming
- Dimming at intervals

Typical Installation

100W SON IP 6X luminaire in a high pollution area with a clean and change every 3 years

Continual dimming

Continual dimming assumes that the lumen output of the lamp is altered daily and that there is a straight line depreciation from the initial installed maintenance factor an the final (design) maintenance factor.

Then initial Maintenance factor at installation =1.0
Design Maintenance factor at clean and bulk change = 0.739

Average = (1.0 – 0.739) / 2

Average reduction in lumens is 13%
Average reduction in energy is 10%

Dimming at intervals

Dimming at intervals means that the lumen output of the lamp is reduced only yearly and it uses known maintenance factors from BS 5489-1: 2003

From BS 5489-1: 2003 Table 4 luminaire maintenance factors and a typical lumen depreciation curve for a 100w SON-T lamp

Table 8.8 – Typical Luminaire and Lumen depreciation values			
Time	**Luminaire Depreciation Factor**	**Lamp Depreciation Factor**	**Total Depreciation Factor**
12	0.91	0.95	0.865
24	0.88	0.90	0.792
36	0.83	0.89	0.739

From the table above we can see that we can lower the lumen output of the lamp by:

Table 8.9 – Typical Reduction in Energy Consumption			
Time	**Total Depreciation Factor (TDF)**	**Lumen Reduction***	**Reduction in energy consumption**
12	0.865	12.6%	10%
24	0.792	5%	4%
36	0.739	0%	0%

*Lumen Reduction to still achieve Design Levels at end of period = TDF – TDF at lamp change.

From the above table it is possible for this particular example to save 10% in energy consumption for the first 12 months and then 4% for the next 12 months, so we can save approximately 4.5% energy over the 3 years.

Both of these dimming regimes can then be repeated after the clean and bulk change.

The difference in achievable energy savings between continual and step dimming is due to over lighting between the steps, with continual dimming there is no over lighting due to maintenance factor as the lamps are continually dimmed.

From the two examples it is clear to see that in order to maximise energy savings then the period between lumen alterations needs to be as short as the system will permit.

8.11 PART NIGHT LIGHTING

Part night lighting is switching of all of the lights in a road at an arbitrary time of the night, usually midnight, by the use of photo electric control units, or a central management system, this has some major advantages as it is fairly cheap to change the switching regime, and there are recognised codes for part night lighting so an immediate saving can be made.

However there are some major disadvantages with part night lighting,

- increase in the fear of crime;
- increase in crime: and
- increase in night time accidents.

Whilst the Authority will make savings in energy and CO_2 the costs are just being transferred to society as a whole, these savings will be at the expense of increased use of private motor vehicles, because people will be more afraid of walking to and from public transport on dark streets, an increase in night time accidents due to the extra traffic, as well as the increase in night time accidents due to the lack of lighting. Every accident has an associated cost to the local community and society as a whole, due to the attendance of the emergency services, medical and hospital costs, rehabilitation costs, costs to employers and the state for the period the victims are off work. Even if nobody is injured or makes an insurance claim there are still the vehicle repair costs to be considered. These increased costs will not only be monetary cost but the associated CO_2 cost as well.

In order to safely operate a part night switching regime then a full risk assessment needs to be completed as well a public consultation exercise undertaken. Rigorous guidelines need to e established and the area monitored to ensure that part night lighting is not having a detrimental effect on the area and if it is then the area should be returned to all night operation

Typical restrictions imposed on the use of part night lighting, where any site falling into these categories would not be considered suitable, include:

- Major lit inter urban dual carriageway traffic routes;
- Conflict sites, e.g. roundabouts (consideration to be given to mini roundabouts within residential estates);
- Sites where street lights installed for accident remedial measures;
- Town centre, shopping and residential type development where there is one or more of the following features:
    a. CCTV sites:
    b. High proportion of high security premises e.g. banks, jewellers etc.:
    c. High crime risk: and
    d. High concentration of people at night such as – transportation interchanges, nightclub areas, etc.
- Main approaches to areas defined in 4 above where there is a mix of development between residential and commercial / industrial i.e. not exclusively residential;
- Sites where the Police can demonstrate that there is likely to be an increase in crime if the lights are switched off;
- Remote alleys linking residential streets; and
- Where there is a statutory requirement.

In addition the use of part night lighting on traffic routes is not recommended, especially on congested roads as when the traffic flow is at its highest during peak hours, the traffic will be congested and slow moving, consequently the majority of accidents will be minor collisions, however when traffic flow are at there lowest vehicle speeds will be at their highest, and so while their will be fewer accidents the accidents will be the most severe. Therefore the installation of part night lighting will reduce the accidents savings at a time when the severity of accidents is at its highest. i.e. part night lighting on traffic routes will result in more serious accidents. A full evaluation of the accident statistics should be undertaken to determine if a road is suitable for part night lighting.

A desktop study was undertaken to asses the cost savings made by installing a part night lighting operating regime on the options for relighting a typical residential area see Appendix B – variable lighting levels for residential areas

Option 1 – A blanket level of S2 applied to all of the roads within the area using SON

Table 8.10 – Typical Savings for Part Night lighting levels in a residential area – Option 1 – Appendix B			
	Energy	**Cost**	**CO_2***
Annual savings due to installing electronic control gear	1,292kWh	£109.78	0.56 tonnes
Annual savings due to applying Variable lighting Levels	5,166kWh	£439.11	2.22 tonnes
Annual savings due to applying dimming to MF	504kWh	£42.81	0.22 tonnes
Total annual savings	6,961kWh	£591.70	2.99 tonnes
Total Annual savings per km	8,701kWh	£740.00	3.74 tonnes

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh

Option 2A – All roads classified according to the requirements of BS 5489-1: 2003 with SON

Table 8.11 – Typical Savings for Part Night lighting levels in a residential area – Option 2A – Appendix B			
	Energy	**Cost**	**CO_2***
Annual savings due to installing electronic control gear	541kWh	£46.00	0.23 tonnes
Annual savings due to applying Variable lighting Levels	3,637kWh	£309.13	1.56 tonnes
Annual savings due to applying dimming to MF	355kWh	£30.14	0.15 tonnes
Total annual savings	4,533kWh	£385.28	1.95 tonnes
Total Annual savings per km	5,666kWh	£482.00	2.44 tonnes

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh

8.12 ELECTRONIC CONTROL GEAR

Many existing lighting systems use high pressure sodium lamps (SON) operated on conventional electro magnetic control gear. The simple conversion, where possible, of these units to full electronic control gear will give an energy saving of approximately 5% whilst increasing the life and reliability of the lamp. It is recommended that as existing high pressure sodium luminaires or control gear fails that it is replaced with electronic control gear.

It must be noted that the electronic control gear is very temperature dependent. All gear will have a maximum case temperature (Tc) listed and if the luminaire chosen can reduce this by over 10 degrees then that can effectively double the life of the gear. This must be considered when looking to fit any electronics within a luminaire.

8.13 DE-ILLUMINATION OF SIGNS

The traffic signs regulations and general directions (TRSGD) contain the legal requirements for the illumination of traffic signs, this is dependant on the sign type and location, including whether the sign is "within 50 metres of any lamp lit by electricity which forms part of a system of street lighting furnished by a means of at least three such lamps placed not more than 183 metres apart."

There are basically 3 types of classification for illumination of signs:

- Must be Illuminated;
- May be illuminated; and
- No Illumination - Reflective only.

Reductions in energy from signs that "must be illuminated" can be made by ensuring that all illuminated signs and bollards only operate during the hours of darkness. In addition the use of energy efficient sign lighting should be considered as well as trying to extend the luminaire clean and lamp replacement intervals, it should be noted that the sign face should still be kept clean to ensure that they are readable.

Reductions in energy from signs that "may be illuminated" can be made by ensuring that signs in this classification are only lit when there is a very good reason to illuminate them and not just because they can be. A solution would be for the Authorities policy to state that signs classified as "may be illuminated" shall not be illuminated unless there is an overwhelming safety case and a risk assessment produced.

As can be seen from the Staffordshire County Council case study, Appendix A, they have invested in reducing the energy consumed by their illuminated traffic signs and they are looking at an estimated payback of between 5 and 10 years.

The predicted benefits are:

Table 8.12 – Typical Savings from De illumination of Signs – Staffordshire County Council - Appendix A

Saving in	Annual Invest to Save Projected Benefits
CO_2 Emissions	314 tonnes
Energy	730,232kWh
Finance	£151,000

For more detailed information see CSS research project SL5 2007 and related guidance document.

CHAPTER 9

9. WHITE LIGHT

The British Standard recommends that all new street lighting should be provided by lamps that a have a colour rendering index (Ra) greater than 20, i.e. low pressure sodium lamps which do not have any colour rendering properties (Ra = 0) are no longer recommended. The use of “white light” sources (lamps with a colour rendering index greater than 60) allows a lower lighting class to be used on residential roads bringing potential savings in energy consumption, reductions in light pollution and increased amenity due to the better colour rendering of the lighting.

The recent developments in white light technology, with the launch of Cosmopolis from Philips and the continued improvements in fluorescent tubes with increased wattages and better lamp life, and the continued improvement in LED technology has meant that the use of white light is more viable than ever.

The majority of the new white light sources have an operational life greater than 3 years whilst still retaining a high Lamp Lumen Maintenance Factor (LLMF) and consequently a good total maintenance factor compared to other light sources.

When considering different lamp types, for both new scheme options and alterations to maintenance replacement policies not only should the lamp replacement interval be assessed but also their lamp lumen maintenance factors at the different intervals.

It is possible with modern lamp technology to not only save energy whilst maintaining the colour rendering of the lamp but also to have a 3 year+ operational life whilst still retaining a high LLMF and excellent optical performance from luminaires designed for the lamp.

So when deciding on a white light solution the costs from different maintenance regimes, i.e. from a 2 year lamp change to 3 years need to be reflected in the scheme operating costs, and the intangible benefits included within the appraisal report. These intangible benefits can be, reduced time on site (less disruption to road users, increased safety to staff as their is less time on site) fewer lamps required for bulk change over time (reduced cost, less raw materials required for lamp, less packaging, less lamp delivery’s). Whilst all of these savings will have a direct impact on cost they will also have a dramatic effect on CO_2 emissions.

From the typical residential area it can be seen that installing a white light scheme to a lower lighting class (option 3) reduces the annual energy consumption compared to a SON scheme (options 2A and 2B). However, in this particular case the use of a white light source increases the annual operating costs and installation cost compared to option 2B however the white light source (option 3) is the most cost effective when you look at the long term cost benefit analysis.

From the typical residential area Appendix B

Table 8.13 – Typical Costs for residential lighting to BS 5489-1: 2003 - Appendix B			
	Option 2A	**Option 2B**	**Option 3**
Installation Costs	£39,720	£37,020	£38,080
1st Year Energy Costs	£690	£673	£456
1st Year Operating Costs	£583	£507	£574
Total Costs 12 years - No Inflation	£54,995	£51,179	£50,438
Total Costs 12 years - Inflation Only	£58,958	£54,852	£53,644
Total Costs for 12 years with inflation & Energy increases	£59,306	£55,192	£53,874
Total Costs 30 years - No Inflation	£77,908	£72,417	£68,975
Total Costs 30 years - Inflation Only	£107,731	£100,062	£93,103
Total Costs for 30 years with inflation & Energy increases	£111,418	£103,659	£95,541

Inflation assumed to be 3.5% per annum.
Additional Energy increase assumed to be 10% over 30 years on Energy Prices

CHAPTER 10

10. ENVIRONMENTAL CONSIDERATIONS

This section looks at the environmental considerations of an Invest to Save lighting policy. The recommendations of this document are to install lighting where it is needed and effective, to only light to the required levels as shown in BS 5489-1: 2003, and where possible install energy savings such as dimming. These measures will also reduce the environmental impact of the road lighting installation.

The benefits will include reductions in light pollution and energy consumption. The reduction in energy consumption will have a corresponding reduction in CO_2 emissions, the value of CO_2 emitted per kWh of electricity produced will vary depending on the evaluation period.

The Carbon Trust recommends the use of DEFRA's 5 year rolling average. Whereas DEFRA use either the 5 year rolling average, for immediate savings, or the long term marginal factor for longer evaluations and reporting on climate change.

The 5 year average factor represents the average CO_2 emissions from the UK national grid per kWh of electricity delivered to site for the last 5 years for which data is available (2001-2005). This is to help reduce short-term annual variability with year on year comparisons for the purposes of these guidelines. The 5 year average factor is a suitable metric for calculating the carbon emissions of a company's use. Emission reductions from activities that bring about short term electricity savings (such as switching off lights and computers at night, reducing air conditioning and heating use, etc.) can be calculated using this factor.

For electricity purchased on a green tariff the grid electricity factor above should generally be used. This factor incorporates UK renewable generation within it.

The long term marginal factor is based on long term investment decisions this assumes that over a long time period (a decade or more) avoided electricity use will displace generation at a new Combined Cycle Gas Turbine (CCGT) plant, and policies and measures that produce long term reductions in electricity use should therefore use this factor to assess what carbon saving will result. In addition carbon savings used for the purposes of Climate Change Agreements (CCs) have historically been calculated using this factor and it should continue to be used for this purpose.

The electricity conversion factors given are the average carbon dioxide emission from the UK national grid per kWh of electricity used at the point of final consumption. These factors include only carbon emissions at UK power stations and do not include emissions resulting from production and delivery of fuel to these power stations (i.e. from gas rings, refineries and collieries, etc.).

The DEFRA conversion factor for 5 year average factor is 0.537kg of CO_2 and for the long term marginal factor 0.43kg of CO_2 (based on June 2007 figures).

When undertaking schemes to reduce CO_2 emissions the impact on the hidden CO_2 costs due to reduced use of public transport and other forms of sustainable transport needs to be identified. Variable lighting levels providing they conform to the guidelines found in BS 5489-1: 2003 will have a negligible effect as the lighting level will still be appropriate for the "use".

Cost savings due to extended maintenance periods will have also have a hidden reduction in $CO_{2,}$ Extended lamp replacement periods will result in CO_2 reductions due to:

- Reduced maintenance vehicle mileage and time;
- Reduced disruption to road users less traffic congestion due to work and the associated traffic management; and

The reduced quantity of new lamps required, which means less lamp manufacture, less raw material excavation, less packaging, less lamp transportation, less lamp disposal.

CHAPTER 11

11. ALTERNATE SOURCES OF FUNDING

There are alternate sources of funding available:

- Local Government, through grants prudential borrowing;
- Various carbon reduction trusts and other charities; and
- European Union for both regeneration and research grants.

In addition some Local Authorities have there own CO_2 reduction budgets that as in the case of Staffordshire County Council can be used for an Invest to Save Scheme.

The production of a cost benefit analysis will help in securing and justifying these additional sources of funding.

Changes in specification can also be used to produce savings with the associated costs being passed on to Developers, especially where the change in use and therefore light class can be clearly demonstrated.

CHAPTER 12

12. RISKS

The potential risks associated with implementing an invest to save policy are:

Energy cost and supply

The future price of electrical energy may reduce or even become free, with the development of new and existing technologies:

- Hydrogen cells;
- The Sahara project with the potential to supply all of the earths energy needs from photovoltaic solar panels or concentrated solar power (CSP) plants, where the sun heats up liquid in a series of pipes and the resulting steam used to drive a turbine, it has been estimated that a CSP solar farm of less than 100 square miles could supply power the entire United States;
- Geo thermal, including recovering solar heat from road surfaces this energy could be used to power the street lighting for the road; and
- Wind turbines.

The future supply of night time electricity could become restricted either due to a shortage in production or increased demand, possibly from the re-charging of electrical vehicles or other "essential" uses and power would not allowed for street lighting at all,

Lighting technology

There are risks associated with the implementation of variable road lighting levels systems.

The use of new and emerging technologies, which have yet to be proven with regard to reliability, life cycle, new technology can be un-reliable.

The poor availability of complete systems, means that installing the system and compatibility between systems, means choices have to be made now without the full facts.

The manufacturers' ability to meet demand, new technology takes time to come on line from a production point of view and demand can be high.

Risks of rapidly increasing operational costs i.e. cost of hosting information new technology may result in equipment becoming obsolete.

Technology

New motor car technology, improved headlights, night time driver aids such as CCTV on windscreen, cars that drive themselves etc., might mean that lighting is not required on vehicle routes and we only light for pedestrians and cyclists.

Improvements in night vision technology could make street lighting obsolete i.e. instead of sunglasses there are night vision glasses.

Whilst the best way to mitigate against these risks would be to wait until they have been resolved, however timescales for this are unknown and some risks must be considered necessary in moving ahead and introducing service improvements and the associated energy and service savings.

