SCOTTISH FUTURES TRUST

Street Lighting Energy Efficiency Outline Business Case

East Dunbartonshire Council

November 2012

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East Dunbartonshire Council

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Executive Summary

Introduction

East Dunbartonshire Council ("EDC") has reviewed the implications of an investment in the energy efficiency of its street lighting stock as one of two pilot projects being undertaken by the Scottish Futures Trust ("SFT"). The need for change within its street lighting service is driven by:

- The condition of the existing network and the public and political expectations in relation to street lighting standards.
- Meeting its strategic objectives in relation to a sustainable, attractive and safe environment.
- The significant revenue budgetary pressures facing the Council along with ongoing and anticipated energy price increases.
- The need to secure energy efficiencies, to reduce carbon emissions and to set an example to others in this area.

The Council's specific objectives for any investment in its street lighting include:

- Reducing carbon emissions.
- Reducing the future burden of energy bills and other associated costs.
- Meeting current commitments and demands relating to embedding of sustainable practices in the Council's activities.
- Being better prepared for future regulatory and monitoring requirements.
- Setting an example to encourage partners and the wider community to make similar changes.
- Raising the environmental profile of the Council.

Approach

The Project Team including EDC, SFT and Ove Arup, the technical advisors, identified a long list of technical options from which the following shortlist of options were selected for further analysis against a Status Quo Option:

Table 1: Shortlist of Options

Option	Definition
Status Quo	A Base Case Option which broadly represents continuation of the current asset strategy. This includes replacing existing lanterns with conventional technology “low energy” sources at a rate similar to current renewal strategy (replacement of 500 lanterns and 300 columns+ lanterns per year).
Option 3	Accelerated replacement of old SOX lamps and introduction of Central Management System (CMS) equipment. Trimming and dimming implemented by 50% between midnight and 6am.
Option 4	LED technology installed on all lights between 2015-2017 with CMS capability. Lantern replacement was based on Status Quo option prior to LED programme. Trimming and dimming implemented by 50% between midnight and 6am.

Results

The quantitative and qualitative impacts of the options were assessed and the results are summarised within the Table below:

Table 2: Summary of Results

Category	Option 3	Option 4
Financial:		
Initial Investment	£3.5m	£6.6m
Forecast savings/(additional cost) post-financing costs	£(0.60)m	£9.4m
Forecast savings pre-financing costs	£3.7m	£18.7m
Energy Efficiency:		
Decrease in annual energy consumption	19.4%	63.5%
Tonnes of carbon saved	7,327	26,752
Benefits	Benefits arise including 19.4% decrease in carbon emissions and lower electricity consumption. These have been quantified above. Other qualitative benefits are broadly neutral. Vehicle and pedestrian safety are assessed as having a marginally negative impact whilst marginally positive benefits are delivered in relation to visual impact and light pollution and central overhead savings.	Significant benefits arise including a 63.5% decrease in carbon emissions and lower electricity consumption. These have been quantified above. Other qualitative benefits are broadly neutral. Vehicle and pedestrian safety are assessed as having a marginally negative impact whilst marginally positive benefits are delivered in relation to visual impact and light pollution and central overhead savings.
Risks	Provides modest protection to the Council against future energy	Provides maximum protection to the Council

Category	Option 3	Option 4
	cost rises.	regarding future energy cost rises but the timing of the procurement will need to take into account the forecast realisation of LED cost savings and increasing energy efficiency. LED technology is still in development and the long life cycle and reliability levels are yet to be fully tested.

The analysis indicates that Option 4:

- Delivers a 63.5% decrease in energy consumption and emissions. As street lighting accounts for c.25% of the Council's electricity bill this results in the Council's overall electricity bill and forecast emissions decreasing by c. 15%.
- Delivers forecast savings of c. £9.4m against a Status Quo case after allowing for financing costs. The overall savings arise from savings in forecast electricity costs which the Council would incur; forecast maintenance costs if the investment is not made and forecast costs of carbon. It has been assumed that the project is funded through Council borrowing. If it was funded through the capital budget or reserves savings would increase to c. £18.7m.
- Is based on assumptions regarding the forecast cost of LEDs and the forecast LED efficiency in the installation period 2015/6 and 2016/7. A sensitivity was run assuming that capital costs were 5% higher than anticipated and this indicated that significant savings were still generated.

The analysis indicated that Option 4 was the most appropriate technical solution and the Table below summarises how it meets the Council's objectives for a street lighting investment:

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Table 3: Meeting the Council's Objectives

EDC Objective	Commentary
Reduce carbon emissions	Option 4 potentially reduces carbon emissions from a base case projection of 54,000 tonnes to 27,300 tonnes.
Reduce the future burden of energy costs and other associated costs	The total savings of £18.7m pre-financing costs include £12.6m of energy cost savings based on the 2011/12 budgeted costs of energy. Following completion of the option appraisal outturn electricity costs for 2011/12 became available – on the basis of this the energy cost savings increased to £15.5m. This indicates the significant potential benefits of such an investment as a hedge against future electricity costs.
Embedding sustainable practices into Council activities	Street lighting currently accounts for c.25% of the Council's energy bill and c.25% of their carbon emissions. An investment in energy efficiency street lighting would have a material impact upon both these variables. A 60% decrease in energy consumption would lower the Council's total electricity bill by 15% and its total carbon emissions by 15%.
Better prepared for future regulatory and monitoring requirements	The investment includes the introduction of a CMS which will allow the Council to monitor the real time performance of their street lighting networks both in performance terms and also in energy consumption terms. This will assist EDC to understand and respond to future regulatory and monitoring requirements.
Setting an example to encourage partners and the wider community to make similar changes	EDC has participated in the development of a SFT business case to test the energy efficiency implications of an investment in the street lighting estate. This business case and an
Raising the environmental profile of the Council	

EDC Objective	Commentary
	associated toolkit will be made available to other Authorities to consider and, where appropriate, take forward similar initiatives.

The analysis was subject to sensitivity testing which confirmed that Option 4 provided EDC with the best protection against future energy and carbon cost increases. There are risks associated with option 4 relating to the LED cost base including both forecast improvements in LED efficiency and forecast decrease in costs. As with any investment project, these risks would require to be monitored and managed in the procurement of a street lighting energy efficiency project. Option 4 was therefore selected as the preferred technical option.

Affordability

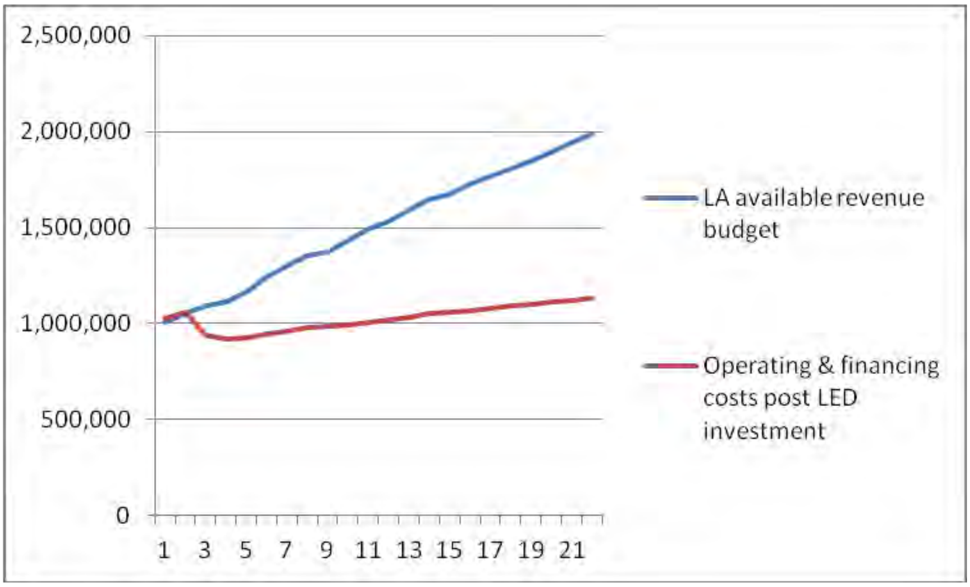
The affordability implications of the project were also reviewed. In considering affordability, EDC took cognisance of:

- the forecast costs of the preferred option and adopted a prudent approach regarding the realisation of energy cost savings and maintenance savings.
- The need for accelerated column replacements at an estimated cost of £3m. This cost will be additional to the cost of the energy efficiency investment quoted in Table 2. EDC will need to accelerate the column replacement programme if the project is progressed. It is assumed that £1.6m of this cost is met through existing capital budgets and £1.4m is financed through PWLB borrowing.

The affordability analysis was based on EDC's current budgets indexed assuming general inflation of 2.5% and real electricity price inflation per DECC indices.

The Diagram below summarises the affordability position for Option 4:

Diagram 1: Affordability Implications of the Preferred Technical Option



The diagram indicates that during the implementation period in 2015/16 and 2016/17 there is a small affordability gap between the Council budgets and the forecast costs of the project. However, thereafter the cost of operating the street lighting network, including repaying the finance, is significantly below budget. This is due to the level of protection the project provides to the Council regarding future electricity costs. Over the 20 year period from the installation of LEDs, the differential between the Council's budget and the costs of the project, including allowance for column replacements, is £10.4m in current prices. The Table below highlights the affordability at key points during this period:

Table 4: Affordability Analysis (£'000s)

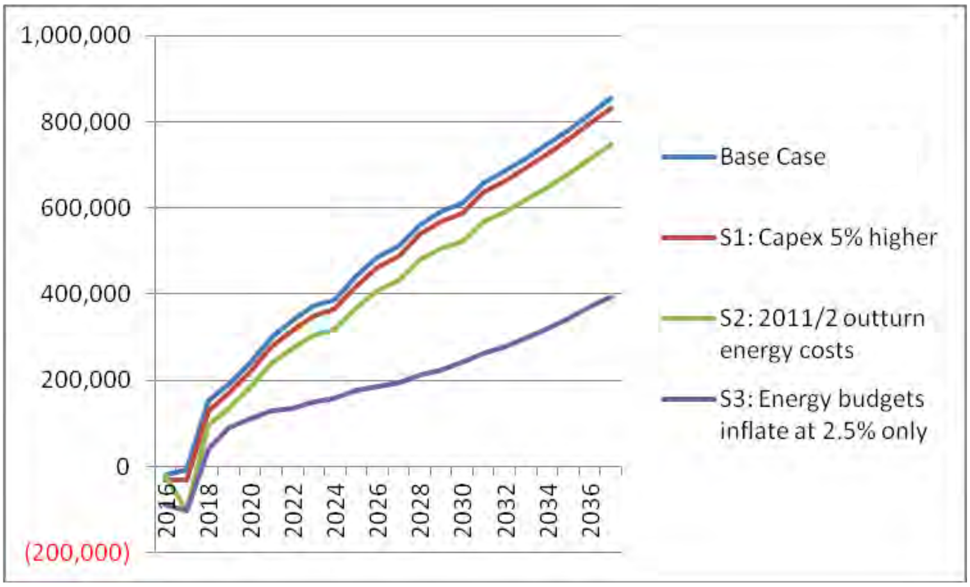
Year	Total	2015/16	2016/17	2017/18	2018/19	2019/20	2024/15	2029/30	2034/35
LA available revenue budget	33,045	1,004	1,053	1,092	1,115	1,167	1,433	1,672	1,894
Forecast cost of LED	(22,620)	(1,024)	(1,061)	(940)	(922)	(924)	(993)	(1,062)	(1,112)
Budgetary Impact	10,425	(20)	(8)	152	193	243	440	810	782

The affordability position was subject to sensitivity analysis to test the following scenarios:

- Capital costs 5% higher than anticipated.
- the cost of electricity based upon the outturn electricity costs for 2011/12 rather than budgeted figures.
- The Council's budget for energy inflating by 2.5% rather than the forecast price increases based on DECC's real price indices.

The results of this analysis are summarised within the Diagram below which indicates that in the worst case scenarios the Council may incur a cost to deliver the project during the two years of installation but that thereafter the project is affordable delivering significant budgetary savings:

Diagram 1.2: Sensitivity Analysis (£) of Affordability Position



On the basis of the analysis, the maximum cost to the Council in these first two years is £86k in year 1 and £103k in year 2 in the event that Council budget's for electricity only inflates by 2.5% per annum.

The analysis indicates that the preferred technical option is affordable to the Council on the basis of forecast budgets.

Next Steps

An energy efficiency project utilising LEDs and incorporating a CMS provides potentially significant savings in carbon and energy costs. It also provides significant protection against future energy and carbon costs. Prior to progressing the project, the business case identifies a number of steps which the Council would need to undertake prior to procuring a street lighting energy efficiency project which includes:

- Undertaking a full column and cabling conditions survey in order to inform the forecast column replacement cost. These are columns whose replacement may need to be accelerated in the event that the Council decides to take this project forward.

- Integrate the column and cabling replacement strategy with the preferred investment option identified within this Business Case.

- Develop a specification for the planned works which the business case assumes will be procured as a design and install contract.

Following these actions, the original business case assumptions should be refreshed to confirm that the project still delivers value for money and is affordable to the Council.

The preferred option assumes that the works commence in 2015/6 and complete in 2016/17 enabling the above steps to be completed prior to a potential procurement in 2014.

1. Strategic Context

1.1. Introduction

East Dunbartonshire Council ("EDC") has reviewed the implications of an investment in the energy efficiency of its street lighting stock as one of two pilot projects being undertaken by the Scottish Futures Trust. This Section reviews the Council's wider strategic context for such an investment and how it assists in meeting Council objectives.

1.2. Strategic Objectives

The East Dunbartonshire Community Planning Partnership has a shared vision with the Council, which is:

Working together to achieve the best with the people of East Dunbartonshire

This vision is underpinned by a core set of values, which are its commitment to:

Its Customers
Pursuit of Excellence
Innovation
Partnership
Its Employees

1.3. Single Outcome Agreement

Through the implementation of the Single Outcome Agreement ("SOA"), EDC is determined to achieve this vision and the following three priorities to support its work.

- The promotion and support of enterprise and employment while protecting and enhancing its natural and built environment.
- The health, safety, wellbeing and success of its communities.
- Improvement in the value of the services it provides and the outcomes it achieves.

The East Dunbartonshire SOA is built on the solid foundations of partnership working across the area. Its local outcomes reflect this relationship and they are:

1. East Dunbartonshire has an expanding economy with a competitive and diverse business and retail base.

2. East Dunbartonshire has an increasingly attractive and accessible built and natural environment for its residents and visitors.

3. Its children and young people are safe, healthy and ready to learn.

4. Its more vulnerable citizens, their families and carers benefit from effective care and support services.

5. Its older population are supported to enjoy a high quality of life.

6. Its communities are healthier.

7. East Dunbartonshire is a safe environment in which to live, work and visit.

8. Its communities are equipped to make the most of training and employment opportunities, activities and facilities that contribute to their quality of life and wellbeing.

9. Its communities are provided with effective, responsive and accessible services through the added value of partnership working.

East Dunbartonshire's Street Lighting network provides a significant contribution towards achieving a number of these outcomes and most significantly in relation to local outcomes 2, 7 and 9.

1.4. Climate Change

Climate change is described as one of the biggest challenges mankind has ever faced, and carbon dioxide is one of its main causes. As an energy user and a community leader, East Dunbartonshire Council has an important role to play, by reducing its own carbon emissions and by setting an example for others to follow.

Sustainable development, including carbon reduction, is now a key strategic priority for EDC, reflected in all levels of work, from strategic plans to practical activities. Through working with the Carbon Trust to revise its Carbon Management Plan and set a new target date of 2015, the Council has taken stock of progress so far towards its target of 25% carbon reduction, and has mapped out further actions that it will take to help reach the established target.

Furthermore, the Council has acknowledged the need to look beyond this target to ensure that improvement is continual and that its further planned actions play a part in meeting Scotland's world-leading climate change targets.

EDC is committed, through various duties, policies and initiatives, to reducing its carbon emissions. Since 2008, there have been some key developments in national legislation and in-house policies, enacting the 'polluter pays' principle. The Climate Change (Scotland) Act 2009 is a key development; this law sets world-leading targets for carbon reduction. There are therefore growing incentives for carbon reduction.

The following list indicates the key drivers that now influence the Council's activities:

- Climate Change (Scotland) Act 2009, which sets a Public Sector Duty
- Energy Performance of Buildings Directive
- Carbon Reduction Commitment
- Scotland's Zero Waste Plan
- Scottish Energy Efficiency Action Plan
- EU Energy Efficiency Action Plan 2011 (including requirement for councils to refurbish at least 3% of buildings every year)
- EDC's Single Outcome Agreement
- EDC's Strategic Improvement Plan
- EDC's Business Improvement Plan
- EDC's Best Value responsibilities
- EDC's Sustainable Development Strategy and Action Plan
- EDC's Climate Change Declaration
- EDC's Green Office Policy
- EDC's Energy Policy

In addition to these specific drivers, the Council is aware of, and anticipates being influenced by, various national developments, including likely reporting requirements emerging from the Financial Reporting Manual, Scottish public sector efficiency indicators and the Scottish Government's Leadership by Example programme. Various EU-level measures are also expected through the forthcoming Directive on Energy Efficiency and Savings.

According to the Department of Energy and Climate Change's Total Emissions 2009 release, the total figure for East Dunbartonshire's "CO2 emissions within the scope of influence of Local Authorities" is 519.7 kt.

While carbon emissions arise from almost every Council activity, the most significant of these can be grouped under a few key headings:

- Buildings and street lighting
- Transport (business travel and commuting)
- Waste (in-house and from Council-operated domestic collections)

This business cases focuses upon the carbon arising from street lighting.

1.5. Street Lighting

The current emissions for street lighting are based on the following information:

- Total number of street lights: approximately 17,500
- Declared annual burning hours are 4,118 per light
- Standard consumption of lamps: 84W
- Energy saving from installation of electronic control gear (applicable to part-night dimming too): 10%
- Energy saving from part-night dimming: 15%
- Energy saving changing from yellow to white light is 26% (84w → 62w)

The Council's Roads Lighting section has taken forward initiatives including energy-efficient control gear in new lanterns, part-night dimming and replacement of yellow lights with white. In the short-term, street lighting measures will continue to be implemented. The Scottish Futures Trust pilot project is of particular importance in shaping how the Council now moves forward with investment in the lighting network given all of the above factors.

1.6. Council Objectives

In participating in this pilot exercise EDC seeks to secure robust financial data which will inform any future investment strategy in the street lighting network. The current financial climate has placed significant pressure on the Council's revenue budget with significant savings having been made over recent years and likely to be required in the future. In being able to reduce its carbon footprint, the Council will not only improve the local environment but will also be able to achieve revenue efficiencies through a reduction in its street lighting energy usage.

The key factors for consideration will be:

- The level of capital investment required and timing.
- The funding sources available to support the necessary capital investment.
- The revenue savings such investment will generate and the payback periods involved.
- The energy reduction outcomes from network upgrading.
- The level of service being consistent with stakeholder expectations and satisfaction levels (current levels of electronic control gear, part night dimming, LED sign lighting and Council commitment to continue / progress these elements).

A business case which establishes that these requirements can be successfully achieved will clearly assist the Council in meeting its objectives. These objectives have been identified by the Council as:

- Reducing carbon emissions.
- Reducing the future burden of energy bills and other associated costs.
- Meeting current commitments and demands relating to embedding of sustainable practices in the Council's activities.
- Being better prepared for future regulatory and monitoring requirements.
- Setting an example to encourage partners and the wider community to make similar changes.
- Raising the environmental profile of the Council.

1.7. Current Condition of the Street Lighting Network

1.7.1. Lighting Columns

EDC has approximately 17, 500 lighting columns in total of which approximately 50% are known to be in good or very good condition. In recent years a number of columns (mainly of mid 70s steel construction) have collapsed across the Council area as a result of structural failure. Fortunately, all cases were without injury to persons or damage to property. Whilst any column considered to be of serious structural condition would be removed as a matter of course by the Council, there are some 4,000 columns across East Dunbartonshire of a similar mid 1970's age and construction. This situation has directly influenced the Council's street lighting capital programme over recent and for future years, with capital investment being directed towards the structural replacement of columns.

1.7.2. Lanterns and Control Systems

The corresponding c.17,500 lanterns include standard energy efficient electronic control gear (20%) and dimmable units (1%). There is an ongoing project to replace all lanterns for illuminated signs with LED type. The existing control system comprises primarily automatic photo electric cells for dawn to dusk switching operations, supplemented by a small number of solar dial time clocks to mimic the above operation in instances where photo cells are impractical.

Whilst EDC is currently retrofitting LED to its externally illuminated street signs and is approximately 50% complete, its use of LED for street lighting units is limited and to date has been restricted to a selected number of new developments. On these occasions the Developer has been instructed to install LED. Once it is installed the Council monitors these installations for faults and performance to determine if the technology is suitable for introduction on a wider basis across East Dunbartonshire.

The Council does not have any equipment or current plans in relation to central management systems for its road lighting network.

Some key points in relation to the lighting infrastructure include:

- Public perception of white light is good.
- Trial of residential roads being dimmed by 30% (midnight – 6am). There have been no complaints to date and public perception seems to be accepting.

- Some main roads are dimmed by 50% due to low traffic volumes compared to design traffic volumes.

Perhaps the most significant reliability issue is with large scale section failures affecting lighting units supplied by network cabling which is under the ownership of the utility companies and therefore outwith the control of the Council. Extended response times in resolving these issues can result in considerable complaints and adverse press / public perception.

1.8. Investment / Replacement Strategy

Despite there being a sustained investment in the street lighting infrastructure by the Council over recent years, East Dunbartonshire suffers from an historic ‘under investment’ in its street lighting stock, dating back many years. Effective Street Lighting is recognised as a public safety issue and naturally attracts a high level of interest from the public and Elected Members. Accordingly the Council attaches a high priority to national KPI's and, in relation to street lighting, has taken measures to direct capital investment towards the replacement and upgrading of its network of street lighting columns and the replacement of its cable network on a planned annual basis. In this regard the Council’s 4 year street lighting capital programme has identified a proposed rolling programme of c. £500,000 per annum. The factors referred to above have had an influence on the types of materials used and specifically in relation to:

- Lamp / lantern specification.
- Programme / investment strategy for column / cabling replacement considers elements comprising structural condition.
- Electrical integrity and fault history.

This combined with inspections and EDC staff knowledge determines the selection of future renewal projects. Priority for lantern replacement programme is directed to areas identified as being suitable where column condition is good. Allowing for a proportional spread of unknown column conditions to poor, average and good categories, it is estimated that some 1,750 columns might require short term replacement at an estimated budget cost of some £3.5 million. At current investment levels, this represents some 7 years work whilst other columns are deteriorating naturally, as is the case with any other asset.

There is an ongoing programme whereby some 500 lanterns are replaced annually through existing capital and revenue funding. All new lanterns have electronic energy efficient control gear and current levels of dimmable equipment are to be further progressed in suitable areas. Current levels of investment would afford replacement of all remaining non-electronic lanterns over approximately 28 years, although targeted investment could expedite this.

Road sign lanterns are currently being replaced with LED's and all road signs will be lit by LED's within the next 1-2yrs.

EDC's key issues in relation to current investment strategy include:

- Guarantees on long lifespan of lamps from manufacturers (e.g. currently SON lamps have a long guarantee).
- Mix of lamp and lantern types to spread the risk of mass failure of new technology.
- Functionality of cable network with new technology.
- Re-cabling to feeder pillars and removing installations from the utility company's supply is important.
- Prioritising more equipment and maintenance within EDC ownership to improve fault responses.
- EDC concerns about having equipment installed on every lantern due to potential weakness created by drilling holes in lanterns.
- EDC will consider LED technology in the future but with a conservative approach whereby detailed consideration will be given to proven installations in other Council areas before installing LED's on a large scale basis.

1.9. The Need for Change

The need for change is therefore driven by a number of key factors

- The desire to continually improve the condition of the existing network and the public and political expectations in relation to standards of street lighting.
- Meeting the Council's objectives in relation to a sustainable, attractive and safe environment.

- The significant revenue budgetary pressures facing the Council along with ongoing and anticipated energy price increases.
- The need to secure energy efficiencies, to reduce carbon emissions and to set an example to others in this area.

It is essential that these factors are considered in a manner which makes best use of the limited resources available, achieves value for money and a sustainable outcome. Any significant capital investment will require to deliver significant revenue savings and a fit for purpose lighting infrastructure, which meets current needs and can readily adapt to future technological improvements.

The remainder of this business case:

- Details the approach adopted to assess the energy efficiency implications of various street lighting investment opportunities.
- Appraises a long list of technical options available to EDC to upgrade its street lighting infrastructure taking cognisance of the Council's objectives and the nature of the existing estate.
- Appraises a short-list of technical options including SON and LED lighting approaches. This includes an analysis of the financial, risk and qualitative aspects of the options;
- Identifies a preferred technical option and examines the affordability implications of this.

It then summarises the next steps required to take forward an energy efficiency business case.

2. Approach

2.1. Introduction

This business case appraises the technical options available to EDC to improve the energy efficiency of its street lighting including lamps, lanterns and central management systems. It tests a range of energy efficient technology options against the Council's objectives outlined in Section 1 which include:

- Reducing carbon emissions.
- Reducing the future burden of energy bills and other associated costs.
- Meeting current commitments and demands relating to embedding of sustainable practices in the Council's activities.
- Being better prepared for future regulatory and monitoring requirements.
- Setting an example to encourage partners and the wider community to make similar changes.
- Raising the environmental profile of the Council.

The Business Case has been developed by:

- East Dunbartonshire Council street lighting and finance teams.
- Scottish Futures Trust; and
- Ove Arup & Partners (Arup), technical advisors.

2.2. Objective

The objective of the business case is to assess the energy saving potential of various technology measures and their ability to deliver efficiencies that benefit EDC in the long term and result in an acceptable payback on an initial investment.

2.3. Approach

The approach adopted to assess the energy efficiency options included five key steps outlined below. It was undertaken in accordance with HM Treasury's The Green Book which provides guidance on option appraisal within government.

Step 1: Data Gathering

The exercise involved the technical advisors, Arup, reviewing and evaluating the Council's street lighting data system and making an assessment of its accuracy. The integrity and robustness of the base data is critical to the option appraisal, informing the selection of the preferred option and is fundamental to ensuring that robust conclusions are drawn.

The street lighting data was categorised and summarised in tables and reports to inform the development of technical options.

The results of this review are summarised within Section 3 of the Business Case.

Step 2: Develop and Evaluate Long List of Technical Options

A long list of 6 technical options and a Status Quo option were developed with EDC, Arup and SFT. The long list of technical options were analysed financially through analysis of the technical cost elements within a financial model which included consideration of the financing implications of the long list of options. Key outputs on initial investment, revenue savings, payback, emissions, energy consumption reduction and "fitness for purpose" were taken into consideration when deciding which options were to be short-listed.

The results of the analysis of the long-list of technical options are detailed within Section 3 of this Business Case.

Step 3: Evaluate Shortlist of Technical Options

A short list of two technical options was selected by the Council for additional analysis including financial, risk and qualitative analysis. A carbon benefits appraisal was also undertaken. The shortlisted options were compared to the status quo option.

Risks were identified for each shortlisted technical solution, and these risks were then categorised with appropriate mitigation strategies aligned to them.

Benefits were appraised to assess the ecological, environmental and social (for example, pedestrian safety and crime) impacts of each shortlisted option.

Sensitivity analysis was carried out on the shortlisted options to understand the factors that had the biggest impact on the predicted base case savings and payback. Assumptions on energy inflation, carbon cost and funding were sensitised as part of this exercise.

The results of the analysis of the shortlist of technical options are detailed within Sections 4, 5 and 6 of this Business Case.

Step 4: Preferred Option

A preferred technical solution was identified on the basis of the evaluation of the short-listed options. This is detailed within Section 7 of this Business Case.

Step 5: Affordability and Next Steps

The affordability implications of the preferred technical option were considered by EDC covering both the energy efficiency aspects of the project and the need to fund column replacements. This is detailed within section 8 of the Business Case. Section 9 considers the approach to implementing the preferred technical option including the next steps required to confirm the investment case.

3. Technical Options Appraisal – Long List

3.1. Introduction

This section of the Business Case:

- Reviews the existing asset inventory and details the key technical assumptions upon which the analysis is based.
- Identifies a long list of technical options taking into consideration column, cabling and feeder box renewals.
- Considers the financial implications of the long list options.
- Considers the qualitative implications of the long list options.
- Selects the short-listed options to be evaluated in more detail.

3.2. Existing Asset Inventory

The street lighting assets have been installed and developed over many decades, with some of the current assets being over 50 years old. At various times over this period each asset is likely to have had components replaced or renewed in its entirety. Inevitably, as is common for nearly every Council around the UK, the records kept of the works vary depending on the priorities and available resources of the Council at the time that the work was done.

EDC currently use a database system called “Hilight Horizon” to record information on the column, lantern, lamp and maintenance history. The database is recognised by the Council to have a number of shortcomings both in the detail and the reliability of the information stored. Data less than 15 years old is considered to be generally reliable, but age details of some of the control and lamps are believed to be unreliable due to their maintenance practice of recycling. For example, “new” controls may have been recorded as having been installed but are actually recycled equipment which has been in use elsewhere for a number of years. The records for assets older than 15 years old are generally felt to be less reliable. Information within the database is limited to historic details; no condition information, predicted asset life or future maintenance requirements are included. EDC are currently in the process of migrating asset information into a new system and are taking the opportunity to cleanse the data and undertake additional surveys as necessary.

The data used in preparing this business case was based on output provided from the Hilight Horizon system but was then adjusted based on discussions with EDC's street lighting asset team drawing on their in-depth knowledge of the assets.

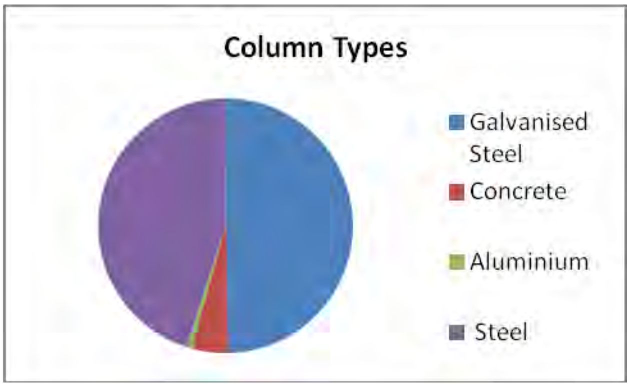
3.2.1. Summary of Street Lighting Assets

The EDC asset register data provided consisted of a number of different search criteria extracted from the database system:

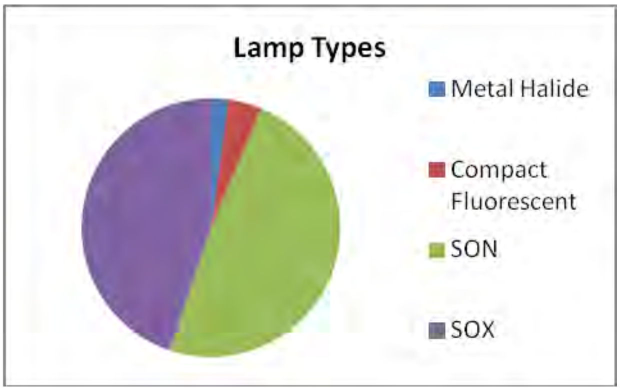
- Data on age, height and material of columns.
- Energy Report detailing quantities of different light source types and wattages – including any dimming installed at the time.
- Control Types.
- Data on road network classification and lengths.

From the data it was possible to establish an age profile of column infrastructure, however as the data did not link columns to lantern types it was not possible to establish a correlation between particular lantern types/wattages and column material type/height or age. In addition to this, the data identified a greater number of columns than lanterns, indicating that some older assets may not have been removed from the database following replacement. An appropriate profile of lantern/column combinations was developed in collaboration with EDC's knowledge and experience of their assets to allocate columns of age, type and height to lanterns as considered appropriate.

More detailed asset sheets are included in Appendix 1.



There are a total of 17,405 street lights considered in the business case. Of these approximately 50% are on galvanised steel columns, 45% on older painted steel columns and the remainder either concrete or aluminium columns.



The EDC asset database indicated a wide range of lighting types in use throughout the region. Approximately 50% of assets are high pressure sodium SON lamps (30% of which being efficient electronic gear), 46% low pressure sodium SOX lamps (94% of which have the higher efficiency type control gear). The remaining 4% of lanterns comprise of metal halide light sources (CDO-TT and CDM-T) and compact fluorescent sources (PL-L lamp).

3.3. Identification of Replacement Solutions

Workshops were held between the study team and EDC officers to discuss EDC's strategic objectives and potential future replacement solutions that would be considered applicable within their individual council area. These workshops consisted of a round table discussion on replacement solution options, ranging from utilising existing conventional technology on a like for like replacement basis to the large scale implementation of new and emerging street lighting technology.

3.3.1. Column, Cabling and Feeder Box Renewals

The asset information available did not allow columns to be matched with lantern types at an individual asset level, nor was specific column condition information available. Therefore, it was not possible to derive an integrated column and lantern replacement programme which was informed by column condition.

It was agreed that the column, cabling and feeder box replacement programme would be effectively separated from the option analysis. All options (excluding the 'Do Nothing' option) would include for the continued replacement of 300 columns per annum along with associated feeder box and cabling work. The lantern replacement programmes assume that they are retrofitted to existing columns, and if at a later date the column was replaced, then the lantern would be recycled where it had not reached the end of its useful economic life.

The common Capex spend assumption included for these items in all business case options is £500k per annum.

The requirement for column replacement impacts upon the affordability of any investment made in the street lighting assets and this was therefore considered within the overall analysis of the affordability of the preferred option, as detailed within Section 8.

3.3.2. Long List Replacement Options

A number of replacement options, each representing a potentially broad range of approaches were established for initial analysis. The main variables considered were:

- Lanterns/light source technologies.
- Control gear replacement and control strategy.
- Phasing.

The following key issues informed the renewal options:

- Existing work programmes. Strategic capital investment over time has allowed the retrofit of high efficiency control gear to almost all SOX and 30% of SON equipment. In addition EDC anticipate that by the end of 2012/13 financial year all signage lighting will have been replaced with LED lighting. EDC has a number of trial dimming installations underway.
- Safety priorities – road and community safety along with public perception. EDC is actively replacing old SOX equipment with 55W PL-L white light sources within residential areas.
- Guarantees on long lifespan of lamps from manufacturers. Manufacturers are now introducing guarantees to match the life-span of LED technology. EDC actively avoids reliance on single source suppliers and ensures a mix of lamp, lanterns and gear suppliers to spread the risk of mass failure of new technology.