APPENDIX A:

Individual Local Authority Case Studies

- Cardiff City Council
- Gloucestershire County Council
- Staffordshire County Council
- Westminster City Council

CARDIFF CITY COUNCIL

Introduction

Cardiff City Council is intending to pursue an "Invest to Save" street lighting initiative. The information below was provided by Mal Dyson, Lighting Engineer, via a questionnaire and a follow-up interview.

Existing Structure

The City is responsible for street lighting, footway lighting, subways, decorative lighting (including LED decorative light), festive lighting, high mast lighting, signs and bollards, bus shelters, school patrol signs and school flashers.

There are a total of 37,073 columns and 40,819 lamps within the City. There are double and triple arm columns as well as twin lamp luminaires.

There are also 3,918 illuminated signs and 515 bollards.

Budget

The 2007/08 budget figures for lighting are as follows:

Details	Budget	Comment
Maintenance	£ 1,446,985	-
New Works	£ 306,623	-
Structural work	£ 172,260	-
Energy	£ 1,237,040	-
Other	£ 282,295	Staff salaries, office rental etc.
Total	**£ 3,445,203**	

The current energy charge is 7.187p/kWh and this charge is based on an annual contract that is renewed on the 1st of April. This rate is negotiated by the "South Wales Consortium" of Lighting Engineers and the contract is with EDF.

The average energy consumption per lamp is 103W.

An attempt to balance the need to maintain a continuous improvement in the lighting in the light of shrinking budgets and increasing costs is achieved by reducing labour costs and by not filling vacant posts

Maintenance

The maintenance regime consists of a bulk clean and lamp change cycle of three years for high pressure sodium (SON) lamps and every two years for low pressure sodium (SOX) lamps. All units are also subject to an annual planned maintenance visit, which is a visual check and a clean if necessary.

There is no painting maintenance regime. The painting that takes place is for cosmetic reasons only.

Invest to Save

In attempting to implement an "Invest to Save" initiative in the City, the main problem has been a lack of finance. Work is currently being carried out on the Asset Management Plan in order to highlight the problems with the street lighting and the lack of finance.

The implementation of an "Invest to Save" initiative is currently still in the investigation stage.

The City's approach to the initiative includes the following:

- Budget proposals for the installation of electronic control gear in all luminaires;
- Investigating new generation lamps; and
- Investigating remote monitoring.

The City would consider a minimum pay back period of between five and ten years.

Whole life costing is considered, but the longer term economic benefits are as yet not looked at because most of the new equipment is not yet considered to be proven or reliable.

Lighting Source

Currently approximately 96% of the lighting stock has SON lamps. The majority of these SON lamps are 70W lamps, with approximately 15% being 100W to 400W lamps. A trial using Cosmo lamps, so as to reduce energy consumption, is being carried out.

A trial with metal halide (CDM-T) lamps has been carried out, but there were an unacceptable amount of early lamp failures.

Control Gear

Several trials using electronic control gear have been carried out. The trials have indicated that the electronic control gear that is currently available is not reliable. This is not just for the higher wattage lamps and it is the reason why a retrofit programme has not been considered yet. There is no capacitor replacement programme.

Trimming

Trimming has not yet been considered. The current switching regime is the standard 70lux/35lux.

Part-Night Lighting

Part-night lighting has not been taken forward because a trial was undertaken on a traffic route and when the lights were off there was a fatal traffic accident. It is unlikely that part-night lighting will be re-considered.

Dimming

The main reservation regarding dimming is that in the city centre dimming may reduce the effectiveness of CCTV surveillance. There is also the perception, of their lighting designers, that dimming will reduce the lighting levels below the required standards.

Remote Monitoring and Central Managements Systems

The annual scouting cost for the City is £ 120,000 and therefore the saving that remote monitoring would provide due to a reduction in staff costs is considered to be small and has therefore not been proposed.

One of the main reservations regarding remote monitoring is the additional staff costs that will be required to analyse the information provided by the remote monitoring systems so that the information can be effectively utilised.

The Mayflower CMS is however being trialled at five sites looking at approximately 800 units. At present these trials are only considered where the equipment is provided by the suppliers at no cost.

The City operates a bulk clean and change system and by dividing the City into zones the need for reactive maintenance has been reduced.

Columns Replacements

There has historically been a problem with concrete columns falling over. In 1996 a programme was put together to replace all concrete columns by 2003. So far approximately half have been replaced; with over 4,000 still requiring replacement.

Barriers to the Invest to Save Initiative

The main barriers against implementing an “Invest to Save” initiative by the City are seen to be the financial considerations of local and central government.

Invest to Save Scheme Details

There are currently no specific “Invest to Save” schemes.

Conclusion

Cardiff City Council are keen to embraced an “Invest to Save” approach with regard to their street lighting and illuminated signs infrastructure, but as yet have only carried out trials.

There is huge pressure on the City to reduce CO_2 emissions, but the view is that the lighting must first operate at the required levels before the emissions are reduced. This is the balance that needs to be met.

GLOUCESTERSHIRE COUNTY COUNCIL

Introduction

Gloucestershire County Council is actively pursuing an "Invest to Save" street lighting initiative. The information below was provided by Barry Greenaway the County Street Lighting Manager via a questionnaire and a follow-up interview.

Existing Structure

The County Street Lighting Manager is responsible for street lighting, footway lighting. subways, decorative and festive lighting, high mast lighting, signs and bollards, bus shelters, school crossing signs, Belisha beacons, guardian angels and variable message signs.

There are a total of 65683 illuminated "units". Included in this total are 4,386 illuminated sign, which included 198 school flashers, 178 Belisha beacons and 32 guardian angels. There are also 2,695 bollards.

Budget

The 2008/09 budget figures for lighting are as follows:

Details	Budget	Comment
Maintenance	£ 1,815,000	Reactive and cyclical maintenance
New Works	£ 370,000	Breakdown – Capital Works associated with traffic and civil engineering projects £ 300,00 and Section 38, 106 etc £ 70,000.
Capital Street Lighting Renewal Programme	£ 918,000	For column replacement and was reduced from £ 1,250,000 due to the floods in July, 2007.
Energy	£ 2,006,000	-
Other	£ 424,000	Staff salaries, superannuation, national insurance, expenses, office equipment, etc..
Total	**£5,533,000**	

The current energy charge is 11.5075p/kWh and this charge is based on an annual contract that is renewed on the 1st of October. (The energy for the year 2007/08 was 6.6227p/kWh, so there has been a 74% increase in the energy charge.)

The average annual energy consumption per street lighting lamp is 411kWh/annum and for signs and bollard lighting it is 192kWh/annum.

An attempt to balance the need to maintain adequate lighting in the light of an increasingly aged lighting stock and increasing costs that significantly exceed the official retail price index (rpi) figures is achieved in the following ways:

- Between 30% to 50% of units below 8m converted from all night to part-night operation (OFF between12:00 midnight to 5:30am) in rural and market towns (following local councils agreement and consultation with the Police);
- Dimming high pressure sodium (SON) lamps mounted at 8m and above; and
- Changing of inappropriate lamps (such as 70W SON lamps/ballasts mounted at 5m which are replaced with 50W SON lamps/ballasts).

Maintenance

The maintenance regime consists of a bulk lamp change cycle of three years for all street lights and an annual lamp change cycle for all sign lighting. These lamp changes are completed as required in conjunction with an annual planned maintenance visit which includes visual electrical and structural inspections and cleaning. Additionally, electrical tests are undertaken every six years for all equipment including Council owned cable networks.

Galvanised steel columns have been the standard used in the County since 1996 and are painted, mainly for aesthetic reasons, when installed. Repainting existing non galvanised steel columns is generally undertaken every ten years. However, because of the high age profile of many of these columns, there is a concern that painting would obscure external defects which, if identified, would indicate a requirement for early renewal. For this reason planned painting is not continued on steel columns aged more than 40 years unless there is a strong aesthetic reason.

Invest to Save

In attempting to implement an "Invest to Save" initiative in the County for part night lighting, the main challenge has been public resistance to service reductions, although there is considerable awareness and support for mitigating the effects of climate change. The perception is that there may be a reduction in personal safety and security and considerable effort is required in the consultation process.

One aspect that has helped is that the public do appear to be very conscious of the climate change issues and generally accept their responsibilities.

The County's approach to the initiative is a phased one, as follows:

Phase 1 - Introduce part-night lighting which is considered as a "quick save" solution. (It must be noted that the consultation process can and has take a long time.) The roll-out follows pilot schemes that have been installed for 18 months in three local council areas. The aim is to convert 7,000 units to part night operation by December 2009.

Phase 2 - Introduce dimming. The roll-out for the dimming will commence in April 2009 and the aim is to convert 10,000 units. Following a pilot, it has been decided that between 10:00pm and 5:30 am converted units will be set to 70% of peak power.

The County would consider a minimum pay back period of five years and this must take into account the increase in energy charges.

Although whole life costing is appropriate and used to evaluate different options for new and renewal installation schemes, the methodology is not easily transferred to existing installations that are deemed life expired and subject to potentially volatile factors such as condition indicators. For this reason the methodologies for risk and consequence evaluations detailed in the Institution of Lighting Engineers Technical Report TR 22 are used by the Council to determine equipment renewal priorities for their capital programmes.

Lighting Source

The Council has no plans at present to change to a "white light" policy for street lighting. This is mainly because of lamp life expectancy concerns and perceived high equipment prices. It has been the Council's policy since 1996 to fit SON lamps in new and replacement installations. Although there has been incremental progress in changing the Council's street lighting light source to SON, 41% of all lamps still remain SOX.

The change from SOX to SON light sources is achieved through capital funded street lighting renewal programmes and the replacement of unserviceable luminaires identified through maintenance regimes that are funded from revenue budgets. The capital funded renewal programmes is currently directed to the backlog of installations that are life expired and identified using TR 22 methodologies. Replacement units are generally installed on a "one for one" basis and significant upgrades are only considered at locations where there are road safety or crime concerns.

Although the development of LED technology for street lighting has been considerable in recent years, and the Council has ordered a trial installation for evaluation, it is perceived that the main use for LED's at present is for illuminated traffic signs and bollards. However, whilst all of the Council's vehicle activated and school crossing signs and Belisha beacons are illuminated by LED's, extending the use of this light source as standard practice for other illuminated signage has been limited due to higher cost of LED's compared to the cost of "conventional" lamps/equipment.

Control Gear

Since 2007 all new control gear installed has been electronic. A retro-fit programme to replace existing SON electromagnetic control has not been considered yet, although electronic gear is being fitted as replacements when existing electromagnetic ballasts fail.

Luminaires

New luminaries are installed when installations are renewed or when existing luminaries are considered unserviceable. In addition to the lighting upgrade provided by the new luminaries sky glow is reduced and it is believed further enhancement is achieved to lighting level uniformity by increasing the luminaire toe-out setting.

Trimming

Consideration is being given to the installation of PECU's set at 55/28lux. However, because of the relatively low cost savings this would generate, implementation would be based on replacing existing 70/35lux PECU's when they fail. It is estimated that a high percentage of PECU's would be replaced within 10 years if this strategy was implemented.

Remote Monitoring and Central Managements Systems

As Gloucestershire is a rural county it has been decided that the high capital and uncertain operational costs and questionable payback period would not make remote monitoring and Central Management systems viable. Although these systems have been considered, other areas of the service are currently considered to have a higher priority for attention.

Barriers to the Invest to Save Initiative

The main barriers against implementing an "Invest to Save" initiative by the Council are seen as:

- Professional resistance to reduced standards;
- Political resistance due to other priorities; and
- Unrealistic/inappropriate cost estimates that only look at quick win solutions.

Invest to Save Scheme Details

The main scheme implemented so far has been the installation of electronic ballasts. The objective of this scheme is to reduce energy and CO_2 emissions.

There are three other initiatives that are being or will be undertaken. These are part-night lighting, dimming and the changing of "inappropriate" lamps. Again, the benefits are the reduction in energy and CO_2 emissions. The details of these schemes are as follows:

- Part-night lighting has been considered in rural and market towns and of the 72 Parish Councils that have responded to the Council's invitation to participate in this initiative 53 have accepted, 6 have declined and 7 require more information. Crime data obtained for the12 months before and after part-night lighting was introduced in three pilot areas shows a marginal decrease in reported crime following the change. Roll-out of the part-night lighting commenced in January 2009 and the aim is to convert approximately 7,000 units by December 2009. Information from our Meter Administrator has confirmed our initial savings estimate as 47% when compared to the energy costs for all night operating units.
  In determining which units might be changed to part-night operation criteria has been developed that requires identification of lighting that is required to remain operating all night. Proposals for each local council area shows that between 30% and 50% of units below 8m should be suitable for conversion to part-night operation.

  The cost of a replacement PECU and it's installation, together with a tag fitted to the unit support identifying the unit as operating part-night, will be £15.00 per unit and will be completed in conjunction with the annual cyclical maintenance programme.

- The dimming will be via a 30% power reduction giving a 45% reduction in light output between 10:00pm and 5:30am. Only SON lamps in the wattage range 100W, to 400W are currently proposed to be dimmed. There are no proposals to dim lighting in town and city centres or other locations where high lighting levels are required to be maintained throughout the night. Approximately 10,000 units have been identified as being suitable for dimming and it is anticipated that energy costs will reduce by 28%.

  Implementation of the dimming works programme is due to commence in April 2009 with completion during March 2010 and will be completed in conjunction with the annual cyclical maintenance programme. Through collaborative working with the dimming ballast supplier, gear trays have been designed that are suitable for retro-fitting into the range of higher wattage SON luminaires installed in the County. Including installation, the unit cost to change to dimming operation is estimated to be £60.

- "Inappropriate lamps" are where 70W SON lamps have been installed in luminaires mounted at 5m. In order to provide what the County considers to be appropriate lighting for a 5m lighting installation, the existing 70W SON electromagnetic equipment will be replaced by 50W SON electronic equipment. It is likely that this work will be funded from savings generated through the part-night and dimming projects.

- Other areas with the potential for reducing the Council's energy demand in the relatively near term include:
  Electronic ballasts for SOX lamps; and
  Dimming ballast for lower wattage SON lamps.

The estimated cost to implement the part-night and dimming projects is £700,000.

The full year savings are predicted to be:

Saving in	**Part-night**	**Dimming**
CO_2 Emissions	396 tonnes	805 tonnes
Energy	920,132 kWh	1,872,000 kWh
Finance	£105,000	£215,000

Energy cost savings are based on the 2008/09 unit cost of 11.5075p/kWh

Conclusion

Gloucestershire County Council has embraced an “Invest to Save” approach with regard to their street lighting and illuminated signs infrastructure. Although there are economic constraints they are achieving savings in energy consumption and thereby reducing CO_2 emissions.

STAFFORDSHIRE COUNTY COUNCIL

Introduction

Staffordshire County Council is actively pursuing an "Invest to Save" street lighting initiative. The information below was provided by Steve Bradbury Lighting and ITS manager and Glynn Hook Principal Lighting Engineer via a questionnaire and a follow-up interview.

Existing Structure

Staffordshire county council is in a PFI contract to replace all street lights they are currently in their core investment period

The County Lighting Engineer is responsible for street lighting, footway lighting. Subways, decorative lighting, festive lighting, high mast lighting, signs and bollards, bus shelters, school patrol signs, Belisha beacons, guardian angels and variable message signs.

There are a total of 105,112 illuminated "units". Included in this total are 12,161illuminated signs, which included 347 school flashers, 275 Belisha beacons and 281 centre island hat pins/marker posts. There are also 3,409 bollards.

Budget

The 2007/08 budget figures for lighting are as follows:

Details	Budget	Comment
PFI	£8,500,000	
Energy	£2,100,000	
Other	£0	
Total	**£10,600,000**	

The current energy charge is 6.81p/kWh and this charge is based on a 12 month contract that is renewed on the 1st October and purchased through the OGC buying group.

The total average energy consumption for the provision of lighting and signing is 31,000,000kWh/annumand the average annual energy consumption per lighting unit is 299.2kWh/annum.

The Council is balancing the need to maintain continuous improvement in the lighting equipment in the light of shrinking budgets and increasing costs by having a PFI lighting renewal contract, the contract also allows for savings produced by changes in policy and equipment to be recovered by the authority.

Maintenance

The maintenance regime is part of the PFI contract and consists of a bulk clean and lamp change cycle appropriate for the lamp type.

Invest to Save

In implementing "Invest to Save" initiatives the Council's options have been limited due to the PFI but they have been very pro active with changes to the specification and policy

The Council's current approach to the initiative is as follows:

- Trimming through a specification review all PECU's on new build and maintenance works will switch on at 55 lux and off at 28 lux they will also be rated at 0.25w energy consumption
- De-Illumination of signs, and where this is not possible ensuring that all signs are only lit at night
- Introduction of bollard switching
- Replacement of illuminated bollards with reflective, where allowed
- Changing the lamp wattage and type on illuminated signs to save energy and future maintenance costs
- Trailing the use of Philips Cosmopolis lamps and gear on new schemes

The Council considers that a payback period of less than 10 years would be preferable as long as there is a payback over the life of the scheme that is acceptable.