3.3.3. Initial Options Analysed

Based upon discussions with the workshops, the following replacement solutions were agreed and a long list of technical options prepared:

Table 3.1: Definition of Options

Option	Definition
Do Nothing	**A 'theoretical test' option to explore the impact if no investment was made into replacing the ageing column stock and it was simply assumed that the light was removed from service if the column condition deteriorated sufficiently to fail.** Replacing lanterns and control gear on a like for like basis upon failure. Columns removed upon failure (based upon an assumed failure rate beyond 35years of age). No change in existing control strategy.
Status Quo	**A Base Case Option which broadly represented continuation of the current asset strategy. Assumptions around the Status Quo option are included within Appendix 6.** Replacing exiting lanterns with conventional technology "low energy" sources at a rate similar to current renewal strategy (replacement of 500 lanterns and 300 columns+ lanterns per year). All sources greater than 70W replaced with SON HF light sources. All sources less than 60W replaced with 55W PL-L. Replacing control gear on a like for like basis upon failure. No change in existing control strategy.
Option 1	**An enhanced Status Quo which introduces energy savings through dimming and trimming.** Replacing existing lanterns with conventional technology "low energy" sources at a rate similar to current renewal basis (replacement of 500 lanterns and 300 columns per year) – similar to the Status Quo option. Upgrade control gear with new dimmable high efficiency technology in new lanterns and control gear replacements. Trim the activation level for group controlled lighting circuits through

Option	Definition
	replacement of Photo Electric Control Units (PECU) from 70/35lux on/off activation to 35/18lux. Dimming of all residential areas by 30% between midnight and 6am. Implement step-dim operation of 10% on arterial roads to 50% output assuming reclassification of lighting standard will be acceptable between midnight and 6am due to reduced traffic flow.
Option 2	**Accelerated replacement of old SOX lamps and increased dimming.** Replace existing lanterns as per Option 1 however assumes the immediate replacement of all SOX sources with conventional light sources within the first two years. Upgrade control gear with new dimmable high efficiency technology in new lanterns and control gear replacements. Trim the activation level for group controlled lighting circuits through replacement of Photo Electric Control Units (PECU) from 70/35lux on/off activation to 35/18lux. Increase dimming of all residential areas by 50% between midnight and 6am. Implement step-dim operation as per Option 1.
Option 3	**As of Option 2 but with the introduction of Central management system (CMS) equipment.**
Option 4	**Replacement of all lanterns with LEDs after 3 years and introduction of Central management system equipment.** LED technology installed on all lights after 3 years (i.e. in 2015/6 and 2016/7) with CMS capability. Lanterns replacement based on Status Quo option prior to LED programme. Trim and dimming similar to Option 2.

A short description of the technologies used in the options above is included in Appendix 2.

3.4. Financial Analysis of Initial Options

Following the workshop, the technical costs were developed for each of the initial options which assessed Capex and Opex (energy, maintenance and carbon costs) including forecast energy consumption and carbon emissions.

The technical costs were then included within a financial model to assess the implications over a 25 year appraisal period. Table 3.2 details the results of the financial analysis of the long list of options - it presents the key outputs from the financial model, comparing the status quo option against the four technical options. This gives the Council a comparative position across all the technical options modelled.

The key assumptions included within this analysis are:

- The technical costs of each option including the Capex, Opex and carbon impact were provided by Arup expressed in real terms with a base date of 2012. Capital costs are inflated at 1% per annum to provide an estimate of the outturn cost. The capital costs for the Status Quo were excluded from the financial analysis as the Status Quo approximates to current EDC practices and there was no guarantee that this capital would be available. The impact of excluding the £4m capital costs from the analysis is to understate the savings generated by the other options.

- The column/cabling replacement programme implemented by EDC is common to all options and therefore is not included in this comparative analysis. It is however likely to have a significant impact on deliverability of any wide scale replacement option taken forward and is considered within Section 8 when looking at the affordability of the preferred option.

- The options include different phases of investment as detailed within Appendix 6.

- Financing costs have been calculated assuming the Council borrows from the Public Works Loan Board at 3.31% for a 20 year term.

- The figures in Table 3.2 assume a 25 year analysis period from 2012/13 to 2036/37 and are stated pre and post financing costs.

- Energy costs are based upon the Council's 2011/12 budget figure of 7.9p per KWh adjusted by the DECC indices[1] to give the forecast real prices over the duration of the analysis.
- Inflation is applied to all revenue costs and is assumed to be 2.5% in accordance with the Treasury Green Book.
- Carbon conversion factors are based on DECC guidance.

The results of the financial analysis are detailed below. The savings are based on the savings (or increased costs) compared to the status quo which broadly equates with the Council's existing street lighting practices.

Table 3.2: Financial Analysis of the Long-list of technical options (£'000)

Option	Nominal Cost of Upgrade £'000	Total savings/(increased cost) post financing £'000	Total savings/(increased cost) pre financing £'000	Percentage reduction in energy consumption
Do Nothing	0	4,026	4,026	50.8%
1	293	120	530	13.3%
2	2,741	246	3,842	19.0%
3	3,463	(599)	3,703	19.4%
4	6,604	9,358	18,711	63.5%

Table 3.3 details the split of the savings between maintenance, energy and carbon cost savings. These savings would then be required to repay any financing costs. The impact of financing costs, assuming the Council funds the investment through borrowing, are indicated in Table 3.2 above.

[1] [1] DECC indices can be found at:
http://www.decc.gov.uk/en/content/cms/statistics/energy_stats/prices/prices.aspx

Table 3.3: Breakdown of savings/(increased costs) (£'000)

Option	Total Maintenance Savings £'000	Total Energy Savings £'000	Total Carbon Savings £'000	Total Cost Savings pre-financing costs £'000
Do Nothing	(1,104)	4,919	211	4,026
1	(1,019)	1,478	71	530
2	408	3,255	179	3,842
3	183	3,337	183	3,703
4	5,397	12,631	683	18,711

The financial analysis indicates:

- **The Do Nothing** scenario indicates that energy consumption is significantly reduced resulting in approximately £4m of savings post-financing costs. However, this is the result of a large reduction in operational columns over the analysis period rather than the introduction of energy efficiency technology. The Do Nothing scenario results in significantly higher maintenance costs because no lantern renewals are included in the Capex budget. Lanterns are assumed to be replaced on failure on a like-for-like basis, leading to higher maintenance costs.

- **Option 1** generates limited savings of £120k post financing due to the low initial investment being paid back quickly from energy savings made. The maintenance costs increase due to the low capital investment resulting in greater levels of ad hoc maintenance. The impact on carbon emissions and energy costs is low. These are key EDC objectives for any investment programme as detailed within Sections 1 and 2.

- **Option 2** indicates savings of £3.8m pre-financing for an investment of £2.7m. Energy consumption is forecast to decrease by 19% and the forecast savings in the Council's energy costs are £3.3m. The option does not include a central management system (CMS) which may limit the generation of additional savings (as the CMS facilitates dimming and trimming and automatic reporting of lantern failures). However, these savings just offset the financing costs with forecast savings post-financing in the region of £246K.

- **Option 3** provides EDC with both maintenance and energy savings over the analysis period for a smaller initial investment than the LED solutions. Option 3 includes a CMS which potentially allows additional in-house management saving which is not quantified within this analysis. Savings over the analysis period are only slightly higher than the initial investment and do not cover the financing costs which result in a net cost to the Council of £599K.

- **Option 4** delivers the highest level of savings and at c.63% a significantly larger reduction in energy consumption than the alternative options. This is based on assumptions regarding (i) forecast decreases in the cost of LED lights; and (ii) forecast improvements in LED energy efficiency. The forecast savings post financing are £9.4m and pre-financing £18.7m.

Further details on the financial analysis of the long list of options are included within Appendix 6.

3.4.1. Qualitative Analysis of Initial Options

The qualitative assessment of the long list of options is summarised below:

Table 3.4: Qualitative Assessment of Long List of Options

Option	Advantages	Disadvantages
Do Nothing	None	Eventual lack of lighting amenity and non-compliance with British Standards would not be acceptable. Would leave EDC exposed to risk of legal action in the event of an accident. It is inconsistent with EDC's objective of embedding sustainable practices within its operations.
Status Quo	Delivery plan in line with current asset management approach. Gradual improvement in lighting quality	No significant reduction in energy consumption over time, resulting in increased energy costs and Carbon Reduction

Option	Advantages	Disadvantages
	through the removal of monochromatic SOX lamps and replacement with PL-L and SON light sources.	Commitment ("CRC") charges.
Option 1	Gradual improvement in lighting quality through the removal of monochromatic SOX lamps and replacement with PL-L and SON light sources. Significant energy saving realised through the application of trimming of operational light levels and dimming of residential.	The introduction of the PL-L lamp solution for residential areas offsets energy saving benefits from the trimming and dimming of circuits resulting in only modest reduction in energy consumption compared to the Status Quo.
Option 2	Accelerated replacement of SOX lamps brings forward light quality benefits. Increased dimming of residential areas reduces energy consumption increasing saving.	Dimming to 50% might not be acceptable to occupants of all residential streets.
Option 3	As for Option 2, the CMS should permit increased efficiencies in programming of routine maintenance, better target preventative maintenance and allow quicker reporting and response to failures, which should result in maintenance cost savings. CMS also permits the remote optimisation of dimming and switching cycles on a column by column basis.	As for Option 2. CMS requires different approach to managing assets if potential savings are to be realised.
Option 4	LEDs provide a significant reduction in energy consumption and maintenance costs compared to conventional technology sources. This is forward looking approach embedding	LED technology is continuing to develop which will influence future price levels and efficiency levels.

Option	Advantages	Disadvantages
	sustainable practices.	

3.5. Short-listing

On the basis of the above financial and qualitative analysis, options 3 and 4 were shortlisted as they best met EDC's objectives as detailed within Sections 1 and 2 of the Business Case.

Option 3 was chosen as it aligned with the Council's objectives of significantly reducing energy consumption and having a level of service consistent with stakeholder expectations. It also has the potential to deliver a step change in how the street lighting assets are managed through the use of a CMS system that would potentially enable more savings through predictive maintenance planning and information sharing systems. Although, Option 2 indicated higher savings per £ of investment, Option 3 was believed to have greater potential and would assist EDC "future proof" their service through including a CMS system. It was recognised that potential additional savings might be realisable under this option which would be tested as a sensitivity in the short-listing process.

Option 4 was selected for additional analysis due to its potential impact on energy efficiency and the shorter pay-payback periods and the total savings over the concession period. These options are analysed in more detail in following chapters.

4. Technical Option Appraisal - Quantitative

4.1. Introduction

The following three options were selected for further business case development and comparative analysis.

- Status Quo – this was used as the base case against which the other options were compared. This broadly equates to EDC's current street lighting practices. Further details on the Status Quo option are included within Appendix 6.

- Option 3 – Full investment in conventional technology lamps with CMS and maximising savings from dimming and trimming.

  Option 4 – Full investment in LED technology lamps with CMS and maximising savings from dimming and trimmings.

For each of these options the Capex, Maintenance, Energy and Carbon modelling was updated and fed into a separate funding model. The detailed assumptions behind these costs are included within Appendices 3 and 3.1.

4.2. Summary of Technical Costs

The technical costs detailed within Appendix 3 are summarised below in nominal (i.e. outturn) terms:

Table 4.1: Summary of Total Technical Costs over 25 years (£'m); Total Energy Consumption over 25 years (GWh) and Total Emissions over 25 years ('000 tonnes)

Cost Category	Status Quo Option	Option 3	Option 4
Total Capex over 25 years	4.0[1]	3.5	6.6
Total Maintenance over 25 years	6.2	6.0	0.8
Total Energy Consumption over 25 years (GWh)	160.6	137.5	74.6
Total Energy Cost over 25 years	22.2	18.9	9.6
Total Emissions over 25 years (tonnes of CO2)	54.0	46.6	27.3

Note 1: Capex of £4m was calculated as being required for the Status Quo within the technical costs. However, as this capex was not necessarily going to be available, it was excluded from the financial analysis of the options. The implication of this is to understate the savings attributable to other options in comparison to the status quo.

4.3. Financial Assumptions

The technical cost data was included within a financial model which calculated the financial implications of the options compared to the Status Quo. The Status Quo is the estimated cost over 25 years of continuing to deliver EDC's current service. The financial assumptions associated with the Status Quo are included within Appendix 6. The Financial Model assumptions are outlined within Section 3.4 of this Business Case.

The results of the financial analysis are included within Table 4.2. These detail the potential savings both post-financing and pre-financing.

Table 4.2: Financial Implications of the Short-listed options

Option	Investment Required (£000)	Savings/(cost) Post Financing (£000)	Savings Pre-Financing (£000)		Percentage reduction in energy consumption over concession
Option 3	3,463	(599)	Maintenance:	183	19.4%
			Energy:	3,337	
			Carbon:	183	
			Total:	3,703	
Option 4	6,604	9,358	Maintenance:	5,397	63.5%
			Energy:	12,631	
			Carbon:	683	
			Total:	18,711	

Table 4.2 indicates that the greatest savings are made under option 4 which is driven by the potential energy and maintenance savings associated with LED technology. This is reflected in the carbon saving associated with this option. Option 3 does contribute to a decrease in carbon emissions but delivers limited energy efficiency and savings.

4.4. Sensitivity Analysis

4.4.1. Capital and Operational Costs

In order to test these results, financial sensitivities were performed on: capital costs, energy costs, energy inflation and carbon costs. These sensitivities were performed on the forecast savings after financing costs and pre-financing costs on the following variables:

- **Cost of Upgrade** – this sensitivity assumed that capital costs were 5% higher than forecast.

- **Energy costs** - the base analysis assumes an electricity cost of 7.9p per KWh which is the 2011/2 budgeted cost to EDC. This cost had increased to 9.712p per KWh as at June 2012 and the impact of this price increase is assessed.

- **Energy cost inflation** - within the analysis the real electricity costs have been calculated by reference to DECC forecast costs which indicate the real increase expected in electricity prices over the analysis period. In order to covert this to a nominal figure RPI of 2.5% is applied to the forecast real costs. This sensitivity tested the impact of the nominal electricity costs increasing by 5% per annum.

- **Cost of carbon** - Within the base case the cost of carbon is assumed to be £12 per tonne (2012) increasing to £30 per tonne by 2023. It is then capped at £30 / tonne until the end of the analysis period. This sensitivity tested the carbon cost increasing by £2 per tonne per year over the 25 year period, i.e. increasing from £12 per tonne in 2012 to £60 per tonne in 2036.

The results of the sensitivity analysis on key cost assumptions are summarised within Table 4.3 below:

Option	Savings pre-financing	Savings post financing	Variation in savings to Base Case	Commentary
Base Case:				
Option 3	3,703	(599)	-	
Option 4	18,711	9,358		
Sensitivity 1: Capital costs increase by 5%				
Option 3	3,703	(814)	215	Savings decrease reflecting the increased cost of financing a 5% increase in capex.
Option 4	18,711	8,890	(468)	
Sensitivity 2: Energy Costs based on 2011/12 outturn				
Option 3	4,469	167	766	Savings compared to the base case increase as energy costs increase due to the lower
Option 4	21,608	12,255	2,897	

Option	Savings pre-financing	Savings post financing	Variation in savings to Base Case	Commentary
				energy consumption following investment
Sensitivity 3: Energy Cost Inflation				
Option 3	5,162	860	1,459	As for sensitivity 2
Option 4	24,386	15,033	5,675	
Sensitivity 4: Cost of Carbon				
Option 3	3,771	(531)	68	Greater savings are generated as the cost of carbon increases reflecting the lower energy consumption of Options 3 and 4 compared to the Status Quo.
Option 4	18,974	9,621	263	

4.4.2. Sensitivity Analysis – financing the investment

There are a range of approaches available to EDC to finance the investment in their street lighting estate. This could include use of capital receipts or capital budgets which do not have a direct cost of finance. However, EDC could also utilise finance from the Public Works Loan Board. Table 4.6 details the impact on the savings assuming PWLB finance is used to fund the full investment of £3.4m for option 3 and £6.6m for option 4. The PWLB is assumed to be fully repaid over a 20 year period. Under the Status Quo, Arup's have indicated a capital financing requirement of £4m however, as this is not included within EDC's current budget forecasts it is assumed that the full investment is financed through PWLB rather than the net investment.

Table 4.4: The impact of financing costs on the realisation of savings (£'000)

Option	Savings pre-financing	Savings post financing	Cost of finance
Base Care: Public Works Loan Board Finance @ 3.31%			
Option 3	3,703	(599)	4,302
Option 4	18,711	9,358	9,353
Sensitivity: Public Works Loan Board Finance @ 4%			
Option 3	3,703	(976)	4,679
Option 4	18,711	8,728	9,983
Sensitivity: Public Works Loan Board Finance @ 5%			
Option 3	3,703	(1,537)	5,240
Option 4	18,711	7,782	10,929

The sensitivities indicate that an increase in the cost of finance of 1.7% results in a 17% decrease in savings.

4.5. Summary

The financial analysis of options indicates that option 4 – the replacement of existing lights with LED lights and a central management system will deliver significant benefits and that a potential investment of £6.6m could deliver savings of £18.7m if capital budgets, capital receipts or reserves were used to finance the investment. These savings decrease to £9.4m over a 25 year period if the £6.6m investment is funded through PWLB borrowing at 3.3%.

The sensitivity analysis indicates that such an investment would provide significant protection to EDC in the event of future increases in energy costs, energy inflation and the cost of carbon. The increase in energy costs from 7.9p per KWh the 2011/12 budgeted cost upon which the business case analysis is based to 9.712p per KWh the actual cost of electricity during this period results in an increase in total savings of £2.9m.

Option 3 is not as attractive as option 4 in terms of the potential savings which can be made under the base case with an investment of £3.5m resulting in forecast savings of £3.7m before financing costs and a forecast cost of £599k after financing costs. However, this option does provide some protection from future increases in energy costs and carbon costs as demonstrated in the sensitivities performed above. It will also deliver additional savings if the CMS system is used to its full potential and central overheads can be saved.

The following sections of this business case explore the qualitative impacts of the two investment options against the status quo and the potential technical risks associated with both.

5. Technical Option Appraisal – Evaluation of Qualitative Benefits

5.1. Introduction

In appraising the options for qualitative benefits, the following criteria are considered relevant to street lighting retro-fit projects:

- Vehicle Safety – the differential impact of the options on maintaining acceptable levels of road safety for the public and vehicles.
- Pedestrian Safety – the differential impact of the options on the safe movement of pedestrians and cyclists.
- Crime and Security – the differential impact of any the options on the fear of crime and sense of security.
- Visual Impact and Light Pollution – the differential impact of the options on the visual impact of an area i.e. visual amenity is generally perceived to be increased by focused, high quality lighting designs that emphasis elements of the urban form. Also considered is the impact on light pollution.
- Ecology – the differential impact of the options on flora and fauna.
- Central overheads – the differential of the options on the ability to implement new ways of working to achieve more efficient use of central overheads.

For each issue the appraisal has taken the form of a qualitative evaluation. The Status Quo and the two shortlisted schemes differ technically only in terms of the lighting source, levels of luminance during off-peak hours and minor adjustments to the hours of operation. No research has been found which accurately quantifies the difference in impacts of the relatively subtle differences between the options on the criteria appraised.

Benefits associated with decreasing energy costs and carbon emissions are discussed within Section 4 of the business case as they have been quantified.

5.2. Evaluation of Benefits

Table 5.1 summarises the main differential benefits that an investment in energy efficiency street lighting is expected to deliver when compared to the Status Quo. A detailed review of these benefits and the ability to appraise them is included in Appendix 8.

Central overheads have been included in the qualitative evaluation since the benefits cannot be quantified at this time but the use of CMS brings additional benefits in this area.

Table 5.1: Summary of Differential in Benefits

Benefit	Status Quo	Option 3	Option 4
Vehicle Safety	Base Case	Marginal negative: depending upon the application of the dimming and trimming policy.	Marginal negative: depending upon the application of the dimming and trimming policy.
Pedestrian safety	Base Case	Marginal negative: depending upon the application of the dimming and trimming policy.	Neutral: the application of the dimming and trimming policies will be offset by the use of good colour rendering light sources.
Crime & Security	Base Case	Neutral: depending upon the application of dimming and trimming.	Marginal negative: the light source will be more focused and may result in some dark spots.
Visual Impact & Light Pollution	Base Case	Marginal Beneficial: due to dimming and trimming there will be less light pollution.	Marginal Beneficial: due to more focused light from the LEDs and the application of dimming and trimming.
Ecology	Base Case	Negligible impact	Negligible impact
Central Overheads	Base Case	Marginal Beneficial: the introduction of a CMS facilitates more efficient planning of maintenance and	Marginal Beneficial: the introduction of a CMS facilitates more efficient planning of maintenance and

Benefit	Status Quo	Option 3	Option 4
		removes the need for night scouting	removes the need for night scouting

The following section of the Business Case reviews the technical risks which may impact upon the option appraisal.

6. Risk Assessment

6.1. Introduction

A high level risk assessment of the three options has been undertaken. Table 6.1 summarises the key perceived technical and cost risks which might impact on the project:

Table 6.1: Risk Assessment

Risk	Issue, Impact and Commentary
Energy Prices	Issue Energy price escalation is either higher or lower than assumed in the business model Impact Energy savings are a key driver to the business case for Options 3 and 4 and an increase in prices above those assumed would improve the business case for these options and Option 4 in particular. Conversely, price rises below those assumed will weaken the business cases. Comment The DECC price forecasts are generally considered conservative and it is felt that price rises are more likely to be above these levels than below. A 'high energy cost' price sensitivity has been modelled. This risk has been covered as a sensitivity in Section 4.4 of this Business Case.
LED Costs	Issue The cost of LED technology for procurement in 2-3 years time (in Option 4) assumes that the unit rates of this technology reduces as market expansion takes place and supplier competition increases. Impact LED costs are a key driver to the business case for Options 4 and the business case would be weakened if predicted unit cost reductions are not realised. This risk has been covered as a sensitivity in Section 4.4 of this

Risk	Issue, Impact and Commentary
	Business Case. Comment Greater actual tendered data will become available over the next 12-24 months.
LED Efficiencies	Issue Energy efficiency of LED lanterns is expected to continue to improve over the next 2-3 years as lantern designs for column retro-fit projects develop. Impact If these improved efficiencies are not realised, the business case for Option 4 is weakened. Comment Greater in service performance data will become available over the next 12-24 months.
LED Life Cycle	Issue LED lanterns are assumed to have a 25 year operational life in line with guarantees of a number of manufacturers, however as they are new technologies they have not been tested in the field for this duration. Impact If contractual arrangements do not pass on the risk of the full replacement cost of lanterns failing before the end of their 25 year guarantee period, any cost transferred to the Council will weaken the business case of Option 4. Comment The extent that manufacturers and contractors will cover all costs within the guarantee period will become more apparent as contracts become more standardised.

6.2. Summary

Table 6.1 summarises the key technical risks associated with the option appraisal. The major risk is around forecast energy costs which has been included within the sensitivity analysis at Section 4.4. The remaining risks, which relate to Option 4, focus upon the assumptions made regarding the cost and efficiency in LED lighting and how quickly these are realised over time.

A more detailed risk assessment (covering condition of existing assets and financing costs) is included within Section 9 which considers the commercial risks associated with any preferred option and procurement strategy. A detailed risk matrix is included within Appendix 9.

7. Preferred Technical Option

7.1. Introduction

This section considers the results of the quantitative, qualitative and risk analysis to identify the Council's preferred technical option. The results of these analyses are summarised within Table 7.1:

Table 7.1: Summary of Option Appraisal Results against the Status Quo on a nominal (or outturn) basis

Category	Option 3	Option 4
Financial:		
Initial Investment	£3.5m	£6.6m
Forecast savings/(additional cost) post-financing costs	£(0.60)m	£9.4m
Forecast savings pre-financing costs	£3.7m	£18.7m
Energy Efficiency:		
Decrease in annual energy consumption	19.4%	63.5%
Tonnes of carbon saved	7,327	26,752
Benefits	Benefits arise including 19.4% decrease in carbon emissions and lower electricity consumption. These have been quantified above. Other qualitative benefits are broadly neutral. Vehicle and pedestrian safety are assessed as having a marginally negative	Significant benefits arise including a 63.5% decrease in carbon emissions and lower electricity consumption. These have been quantified above. Other qualitative benefits are broadly neutral. Vehicle and pedestrian safety are assessed as having a marginally negative

Category	Option 3	Option 4
	impact whilst marginally positive benefits are delivered in relation to visual impact and light pollution and central overhead savings.	impact whilst marginally positive benefits are delivered in relation to visual impact and light pollution and central overhead savings.
Risks	Provides modest protection to the Council against future energy cost rises.	Provides maximum protection to the Council regarding future energy cost rises but the timing of the procurement will need to take into account the forecast realisation of LED cost savings and increasing energy efficiency. LED technology still in development and the long life cycle and reliability levels yet to be fully tested.

On the basis of the above analysis, Option 4 is identified as the preferred technical option as this approach maximises the long term benefits to the Council in terms of meeting their objectives which were detailed in Sections 1 and 2 of this business case. There are risks associated with this approach in terms of the level of development of the technology and the timing of the realisation of LED cost and efficiency savings. However, the business case has adopted a prudent approach and under option 4 it is assumed that any such investment is not made until 2015. Section 7 of the Business Case details the affordability implications of the project to the Council and Section 8 reviews the pre-procurement activities that EDC would require to undertake. This would include further market testing to confirm the business case and the assumptions around costs and technologies prior to any procurement exercise.

Table 7.2 details how option 4 meets the Council’s objectives for this investment:

Table 7.2: EDC's Objectives and the Preferred Technical Option

EDC Objective	Commentary
Reduce carbon emissions	Option 4 potentially reduces carbon emissions from a base case projection of 54,000 tonnes to 27,300 tonnes.
Reduce the future burden of energy costs and other associated costs	The total savings of £18.7m pre-financing costs include £12.6m of energy cost savings based on the 2011/12 budgeted costs of energy. Following completion of the option appraisal outturn electricity costs for 2011/12 became available – on the basis of this the energy cost savings increased to £15.5m. This indicates the significant potential benefits of such an investment as a hedge against future electricity costs.
Embedding sustainable practices into Council activities	Street lighting currently accounts for c.25% of the Council's energy bill and c.25% of their carbon emissions. An investment in energy efficiency street lighting would have a material impact upon both these variables. A 60% decrease in energy consumption would lower the Council's total electricity bill by 15% and its total carbon emissions by 15%.
Better prepared for future regulatory and monitoring requirements	The investment includes the introduction of a CMS which will allow the Council to monitor the real time performance of their street lighting networks both in performance terms and also in energy consumption terms. This will assist EDC to understand and respond to future regulatory and monitoring requirements.
Setting an example to encourage partners and the wider community to make similar changes	EDC has participated in the development of a SFT business case to test the energy efficiency implications of an investment in the street lighting estate. This business case and an
Raising the environmental profile of the Council	

EDC Objective	Commentary
	associated toolkit will be made available to other Authorities to consider and, where appropriate, take forward similar initiatives.

8. Affordability

8.1. Introduction

This section reviews the affordability implications of the preferred technical option against existing EDC budgets.

8.2. Council Budgets

Table 8.1 summarises the existing Council budgets for lighting and identifies that element of the budgets attributable to the scope of the street lighting project i.e. the energy costs and maintenance costs. An additional allowance has been made for the cost of carbon associated with street lighting.

Table 8.1 East Dunbartonshire Council: Annual Street Lighting Budget (1012/3)

	Council Lighting Budget 2012/13 (£)	Council Budgets Available to Fund an energy efficiency project (£)
Capital Budget		
	400,000	400,000 available from 2013/4 to 2016/7
Revenue Budget		
Employee Costs	296,486	0
Supplies & Services	511,524	180,000
Electricity	645,000	645,000
Less: Income	(456,741)	
Total	996,269	825,000
Add: future budget required for carbon		38,740
Total **Total inflated to 2015/16**		863,740 1,004,495

Within the affordability analysis, it is assumed that supplies and services inflation will be 2.5% and that the electricity budget will inflate by the DECC indices to give the real electricity costs and then by inflation which is assumed to be 2.5% to give the nominal budget figure for electricity.

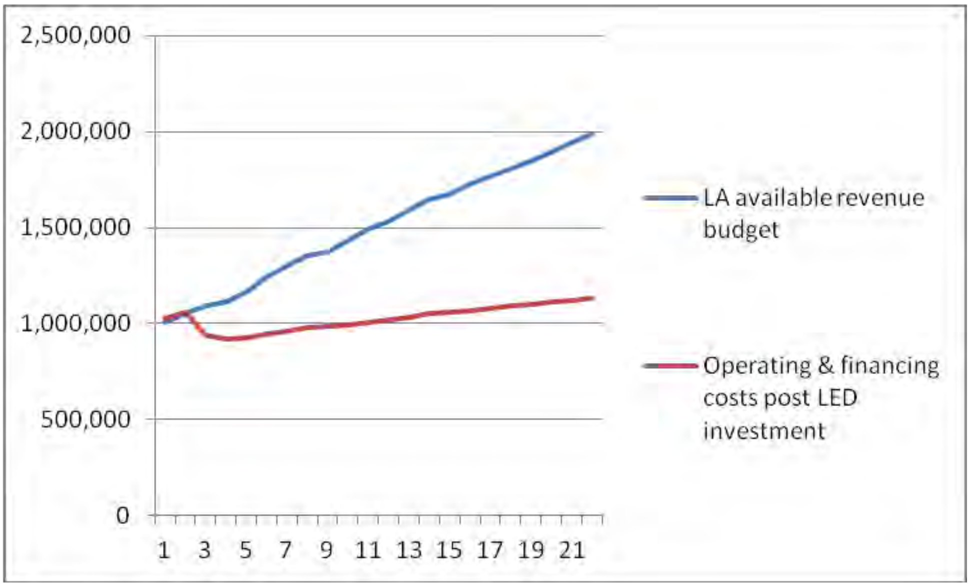
8.3. Affordability

In considering affordability, EDC have taken cognisance of:

- the forecast costs of the preferred option and adopted a prudent approach regarding the realisation of energy cost savings and maintenance savings. These assumptions are detailed within Appendix 6.
- The need for accelerated column replacements at an estimated cost of £3m. This cost will be additional to the cost of the energy efficiency investment quoted in Table 2. EDC will need to accelerate the column replacement programme if the project is progressed. It is assumed that £1.6m of this cost is met through existing capital budgets and £1.4m is financed through PWLB borrowing.

The affordability analysis is summarised within the Diagram 8.1:

Diagram 8.1: Affordability Analysis



The diagram indicates that during the implementation period in 2015/16 and 2016/17 the cost reductions against budget are marginal. The budgets are assumed to inflate in line with forecast increases in electricity costs (based on forecast real price increases provided by DECC and an assumption of a nominal inflation factor of 2.5%) and an inflation factor of 2.5% for carbon and supplies and services budgets. The diagram indicates the significant protection provided to the Council regarding the impact of future electricity costs - over the 20 year period from the installation of LEDs the Council is reducing forecast costs by £10.4m in current prices compared to budgets. Table 8.2 highlights the affordability at key points during this period.

Table 8.2 Affordability Analysis - nominal (£'000s)

Year	Total	2015/16	2016/17	2017/18	2018/19	2019/20	2024/15	2029/30	2034/35
LA available revenue budget	33,045	1,004	1,053	1,092	1,115	1,167	1,433	1,672	1,894
Forecast cost of LED	(22,620)	(1,024)	(1,061)	(940)	(922)	(924)	(993)	(1,062)	(1,112)
Budget Impact	10,425	(20)	(8)	152	193	243	440	810	782

8.4. Sensitivity Analysis

The affordability analysis was tested through sensitivity analysis as follows:

- Capital costs 5% higher than anticipated.
- The cost of electricity is based upon the 2011/12 budget figures. The affordability of the project was tested against the outturn electricity costs for 2011/12.
- The Council's budget for energy only inflates by 2.5% rather than the DECC forecast increase in real energy costs and a 2.5% inflation allowance.

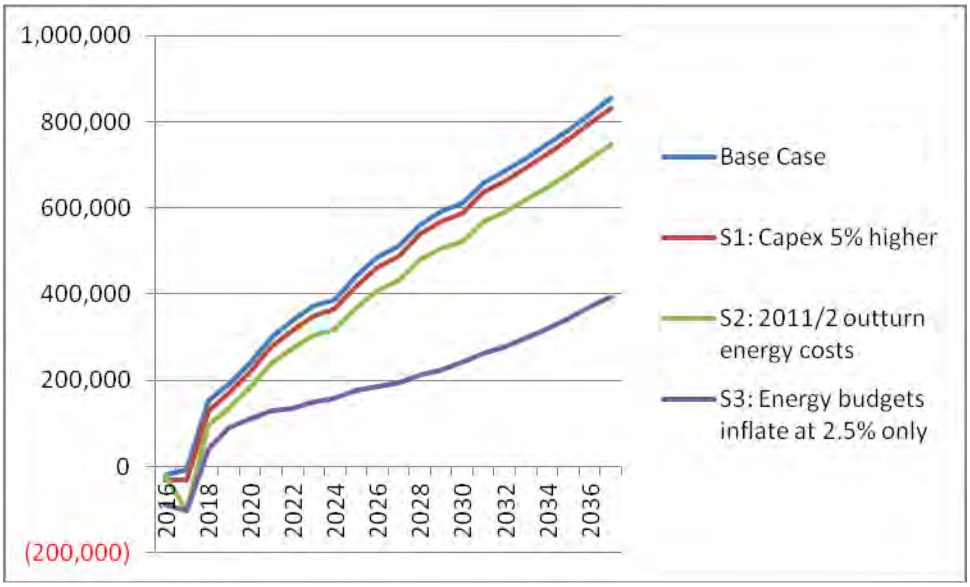
The results of this analysis are summarised within Table 8.3:

Table 8.3 Affordability Sensitivity Analysis

Sensitivity	Total	2015/16	2016/17	2017/18
LED costs 5% higher than anticipated				
Council Budgets	33,045	1,004	1,053	1,092
LED Cost	23,111	1,036	1,084	963
Forecast Savings/(Cost)	9,934	(32)	(31)	129
Forecast electricity costs based on 2011/12 outturn				
Council Budgets	33,045	1,004	1,053	1,092
LED Cost	24,332	1,024	1,157	994
Forecast Savings/(Cost)	8,712	(20)	(104)	98
Council energy budgets only inflate by 2.5%				
Council Budgets	26,794	938	959	981
LED Cost	22,620	1,024	1,061	940
Forecast Savings/(Cost)	4,144	(86)	(102)	41

Diagram 8.2 summarises the different savings profiles for each sensitivity against the base case:

Diagram 8.2: Affordability profile (£'s) per sensitivity



8.5. Summary

The analysis indicates that:

- The preferred technical option is affordable to the Council on the basis of forecast budgets.
- The affordability is influenced by forecast energy costs. It is assumed that both the cost of electricity and capital budgets increase in line with DECC's forecast of real energy price inflation and a general inflation factor of 2.5%.
    - The impact of using the 2011/12 outturn electricity cost is to decrease the total savings over the period from £10.4m to £8.7m. It also results in a forecast cost to the Council during the implementation phase of £19k in Year 1 and £103k in Year 2. Thereafter annual savings are generated.
    - In the event that Council budgets increase at a lower rate than the forecast electricity costs (i.e. by 2.5% only), the total savings from the project decrease to £4.9m with a cost to the Council in year 1 of installation of £86k and £102k in year 2 of installation. Thereafter annual savings are generated.