Whole life costing has been undertaken in order to bid for funding for the invest to save initiatives.

Lighting Source

The council is reviewing the light source they are trailing Philips Cosmopolis lamps and they have already changed the specification for sign lights to LED's on all new works.
The standard light source for the PFI lighting replacement SON for Me classes and compact fluorescent for S classes.

Control Gear

The majority of new control gear is electronic. A retro-fit programme to replace the existing electromagnetic control has not been considered yet.

Luminaires

The PFI contract has ensured that the new luminaires are as efficient as they can be for each installation.

Trimming

Trimming has been undertaken but for new works only by changing the specification all new installations will have a 55lux/28lux switching regime using 0.25w photocells.

Remote Monitoring and Central Managements Systems

As Staffordshire is a rural county the use of a remote monitoring and Central Management systems have been investigated but maintenance is undertaken by the PFI contractor so any changes to the maintenance regime needs to be agreed and so it is not a viable option for the council to pursue further, at this time. However, Staffordshire are keeping a watching brief on developments in the industry.

Barriers to the Invest to Save Initiative

The main barriers against implementing an "Invest to Save" initiative by the Council are seen as:

- Existing PFI contract; and
- Political resistance due to other priorities;

Invest to Save Scheme Details

The main scheme implemented so far has been to reduce the illumination of signs, the objective of this scheme is to reduce energy and CO_2 emissions.

Internal funding of £750,000 was secured based on the councils policy to reduce CO_2 emissions and an estimated payback of between 5 and 10 years

The scheme looked at:

De-illuminating signs were possible
Changing Lamp type and reducing the wattages to improve efficiency
Ensuring signs are only illuminated at night

The scheme included:

500 de-illuminated signs
1200 Illuminated bollard
2000 reduced burning hours

The annual savings are predicted to be:

Saving in	**Invest to save projected benefits**
CO_2 Emissions	314 t CO_2
Energy	730,232 kWh
Finance	£151,000

Conclusion

Staffordshire County Council has embraced an "Invest to Save" approach with regard to their street lighting and illuminated signs infrastructure.

They have not let the fact that they are in a PFI contract stop them from trying to maximise both monetary and CO_2 savings for the council.

WESTMINSTER CITY COUNCIL

Introduction

Westminster City Council is reviewing its complete highway asset management delivery and this includes the public lighting service. The review is top down starting with the Transportation Asset Management Plan (TAMP), Public Lighting Maintenance Management Plan (PLMMP), the introduction of SMART Lights, which includes a review of lighting policy and the Westminster Asset Prioritisation Process (WAPP) giving due consideration at all stages to energy and environmental reductions whilst improving service delivery. A whole life costing approach is being taken.

Existing Structure

The City is responsible for street lighting, footway lighting, subways, tunnels, decorative lighting (including LED decorative light), festive lighting, signs and bollards and bus shelters.

There are a total of 14,000 columns and lamps within the City.

Budget

The current energy charge is 7.8p/kWh.

The average energy consumption per lamp is 103W.

Maintenance

The maintenance regime consists of a bulk clean and lamp change cycle of two years for CDO lamps. All units are also subject to an annual planned maintenance visit and clean.

Invest to Save

The implementation of an "Invest to Save" initiative is underway with a complete review and development of the TAMP and PLMMP.

The SMART Lights project includes the following considerations:

- Change from CDO lamps and magnetic control gear to CPO lamps and electronic dimmable control gear;
- A change in maintenance regime due to the lamp life associated to the new lamp technology;
- The introduction of a Central Management System (CMS) to remotely monitor and switch the lighting, trials of a number of systems are currently underway across Westminster;
- Trimming of the operating hours of the public lighting installations;
- The correct application of the British and European Standards in the choice of lighting class for all public areas;
- Standardisation of equipment used to suit style, performance and asset management requirements;
- Dimming of public lighting where applicable under the British Standards;
- Balancing of scouting costs against the 'hidden' back ground service costs for CMS systems; and
- A full asset management plan with scheduled replacement of equipment to reduce random failure rates and associated costs hence improving service to the public.

The City considers a pay back period of less that the equipments operational life to be acceptable with good savings shown after the payback period is achieved; the current payback period is estimated at 13.4 years.

Whole life costing is considered for all projects, the base data being reviewed from time to time.

Lighting Source

Currently the majority of the lighting is by CDO-TT lamps retro-fitted some years ago as part of the implementation of a white light strategy. Cosmo lamps are now being used as standard to reduce energy costs, improve design factors due to their higher lamp lumen maintenance factor and to extend lamp change frequencies to to their longer operational life.

Control Gear

Electronic control gear is now being fitted as standard with full awareness of the proposed requirements under energy efficient legislation for street lighting installations. This includes a consideration for full CSS, dimming and trimming.

Trimming

Trimming is being considered and will be operated by the CMS.

Dimming

The majority of the City operates on a 24/7 basis and as such dimming is not really a consideration, however some residential areas north of Paddington may receive consideration in due course.
However consideration is being given to increasing lighting levels around say Leicester Square when the night clubs and entertainment facilities close increasing the lighting levels on the key routes out of the area hence looking to address street crime at these times.

Remote Monitoring and Central Managements Systems

A cross section of available CMS are being trialled and assessed, this has just commenced and looks to report back in late August / September 08. The trials include wireless, WiFi and mains borne systems.

Retrofitting trails are also underway to ensure that the equipment can operate within the required luminaires within all required tolerances especially with regard to temperature.

A concern is the 'hidden' support costs involved in collecting the data from site, processing it onto an available web site, maintaining and upgrading the software and server support and the like, this can mount up and cost more that the original scouting operations, this can also affect the payback period. However it should be ore reliable, report faults as they occur and assist in monitoring the energy consumption and hence the energy bill.

Column Replacements

The Westminster Asset Prioritisation Plan has been reviewed, it considers and applies weightings to the structural condition of the stock, the lighting performance of the installations, street crime, road user mix and the like to prioritise where equipment most needs replacing.

Barriers to the Invest to Save Initiative

The only potential barrier would not being able to demonstrate a payback period.

Conclusion

Westminster City Council are keen to embraced an “Invest to Save” approach with regard to their street lighting and a full whole life costing assessment is underway with trial sites installed and performance being monitored. They are committed to energy and environmental reductions at the same time looking to maintain if not improve the service levels to the public.

The following savings are currently expected:

- Change from CDO to CPO lamps — energy reduction of cc 17%
- Implementation of trimming & CPO lamps — energy reduction of cc 20%

The revised asset plan introduces operation savings through an increased period between bulk lamp change and clean regimes, thus reducing vehicle mileage and associated CO2 emissions and traffic congestion.

- Lamp changes revised from 2 to 3 years with the CPO lamp and electronic gear, this will be monitored to see if it can be extended
- Use of the CPO lamp with higher lamp lumen depreciation factors at lamp change time reduces over lighting when the road design standards are applied correctly
- Columns and luminaires will be cleaned at the time of lamps change and not annually, the column paint finish has been revised to suit this and maintain the required gloss shine for longer.
- Columns are based and will be maintained based upon a 40 years, with luminaire bowl, reflector and control gear replaced at 20 years, this is being monitored especially with regard to the control gear of which a major consideration is the operational temperatures within the luminaire which need to be as low as possible.

Central Management System, these are being considered and the cost of components, communication and data processing being carefully assessed, these costs can mount up at current prices and have a considerable affect on the payback periods.

APPENDIX B:

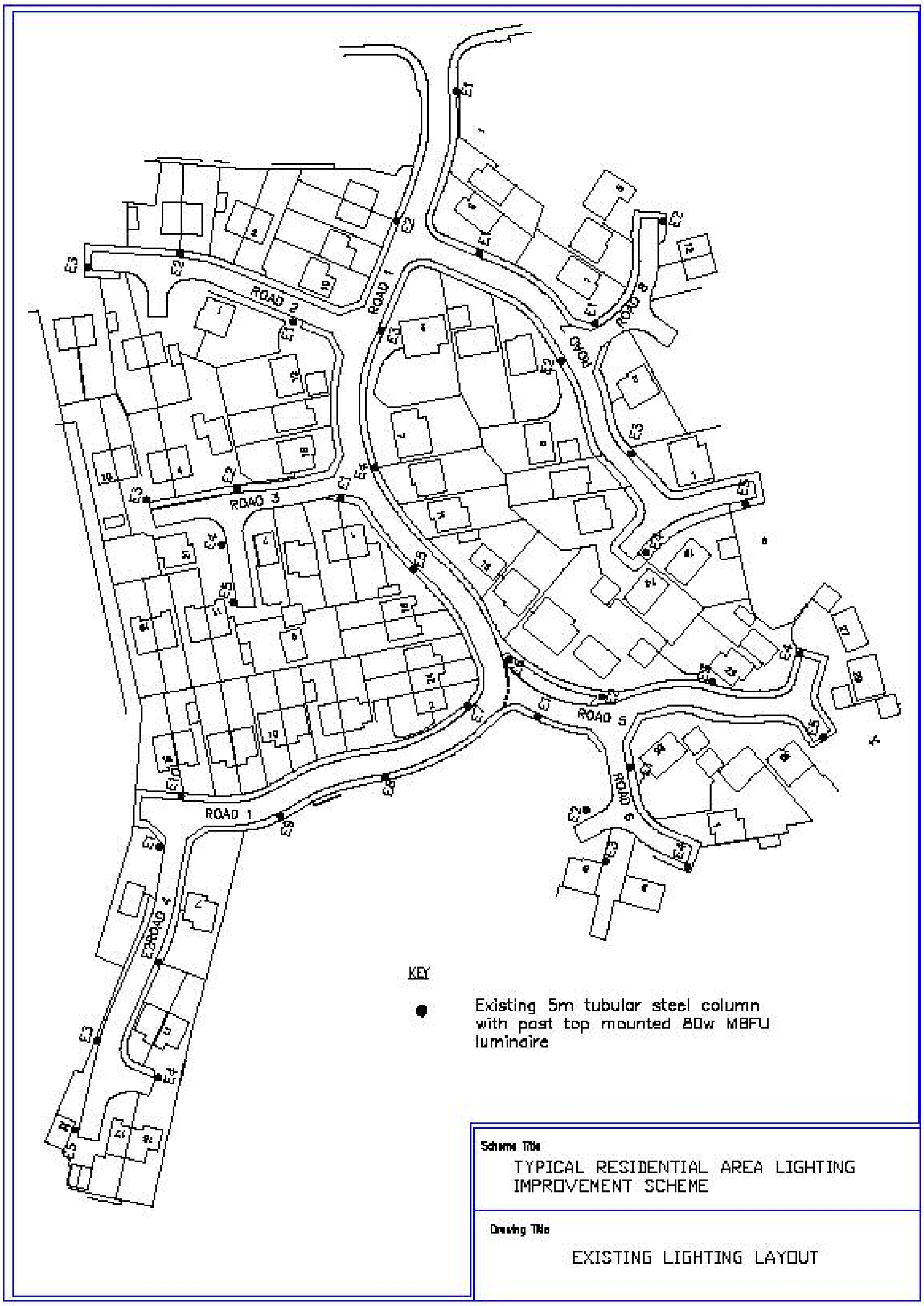
Desktop Studies

- Relighting Scheme for a Typical Residential Area
- Dimming Motorway Lighting
- Dimming Traffic Route Lighting
- Dimming Residential Road Lighting
- Part Night Lighting

Relighting Scheme for a Typical Residential Area

The following area is a typical small residential area consisting of a main estate road and several small side roads and cul-de-sacs, the existing lighting is approximately 35 years old and comprises 39 No. 5m tubular steel columns with a post top mounted deep refractor bowl luminaire complete with an 80W MBFU lamp and gear.

Existing Lighting Layout



METHODOLOGY

For the purposes of this study it is proposed to evaluate 3 options

- Option 1 – A blanket level of S2 applied to all of the roads within the area using SON
- Option 2 – All roads classified according to the requirements of BS 5489-1: 2003 with SON
- Option 3 - All roads classified according to the requirements of BS 5489-1: 2003 with a white light source (Ra≥60)

The area was surveyed to identify the location and type of the existing lighting equipment, the survey also identified any existing obstructions that would prohibit the installation of the proposed columns.

Lighting calculations were then undertaken for all of the options with a typical selection of luminaires in order to optimise the design spacing's, the appropriate maintenance factors were applied for each lamp type and wattage.

A proposed lighting scheme was then designed, taking into account the existing obstructions, to produce a proposed lighting layout for each option.

For each of the proposed options a cost benefit analysis was undertaken using typical costs obtained from several contractors and Authorities.

Option 1 – A blanket level of S2 applied to all of the roads within the area using SON

Classification of roads according to BS 5489-1: 2003

All roads are lit to a blanket level of S2

Road 1 – main estate road

Typical design spacing's:

Lighting Class	Lamp Type	Arrangement	Maximum Spacing	Minimum Spacing
S2 (Ra<60)	70W Son T	Staggered	28m	19m
S2 (Ra<60)	70W Son T	Single Sided	28m	19m

Roads 2, 3, 4, 5, 6, 7 and 8 – side roads and cul-de-sacs

Typical design spacing's:

Lighting Class	Lamp Type	Arrangement	Maximum Spacing	Minimum Spacing
S2 (Ra<60)	70W Son T	Staggered	28m	19m
S2 (Ra<60)	70W Son T	Single Sided	28m	19m

Proposed lighting layout

Road 1: 12 No. 6m columns with post top mounted 70W SON shallow bowl luminaires.

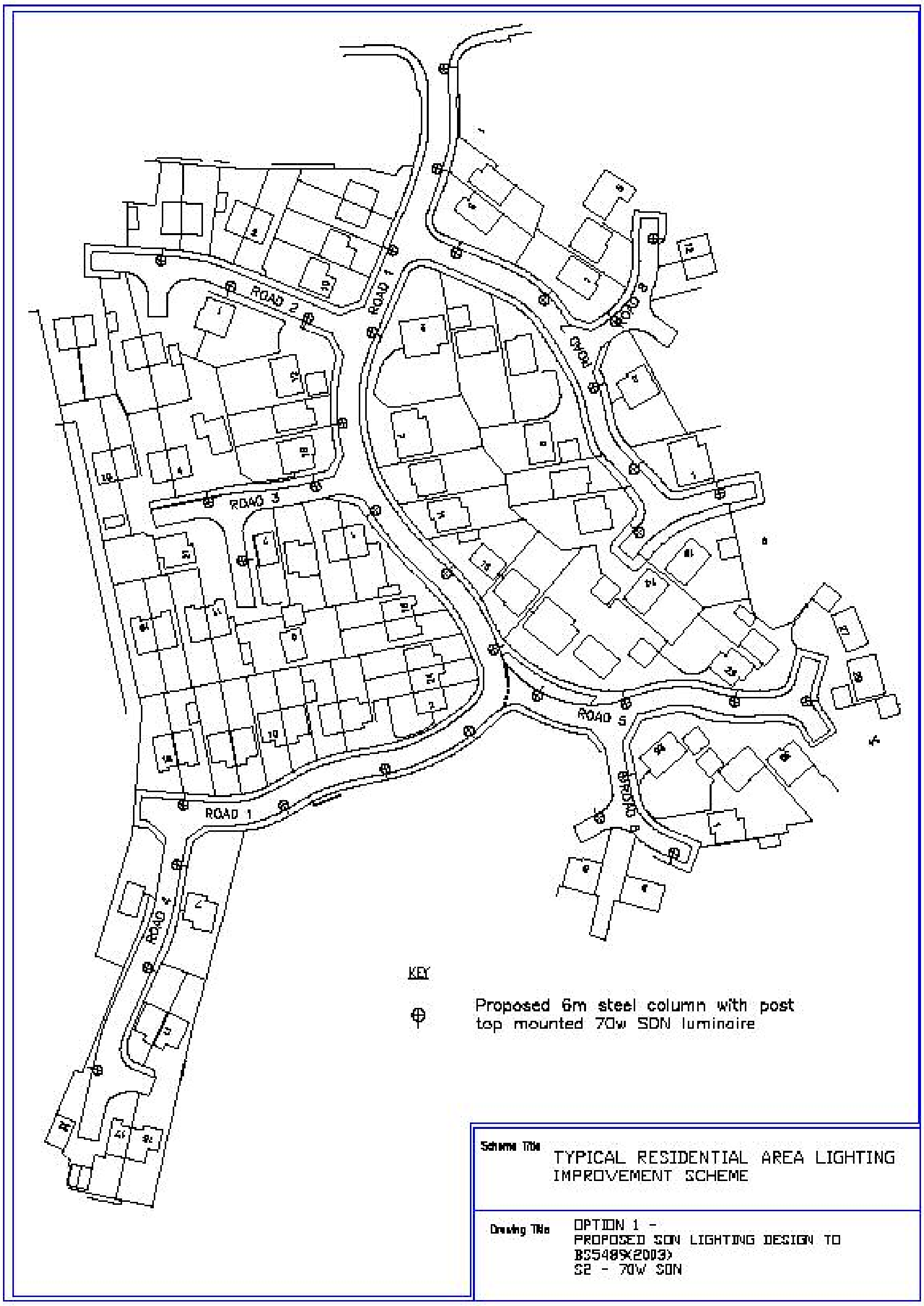
Roads 2, 3, 4, 5, 6, 7 and 8: 23 No. 6m columns with post top mounted 70W SON shallow bowl luminaires.