- The project remains affordable to the Council in the event that the capital costs are 5% higher than forecast. In this scenario total savings over the period decrease from £10.4m to £9.9m. In the first two years of implementation there is a potential cost to the Council of £36k and £31k. Thereafter the project generates savings.

9. Procurement

9.1. Introduction

Option 4 is identified as the Council's preferred technical option. This option includes the replacement of all lanterns with LEDs over a two year period commencing in 2015/16. CMS technology would be adopted on all lanterns with a general policy of dimming lights between midnight and 6am.

The Business Case will be presented to the Council for consideration and if approved included within the Council's capital plan.

This section of the business case reviews the potential procurement approach and the areas which the Council would require to address prior to procurement.

9.2. Procurement Approach

Following a review of the affordability implications of the project, the proposed procurement approach would be to enter into a supply and install contract with a contractor who can supply the required goods over a two year period. EDC would require to confirm the most appropriate financing mechanism to take forward any option. This business case assumes that the Council will borrow from the Public Works Loan Board to finance the LED lights and the Central Management Systems and that column replacements will be financed through a mix of Council borrowing and capital budgets.

The business case has assumed installation of the LED technology and the Central Management System in 2015/16 and 2016/17. It is anticipated that the Council would undertake the pre-procurement steps outlined within Section 9.3 below during 2013. Following completion of these steps, the business case would be updated and the proposed timescales would be subject to confirmation at this time.

9.3. Pre-procurement Next Steps

EDC are currently updating their street lighting database and migrating onto a new asset register. This register would require to be tested for robustness, completeness and integrity prior to EDC developing a street lighting specification. Prior to entering into any procurement process, EDC would require to take forward the following pre-procurement actions:

- undertake a full column and cabling condition survey and include predictive maintenance and renewal dates in the updated database.

- integrate the preferred lantern and control gear replacement option with their column and cabling replacement strategy.

- develop a specification to enable bidders to tender for the provision and installation of the street lighting and control systems.

- develop the tender documentation and contract for the projects. There would be economies of scale in this area if a national framework was available which EDC could draw from. This would also include testing of the LED cost and efficiency assumptions which have been made within the business case to determine the timing of the procurement.

9.4. Risk Management and Mitigation

The suggested procurement approach would be to contract for the supply and installation of the lights and control systems. Appendix 9 includes a risk register of the key delivery risks involved in taking forward such procurement. The key risks which would be retained by EDC are summarised in the Table below together with a suggested mitigation strategy for these risks:

Table 9.1: Summary Risk Analysis and Mitigation

Risk	Mitigation Strategy
Specification is inaccurate or incomplete	EDC are currently updating their asset registers for street lighting which would form the basis of any specification. A programme of auditing and verifying the specification would require to be undertaken pre-procurement.
LED cost savings and efficiencies are not realised	Part of the pre-procurement work would be to verify and confirm the market position around such areas.
Delays are incurred during installation	EDC would seek to transfer the risk of the timing of the installation under a supply and install contract. Risks which impact on delay and which cannot be transferred would be managed on a risk register.

Risk	Mitigation Strategy
Cost of finance	EDC manage the funding associated with their capital plans and would track the cost of any finance required, managing it as part of their wider Treasury function.
Savings are not realised	Savings may not be realised for a number of reasons such as EDC unable to implement dimming & trimming; LED lights do not achieve forecast efficiencies; future cost rises in areas such as energy costs are lower than anticipated within the business case; LED lights fail and although the light is covered by the warranty, the labour to replace the light is not. EDC would develop a live risk register to allow these risks to be tracked and managed.

This risk register would be a live document during the development of the specification and procurement of the street lights.

9.5. Project Management and Governance

Project Management

EDC would require to establish a Project Delivery Team with representatives from all sectors who are able to support the project, including:

- an experienced Project Director.
- an experienced Project Manager.
- Technical specialists who can manage the integrity of the street lighting data and specification.
- Procurement, finance and legal officers as required.

EDC will take cognisance of any central support which may be available for such a project.

Governance

EDC would require to establish appropriate governance arrangements to deliver the project

APPENDICES

Appendix 1: Schedule of Existing Lantern Types (excludes signage lights and school flasher lights)

East Dunbartonshire Council

Existing Lantern Schedule

Existing Lanterns

Type	Power (W)	Cct (W)	2012
CDMT	35	38	7
CDMT	150	154	25
CDO-TT	70	84	10
CDO-TT	100	114	92
CDO-TT	150	172	28
CDO-TT	250	279	11
CDO-TT-HF	70	74	14
CDO-TT-HF	100	110	8
CDO-TT-HF	150	158	168
CDO-TT-HF	250	269	11
CPO-HF	60	67	17
PL-L	55	62	242
SON	70	84	4,145
SON	100	114	310
SON	150	172	1,341
SON	250	279	269
SON	400	434	16
SON-HF	70	79	1,763
SON-HF	100	110	461
SON-HF	150	158	411
SON-HF SELC	70	79	23
SON-HF-DIMM	150	156	1
SON-L	250	279	8
SOX	35	158	18
SOX	55	84	431
SOX	90	123	21
SOX	135	175	10
SOX-HF	55	59	362
SOX-L	35	48	394
SOX-L	55	67	6,114
SOX-L	90	104	483
SOX-L	135	159	191
Total Number of Existing Lanterns			17,405

Appendix 2: Description of System Technologies and Terms

Acronyms and Definitions

Acronyms

CCT	Correlated Colour Temperature
CCTV	Closed Circuit Television
CRI	Colour Rendering Index
DLOR	Downward Light Output Ratio
DMRB	Design Manual for Roads and Bridges (Highways Agency)
GR	Quantifiable unit of anticipated glare experience - Glare Rating as defined in CIE Technical Report 112 "Glare Evaluation System for use within Outdoor Sports and Area Lighting"
HF	High Frequency
IPXX	Ingress Protection (followed by number classification e.g. IP65)
LLMF	Lamp Lumen Maintenance Factor
LMF	Luminaire Maintenance Factor
LOR	Light Output Ratio
LSF	Lamp Survival Factor
MF	Maintenance Factor
PECU	Photoelectric Control Unit
PA	Public Address
Ra	Classification unit of the General Colour-Rendering Index

Definitions

Ballast
Electrical device used with discharge lamps for stabilising the current in the discharge.

The different types of ballast are as follows:

- Magnetic – an inefficient ballast that uses a core and coil assembly transformer to perform the minimum functions required to start and operate the lamp

- Hybrid or low frequency electronic – magnetic ballast with electronic components that switch off voltage to the lamp coil after the lamp has started. An increase in efficiency is possible through the use of high-end core material and a reduction of power to lamp coils during operation

- High frequency electronic – operates lamp at frequencies typically above 20kHz. Maximum efficiency is obtained through use of electronic circuitry and optimum lamp operating characteristics.

CDM-T
Ceramic Metal Halide discharge lamp source. Excellent colour rendering due to its white light properties though at the expense of operational life time in comparison to other conventional highway light sources. The ceramic technology provided an increased light output and improved maintenance cycle when compared to traditional quartz metal halide technology.

CDO-TT
A direct retrofit solution for SON lamp installations to provide a white light as opposed to traditional yellow SON installations. This is a Ceramic Metal Halide discharge lamp source with a clear tubular outer bulb. Comfortable warm colour, with good colour rendering properties though at the expense of operational life time.

CMS
Central Management System. Wide area lighting control systems capable of two way data communication providing remote dimming control capability and feedback on lantern operational status.

Correlated Colour Temperature
The temperature of the Planckian (black body) radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under the same viewing conditions. Quantified in Kelvin (K)

Colour Rendering
Effect of a light source on the colour appearance under a reference light source.

Expressed as a general colour-rendering index of a light source (Ra) to specify the degree to which objects illuminated by a light source have an expected colour relative to the colour under a reference light source. Ra has a maximum value of 100 though a value over 60 is generally considered to offer good recognition properties in an external environment.

CPO
New-generation of conventional ceramic metal halide lamps for outdoor lighting with a white light. Lamp has high energy efficiency, long life and a compact size allowing for optimised optic and luminaire design. Optical efficiency allows for a greater spacing between lanterns. Currently available from a single manufacturer.

Efficacy (Luminaire/Source)
Overarching metric of operational efficiency of luminaire (reflector and lamp) or source performance in relation to total electrical input and usable light output.
Luminaire Efficacy calculated using:

- Initial 100hour lamp lumen output of all lamp(s) within the luminaire. (Lamp-lum)
- Light Output Ratio (LOR)
- Total circuit watts – total power consumption of luminaire including losses within control gear.(cctW)

Calculated using the formula:

Efficacy = (Lamp-lum x LOR)/cctW

Presented in units ‘Luminaire-Lumens/Circuit-Watt’.

Source efficacy defined as

Efficacy = Lamp-lum / cctW

Presented in units ‘Lamp-Lumens/Circuit-Watt’.

Glare
The sensation produced by brightness within the visual field that are sufficiently greater than the luminance to which the eyes are adapted so as to cause annoyance, discomfort, or loss in visual performance and visibility.

Illuminance (Horizontal/Vertical)
The measure of density of luminous power arriving at an analysis point, measured in Lux.

- Horizontal – luminous power arriving at an analysis point on a horizontal plane. E.g. light level incident on the ground. Horizontal illuminance is a common method of classifying and calculating lighting levels for particular tasks, though it does not necessarily ensure good levels of light on vertical objects.

- Vertical – luminous power arriving on a vertical plane where the analysis point normal is orientated parallel to a horizontal plane. E.g. light level incident on a wall or vertical surface. Vertical illuminance is considered a good method of classifying and ensuring good levels of light over a vertical surface for image recording.

LED
Light Emitting Diode used as a light source. Solid-state semiconductor device that converts electrical energy directly into light of a specific colour or white light. Often used in collaboration with integrated lens attachments to distribute light over an area.

Light Output Ratio (LOR, DLOR, ULOR)
The ratio of the total flux of the luminaire to the sum of the individual luminous fluxes of the same lamp when operated outside of the luminaire. This can be taken as the efficiency of the lamp/reflector/luminaire housing combination.

Can be separated into Downward Light Output Ratio (DLOR) and Upward Light Output Ratio (ULOR) as a flux fraction directed up or down when orientated in the same direction as the photometric measurements were taken.

Luminance
The light intensity per square metre of apparent area of the light source, luminaire or illuminated surface. Where surfaces are lit, the luminance depends upon both lighting level

and reflection characteristics of the luminous surface. Used extensively in road lighting calculations. Quantified in Candela per square meter.

Luminous Flux
The total light emitted by a light source and also the total light falling on a surface. The light output of a source is measured in lumen.

Lux
The standard unit of illuminance of a surface being lit. One Lux equals one lumen per square metre.

Maintenance Factor
Ratio of the average illuminance on the analysis plane after a certain period of use of a lighting installation to the average illuminance obtained under the same conditions for the installation considered conventionally as new.

For exterior lighting the Maintenance Factor comprises of 3 parts – each defined as a value between 0.0 and 1.0

MF = LLMF x LMF x LSF

- LLMF - Lamp Lumen Maintenance Factor – Allows for depreciation in light output from the source over a defined period. As provided by lamp manufacturer’s technical data.
- LMF - Luminaire Maintenance Factor – Makes allowance for the depreciation in light output from the luminaire due to dirt build-up on luminaire coverglass and optics over a defined cleaning cycle. As stated within BS EN 5489-1:2003
- LSF - Lamp Survival Factor – Makes allowance for the premature failure of light sources within an installation. For the purpose of highway and pedestrian lighting LSF is assumed to be 1.0 assuming lamps are spot-replaced through night time inspections by the responsible authority.

Maintained Illuminance
Value below which the average illuminance on the specified surface is not allowed to fall. The maintained illuminance is specified at the end of the maintenance cycle, taking into consideration the maintenance factor. Quantified in Lux

PL-L

Low pressure mercury compact fluorescent lighting source. White light source with excellent colour rendering properties (Ra > 80), near instantaneous ignition and excellent dimming control under. Fluorescent light sources are not ideally suited for external use due to reduced light output within cold environments and relatively large source and hence poor optical control.

Sky Glow

The brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered by the atmosphere in the direction of observation. Sky glow from man-made sources (i.e. outdoor electric lighting) is the radiation that is emitted directly upwards and reflected from the surface of the earth.

SON

High pressure sodium lamp typically identified by its golden/orange hue. Offers improved maintenance and colour rendering properties in comparison to SOX light sources in additional to a smaller brighter source allowing better optical design and greater efficacies. These properties in combination with

SOX

Low pressure sodium lamp typically identified by its monochromatic orange appearance; therefore has very poor colour rendering performance. Traditionally the most common light source used in street lighting though generally being phased out by local authorities. While considered to be an extremely efficient light source, its bulky size and poor optical performance results in a significant amount of light being spilt beyond the intended area to be lit and directly into the sky.

Spill light

Light emitted by a lighting installation which falls outside the boundaries of the site for which the lighting installation is designed.

Step-Dim Control Gear

Integral timer based dimming control allowing for the dimming of lighting during a pre-defined period of the darkness. Typically a period of lower anticipated traffic/pedestrian flows (pre defined 6, 8 or 10 hour period) where output can be dimmed to a reduced output therefore saving energy.

Uniformity

The ratio of minimum illuminance to average illuminance over an analysis grid. Used to establish even distribution of light over a surface.

Appendix 3: Cost and Consumption Model Assumptions (unit cost rates, failure rates, replacement lifecycles)

A3.1 Technical Assumptions

The following technical assumptions have been adopted for the option appraisal. The results of this analysis are included within Section 4 of this Business Case.

A3.1.1 Capex, Maintenance, Energy and Carbon Model Assumptions

A spreadsheet model was developed to assess the Capex, maintenance cost, energy consumption and carbon emissions of the options over a 25 year horizon extending from 2012 to 2036. The key components of the model are described below and details of specific technical assumptions are provided in Appendix 3.1 including a schedule of lamp types along with their wattage, circuit wattage and number of assets.

For each lamp type, a lifecycle replacement duration was assigned and in the absence of detailed data on lamp ages, it was assumed that the age spread was distributed evenly over this duration. For example, SON-T lamps were assumed to have an average replacement life of 7 years. In the base year 2012, it was assumed that the age distribution of the existing lamps were evenly distributed with 1/7th of the lamps being less than a year old, 1/7th being between 1-2 years old etc.

Energy consumption is calculated each year by considering the total number of lamps of each type, their circuit wattage, the operating hours of each lamp and adjusting for any dimming.

Energy costs are based on the consumptions calculated above, and a unit price of £79.00 /MHz in 2012[2] (7.9p/kwh). Future year prices are then based on year on year price inflation forecasts provided by DECC IAG's Guidance for Policy Appraisal Toolkit (Central Forecasts).

Annual Capex estimates are based on an assessment of lantern and control system upgrade investments in each year. Unit cost rates for items of work are based on EDC's own assessed costs and benchmarked against industry norms. A Capex allowance is included as a separate line item in all options for the replacement of 300 columns per year. In the Status Quo, the continuation of EDC's lantern replacement programme at a rate of 500

[2] Based on EDC's 2011/12 budget cost

lanterns per annum is included as a Capex item. (300 columns are funded through capital budgets and 200 columns through maintenance operations).

Maintenance costs included in the model cover only those relating to the replacement of life expired lamps, lanterns and control units. Scouting costs, routine electrical inspections, column, cabling and feeder box maintenance and central office overhead costs are excluded from the analysis as they will be incurred across all three options.

Annual carbon emissions estimates have been derived from the total annual energy consumption along with DECC IAG's relevant CO2 emission factor for each assessed year.

All costs are real prices with 2012 as the base year. These have been assumed to inflate by 1% per annum to provide an estimated outturn cost.

A3.1.2 LED System Assumptions

LED street lighting systems are showing great potential to provide significant energy savings and maintenance costs as a result of long lifecycle periods predicted for the lanterns. The energy savings are derived principally from the ability to focus light where it is needed and to readily control lighting levels without deterioration of the lamps (indeed dimming LEDs will generally extend lamp life unlike conventional lamps where lamp life can be shortened). Also, the consistency of performance over time of LEDs means that they do not have to be 'over-rated' on installation, in anticipation of deteriorating performance over time.

The technology and the supply market are developing rapidly. In particular, advances are being made in the production of units which can be adjusted and optimised for variable column spacing while still maximising energy savings. Also, the number of suppliers is increasing and scaling of the market means that the unit costs of LED is dropping.

For Option 4 it has therefore been necessary to project forward and anticipate what products will be available for installation in 2015/16 and their likely costs. The approach to deriving energy consumption and pricing forecasts along with source references are described further in Appendix 4.

A3.1.3 CAPEX Assumptions

The Capex spend profile in 2012 prices for each option, summarised in 5 year periods, is tabulated below:

Table A3.1: Summary of phased capex spend per option in 2012 prices (£'000)

Capex/period	2012-2016 £'000	2017-2021 £'000	2022-2026 £'000	2027-2031 £'000	2032-2036 £'000	Total Real £'000	Total Outturn £'000
Status Quo	672	840	840	840	840	4,032	4,032
Option 3	2,389	962	-	-	-	3,351	3,462
Option 4	6,378	-	-	-	-	6,378	6,604

The key features are:

- The Status Quo includes £152k of Capex in each year (except the base year 2012 where no Capex has been included in any option) for the replacement of 500 lanterns each year. As noted earlier within the Business Case, the status quo option approximates to the Council's existing street lighting practices and it was not clear that capital budgets would be available to meet this cost. This was therefore excluded from the financial analysis associated with the option appraisal. The impact is to understate the savings associated with the other options.

- Option 3 includes £1.8m for the replacement of 7,440 SOX lamps between 2013 and 2014 with SON-HF lanterns. Between 2015 and 2020, 4145 low efficiency SON lamps are replaced with high efficiency units with dimming capability and an investment of £665k is included for a CMS system.

- Option 4 includes approximately £5.5m for replacement of 17,405 lamps with LED units at an average installed cost of £317 per unit. A full CMS is also installed at a cost of £850k.

A.3.1.4 Maintenance Assumptions

Only maintenance costs relating to the replacement of life expired lamps, lanterns and control units are included in the comparative model analysis. Scouting costs, routine electrical inspections, column, cabling and feeder box maintenance and central office overhead costs are not covered but are discussed below in relation to CMS systems.

We have derived a bottom up estimate of the cost of the replacement maintenance work, based on assumed component failure criteria to estimate the number of components which might need replacing. Unit costs rates have been applied to this based on EDC's estimates which have been reviewed against industry averages. Details of the failure and unit cost rates are included in Appendix 4.

Using this bottom up approach, for all options in 2012, we have included for the replacement of approximately 2,900 lamps, 700 lanterns (incl. lamps) and 1,700 control gear units at a cost of £213k. This compares to EDC's estimated total budget of £510k which would imply that around £300k would be spent on other activities such as inspections and central office costs. This has been discussed with EDC and is considered to be a reasonable assumption.

A summary of the comparative maintenance costs (in 2012 prices) included in the business cases are tabulated below:

Table A3.2: Summary of phased maintenance costs in 2012 prices (£'000)

Maintenance period	2012-2016 £'000	2017-2021 £'000	2022-2026 £'000	2027-2031 £'000	2032-2036 £'000	Total Real £'000	Total Outturn £'000
Status Quo	1,024	931	861	883	889	4,588	6,218
Option 3	1,156	767	781	986	793	4,483	6,036
Option 4	563	36	43	43	43	728	821

The key features are:

- The Status Quo includes ongoing lantern, gear and lamp replacement upon failure. The model includes for on average 250 lanterns, 1,100 control units and 3,000 lamps to be replaced per annum.
- Option 3 includes reduced replacement rate of lanterns due to refresh of equipment stock.

- Option 4 includes continued lamp replacement prior to investment in LED technology. Ongoing allowance for a replacement cost to EDC of 0.1% LED lanterns due to failure each year. It is assumed that the cost of replacing the lanterns is met through manufacturer's warranties and guarantees which are available from certain manufacturers to cover the life expectancy of the lamps.

Central Management Systems

Central Management Systems (CMS) are a wide area control system that rely on either wireless technology (radio waves, GSM/GPRS) or mains borne cabling to communicate with individual lanterns from a central server. This allows the dimming and/or switching of the street lighting to be controlled from a central server. Unlike conventional control strategies, individual luminaries can be switched or dimmed at any time and settings can be changed remotely by the Controlling Authority.

Another benefit of CMS is that the system enables two way communication of information on the lamp life of individual lanterns to be relayed back to the control centre, informing the operator whether or not any given lantern is operational. Therefore unnecessary day burning of lamps can be prevented, and night time inspections of installations can be minimised (fittings with LED light sources may not currently be able to relay this information).

CMS can provide a wide range of remote monitoring functionality which can have the following benefits for maintaining the assets:

- Improved fault identification and location of fault prior to leaving depot.
- Lamp failure prediction based on out of tolerance monitoring of electrical characteristics. Under-performing lanterns can be worked into future maintenance programmes.
- Interface with asset management database for sharing and analysing data.
- Minimising the need for night scouting inspections.

Other features and advantages/disadvantages are detailed in Appendix 6.

CMS Sensitivity

The introduction of a CMS can potentially bring significant reductions to central office costs as well as reduce the need for routine surveys. The level of these savings depends on the extent that departmental processes and procedures are optimised to take advantage of the real-time and historic information. In discussions with EDC, given the range of responsibilities within the department, and the very small team in place (4 staff) they felt it was not immediately clear that these potential efficiencies could in practice be realised. There may however be opportunities to redeploy time to other activities which are brought into the qualitative analysis.

A3.1.5 Energy Consumption and Cost Assumptions

The energy consumption has been calculated on an annual basis considering the number and type of lamps, the control units, operating hours and any dimming assumptions. The energy consumptions for the conventional technology lamps are well known and tested. As LED technology is moving rapidly, there is greater uncertainty over the efficiency of LED lamps that will be available in 3 years time for installation between 2015/16. However, there are a growing number of installations, demonstrator projects and research to draw upon and in Appendix 4 we have outlined how we have estimated energy efficiencies of future LED units.

Table A3.3: Phased Energy Consumption (GWh) and Expenditure (£'000s)

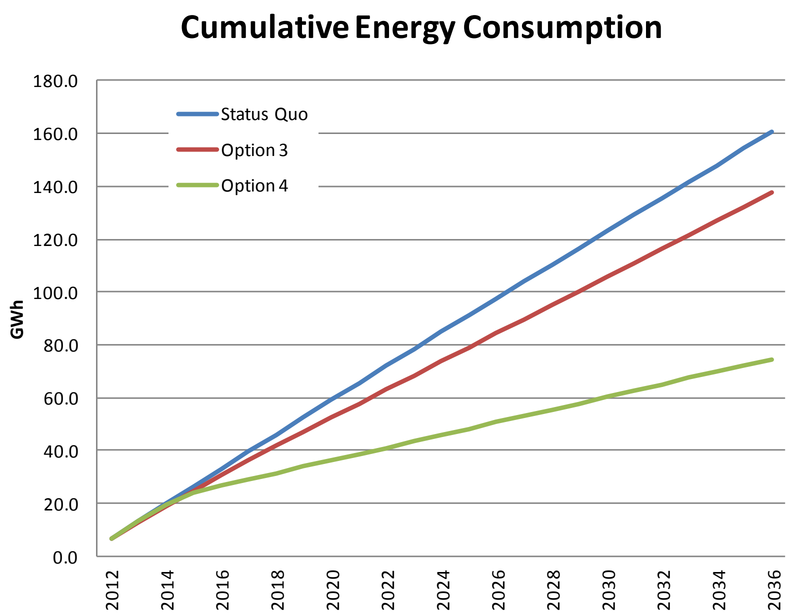
Consumption/ (Expenditure)	2012-2016	2017-2021	2022-2026	2027-2031	2032-2036	Total Real	Total Nominal £'000
Status Quo	32.8 (2,788)	32.5 (3,047)	32.1 (3,314)	31.8 (3,452)	31.4 (3,458)	160.6 (16,060)	(22,245)
Option 3	30.4 (2,580)	27.3 (2,555)	26.6 (2,740)	26.6 (2,905)	26.6 (2,925)	137.5 (13,705)	(18,908)
Option 4	26.6 (2,228)	12.0 (1,125)	12.0 (1,240)	12.0 (1,314)	12.0 (1,323)	74.6 (7,230)	(9,614)

The key features are:

- The Status Quo includes the replacement over time of outdated SOX lamp technology with white light alternatives and dimming equipment in existing lanterns. The energy saving is marginal as the new white light lamps are not materially more efficient than the old SOX lamps and consequently the total energy consumption at the end of the 25 year period will be around 96% of current levels. Annual energy costs will increase as unit prices inflate.

- Option 3 includes immediate replacement of all SOX lanterns with modern conventional technology incorporating increased dimming and CMS technology. The trimming and dimming is the main contributor to the drop in energy consumption at the end of the period to around 87% of current consumption levels. However, as energy prices are forecast to rise by more than this, the annual energy costs at the end of the period will be 12% higher than current annual costs.

- Option 4 includes bulk replacement of all lanterns with LEDs with dimming and CMS capability resulting in dramatic energy reduction. In total the annual consumption is estimated to reduce by 63% compared to existing levels.

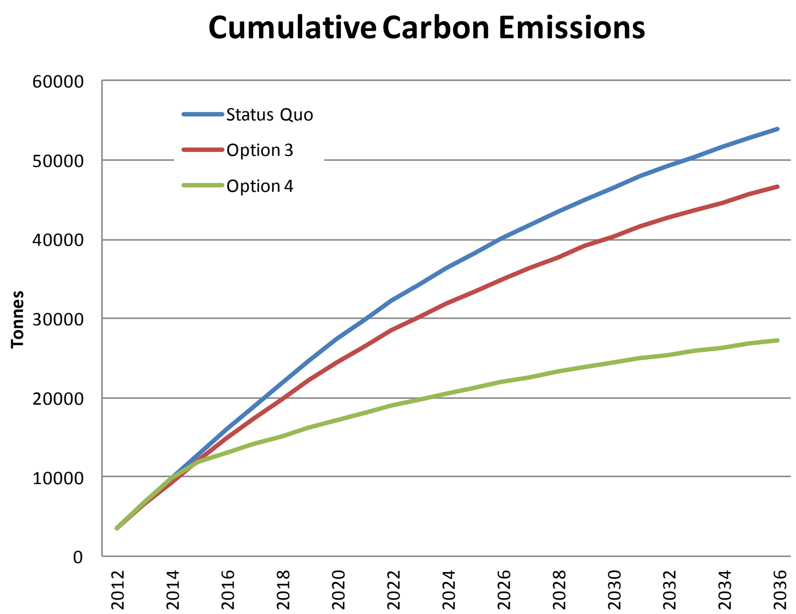


From the energy consumption estimates, DECC CO_2 emissions factors have been applied to derive annual emission estimates.

Table A3.4: Annual Emissions Estimates ('000s tonnes)

CO2 Emissions	2012-2016	2017-2021	2022-2026	2027-2031	2032-2036	Total
Status Quo	15.9	13.9	10.2	7.9	6.1	54.0
Option 3	14.8	11.7	8.4	6.6	5.2	46.7
Option 4	13.0	5.1	3.8	3.0	2.3	27.2

The emissions levels in later years are significantly lower than current levels. This is not only



a result of the reduced energy consumption, it also reflects predicted drops in carbon emissions per unit of electricity generated as a result of the use of greater proportions of renewable energy sources and carbon capture technologies. The DECC CO2 emissions factor for 2036 is 64% lower than the equivalent factor in 2012.

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Appendix 3.1: Technical Model Cost Assumptions

Model Assumptions

Energy Prices	Base Electricity Tariff 2012	79.00	[£/MWh]
	Future years inflation based on DECC IAGGuidance for Policy Appraisal Toolkit, Tables 4-9: Energy prices - Central, 2011 prices: ELECTRICITY - retail: commercial		
Carbon Emissions Conversion Factor	DECC IAGGuidance for Policy Appraisal Toolkit, Table 1: Electricity emissions factors to 2100, kgCO2/kWh		
Component Replacement Cycles	Lanterns - conventional	25	Years
	Lanterns - LED	25	Years
	Control Gear (existing)	10	Years
	Control Gear (new)	20	Years
	Lamp - SON-T	7	Years
	Lamp - CDO-TT	3.5	Years
	Lamp - CDM-T	3	Years
	Lamp - PL-L	4.75	Years
	Lamp - SOX	5.25	Years
Component Unit Costs	Lanterns - conventional (All)	210	£/unit
	Lanterns - LED (36W)	264	£ (installed in 2015/6)
	Lanterns - LED (54W)	317	£ (installed in 2015/6)
	Lanterns - LED (150W)	422	£ (installed in 2015/6)
	Lanterns - LED (250W)	449	£ (installed in 2015/6)
	Lamps - conventional (All)	25	£/unit
	Switch gear - conventional	50	£/unit
	CMS -per point	50	£ (installed in 2015/6)

Schedule of Lanterns

East Dunbartonshire Council - Status Quo Lantern Schedule

Existing Lanterns

Type	Power (W)	Cct (W)	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
CDMT	35	38		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
CDMT	150	154		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
CDO-TT	70	84		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
CDO-TT	100	114		92	92	92	92	92	92	92	92	92	92	92	92	92	92	92
CDO-TT	150	172		28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
CDO-TT	250	279		11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
CDO-TT-HF	70	74		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
CDO-TT-HF	100	110		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
CDO-TT-HF	150	158		168	168	168	168	168	168	168	168	168	168	168	168	168	168	168
CDO-TT-HF	250	269		11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
CPO-HF	60	67		17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
PL-L	55	62		242	242	242	242	242	242	242	242	242	242	242	242	242	242	242
SON	70	84		4,145	4,145	4,145	4,145	4,145	4,145	4,145	4,145	4,145	4,145	4,145	3,351	2,551	1,751	951
SON	100	114		310	310	310	310	310	310	310	310	310	310	310	310	310	310	310
SON	150	172		1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341
SON	250	279		269	269	269	269	269	269	269	269	269	269	269	269	269	269	269
SON	400	434		16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
SON-HF	70	79		1,763	1,763	1,763	1,763	1,763	1,763	1,763	1,763	1,763	1,763	1,763	1,763	1,763	1,763	1,763
SON-HF	100	110		461	461	461	461	461	461	461	461	461	461	461	461	461	461	461
SON-HF	150	158		411	411	411	411	411	411	411	411	411	411	411	411	411	411	411
SON-HF SELC	70	79		23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
SON-HF-DIMM	150	156		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SON-L	250	279		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
SOX	35	158		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
SOX	55	84		431	24	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX	90	123		21	21	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX	135	175		10	10	10	-	-	-	-	-	-	-	-	-	-	-	-
SOX-HF	55	59		362	362	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX-L	35	48		394	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX-L	55	67		6,114	6,114	6,114	5,606	4,806	4,006	3,206	2,406	1,606	806	6	-	-	-	-
SOX-L	90	104		483	483	90	-	-	-	-	-	-	-	-	-	-	-	-
SOX-L	135	159		191	191	191	-	-	-	-	-	-	-	-	-	-	-	-
Total Number of Existing Lanterns				17,405	16,604	15,804	15,005	14,205	13,405	12,605	11,805	11,005	10,205	9,405	8,605	7,805	7,005	6,205

New Lanterns

Type	Power (W)	Cct (W)	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
PL-L PL-L	55	62		-	801	1,187	1,695	2,495	3,295	4,095	4,895	5,695	6,495	7,295	7,301	7,301	7,301	7,301
SON-HF SON-T	70	79		-	-	-	-	-	-	-	-	-	-	-	794	1,594	2,394	3,194
SON-HF SON-T	100	110		-	-	414	504	504	504	504	504	504	504	504	504	504	504	504
SON-HF SON-T	150	158		-	-	-	201	201	201	201	201	201	201	201	201	201	201	201
Total No. of New Lanterns				-	801	1,601	2,400	3,200	4,000	4,800	5,600	6,400	7,200	8,000	8,800	9,600	10,400	11,200

Total Lanterns

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total No. of Lanterns	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**

East Dunbartonshire Council - Option 4 Lantern Schedule

Existing Lanterns

Type	Power (W)	Cct (W)	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
CDMT	35	38		7	7	7	4	-	-	-	-	-	-	-	-	-	-	-
CDMT	150	154		25	25	25	13	-	-	-	-	-	-	-	-	-	-	-
CDO-TT	70	84		10	10	10	5	-	-	-	-	-	-	-	-	-	-	-
CDO-TT	100	114		92	92	92	46	-	-	-	-	-	-	-	-	-	-	-
CDO-TT	150	172		28	28	28	14	-	-	-	-	-	-	-	-	-	-	-
CDO-TT	250	279		11	11	11	6	-	-	-	-	-	-	-	-	-	-	-
CDO-TT-HF	70	74		14	14	14	7	-	-	-	-	-	-	-	-	-	-	-
CDO-TT-HF	100	110		8	8	8	4	-	-	-	-	-	-	-	-	-	-	-
CDO-TT-HF	150	158		168	168	168	84	-	-	-	-	-	-	-	-	-	-	-
CDO-TT-HF	250	269		11	11	11	6	-	-	-	-	-	-	-	-	-	-	-
CPO-HF	60	67		17	17	17	9	-	-	-	-	-	-	-	-	-	-	-
PL-L	55	62		242	242	242	121	-	-	-	-	-	-	-	-	-	-	-
SON	70	84		4,145	4,145	4,145	2,073	-	-	-	-	-	-	-	-	-	-	-
SON	100	114		310	310	310	155	-	-	-	-	-	-	-	-	-	-	-
SON	150	172		1,341	1,341	1,341	671	-	-	-	-	-	-	-	-	-	-	-
SON	250	279		269	269	269	135	-	-	-	-	-	-	-	-	-	-	-
SON	400	434		16	16	16	8	-	-	-	-	-	-	-	-	-	-	-
SON-HF	70	79		1,763	1,763	1,763	882	-	-	-	-	-	-	-	-	-	-	-
SON-HF	100	110		461	461	461	231	-	-	-	-	-	-	-	-	-	-	-
SON-HF	150	158		411	411	411	206	-	-	-	-	-	-	-	-	-	-	-
SON-HF SELC	70	79		23	23	23	12	-	-	-	-	-	-	-	-	-	-	-
SON-HF-DIMM	150	156		1	1	1	1	-	-	-	-	-	-	-	-	-	-	-
SON-L	250	279		8	8	8	4	-	-	-	-	-	-	-	-	-	-	-
SOX	35	158		18	18	18	9	-	-	-	-	-	-	-	-	-	-	-
SOX	55	84		431	431	431	216	-	-	-	-	-	-	-	-	-	-	-
SOX	90	123		21	21	21	11	-	-	-	-	-	-	-	-	-	-	-
SOX	135	175		10	10	10	5	-	-	-	-	-	-	-	-	-	-	-
SOX-HF	55	59		362	362	362	181	-	-	-	-	-	-	-	-	-	-	-
SOX-L	35	48		394	394	394	197	-	-	-	-	-	-	-	-	-	-	-
SOX-L	55	67		6,114	6,114	6,114	3,057	-	-	-	-	-	-	-	-	-	-	-
SOX-L	90	104		483	483	483	242	-	-	-	-	-	-	-	-	-	-	-
SOX-L	135	159		191	191	191	96	-	-	-	-	-	-	-	-	-	-	-
Total Number of Existing Lanterns				17,405	17,405	17,405	8,703	-	-	-	-	-	-	-	-	-	-	-

New Lanterns

Type	Power (W)	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
LED	36		-	-	-	3,802	7,585	7,585	7,585	7,585	7,585	7,585	7,585	7,585	7,585	7,585	7,585
LED	54		-	-	-	2,978	5,955	5,955	5,955	5,955	5,955	5,955	5,955	5,955	5,955	5,955	5,955
LED	100		-	-	-	688	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375
LED	170		-	-	-	1,088	2,175	2,175	2,175	2,175	2,175	2,175	2,175	2,175	2,175	2,175	2,175
LED	255			-	-	158	315	315	315	315	315	315	315	315	315	315	315
Total No. of New Lanterns			-	-	-	8,712	17,405	17,405	17,405	17,405	17,405	17,405	17,405	17,405	17,405	17,405	17,405

Total Lanterns

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Total No. of Lanterns	**17,405**	**17,405**	**17,405**	**17,415**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**	**17,405**

Appendix 4: LED Future Predictions of Unit Efficiencies

LED manufacturers widely advertise increased performance and efficiency of chip units. The industry expect LED manufacturing research to develop and improve over at least the next 10 years, anticipating significant gains in the efficacy and performance of chips available on the commercial market.