Option 1 Proposed Lighting Layout

Lighting design to BS 5489-1: 2003 - S2, Road 1 Main estate road and the side roads and cul-de-sacs roads 2, 3, 4, 5, 6, 7, and 8

Road 1: 12 No. 6m columns with post top mounted 70W SON shallow bowl luminaires.

Roads 2, 3, 4, 5, 6, 7 and 8: 23 No. 6m columns with post top mounted 70W SON shallow bowl luminaires.



Option 2 – All roads classified according to the requirements of BS 5489-1: 2003 with SON

Classification of roads according to BS 5489-1: 2003

The area is a residential area within environmental zone :- E2 - Rural, small village

Road 1 – main estate road

Traffic Flow: Normal – housing estate access road
Crime Rate: - Low
Recommended lighting class for Ra < 60 - S4

Roads 2, 3, 4, 5, 6, 7 and 8 – side roads and cul-de-sacs

Traffic Flow: Low – traffic usage is of a level equivalent to a residential and solely associated with the adjacent properties.
Crime Rate: - Low
Ra < 60 - lighting class S5

Road 1 – main estate road

Typical design spacing's.

Lighting Class	Lamp Type	Arrangement	Maximum Spacing	Minimum Spacing
S4 (Ra<60)	50W Son T	Staggered	35m	24m
S4 (Ra<60)	50W Son T	Single Sided	35m	23.5m
S4 (Ra<60)	70W Son T	Staggered	48m	37.5m
S4 (Ra<60)	70W Son T	Single Sided	49.5m	37.5m

As there are 2 viable options for the main estate road, 50W SON and 70W SON both options have been evaluated, Option 2A Road 1 – main estate road 50W SON and Option 2B Road 1 – main estate road 70W SON.

Roads 2, 3, 4, 5, 6, 7 and 8 – side roads and cul-de-sacs

Typical design spacing's:

Lighting Class	Lamp Type	Arrangement	Maximum Spacing	Minimum Spacing
S5 (Ra<60)	70W Son T	Staggered	No solution	No solution-
S5 (Ra<60)	70W Son T	Single Sided	-No solution	No solution-
S5 (Ra<60)	50W Son T	Staggered	42.5m	33m
S5 (Ra<60)	50W Son T	Single Sided	42.5m	33m

there was no compliant design solution found for a 70W SON scheme for the side roads and cul-de-sacs.

Option 2A - Proposed lighting layout

Road 1: 12 No. 6m columns with post top mounted 50W SON shallow bowl luminaires.
Roads 2, 3, 4, 5, 6, 7 and 8: 21 No. 6m columns with post top mounted 50W SON shallow bowl luminaires.

Option 2B - Proposed lighting layout

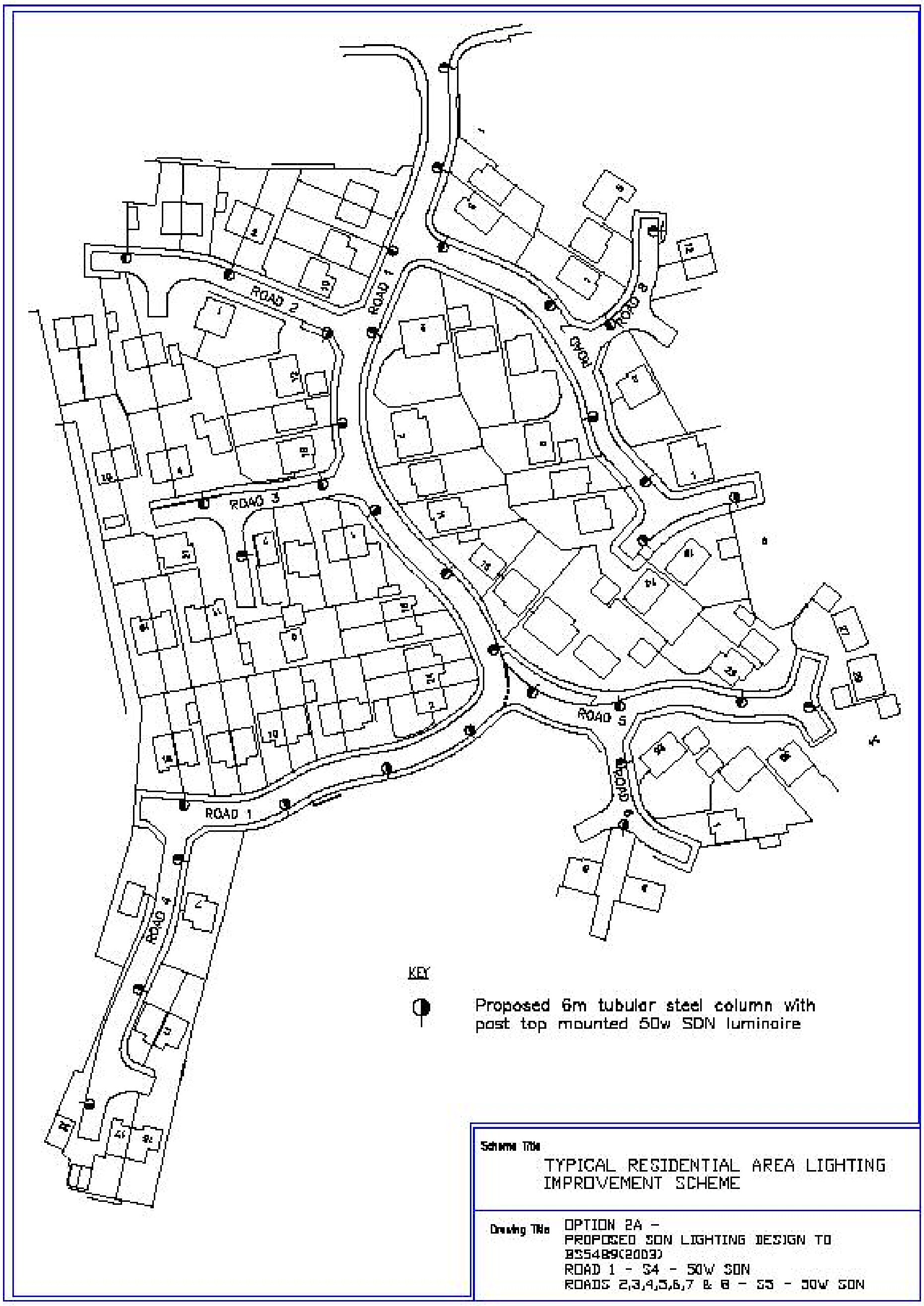
Road 1: 8 No. 6m columns with post top mounted 70W SON shallow bowl luminaires.
Roads 2, 3, 4, 5, 6, 7 and 8: 21 No. 6m columns with post top mounted 50W SON shallow bowl luminaires.

Option 2A Proposed Lighting Layout

Lighting design to BS 5489-1: 2003 Road 1 lit to S4, Roads 2, 3, 4, 5, 6, 7, and 8 lit to S5

Road 1: 12 No. 6m columns with post top mounted 50W SON shallow bowl luminaires.

Roads 2, 3, 4, 5, 6, 7 and 8: 21 No. 6m columns with post top mounted 50W SON shallow bowl luminaires.

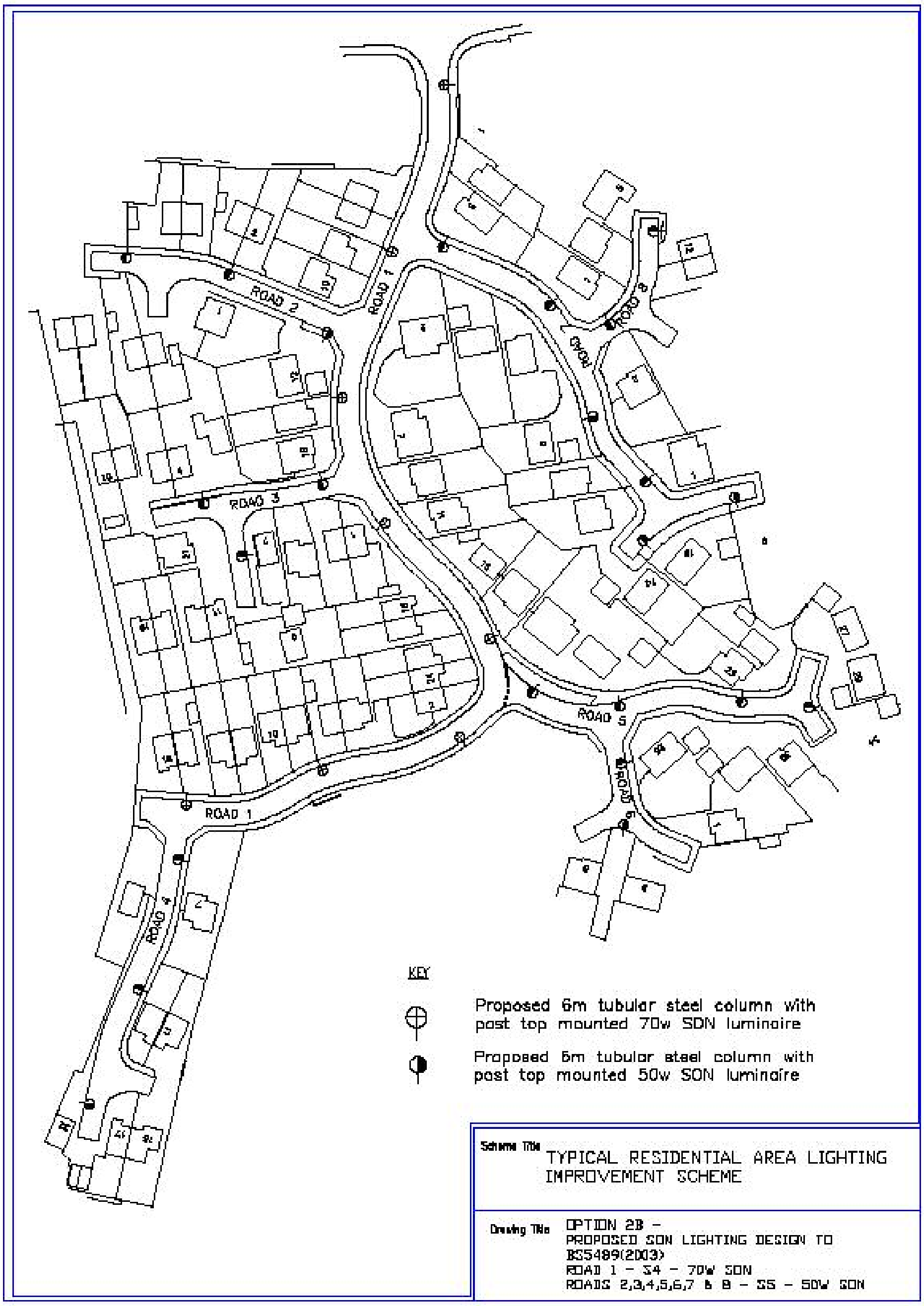


Option 2B - Proposed lighting layout

Lighting design to BS 5489-1: 2003 Road 1 lit to S4, Roads 2, 3, 4, 5, 6, 7, and 8 lit to S5

Road 1: 8 No. 6m columns with post top mounted 70W SON shallow bowl luminaires.

Roads 2, 3, 4, 5, 6, 7 and 8: 21 No. 6m columns with post top mounted 50W SON shallow bowl luminaires.



Option 3 – All roads classified according to the requirements of BS 5489-1: 2003 with a white light source (Ra≥60)

Classification of roads according to BS 5489-1: 2003

The area is a residential area within environmental zone :- E2 - Rural, small village

Road 1 – main estate road

Traffic Flow: Normal – housing estate access road
Crime Rate: - Low
Recommended lighting class for Ra ≥60 – S5

Roads 2, 3, 4, 5, 6, 7 and 8 – side roads and cul-de-sacs

Traffic Flow: Low – traffic usage is of a level equivalent to a residential and solely associated with the adjacent properties.
Crime Rate: - Low
Recommended lighting class for Ra ≥60 – S6

Road 1 – main estate road

Typical design spacing's:

Lighting Class	Lamp Type	Arrangement	Maximum Spacing	Minimum Spacing
S5 (Ra≥60)	45W Cosmopolis	Staggered	43m	31.5m
S5 (Ra≥60)	45W Cosmopolis	Single Sided	37m	31.5m

The design for this scheme requires 8 No. 6m columns with a post top mounted shallow bowl luminaire incorporating a 45W Cosmopolis lamp and gear, in order to avoid all of the obstructions to proposed column locations.

Roads 2, 3, 4, 5, 6, 7 and 8 – side roads and cul-de-sacs

Typical design spacing's:

Lighting Class	Lamp Type	Arrangement	Maximum Spacing	Minimum Spacing
S6 (Ra≥60)	45W Cosmopolis	Staggered	43m	38.5m
S6 (Ra≥60)	45W Cosmopolis	Single Sided	39m	38.5m
S6 (Ra≥60)	42W PLT	Staggered	37m	36m
S6 (Ra≥60)	42W PLT	Single Sided	39m	38.5m
S6 (Ra≥60)	36W PLL	Staggered	35.5m	32m
S6 (Ra≥60)	36W PLL	Single Sided	35.5m	32m

Due to the constraints of the road geometry and obstructions and the poor installation window a "workable" compliant solution could not be found with either 45W Cosmopolis or 42W PLT

Option - Proposed lighting layout

Road 1: 8 No. 6m columns with post top mounted 45W Cosmopolis shallow bowl luminaires.

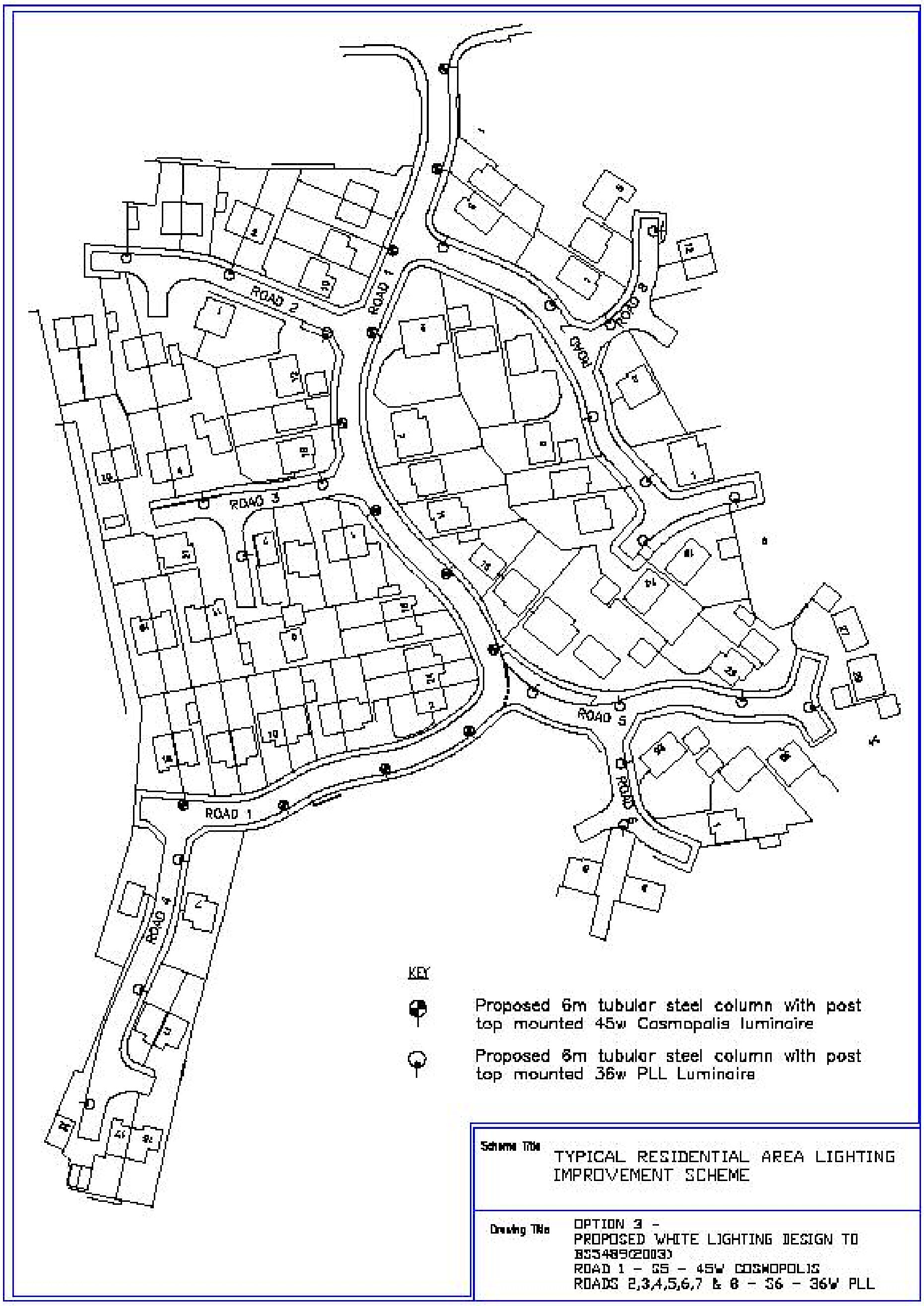
Roads 2, 3, 4, 5, 6, 7 and 8: 23 No. 6m columns with post top mounted 36W PLL luminaires

Option 3 - Proposed lighting layout

Lighting design to BS 5489-1: 2003 Road 1 lit to S5, Roads 2, 3, 4, 5, 6, 7, and 8 lit to S6

Road 1: 8 No. 6m columns with post top mounted 45W Cosmopolis shallow bowl luminaires.