While it can be difficult to predict the speed at which technology will develop the US Department of Energy have researched and set out white light LED package efficacy targets within their report "Solid-State Lighting Research and Development; Multi Year Program Plan" (March 2011).

This report stipulates current commercial warm white LED packages are achieving an efficacy of 140lm/W and cool white LED packages; 175lm/W.

In 2020 the target LED package have a predicted efficacy of 250lm/W (both cool and warm white solutions) which is a 78% efficacy increase for warm white packages and a 43% efficacy increase for cool white packages.

The majority of LED street lighting products currently use cool white LED chips to maximise energy saving potential and these have been assumed within the business case. On this basis we have used the US DoE target performance forecast for 3-5 years time as a guide to the possible energy efficiency that may be available at that time. As a result we have assumed a reduction in energy consumption equating to approximately 37% compared to the average products currently available on the market.

LED Future Predictions in Unit Costs

The LED street lighting market is a relatively new market and very much a developing sector within the lighting industry. A number of manufacturers are in the early stage of integrating LED functional lighting into their catalogue providing a limited offering with their first or perhaps second generation LED products representing their early steps into a rapidly developing field. While many manufacturers identify the commercial potential of LED products, there is a fundamental shift in manufacturing technology required to enter the LED market.

This change in process has required manufacturers to evolve their way of design and production from the delivery of a single lamp, reflector and gear within a formed housing to an integrated semi-conductor array LED chips, heat-sink and driver units. Designing with LEDs also requires a fundamental change to photometric design, moving away from a single large light source to multiple small sources and impact on light distribution and glare.

This swing in design techniques/technology/materials/production processes reflects a step change in how traditional lantern manufacturers operate, requiring significant investment in the developing the necessary skills, suppliers and production lines.

As with many new technologies this results in an initial high purchasing cost to those early adopters to support this initial investment. With this in mind it is appropriate to consider that as technology and design services becomes more failure within the market, investment is recouped and competition grows within the sector unit prices will begin to fall.

This is true for both the luminaire manufacturers and their OEM suppliers. The US Department of Energy report on "Solid-State Lighting Research and Development; Multi Year Program Plan" (March 2011) predicts cost decrease in the LED chip component of 85% between 2010 and 2015. See below table:

Year	Cost/1000 lumen output ($)
2010	91
2012	42
2015	14

These figures are based upon an anticipated large increase in LED production based upon demand, manufacture process improvement and increased reliability of the product resulting in less wastage. However the cost of LED chips are only one component within a luminaire package and similar reductions, though possibly not to the same extent, can be expected for lens design/manufacture, improved heat sink technology and standardisation in the market place for both products and testing procedures.

The materials used within LED luminaries will also have a significant contribution to product costs and as a result will also fluctuate in response to the financial markets. This will impact a number of the components within LED products such as copper wires, gold in circuit boards and rare earth materials in semiconductor chips and microprocessors. However the largest single component is often the heat-sink used to ensure the LED chip stays within defined operating boundaries. These heat sinks are often constructed of die-cast aluminium forming the housing of the body to maximise heat dissipation. Therefore as LED technology develops and achieves greater efficiency and lower energy consumption manufacturers will be able to gradually reduce the overall aluminium content.

Significant reductions in prices have already been witnessed through Arup's wider project involvement where in one case a manufacturers list price (not necessarily the project price) for a 2nd generation LED street lighting product has reduce by 45% in the past 18 months though reduced component cost and increased competition in the market.

Based upon our experience of technology prices and involvement in large scale procurement projects we have made judgements of the discount rate that contractor might offer against current published trade prices for procurement in 3 years time. The table below indicates the methodology be have used which take the current published trade prices of good quality LED units as the starting point. We have then considered the level of discount the manufactures might offer against these published rates for a volume of around 15,000 units to derive the '2012 Project Scale Discounted rate'. Based on the considerations discussed above we have then applied a further discount in order to estimate the unit rates in 2015.

LED	2012 Published Trade Price	2012 Project Scale Discount (30-35%)	2015 Projected Unit Price (Real) (33%)
36w	£575	£400	£264
54w	£675	£480	£317
150w	£875	£640	£422
250w	£925	£680	£449

Appendix 5: Central Management Systems

Central Management Systems (CMS) are a wide area control system that relies on either wireless technology (radio waves, GSM/GPRS) or mains borne cabling to communicate with individual lanterns from a central server.

The software in the system allows the dimming and/or switching of the street lighting to be controlled from a central server. Unlike conventional control strategies, individual luminaries can be switched or dimmed at any time and settings can be changed remotely by the Controlling Authority.

Many systems require permanent provision of power to column bases and therefore may require adjustment to existing group controlled circuits as part of the installation process. However a number of different suppliers of management systems are operational with the market place, each with a different technology offering.

Other benefits of CMS are that the system enables two way communication of information on the lamp life and other parameters of individual lanterns to be relayed back to a central control centre, informing the operator whether or not any given lantern is operational. Therefore unnecessary day burning of lamps can be prevented, and costly night time inspections of installations can be avoided.

Central Management Systems can provide a wide range of remote monitoring and switching/dimming which can have the following benefits:

- Improved fault identification and location of fault prior to leaving depot.
- Identification of “day burning” and therefore rectification of faults to reduce energy consumption.
- Lamp failure prediction based on out of tolerance monitoring of electrical characteristics. Under-performing lanterns can be worked into future maintenance programmes.
- Remote switch control/dimming facility – maximising energy efficiency and streamlining the management process. CMS allows changes to the system to be much easier to implement responding to the evolution of the road network and changing traffic flows as

- Improved variable dimming control as opposed to step-dim operation and factory set times.
- Interface with asset management database.
- Reduced night scouting inspections and administration of maintenance regime
- Permits performance monitoring of maintenance task (in house or monitoring of outsourced contracts) and eases data gathering and checking performance against KPIs
- Improved and automated power consumption recording
- The ability to easily identify and demonstrates a commitment to sustainability and carbon reduction though more accurate reporting.
- CMS inventory outputs produce accurate energy consumption data which can be used by the Local Authority when agreeing the street lighting inventory energy consumption figures with the Distribution Network Operator (DNO).

However, Intelligent Management has the following perceived drawbacks:

- High initial capital cost – implementation of systems are expensive.
- Some manufacturers are currently unwilling to warranty lamps of some types if used with a third party control gear.
- GSM/GPRS (wireless) systems are limited to areas with mobile phone reception and require a phone communication contract.
- Most management systems are offered on a closed protocol/technology solution, and therefore result in reliance on a single supplier.

Appendix 6: Financial Analysis

Introduction

The following appendix details:

- The financial assumptions included within the Status Quo option.
- The financial results associated with the long list of options.
- A summary of the results of the sensitivity analysis.

Extracts from the financial model for the short-listed option 3 and option 4 is attached as Appendix 7 of this Business Case.

Status Quo Option

The Status Quo broadly follows EDC's core strategy for investing and maintaining their street lighting assets. The key assumptions which underpin it are:

- Capital costs – have been assumed to be £4m to reflect a programme of lantern and switch unit renewals. It is assumed that c.500 lanterns are replaced per annum.
- Maintenance Costs – have been calculated on the basis of the age profile of EDC's existing asset base. It has been flexed to reflect the role out of the existing replacement policies – for example, light and lantern replacements met from existing budgets.
- Energy Costs have been based on the following:

Heading	Value	Source
Street Lighting Wattage for EDC	6,770,832 KWh	EDC marked up spreadsheet
Exclude school and signage lights	(181,711) KWh	EDC marked up spreadsheet
Total Street Light Energy Usage	6,589,121 KWh	
Electricity price	£0.079 / KWh	Electricity Tariff

Heading	Value	Source
Annual Energy Cost within Model	£520,541	This approximates to the 2011/12 budget of £507,375

Within the financial model, the Status Quo is used as the base case against which the savings for the technical options are applied.

Financial Analysis of Long List of Options

The Tables below summarise the key outputs included within the Long List of Options:

Option 1

Option 1, as identified in Section 3.3.3, is to introduce basic levels of dimming and trimming. Key outputs from the financial model for Option 1 are as follows:

Key Output	Value
Initial Investment (£) and phasing	292,945 2013-2016: £292,945 2017-2020: £0 2021-2024: £0
Total Savings compared to Status Quo pre financing (£)	529,855
Finance Route	PWLB funding at 3.31%, payable over 20 years
Total Savings compared to Status Quo post financing (£)	119,823
Payback period pre financing (years)	10
Payback period post financing (years)	> year 2037
Tonnes of carbon saved over the concession (tonnes)	2,628
Energy reduction over concession (%)	13.3%

From these results, the following can be inferred:

- The initial investment creates energy savings over the concession period of c.£1.2m more than the Status Quo.
- Annual savings decrease after year 2027 due to an increased amount of lanterns needing to be replaced annually. The increased level of lantern replacement results in an increased annual cost towards the end of the concession.
- There are increased maintenance costs over the concession of £1,019k, due to replacing a large proportion of lanterns within the network for dimming and trimming capabilities, rather than when each lantern fails.
- Total savings are marginal when finance costs are taken into consideration.

Option 2

Option 2, as identified in Section 3.3.3 , is to replace all existing SOX lanterns with conventional low energy lanterns. Key outputs from the financial model for Option 2 are as follows:

Key Output	Value
Initial Investment (£) and phasing	2,740,503 2013-2016: £1,761,571 2017-2020: £709,736 2021-2024: £269,196
Total Savings compared to Status Quo pre financing (£)	3,842,309
Finance Route	PWLB funding at 3.31%, payable over 20 years
Total Savings compared to Status Quo post financing (£)	245,923
Payback period pre financing (years)	18
Payback period post financing (years)	> year 2037

Key Output	Value
Tonnes of carbon saved over the concession (tonnes)	7,168
Energy reduction over concession (%)	19%

From these results, the following can be inferred:

- The initial investment creates energy savings over the concession period of nearly 1.4 times the initial investment.
- Annual savings decrease for the years from 2023 to 2025 due to an increased amount of gear controls needing to be replaced annually. There are minimal maintenance cost savings over the concession of £408k, due to replacing a large proportion of lanterns within the network for dimming and trimming capabilities, rather than when each lantern fails.
- Savings in monetary terms post financing are minimal over the concession period.
- Total savings are still more than option costs even when finance costs are taken into consideration.

Option 3

Option 3, as identified in the Section 3.3.3, is to replace all existing SOX lanterns with conventional low energy lanterns. Key outputs from the financial model for Option 3 are as follows:

Option 3 Key Output	Value
Initial Investment (£) and phasing	3,462,625 2013-2016: £2,185,279 2017-2020: £944,056 2021-2024: £333,290
Total Savings compared to Status Quo	3,702,536

pre financing (£)	
Finance Route	PWLB funding at 3.31%, payable over 20 years
Total Savings compared to Status Quo post financing (£)	(598,730)
Payback period pre financing (years)	15
Payback period post financing (years)	>Year 2037
Tonnes of carbon saved over the concession (tonnes)	7,327
Energy reduction over concession (%)	19.4%

From these results, the following can be inferred:

- Cumulative pre-financing savings over the analysis period are c.£250k above the initial investment, leading to a relatively long payback period.
- Over the analysis period, there are no savings after finance costs until the debt is repaid.
- Option 3 creates significant energy savings over the analysis period but the value of these match the initial investment. Option 3 does however, provide protection against future increases in energy costs.

Option 4

Option 4, as identified in the Section 3.3.3, is to replace all lanterns with LED after 3 years. Key outputs from the financial model for Option 4 are as follows:

Key Output	Value
Initial Investment (£) and phasing	6,604,377 2013-2016: £3,285,760 2017-2020: £3,318,617 2021-2024: £0
Total Savings compared to Status Quo pre financing (£)	18,710,559
Finance Route	PWLB funding at 3.31%, payable over 20 years
Total Savings compared to Status Quo post financing (£)	9,357,776
Payback period pre financing (years)	8
Payback period post financing (years)	16
Tonnes of carbon saved over the concession (tonnes)	26,752
Energy reduction over concession (%)	63.5%

From these results, the following can be inferred:

- Post installation the nominal annual saving is c.£675k pa increasing to over £1m by 2032/3 (before financing costs).
- Annual nominal savings are still significant after finance costs, consistently achieving above c.£300k pa. When the debt is paid off (after the analysis period), total nominal savings would amount to over £1.1m per year.

- The LED solution shows a marked reduction in energy consumption, compared to previous options.
- Of all the options, this option provides the largest savings over the analysis period. Payback is also favourable, with the investment being paid back within 8 years if funded through capital budgets, capital receipts or reserves.

Appendix 7: Financial Model

Financial Model

The financial model is structured so that the costs savings for the option relative to the Status Quo are clearly identified in comparison to current and future council spending on their street lighting network.

The model seeks to ensure that all elements relevant to the project are included, and that the outputs accurately reflect the scenario being evaluated.

The model has assessed the street lights and not the street columns. This is purely an energy efficiency business case, and concentrates on the savings that can be made from installing energy efficiency lamps, lanterns and CMS systems. These savings can then be applied to fund a column replacement programme at the discretion of the Council.

The relevant sub headings of the 'comparison cash flow' sheet within the financial model, and how they are sourced are shown below.

Council status quo costs

The starting point for the financial model is the current cost to the authority of operating their street lighting network (including maintenance and energy costs) which is extended forward over the lifetime of the project (the 'Status Quo' scenario). This includes assumptions as to on-going capital expenditure (for essential replacements) and the energy consumption of the network. An annual cost is calculated for each year.

Construction Costs

Construction costs are the additional construction costs that are needed to deliver the option over and above the status quo capex cost. Costs are derived from technical modelling

Option Costs

The option costs are formed from the energy, maintenance and carbon costs for the option, that can be directly comparable to the status quo cost categories. These costs are derived from the technical modelling

Savings pre financing costs

The financial model 'comparison cash flow' details the savings the modelled option could generate before any financing costs are incorporated. It directly compares the status quo costs and options costs to calculate an annual saving (or increased cost). It is from this row of numbers that the payback is calculated from.

Financing Costs

Financing costs are derived from current market rates for the selected funding source.

The financial model details the cost of the capital and interest payments on the amounts borrowed. Capital repayments are based on an annuity repayment profile. The amount of financing drawdown relates to the amount of construction costs.

Savings after financing costs

The financial model calculates savings after financing costs, and is derived from the categories above. The calculated figures are from the total cost of the base case scenario over the concession period, less the total cost of the relevant technical cost option tested, and less the funding costs associated with the option.

Key Financial Model Assumptions

The table below provides a summary of the key input assumptions made in undertaking the modelling of the base case scenario. All price data are values as at 1 April 2012. These will include inflation to the point of project commencement.