Roads 2, 3, 4, 5, 6, 7 and 8: 23 No. 6m columns with post top mounted 36W PLL luminaires



SCHEME EVALUATION

Typical Scheme Costs

	Option 1	Option 2A	Option 2B	Option 3	Existing
Installation Costs	41220	39720	37020	38080	N/A
1st Year Energy Costs	1025	690	673	456	1278
1st Year Operating Costs	594	583	507	574	1165

Energy Consumption

	Option 1	Option 2A	Option 2B	Option 3	Existing
Total Energy Consumption per Option KWh per annum	12054	8118	7921	5367	15031
Total Saving in Energy Consumption KWh per annum compared to the Existing	2977	6913	7109	9664	0
Total Saving in Energy Consumption KWh per annum compared to Option 1	0	3936	4133	6687	-2977

A simple cost benefit analysis was then undertaken to include both a 12 year and 30 year evaluation period, including an estimate of future operating costs, these were done both forno inflation and allowing for inflation with an increase in energy costs above inflation.

Cost Benefit Analysis

	Option 1	Option 2A	Option 2B	Option 3	Existing
Total Costs 12 years - No Inflation	£60,638	£54,995	£51,179	£50,438	£29,317
Total Costs 12 years - Inflation Only	£67,224	£58,958	£54,852	£53,644	£36,922
Total Costs for 12 years with inflation & Energy increases	£66,721	£59,306	£55,192	£53,874	£37,567
Total Costs 30 years - No Inflation	£89,766	£77,908	£72,417	£68,975	£73,292
Total Costs 30 years - Inflation Only	£133,153	£107,731	£100,062	£93,103	£130,531
Total Costs for 30 years with inflation & Energy increases	£139,170	£111,418	£103,659	£95,541	£137,357

Inflation assumed to be 3.5% per annum
Additional Energy increase assumed to be 10% over 30 years on Energy Prices

Typical Installation Costs

Description	Unit	Typical Cost
		Rate (£)
Take up or Down and remove to Contractors Tip Road lighting Column any type and any height including bracket(s) and luminaire(s)	No.	100.00
Permanent reinstatement of footpath	m2	30.00
Steel galvanised road lighting column of 6m nominal height with planted base and post top mounted luminaire incorporating a 36W PLL lamp and photo electric control unit.	No.	430.00
Steel galvanised road lighting column of 6m nominal height with planted base and post top mounted luminaire incorporating a 45W Cosmopolis lamp and photo electric control unit.	No.	490.00
Steel galvanised road lighting column of 6m nominal height with planted base and post top mounted luminaire incorporating a 50W SON lamp and photo electric control unit.	No.	450.00
Steel galvanised road lighting column of 6m nominal height with planted base and post top mounted luminaire incorporating a 70W SON lamp and photo electric control unit.	No.	450.00
DNO New Service	Item	450.00
DNO transfer of Service	Item	400.00
DNO permanent Disconnection	Item	250.00

Typical Energy Costs

Description	p per KWh	System wattage	Operating Hours
		Watts	Per/Annum
Steel galvanised road lighting column of 6m nominal height with planted base and post top mounted luminaire incorporating a 36W PLL lamp and photo electric cell.	8.50	39.00	4100.00
Steel galvanised road lighting column of 6m nominal height with planted base and post top mounted luminaire incorporating a 45W Cosmopolis lamp and photo electric cell.	8.50	51.50	4100.00
Steel galvanised road lighting column of 6m nominal height with planted base and post top mounted luminaire incorporating a 50W SON lamp and photo electric cell.	8.50	60.00	4100.00
Steel galvanised road lighting column of 6m nominal height with planted base and post top mounted luminaire incorporating a 70W SON lamp and photo electric cell.	8.50	84.00	4100.00
Existing 80W MBFU luminaire	8.50	94.00	4100.00

Typical Operating Costs

Description	Cost (£)	Frequency (years)	Cost per Annum (£)
Inspection and maintenance in accordance with TD 23/86 "Maintenance of Road Lighting"	8.00	6	1.33
Lamp Replacement (every 3 years) 36W PLL	12.78	3	4.26
Lamp Replacement (every 3 years) 45W Cosmoplolis	35.00	3	11.67
Lamp Replacement (every 3 years) 50W Son	15.99	3	5.33
Lamp Replacement (every 3 years) 70W Son	13.88	3	4.63
Lamp Replacement (every 2 Years) 80W MBFU	14.10	2	7.05
Night Patrol Scouting	3.00	1	3.00
Accident damage and Non-routine Maintenance	8.00	1	8.00
Column structural testing due to existing condition	33.00	6	5.50
Column painting 2 coats	75.00	15	5.00

DIMMING MOTORWAY LIGHTING

This is a desktop study based on a typical section of dual 4 lane motorway

A detailed trial of higher wattage SON electronic ballasts has not yet been carried out on the Highways Agency's motorway network. We have been informed by the Highways Agency that they intend to carry out their own detailed desktop study of the systems and procedures before carrying out their own trials. It will be only once this has been completed that the Highways Agency will approve variable road lighting levels systems for use on their network.

METHODOLOGY

For this study it is proposed to evaluate the viability of utilising variable lighting and the estimated costs and cost savings

For this study it is proposed to look at:

a) Variable lighting levels due to variations in traffic flow.
b) Dimming due to over lighting
c) Dimming to Maintenance factor

In addition the energy reduction in changing from conventional electromagnetic control gear to electronic was calculated.

Details of the existing lighting layout and equipment type were obtained.

a) Variable Lighting Levels due to Variations in Traffic Flow

Existing traffic flow data, for 3 months was obtained and evaluated to determine the switching point between lighting classes

The Highways Agency standards for design and maintenance of road lighting were investigated to determine if a reduction was available. Note 2 in Table B.2 in Annex B of BS 5489-1: 2003 gives advice on the application of ADT in selecting the appropriate road lighting class.

Lighting calculations were then undertaken to determine the reduction in lumens required to reduce the levels to those of the lower classes.

This percentage reduction in lumens was then converted into an energy reduction.

Typical installation costs obtained from several contractors and Operational costs from the maintaining Agent for several Highways Agency areas.

b) Dimming due to Over Lighting

Lighting calculations were then undertaken to determine if a reduction in lumens was possible to reduce the average luminance to the required level.

c) Dimming to Maintenance Factor

Calculations were undertaken to determine the potential savings available from reducing the over lighting caused by applying a maintenance factor.

APPLICATION OF VARIABLE ROAD LIGHTING LEVELS DUE TO TRAFFIC FLOW

General

The Existing road lighting was designed to comply with the motorway lighting standard current at the time, BS 5489-10: 1992. Design calculations have been undertaken that have established that existing installed lighting also complies with the lighting class ME1, as required by the current road lighting standards BS 5489-1: 2003 and BS EN 13201-2: 2003.

The existing installed road lighting on the main carriageway is as follows:

- Verge mounted opposite arrangement;
- 15m mounting height columns with 1m brackets arms; and
- 400W SON-T flat glass luminaires mounted horizontally.

The existing columns and cable network are in a very good condition and do not require replacing, Therefore the only costs are for upgrading to electronic control gear and installing the communication and central management system.

Traffic Flow Data and Lighting Classes

As the varying of the road lighting levels will be determined by hourly traffic flows, detailed traffic flow data has been obtained from traffic counters located in the carriageway. The traffic flow data for three months in 2007, June, August and December, has been analysed.

“The guidance on lighting class application for motorways and traffic routes uses average daily traffic flow (ADT), which is the normal concept in traffic planning, and is usually known. Peak traffic is generally taken to be 10% and 12% of ADT in rural and urban areas respectively. If hourly flows are known, and the peak hour traffic is greater than 12%, the peak traffic should be taken into account when selecting the lighting class.”

The value for ADT is required for the initial selection of the road lighting class. In order to use variable road lighting levels through the night the hourly traffic flows are required. The value of ADT for each lighting class needs to be converted to hourly traffic flows using the advice above. The relevant hourly traffic flows for each lighting classes is shown in the table below

The hourly traffic flow transition levels will be as follows:

Lighting Class	ME1	ME2	ME3a
Hourly Traffic Flow (Vehicles)	>4,000	≤4,000 ≥1,500	<1,500

Table 1: Lighting Class and Hourly Traffic Flow

From an analysis of the hourly traffic flow it can quickly be established when the road lighting can be switched between classes.

It must be remembered that there is also a morning peak flow.

Table 2 shows the traffic flow data per hour and the applicable lighting class. Approximate sunrise and sunset times are also shown in order to establish when the different lighting classes are applicable.

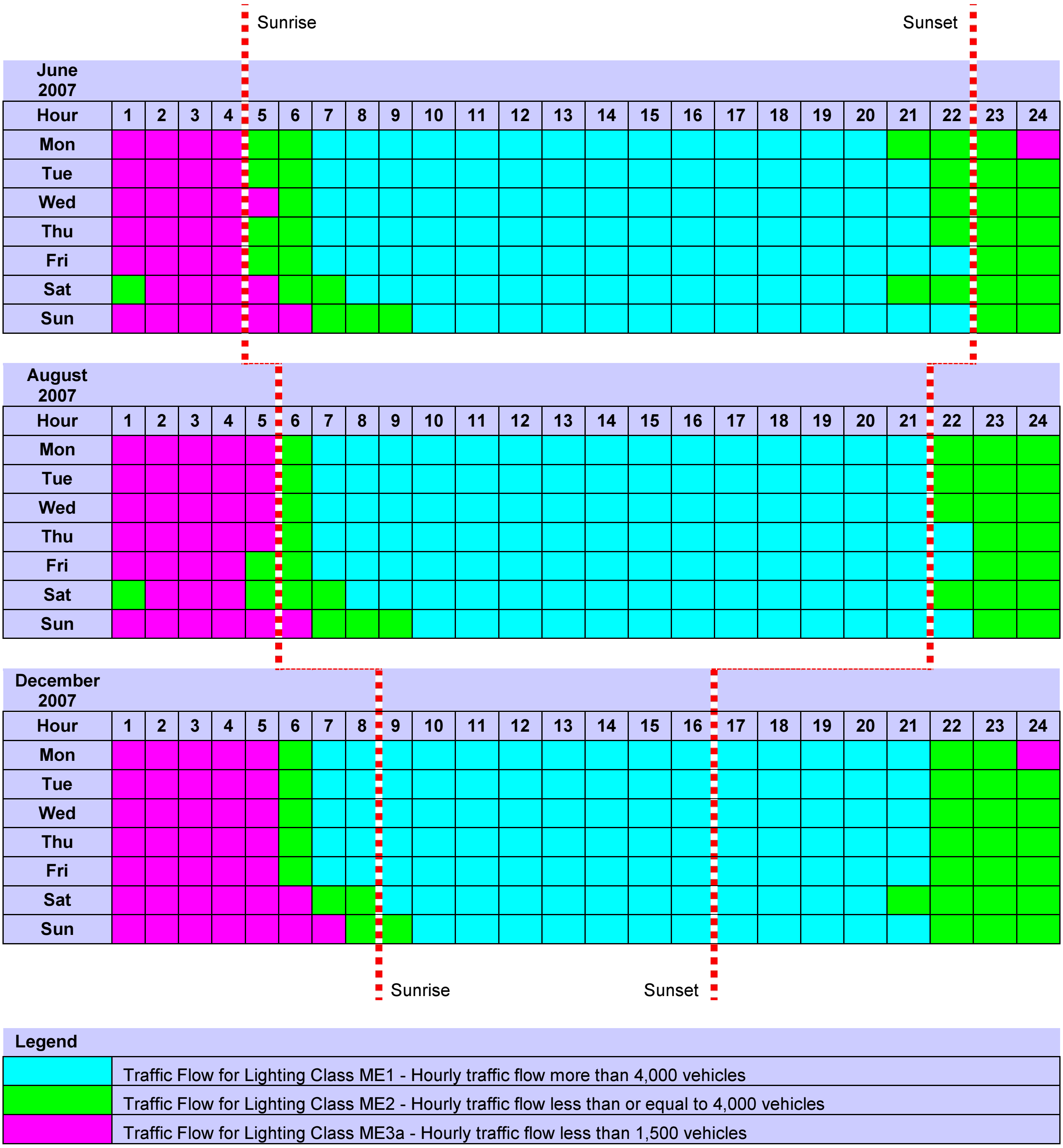


Table 2: Summary of Monthly Two-way Traffic Flow per Weekday and the Applicable Lighting Class

A summary of the Table 2 can be used to determine when each lighting class is applicable.

The hours of darkness for each week are as follows:

Month	**Approximate Hours of Darkness per Week**
June	42 hours
August	56 hours
December	112 hours

Table 3: Hours of Darkness

The lighting classes as determined by the hourly traffic flow data are as follows:

Lighting Class ME1

Day	**Month**			**Total**
	June (hours)	**Aug** (hours)	**Dec** (hours)	(hours)
Monday	0	0	7	7
Tuesday	0	0	7	7
Wednesday	0	0	7	7
Thursday	0	1	7	8
Friday	0	1	7	8
Saturday	0	0	4	4
Sunday	0	1	5	6
Total	0	3	44	47

Lighting Class ME2

Day	**Month**			**Total**
	June (hours)	**Aug** (hours)	**Dec** (hours)	(hours)
Monday	5	5	6	16
Tuesday	4	5	5	14
Wednesday	4	5	5	14
Thursday	4	5	5	14
Friday	4	4	5	13
Saturday	3	3	6	12
Sunday	4	5	7	16
Total	28	32	39	99

Lighting class ME3a

Day	**Month**			**Total**
	June (hours)	**Aug** (hours)	**Dec** (hours)	(hours)
Monday	1	3	3	7
Tuesday	2	3	4	9
Wednesday	2	3	4	9
Thursday	2	2	4	8
Friday	2	3	4	9
Saturday	3	5	6	14
Sunday	2	2	4	8
Total	14	21	29	64

Table 4: Lighting Classes determined by Traffic Flows

Energy Savings

The energy savings applicable to the appropriate lighting classes when using electronic control gear are shown in Table 5. This saving is based on the information provided in Graph 1.- appendix A-1

Designed Lighting Class		**Varied Lighting Level Lighting Class**		**Percentage Difference in Lighting Levels**	**Percentage Saving in Energy**
Class	**L_{ave} (cd/m^2)**	**Class**	**L_{ave} (cd/m^2)**	**(%)**	**(%)**
ME1	2.0	ME2	1.5	25.0	19.0
ME1	2.0	ME3a	1.0	50.0	35.0

Table 5: Percentage Energy Savings between Applicable Lighting Classes

The energy savings, in Watts, per each 400W SON lamp, when reducing the lighting output between the applicable lighting classes are shown in Table 6. It must again be noted that a 400W SON lamp using electronic control gear operates at 430W.

Designed Lighting Class			**Varied Lighting Level Lighting Class**			**Percentage Saving in Energy**	**Actual Energy Saved**
Class	L_{ave} (cd/m^2)	Lamp Energy (Watts)	Class	L_{ave} (cd/m^2)	Lamp Energy (Watts)	(%)	(Watts)
ME1	2.0	430	ME2	1.5	348	19.0	82
ME1	2.0	430	ME3a	1.0	280	35.0	150

Table 6: Actual Energy Saving using 400W SON Lamps

On this typical section of motorway there are 928 – 400W SON lamps lighting the main carriageway. These are the lamps that can be considered suitable for applying variable lighting levels.

The energy saving per week per month for the months analysed are shown in Table 7.

Month	Weekly Hours of Darkness (hours)	Total Energy Usage for Lighting Class ME1 using Electronic Ballasts (kWh)	Energy Usage for each Lighting Class based on Traffic Flows as shown in Table 7 and Lamp Energy Usage as shown in Table 9 (kWh)			Total Energy Usage after the Application of Variable Lighting Levels (kWh)	Energy Saved each week by using Variable Lighting Levels (kWh)
			ME1	ME2	ME3a		
June	42	16,760	0	9,042	3,638	12,680	4,080
August	56	22,346	1,197	10,334	5,457	16,988	5,358
December	112	44,692	17,558	12,595	7,535	37,688	7,004

Table 7: Energy Savings using Variable Lighting Level

The above figures indicate that during June and August the saving in energy when using variable road lighting levels is 24%. In December the saving is reduced to 16%. Extrapolating these savings it can therefore be assumed that throughout the year the average energy saving with be approximately 20%.

Therefore the total annual energy usage for the road lighting of the main carriageway using electronic control gear and based on 4,317 burning hours per annum, is 1,722,656kWh.

A 20% saving in energy usage would therefore be 344,531kWh/annum.

The savings above are only due to variable lighting levels and do not take into account varying the road lighting levels due to the maintenance factor or overlighting.

DIMMING DUE TO OVER LIGHTING

The lighting design calculations indicate that there would be no saving due to over lighting, as the limiting design requirement is the average luminance level.

DIMMING TO MAINTENANCE FACTOR

The original lighting design was produced under the old Highways Agency standards and a maintenance factor of 0.81 was used. The current Highways Agency maintenance standard is for a 3 year clean and lamp replacement cycle.

An additional energy saving can be made if the lighting levels were reduced to compensate for the over lighting provided by the maintenance factor.

Assuming that the depreciation in light is constant over time

Then saving at start =19% saving at end 0% average saving 9.5%

This would provide a further energy saving of approximately 9%,

Cost Benefit Analysis

An example of whole life cost benefit analysis for a variable road lighting levels system is detailed in Table 8.

The following assumptions have been made in producing this analysis:

- the existing lamp control gear is electromagnetic;
- the cost of energy over the life of the lighting installation will be 10p/kWh;
- the life of the installation will be 30 years (as per TA 49/07);
- the initial cost of the variable road lighting equipment and the installation will be £300.00 per luminaire;
- the equipment installation cost of £25.00 per luminaire;
- the electronic ballast will require replacement once during the life of the installation at a cost of £75.00 per ballast; and

the following cost have not been included as they are currently difficult to quantify:

- reduced scouting patrols;
- the increase in lamp life due to advances in lamp technology and the benefits to the lamps from the electronic ballasts;
- the increased lamp reliability due to the operation of the electronic ballasts; and
- the removal of the need for a capacitor replacement programme.

Details	Units	Electro-magnetic Control Gear	Electronic Control Gear
<u>Capital Cost for Variable Lighting levels per Luminaire</u> Variable Road Lighting Levels Equipment Installation Cost Ballast Replacement after 15 years		 - - -	 £300.00 £25.00 £75.00
Cost per Luminaire		£0.00	£400.00
Total No. of luminaires		928	928
Total Cost for Variable Lighting Levels		£0.00	£371,200.
<u>Energy Costs</u> Circuit Wattage per 400W SON Lamp Total No. of Luminaires	 (kW)	 0.46 928	 0.43 928
Total Wattage for Installation (full lamp power)	(kW)	427	399
Burning Hours per Annum	(hours)	4,317	4,317
Total kWh per Annum	(kWh)	1,842,841	1,722,656
<u>Savings in Energy due to Variable Lighting Levels</u> Variable Lighting Levels due to Traffic Flow - 20% Reducing Lighting Levels due to Maintenance Factor - 9%	 (kWh) (kWh)	 - -	 344,531 155,039
Total Energy Saving per Annum	(kWh)	-	499,570
Total Energy Consumed per Annum	(kWh)	1,842,841	1,223,086
<u>Total Energy Cost</u> Total Energy Cost per Annum (@10p/kWh) Scheme Life	 (years)	 £184,284 30	 £122,308 30
Total Energy Cost over the Life of the Installation		£5,528,522.	£3,669,256.
Total Energy Cost Saving using Variable Road Lighting Levels		-	£1,859,266.
Period Required to Pay for the Variable Road Lighting Levels Equipment	(years)	5.99	Years

Cost Benefit Analysis for Variable Lighting

CO_2 Emissions

The reduction in energy usage has a direct relationship with CO_2 emissions. According to the DEFRA guidelines grid electricity produces 0.43 kg of CO_2 per kWh generated.

The reductions in CO_2 emissions per annum would be 215 tonnes.

The total reduction in CO_2 emissions over the 30 year life of the scheme would therefore be 6,450 tonnes.

The cost of the variable road lighting levels equipment will be paid for by the savings in energy costs in 6 years.

The annual energy saved, compared with a standard electromagnetic control gear installation, would be 617,755kWh. This gives a total energy saving over the 30 year life of the installation of 18,532,650kWh.

Appendix A-1 – Flowchart for Cost Benefit Analysis

When carrying out a cost benefit analysis of the variable lighting level schemes, the following points need to be considered:

The scheme life
The number of lamps in the scheme
The initial capital cost of the scheme considering:

- Type of control gear; and
- Type of control system.

The Lamp

- Lamp life with conventional electromagnetic control gear;
- Lamp life with electronic control gear; and
- The cost of the lamp.

Maintenance

- The clean and group change frequency due to extended lamp life. The extended lamp life can be due to developments in lamp design and/or the use of electronic control gear and/or dimming;
- The consequences of extending the cleaning interval to greater than 36 months must to be established;
- Unplanned maintenance costs; and
- The labour and transport costs for routine and unplanned maintenance.

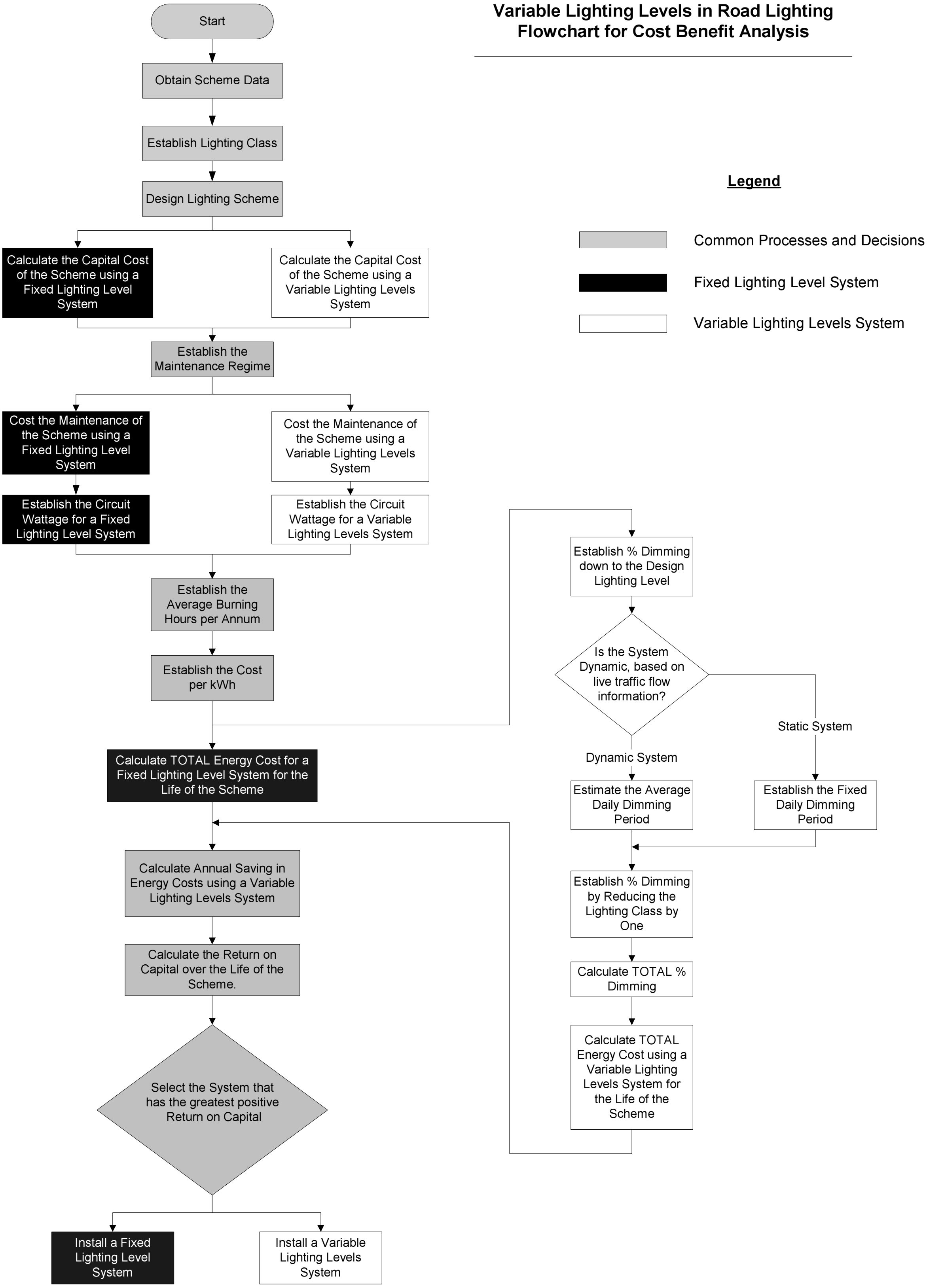
Energy

- The circuit wattage for the lamp and control gear;
- Burning hours;
- Scheme life in years; and
- Cost per kWh for varied/non-varied lighting.

Variable Lighting Levels

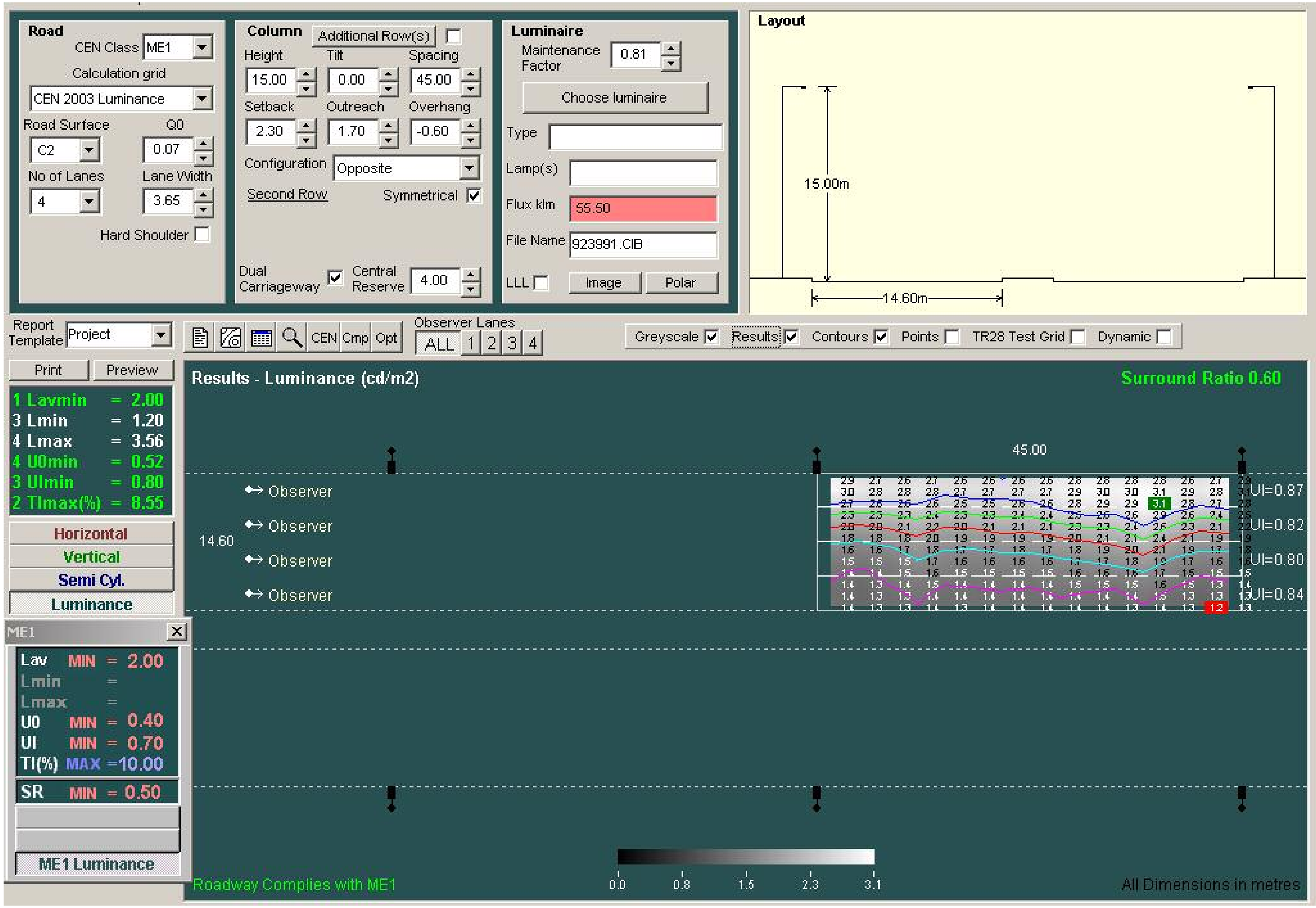
- Additional percentage dimming down to minimum design level;
- Percentage dimming down by one class as triggered by reduced traffic flow if a dynamic variable lighting levels system is utilised;
- Percentage dimming down by one class based on historic traffic flow data;
- Percentage energy saving with reduced lighting levels; and
- Total energy costs with varying lighting levels.
- Return on capital

Variable Lighting Levels in Road Lighting
Flowchart for Cost Benefit Analysis



Appendix A-2 – Motorway Lighting Design Calculations

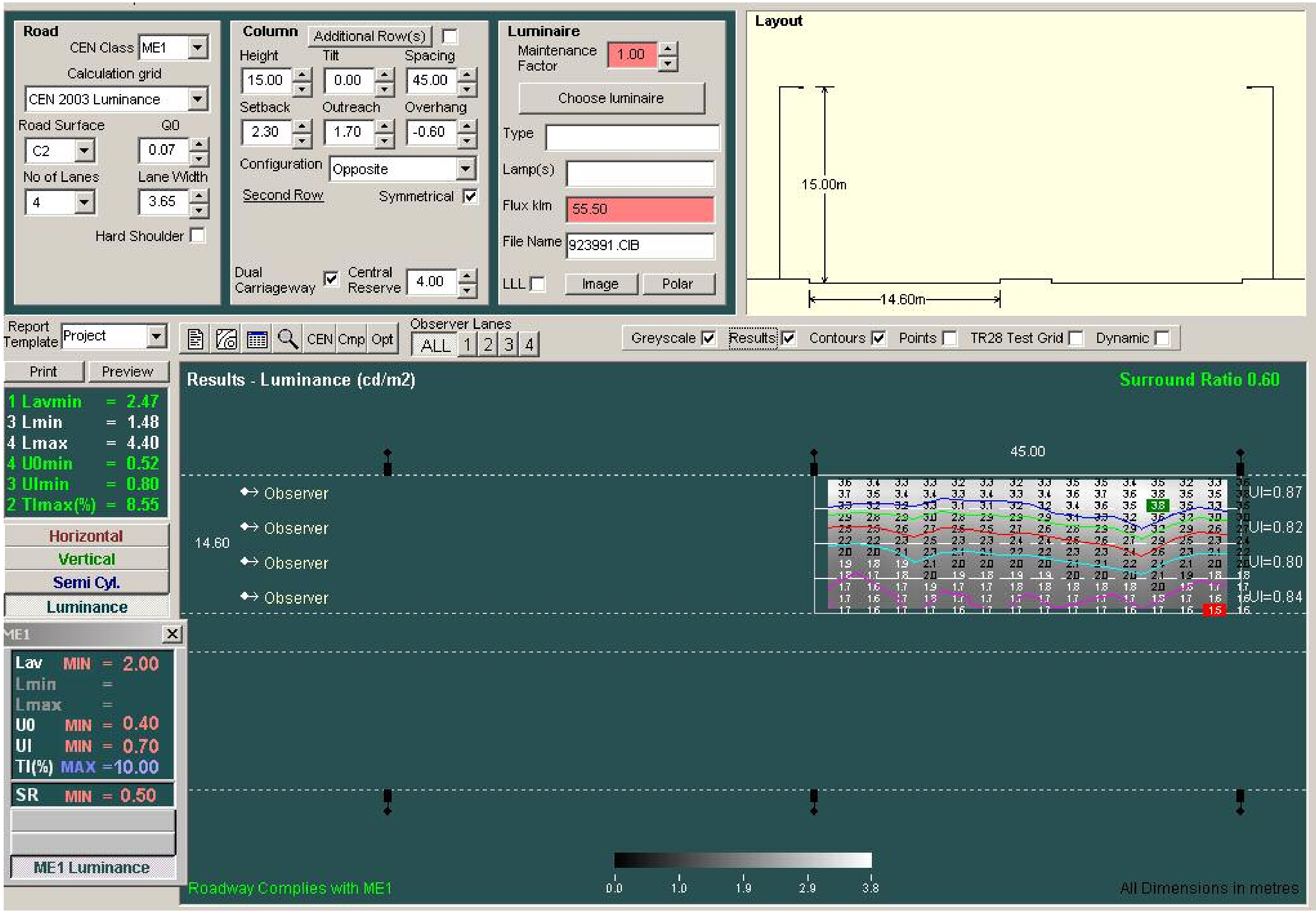
Existing Road Lighting to Lighting Class ME1 (Maintenance Factor = 0.81 – End of Lamp Life)



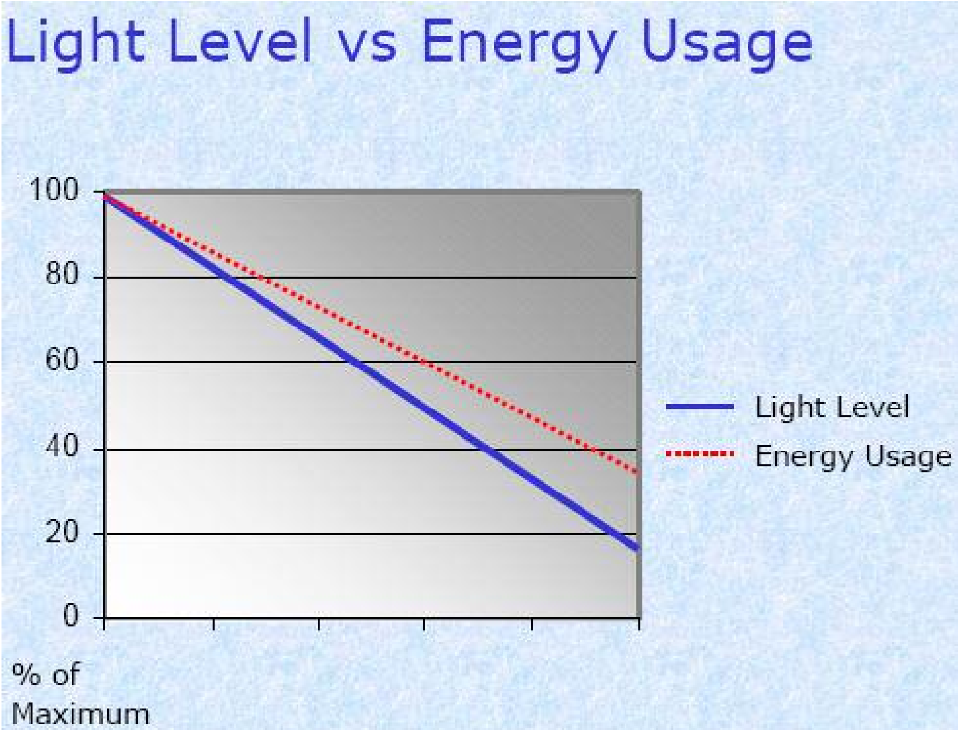
Existing Lighting Lighting ME1

Road to Class

(Maintenance Factor = 1.00 – i.e. Brand New Lamp)



Appendix A-3



Graph 1 – Typical relationship between lumen output and energy used

DIMMING TRAFFIC ROUTE LIGHTING

This is a desktop study based on a typical traffic route network consisting of a single 2 lane carriageway

METHODOLOGY

For this study it is proposed to evaluate the viability of utilising variable lighting and the estimated costs and cost savings

it is proposed to evaluate the use of:

a) Variable lighting levels due to variations in traffic flow.
b) Dimming due to over lighting
c) Dimming to Maintenance factor

In addition the energy reduction in changing from conventional electromagnetic control gear to electronic was calculated.

Details of the existing lighting layout and equipment type were obtained.

This grid road forms part of the main access route around the city and consists of a 2 lane single carriageways, with speed limits varying between, derestricted and 40mph. The road has infrequent junctions leading to the residential, industrial and commercial parts of the city. The grid road has been classified as a Strategic Routes.

a) Variable lighting levels due to variations in traffic flow.

Existing traffic flow data, was obtained and evaluated to determine the correct lighting class and the switching point between lighting classes

Lighting calculations were then undertaken to provide average design spacing's and to determine the reduction in lumens required to reduce the levels to those of the lower classes.

This percentage reduction in lumens was then converted into an energy reduction.

Typical installation and operational costs were obtained from several contractors.

b) Dimming due to over lighting

Lighting calculations were then undertaken to determine if a reduction in lumens was possible to reduce the average luminance to the required level.

c) Dimming to Maintenance factor

The savings available from dimming to the maintenance factor were evaluated.

General

The existing carriageway is approximately 2km long

The existing installed road lighting on the main carriageway is as follows:

Verge mounted staggered arrangement;
10m mounting height columns with 1m brackets arms; and
90W SOX deep bowl luminaires mounted with 5 degrees uplift
Private cable network fed from DNO supplied feeder Pillars

The existing feeder pillars are considered suitable for reuse all of the other existing equipment is not suitable for reuse

Proposed Layout

The propose replacement lighting scheme uses 74 No 10m mounting height columns with post top mounted 250W SON flat glass luminaires and approximately 4km of private cable network.

Maintenance factor

Proposed IP 6X luminaire
36 Month Cleaning Interval
Low pollution Area

Luminaire Maintenance factor = 0.90

Lamp lumen maintenance factor from data sheets is 0.90

Maintenance factor = 0.90 x 0.90 = 0.81.

Traffic Flow Data and Lighting Classes

It has been determined that the road is a strategic route, with traffic flow (ADT) of approximately 16,880. Under BS EN 13201-2: 2003 Road Lighting – Performance requirements the road should be illuminated to lighting class ME2.

As the varying of the road lighting levels will be determined by hourly traffic flows, detailed traffic flow data has been obtained and analysed.

"The guidance on lighting class application for motorways and traffic routes uses average daily traffic flow (ADT), which is the normal concept in traffic planning, and is usually known. Peak traffic is generally taken to be 10% and 12% of ADT in rural and urban areas respectively. If hourly flows are known, and the peak hour traffic is greater than 12%, the peak traffic should be taken into account when selecting the lighting class."

The value for ADT is required for the initial selection of the road lighting class. In order to use variable road lighting levels through the night the hourly traffic flows are required. The value of ADT for each lighting class needs to be converted to hourly traffic flows using the advice above. The relevant hourly traffic flows for each lighting classes is shown in the table below

The hourly traffic flow transition levels will be as follows:

Lighting Class	ME2	ME3a
Hourly Traffic Flow (Vehicles)	≥1,500	<1,500

Table 1: Lighting Class and Hourly Traffic Flow

From an analysis of the hourly traffic flow it has been established that the transition levels occur at 10.00pm and 5.00am therefore the lights can be dimmed for 7 hours a night.

The road length is 2km

Design spacing is 30m
The proposed layout requires 74 columns

SCHEME EVALUATION

ENERGY SAVING DUE TO APPLICATION OF VARIABLE ROAD LIGHTING LEVELS DUE TO TRAFFIC FLOW

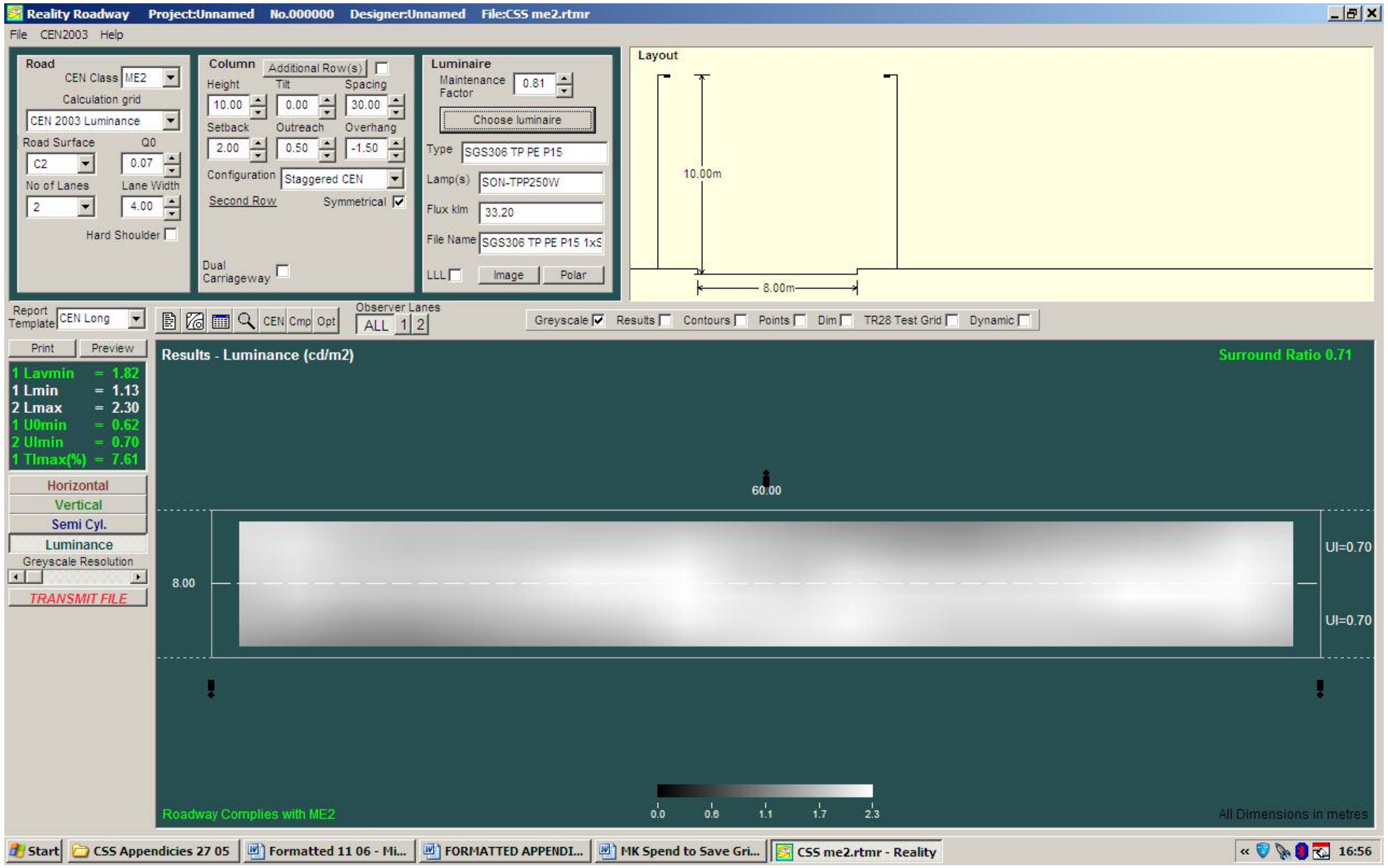
Details	**Units**	**Electro-magnetic Control Gear**	**Electronic Control Gear**
-			
Total No. of luminaires		74	74
Total Installation Cost for Proposed Scheme		£208,460.00	£222,760.00
Energy Costs			
Circuit Wattage per 250W SON Lamp	(kW)	0.28	0.265
Total No. of Luminaires		74	74
Total Wattage for Installation (full lamp power)	(kW)	20.72	19.61
Burning Hours per Annum	(hours)	4,317	4,317
Total kWh per Annum	(kWh)	89,448	84,656
Energy Saving due to dimming			
Variable Lighting Levels due to Traffic Flow - 15%	(kWh)	-	12,698
Reducing Lighting Levels due to Overlighting - 15%	(kWh)	-	12,698
Reducing Lighting Levels due to Maintenance Factor - 7.6% (9% of 85%)			6,434
Total Energy Saving per Annum	(kWh)	-	31,831
Total Energy Consumed per Annum	(kWh)	89,448	52,826
Total Energy Cost			
Total Energy Cost per Annum (@8.5p/kWh)		£7,603	£4,490
Scheme Life	(years)	30	30
Total Energy Cost over the Life of the Installation		£228,093.01	£134,705.22
Total Energy Cost Saving using Variable Road Lighting Levels		-	£93,387.80
Period Required to Pay for the additional costs of Installing the Variable Road Lighting Equipment	(years)	4.59	

Average Annual Savings

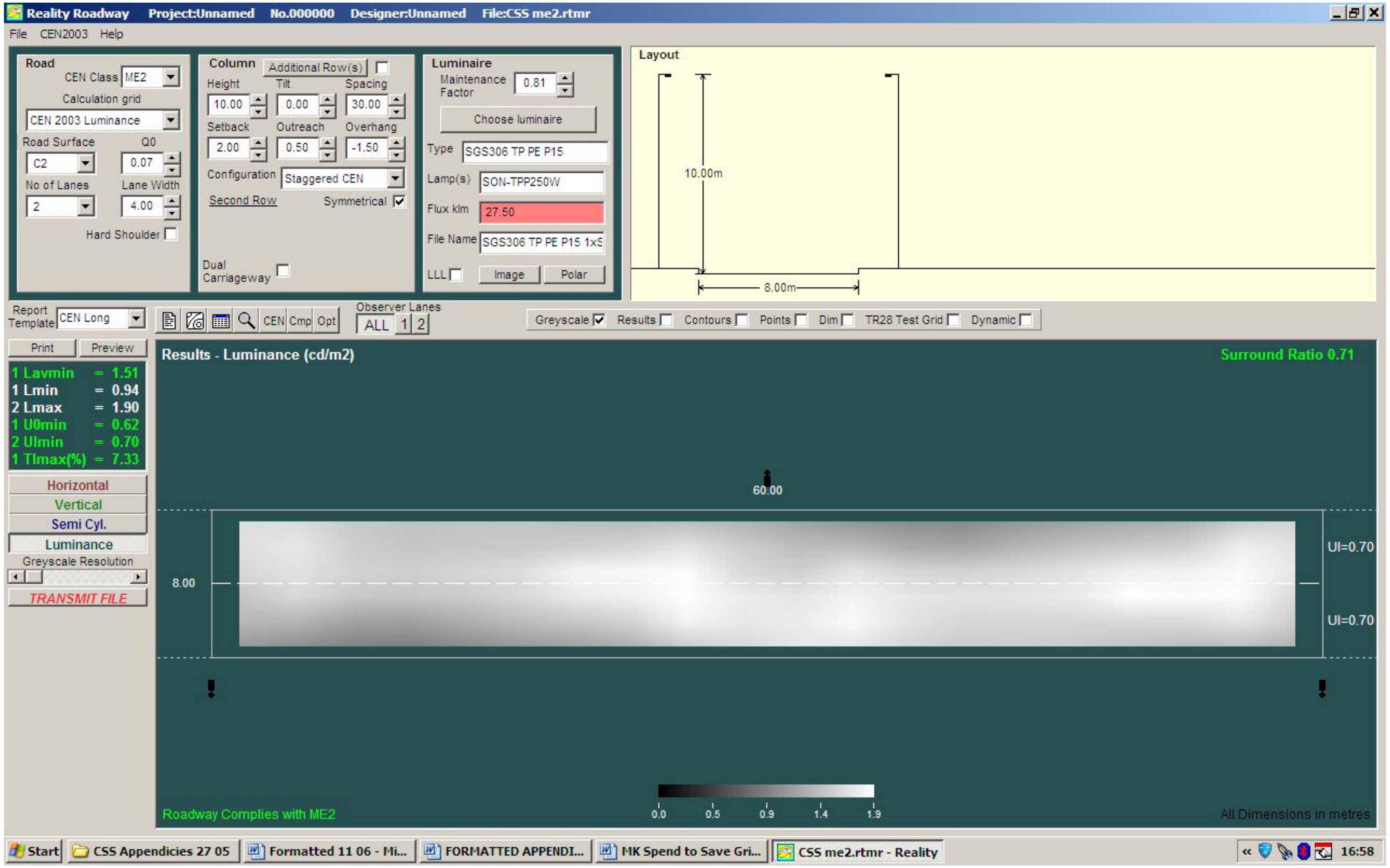
	Energy (kWh)	Cost (£)	*CO2 (Tonnes)
Annual savings due to installing electronic control gear	4,792	407.31	2.06
Annual savings due to applying Variable lighting Levels	12,698	1,079.37	5.46
Annual savings due to reducing Over Lighting	12,698	1,079.37	5.46
Annual savings due to applying dimming to MF	6,434	5,46.88	2.77
Total annual savings	36,623	3,112.93	15.75
Total Annual savings per km	18,311	1,556	7.87

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh

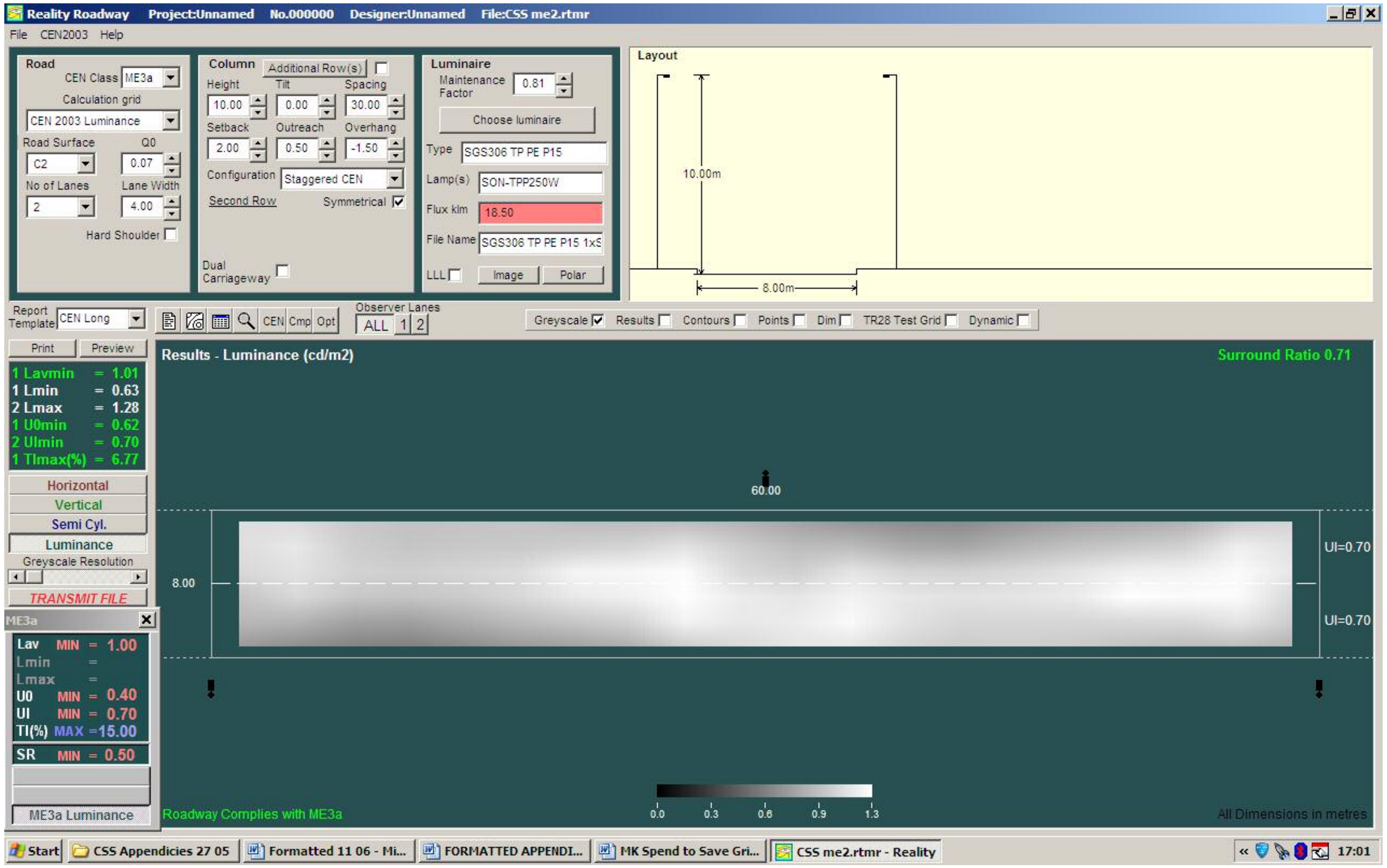
Proposed Road Lighting to Lighting Class ME2 (Maintenance Factor = 0.81 – End of Lamp Life)



Proposed Road Lighting to Lighting Class ME2 (Maintenance Factor = 0.81 – End of Lamp Life) with Lumen reduction to account for over lighting



Proposed Road Lighting to Lighting Class ME2 (Maintenance Factor = 0.81 – End of Lamp Life) with Typical Lumen reduction to reduce lighting class to ME3a



Dimming Residential Roads

This is a desk top study based on the typical residential area lighting

METHODOLOGY

For this study it is proposed to evaluate the viability of utilising variable lighting and the estimated costs and cost savings for option 1 and option 2A

For this study it is proposed to look at:

a) Variable lighting levels due to variations in traffic flow.
b) Dimming due to over lighting
c) Dimming to Maintenance factor

In addition the energy reduction in changing from conventional electromagnetic control gear to electronic was calculated.

a) Variable lighting levels due to variations in traffic flow.

From the definitions of traffic flow for subsidiary roads, normal and high traffic flows "are associated with local amenities such as clubs, shopping facilities, public houses, etc"

So as these local amenities are not open all night and so it could be argued that the traffic flow changes during the night and the lighting level altered when these amenities are closed.

For the purposes of this study it is assumed that the local amenities close at 11.00pm and all local traffic as dispersed by midnight and that the local shops open at 06.00 therefore allowing for the increase in traffic flow prior to the shops opening we have decided to dim for 5.5 hours per night.

Lighting calculations were then undertaken to determine the reduction in lumens required to reduce the levels to those of the lower classes.

This percentage reduction in lumens was then converted into an energy reduction.

b) Dimming due to over lighting

Lighting calculations were then checked to see if a reduction in lumens was possible to reduce the average luminance to the required level.

c) Dimming to Maintenance factor

The savings available from dimming to the maintenance factor were evaluated.

Option 1 – A blanket level of S2 applied to all of the roads within the area using SON

Details	**Units**	**Electro-magnetic Control Gear**	**Electronic Control Gear**
-			
Total No. of luminaires		35	35
Total Installation Cost for Proposed Scheme		41220	45420
Energy Costs			
Circuit Wattage per 70W SON Lamp	(kW)	0.084	0.075
Total No. of Luminaires		35	35
Total Wattage for Installation (full lamp power)	(kW)	2.94	2.625
Burning Hours per Annum	(hours)	4,100	4,100
Total kWh per Annum	(kWh)	12,054	10,763
Energy Saving due to dimming			
Variable Lighting Levels due to Traffic Flow - 22%	(kWh)	-	2,368
Reducing Lighting Levels due to Maintenance Factor - 9%			969
Total Energy Saving per Annum	(kWh)	-	3,336
Total Energy Consumed per Annum	(kWh)	12,054	7,426
Total Energy Cost			
Total Energy Cost per Annum (@8.5p/kWh)		£1,025	£631
Scheme Life	(years)	30	30
Total Energy Cost over the Life of the Installation		£30,737.70	£18,936.62
Total Energy Cost Saving using Variable Road Lighting Levels		-	£11,801.08
Period Required to Pay for the additional costs of Installing the Variable Road Lighting Equipment	(years)	10.68	Years

Option 1 – A blanket level of S2 applied to all of the roads within the area using SON

	Energy (kWh)	Cost (£)	*CO2 (Tonnes)
Annual savings due to installing electronic control gear	1,292	109.78	0.56
Annual savings due to applying Variable lighting Levels	2,368	201.26	1.02
Annual savings due to applying dimming to MF	969	82.33	0.42
Total annual savings	4,628	393.37	1.99
Total Annual savings per km	5,785	492	2.49

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh

Option 2A – All roads classified according to the requirements of BS 5489- 1: 2003 with SON

Details	Units	Electro-magnetic Control Gear	Electronic Control Gear
-			
Total No. of luminaires		33	33
Total Installation Cost for Proposed Scheme		39720	43680
Energy Costs			
Circuit Wattage per 50W SON Lamp	(kW)	0.06	0.056
Total No. of Luminaires		33	33
Total Wattage for Installation (full lamp power)	(kW)	1.98	1.848
Burning Hours per Annum	(hours)	4,100	4,100
Total kWh per Annum	(kWh)	8,118	7,577
Energy Saving due to dimming			
Variable Lighting Levels due to Traffic Flow - 18%	(kWh)	-	1,364
Reducing Lighting Levels due to Maintenance Factor - 9%			682
Total Energy Saving per Annum	(kWh)	-	2,046
Total Energy Consumed per Annum	(kWh)	8,118	5,531
Total Energy Cost			
Total Energy Cost per Annum (@8.5p/kWh)		£690	£470
Scheme Life	(years)	30	30
Total Energy Cost over the Life of the Installation		£20,700.90	£14,104.21
Total Energy Cost Saving using Variable Road Lighting Levels		-	£6,596.69
Period Required to Pay for the additional costs of Installing the Variable Road Lighting Equipment	(years)	19.10	Years

Option 2A – All roads classified according to the requirements of BS 5489-1: 2003 with SON

	Energy (kWh)	Cost (£)	*CO2 (Tonnes)
Annual savings due to installing electronic control gear	541	46.00	0.23
Annual savings due to applying Variable lighting Levels	1,364	115.93	0.59
Annual savings due to applying dimming to MF	682	57.96	0.29
Total annual savings	2,587	219.89	1.11
Total Annual savings per km	3,234	275	1.39

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh

Part Night Lighting on Residential Roads

This is a desk top study based on the typical residential area lighting

METHODOLOGY

For this study it is proposed to evaluate the savings made from operating a part night lighting regime on option 1 and 2A from the typical residential area relighting.

In addition the energy reduction in changing from conventional electromagnetic control gear to electronic was calculated.

For the purposes of this study it is assumed that the local amenities close at 11.00pm and all local traffic as dispersed by midnight and that the local shops open at 06.00 therefore allowing for the increase in traffic flow prior to the shops opening we have decided to turn off the lights for 5.5 hours per night.

Option 1 – A blanket level of S2 applied to all of the roads within the area using SON

Details	**Units**	**Electro-magnetic Control Gear**	**Electronic Control Gear**
-			
Total No. of luminaires		35	35
Total Installation Cost for Proposed Scheme		41220	45420
Energy Costs			
Circuit Wattage per 70W SON Lamp	(kW)	0.084	0.075
Total No. of Luminaires		35	35
Total Wattage for Installation (full lamp power)	(kW)	2.94	2.625
Burning Hours per Annum	(hours)	4,100	4,100
Total kWh per Annum	(kWh)	12,054	10,763
Energy Saving due to dimming			
Energy saving due to Part Night - 48%	(kWh)	5785.92	5,166
Reducing Lighting Levels due to Maintenance Factor - 9%			504
Total Energy Saving per Annum	(kWh)	5785.92	5,670
Total Energy Consumed per Annum	(kWh)	6,268	5,093
Total Energy Cost			
Total Energy Cost per Annum (@8.5p/kWh)		£533	£433
Scheme Life	(years)	30	30
Total Energy Cost over the Life of the Installation		£15,983.60	£12,986.68
Total Energy Cost Saving using Part Night Lighting		£14,754.10	£14,457.70

	Energy (kWh)	Cost (£)	*CO2 (Tonnes)
Annual savings due to installing electronic control gear	1,292	109.78	0.56
Annual savings due to applying Variable lighting Levels	5,166	439.11	2.22
Annual savings due to applying dimming to MF	504	42.81	0.22
Total annual savings	6,961	591.70	2.99
Total Annual savings per km	8,701	740	3.74

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh

Option 2A – All roads classified according to the requirements of BS 5489-1: 2003 with SON

Details	**Units**	**Electro-magnetic Control Gear**	**Electronic Control Gear**
-			
Total No. of luminaires		33	33
Total Installation Cost for Proposed Scheme		39720	43680
Energy Costs			
Circuit Wattage per 50W SON Lamp	(kW)	0.06	0.056
Total No. of Luminaires		33	33
Total Wattage for Installation (full lamp power)	(kW)	1.98	1.848
Burning Hours per Annum	(hours)	4,100	4,100
Total kWh per Annum	(kWh)	8,118	7,577
Energy Saving due to dimming			
Energy saving due to Part Night - 48%	(kWh)	3896.64	3,637
Reducing Lighting Levels due to Maintenance Factor - 9%			355
Total Energy Saving per Annum	(kWh)	3896.64	3,991
Total Energy Consumed per Annum	(kWh)	4,221	3,585
Total Energy Cost			
Total Energy Cost per Annum (@8.5p/kWh)		£359	£305
Scheme Life	(years)	30	30
Total Energy Cost over the Life of the Installation		£10,764.47	£9,142.62
Total Energy Cost Saving using Part Night Lighting		£9,936.43	£10,178.22

Table 8: Cost Benefit Analysis for Variable Lighting

	Energy (kWh)	Cost (£)	*CO2 (Tonnes)
Annual savings due to installing electronic control gear	541	46.00	0.23
Annual savings due to applying Variable lighting Levels	3,637	309.13	1.56
Annual savings due to applying dimming to MF	355	30.14	0.15
Total annual savings	4,533	385.28	1.95
Total Annual savings per km	5,666	482	2.44

*Long Term - DEFRA long term marginal factor 0.43 kg CO_2 per kWh

Appendix C:

Energy Costs

Table of current energy contacts and costs

	Cornwall	Plymouth	Torbay	Devon	Somerset	N. Somerset	Bristol	Dorset	Poole	Wiltshire	Swindon	Gloucestshire
L+S Units (1000's)*	**52**	**33**	**16.5**	**84**	**52**	**18**	**40**	**40**	**20**	**45**	**27**	**65**
Unit Rate (p)**	**5.92**	**9.50**	**7.23**	**6.02**	**6.14**	**8.70**	**7.64**	**7.47**	**8.80**	**6.34**	**5.84**	**6.63**
Period (mths)	24	24	12	24	24	12	12	12	12	24	12	12
Supplier	EDF	EIC	EDF	nPower	-	-	-	SSE	EDF	EDF	SSE	EDF
Purchaser	Negotiated	Contract	OGC	Contract	Contract	-	-	PFI Contract	OGC	Contract	-	OGC
% Green	10	0	100	0	100	100	100	-	100	100%	-	100
% Brown	90	100	0	100	0	0	0	-	0	0	-	0
Bid Period	Jan-07	Feb-08	-	Oct-07	-	-	-	-	-	Nov-07	-	Oct-07
End Date	Jun-09	Mar-08	Oct-08	Sep-09	Oct-09	Sep-08	Dec-08	Apr-09	Mar-09	Oct-09	Aug-08	Oct-08
Est. Change from previous	↓ 12%	↑ 20%	-	↓ 7%	-	-	-	-	-	↓ 11%	-	-

* Figures taken from the HE News Map
** Numbers rounded up to two decimal points

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TRL

Invest to save – sustainable street lighting

Recent increases in the cost of electrical energy have caused lighting authorities to review their policy on the provision, operation and maintenance of street lighting. There is also an increased awareness of both light pollution and CO_2 emissions, and these are often cited as additional reasons to switch off street lighting. However, such decisions need to be balanced against the major benefits that accrue from the provision and operation of appropriate and well-maintained street lighting. The benefits of lighting are lost when the lights are switched off, whereas if the lighting is reduced to a lower level it will still provide appropriate illumination, giving security and safety to all road users, particularly pedestrians and cyclists.

There are many ways in which the use and thus the cost of electrical energy for street lighting can be reduced; however, these will generally require the authority to "Invest to Save". This project reviewed the ways in which authorities can make savings in energy use and the cost of providing street lighting, without necessarily switching off. This report makes a number of recommendations towards this objective. These include: that lamp type and lighting class are chosen carefully, in accordance with the British and European Standards; that appropriate cost-benefit analyses are used to compare the different options when setting policies and procedures, or when replacing existing street lighting; that traffic signs and bollards be illuminated only when required under photo electric cell control and not 24 hours per day as is common; and that street lighting should only be switched off or removed where this can be demonstrated as safe and practical, and after community consultation.

Typical energy costs and details of the calculations of potential savings from implementing variable lighting levels are presented, for a wide range of street lighting scenarios. Several case histories are also given as further demonstrations of what can be achieved.

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