Variable	Assumption modelled
Timings	The appraisal period for the street lighting project is modelled at 25 years from 1 April 2012. Under the technical options, investment is made at different times over this appraisal period. For example, under the preferred option a 25 year period is modelled; the investment is made in 2015/16 and 2016/17 and there is a 20 year operational period following this investment.
Capital Expenditure ("Capex")	The Capex costs for the project are expressed in 2012 prices by Arup's and inflated at 1% per annum. Option 4 LED costs were provided as outturn costs as outlined within Appendix 4.
Energy Cost Prices	Energy cost is assumed to be as per the Department of Energy and Climate Change (DECC)'s long term forecasts. Electricity prices are prepared by DECC's Inter-departmental Analysts' Group over a long term period, using the 'retail: commercial' prices.

Variable	Assumption modelled
Energy Cost inflation	DECC's electricity prices are quoted, based on a real basis. An indexation rate of 2.5% per annum has then been applied to the real numbers.
Maintenance inflation	Maintenance costs have been inflated at 2.5% per annum.
Street Lighting and the CRC	It is assumed that all of the Council's street lighting electricity consumption will be measured as part of its CRC scheme obligations, and will accordingly be a cost to the council.
The cost of carbon	It is assumed that the cost to purchase carbon allowances will be at an initial fixed price of £12 per tonne of CO2 (per government announcements). However, from 2013, carbon prices will be market driven. After discussion with industry experts, and publicly available information, it has been assumed for the purposes of this business case that the cost of carbon allowances will rise to £30 per tonne by 2023. It is assumed that carbon allowances will then stay at this level for the rest of the concession period.
Column replacement	It is assumed that the business case concentrates on energy efficiency elements. Therefore, column replacement programmes have been omitted from the option analysis. It is assumed that the councils current column replacement strategy and programme will be sufficient in replacing life expired columns. Within the Financial Model, an affordability analysis is included which incorporates an estimate of the likely spend on columns to understand the impact of this project and column replacement on Council cash flows.
Labour costs for maintenance	Assumed no salary costs for maintenance staff. This is due to the maintenance team not solely working on street lighting replacements. They are a maintenance team that is also dedicated to other traffic, road and highway issues. Therefore, the teams' salary costs and overheads would be covered elsewhere within the council budget.
CMS contingency costs	It's assumed that there are no contingency costs or reserve funds for any potential CMS failures. It is assumed any CMS system implemented will work effectively for the concession length, and therefore, no CMS maintenance or lifecycle costs have been included.

Prudential Borrowing Loan Term

Prudential borrowing enables the Council to match the term of the loan with the core constituent elements of the street lighting apparatus. Due to the focus of this business case on energy efficiency and the installation of street lamps, the prudential borrowing loan term has been matched to the lifetime of a street light lamp and lantern. LED lamps have a design life of at least 15 years, and some providers are guaranteeing the lamps for 25 years. Therefore, for the purposes of this business case, the assumed life term of a standard LED lamp is 20 years. Therefore, the assumed loan term for prudential borrowing is 20 years.

Affordability Work Sheet

A work sheet to calculate the affordability of the project to the Council has been included. This calculates the available Council budget based upon:

- Supplies and services - £180k pa available in 2012 prices inflated at 2.5% per annum.
- Electricity - £645k per annum available which inflates at DECC forecast electricity cost price rises and a general inflation factor of 2.5%
- Carbon - £39k based on the Council's estimated cost of carbon for the street lighting estate.

In analysing affordability, the Council have adopted a more prudent approach to cost savings for electricity costs during the installation period and maintenance costs.

Financial Model

A copy of the financial model is attached in the excel files.

Appendix 8: Evaluation of Benefits

Within this Appendix, the qualitative benefits associated with the short-listed options are summarised. These cover:

- Vehicle safety
- Pedestrian safety
- Crime and Security
- Visual Impact and Light Pollution
- Ecology
- Central Management Costs

Vehicle Safety

The safety of the public and vehicle use is the primary determinant as to whether a route is lit or not, therefore any proposed alterations to EDC's lighting network must firstly ensure that the proposal will maintain acceptable levels of road safety. Each option has been appraised in turn to identify any potential impact on the safety of road users and subjectively assess the implications of these proposals.

The appraisal has been carried out assuming that the application of any dimming suggested within the cost models would be applied in accordance with BS EN 5489 "Code of practice for the design of road lighting". This document allows for selection of lighting classifications based upon the road type/classification, rural/urban environment and traffic flow, the latter of which may change significantly throughout different periods of the day therefore permitting a reduction in lighting levels during periods of low activity.

As the application of LEDs and white light on a large scale for vehicle routes are a relatively new development, very little scientific research has been carried out in the comments raised below. Many of the observations are based upon anecdotal evidence and discussions made within the street lighting design community and raised for discussion within industry publications such as the Lighting Journal (published by the Institution of Lighting Professionals). These are documented in Table A8.1 for information.

Table A8.1: Vehicle Safety Appraisal of Options

	Status Quo Option	Option 3	Option 4
Appraisal Summary	Base Case	Marginal negative impact on vehicle safety	Marginal negative impact on vehicle safety
Notes and comments	There is anecdotal evidence that the application of white light sources within residential areas may result in a marginal improvement in visibility of obstacles within the road.	The implementation of dimming in the early hours of the morning would be adopted in response to reduced anticipated traffic flows during this time. The application of CMS for new lanterns will allow for more efficient management of the lighting stock including quicker response to lantern failure	There is some evidence that the use of white light within foggy environments can increase the experienced brightness of the environment, marginally reducing the contrast between the fog and vehicles in front. Further research is required into the phenomenon, however the application of a CMS would permit remote dimming of lighting in affected areas, as and when required, which may reduce contrast levels.

Pedestrian Safety

The safe movement of pedestrians and cyclists, particularly where routes may interface with vehicle traffic, is a key requirement for any lighting installation. Each option has been appraised in turn to qualitatively assess the potential impact of the proposals on the ability of pedestrians to see potential obstructions/change in level and be seen by vehicle traffic in order to safely move within the public realm during hours of darkness.

The appraisal has been carried out using guidance within BS EN 5489 “Code of practice for the design of road lighting”, industry based technical papers and the experience of the author. The British Standard specifies minimum performance criteria for road and footpath lighting to achieve a minimum acceptable standard for lighting of both areas surrounding vehicle traffic routes and for dedicated foot/cycle ways. Each option has been reviewed considering what key performance changes may be brought about through the adoption of the proposals in reference to EDC's current lighting stock.

Table A8.2: Pedestrian Safety Appraisal of Options

	Status Quo Option	Option 3	Option 4
Appraisal Summary	Base Case	Marginal negative impact on pedestrian safety	Negligible impact on pedestrian safety
Notes and comments	The use of white light (PL-L lamps) on pedestrian routes when introduced will give perception of a better lit and brighter environment, though is unlikely to result in a tangible improvement in safety.	The dimming of residential areas could be considered to equate to a reduction in pedestrian safety i.e. a reduction in ability to be seen by vehicle traffic. Some dimming trials have already been carried out by EDC in residential areas with no negative feedback from the public, however the option presented suggests trial and implementation of a more aggressive dimming strategy in some areas. The application of CMS for new lanterns will allow for more efficient management of the lighting stock including quicker response to lantern failure and prevention of dark locations for prolonged periods.	The dimming of residential areas could be considered to equate to a reduction in ability to be seen by vehicle traffic, however the use of good colour rendering light sources will increase the visibility of pedestrians to road users. LED lighting solutions should be developed to ensure adequate lighting of road verges/footpaths and to ensure pedestrians are visible to road users. The application of CMS for new lanterns will allow for more efficient management of the lighting stock including quicker response to lantern failure and prevention of dark locations for prolonged periods.

Crime and Security

The fear of crime and sense of security created by a lighting installation can influence the perception of an area and in turn the perceived risk of crime that is not necessarily reflected in reported crime figures.

There is much ongoing research into the impact of improved lighting provision on crime and security within areas as a result of improved lighting provision, however findings are often inconclusive due to the complexity of the variables within a locality or different reports delivering conflicting findings.

With this in mind the general consensus of lighting professionals are as follows, elements of which are strongly supported by small scale academic research on the perception of safety experienced by pedestrians:

- Use of white light with good colour rendering properties increases the sense of security within an area.
- The perception is that white light is “brighter” than traditional sodium technology and therefore less light is required to achieve the same sense of security.
- The greater the density of people or traffic flow the greater the light level required to achieve the same perceived sense of security.

Each cost model option has been qualitatively appraised against the anticipated change in perception of security generated by the implementation of the lighting option. The appraisal has considered how people may experience the difference in perception of safety and therefore perceived risk or being a victim of crime, but also considering how the initiatives may aid or combat the creation of negative experiences. i.e. the time taken to repair faults.

Table A8.3: Crime & Safety Appraisal of Options

	Status Quo Option	Option 3	Option 4
Appraisal Summary	Base Case	Neutral impact on Crime and Security	Marginal negative impact on Crime and Security
Notes and comments	Introduction of white light over time will improve the perceived safety of the lit environment.	The dimming of lighting within residential areas during the early hours of the morning may be thought to impact on crime and security, however it is unlikely that the proposals will be so significant as to be noticeable to the casual observer. The application of CMS allows the actually dimmed levels to be optimised as appropriate on a column by column basis to meet requirements.	The tightly controlled light distribution and efficiency features of LED lighting equipment can result in the loss of amenity to private land (drives, gardens etc.) and as such can result in the creation of dark areas previously lit by inefficient lighting installations. This could have a negative impact on the perception of crime and security, while it is not significant enough to preclude the lighting solution, the potential impact of such should be considered during implementation of a scheme.

Environmental – Visual Impact and Light Pollution

Visual impact and light pollution are important issues for consideration in designing street lighting. Although subjective, visual amenity is generally increased by focused, high quality lighting design that emphasises elements of the urban form. The introduction of trimming and dimming technology will allow greater control of the timing and intensity of light to complement the ambient environment.

Light pollution is an increasing problem within urban centres, particularly as population densities increase. The effects of light pollution are commonly reported within the media as the ability to see the night sky. In addition to this, street lighting can also have a significant impact on sleep disturbance if bright, poorly located or poorly maintained lamps affect on habitable rooms.

Table A8.4: Environmental – Visual Impact and Light Pollution Appraisal of Options

	Status Quo Option	Option 3	Option 4
Appraisal Summary	Base Case	Marginal beneficial impact on visual impact and light pollution.	Marginal beneficial impact on visual impact and light pollution.
Notes and comments	The replacement of SOX light sources will reduce the visual impact of the illuminated streets. SON light sources are often considered to provide a warmer, aesthetic appearance however the use of white light can be cool and appear harsh and much brighter. The gradual replacement of outdated SOX lanterns with modern conventional lanterns will result in a better control of light and less light spilt directly into the sky. Campaigners for Dark	Dimming, particularly in residential areas will increase the visual amenity at night and may help prevent light pollution from being a primary cause of sleep disturbance during the hours of midnight to 6am. Dimming is contentious in some areas due to perceived crime and safety issues, yet this reduces light levels and therefore reduces light pollution. In addition the provision of CMS allows lighting to be easily adjusted for change in use/traffic during the life of the installation.	LED lamps provide a visually aesthetic source of lighting and can be unobtrusive in terms of light pollution, though this is dependent on the design of light fittings to direct light downwards. LED sources offer good light control and reduced light pollution if good beam control and dimming control is provided. The blue emission with 'cool' sources can be high and warm sources should be considered with lower blue light content – however these

	Status Quo Option	Option 3	Option 4
	Skies often prefer the use monochromatic SOX light for astronomical purposes.		sources are currently significantly less efficient. The overall success of an LED scheme requires careful design and selection of appropriate equipment to optimise the scheme however the potential benefits are greater than with other lamp types.

Environmental – Ecology

Ecology has evolved within a natural light environment, so any impacts associated with artificial light are as a result of the influence of individual and collective lamp schemes. Light has a multitude of impacts on ecology associated with behaviour, including foraging and predation risk for fauna, whilst having photosensitive effects on flora.

Research and guidance primarily focuses on the avoidance of ultraviolet (UV) radiation within the environment, encouraging selection of light sources with predominantly longer wavelength distribution to minimise the impact. Traditionally this has encouraged the use of monochromatic light sources, such as SOX lamps, and discouraged broad spectrum lamps such as white light and mercury sources (including fluorescent lamps) due to the disruption on the natural circadian rhymes of surrounding wildlife. The introduction of LEDs has challenged the traditional advice as the tuned output of the light source to predominantly the visible spectrum minimises exposure to UV radiation and therefore encourages their use within ecologically sensitive areas.

The effects of lighting are very specific depending on the location, though generally, lighting schemes that use less intense lamps that are fully controllable and run efficiently are better for the natural environment. Local authorities have a duty under the Nature Conservation

(Scotland) Act 2004 to conserve and enhance biodiversity, so careful consideration should be given to ecological issues based on location.

Table A8.5: Environmental – Ecology Appraisal of Options

	Status Quo Option	Option 3	Option 4
Appraisal Summary	Base Case	Negligible impact on ecology	Negligible impact on ecology
Notes and comments	SOX are generally seen as better than other light sources due to the monochromatic output in a narrow band of the electromagnetic spectrum, particularly the absence of light in the UV area of the spectrum. The introduction of white light, particularly fluorescent lighting, is considered to significantly change behaviour of flora and fauna due to the enhanced UV component of light. Some areas of environmental sensitivity may be better served with SOX lamps retained.	As per the Status Quo the removal of SOX lanterns and replacement with SON and PL-L sources will increase the impact the lighting installations have on the local ecology. However dimming, trimming and reducing light levels where appropriate will decrease light pollution and therefore the affect on wildlife. The introduction of modern lanterns allows reduction in spill light outside of the intended target area and therefore better definition of ecological dark corridors and areas that are not illuminated.	LEDs are generally considered by ecologists to have a beneficial impact on the lit environment due to their negligible output in the Ultra Violet portion of the electromagnetic spectrum. There is debate within the ecological and lighting community as to the impact of light in the visible spectrum on fauna and flora, however there is currently little academic research supporting either argument. The potential of LED lighting is good as the source offers excellent beam control to minimise light spill and pollution. LED

	Status Quo Option	Option 3	Option 4
		The ability to control lighting allows the potential for altering the lighting to take account of changing conditions and increasing knowledge of the effects of lighting on natural systems.	technology offers greater potential for ecological design when used correctly.

Appendix 9: Risk Matrix

The following details the key risks associated with an investment in street lighting environment assuming a supply and install contract:

Technical Risks

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
Technical Risks			
Changes in Design Standards & Codes of Practice **Changes in design due to influences external to the Local Authority** **Compatibility with Existing Systems** **Continuing Development of Design** **Design Delays and Amendments** **Fitness for purpose (is the design satisfactory to meet operational requirements?)** **Public & Third Party Consultation results in a change in requirement** **Redesign/Design Defects** **Incorporation of new works associated with new development complicates specification requirements or timing**	Design	Increase in cost Delay to timetable Project uncertainty	Effective project management Strong leadership Pull in extra resources where required Peer reviews of projects at critical stages
Accuracy of Inventory and all Surveys **Coordination with column replacement programme** **Coordination with other parties/other highway works** **Connection Arrangements (including Delays)** **Delays caused by Utilities** **Electrical Testing identified defects** **Failure to Install to Design Standards/Design Brief**	Installation	Increase in cost Delay to timetable Project uncertainty	Experienced delivery team

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
Implementation Issues to comply with planning legislation **Industrial Action** **Traffic Management** **Programming of works**			
LED Costs greater than expected **LED Efficiencies not realised** **LED Lifecycle less than expected** **LED not as reliable as claimed** **CMS systems prove unreliable** **CMS information underutilised and no management savings realised**	Changes in technology	Potential weakening of the business case if predicted unit cost reductions are not realised.	Monitor market progress including soft market testing Benchmarking Monitor actual tended data that becomes available Phased programme. Keep up-to-date on technology developments that are deliverable.
Capital Costs Overrun **Cost of Alterations** **Material Costs & Supply** **Incorrect cost and cost estimates** **Installation Costs**	Costs	Increased costs and increased finance Reduction in project affordability	Issue of a fixed price contract to supply and install street lights. Clear understanding of the commercial arrangements and when the successful contractor will be able to make claims against the Council.
Compliance with Design Standards/ Codes of Practice **Heritage/Conservation Area Works and Compliance** **Compliance with Good Industry Practice** **Compliance with Output Specification** **Compliance with Quality Standards** **Compliance with Third Party Requirements**	Compliance	Delay to timetable	Transfer under a supply and install contract once the specification has been produced. Installation risks would cover inaccuracies within the specifications and surveys.

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
Electrical Safety of all Apparatus & Equipment Installed **Health & Safety Case** **Legislative/Regulatory Change** **Local Authority Policy Changes** **Site Security and Safety**			
Access Agreements and Consents **Planning Approvals/Consents / Permissions** **Easements required**	Consents	Delay to timetable	
Environmental Liabilities/Damage **Pollution** **Change in appearance of new lighting source has greater impact on environment than anticipated**	Environmental	Adverse publicity	Environmental risk assessment prior to undertaking works Keep up to date with new technology

Financial Risks

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
PWLB interest rates higher than forecast	Project Affordability	Could lead to fewer saving and a longer payback.	Include a 'buffer' when modelling interest rates Sensitivity analysis to quantify impact
Changes in forecast inflation impacting upon realisation of savings including	Financial	Variation in forecast savings from the project	Inflation and energy prices to be tracked during the development of the

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
energy prices. CRC charges escalate higher than forecast			project to confirm likely outturn prior to procurement and following receipt of tenders.

Pre-procurement Risks

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
Asset inventory inaccurate and/or incomplete or knowledge of asset condition inaccurate or incomplete Accuracy of Management Information System	Asset Register Inaccuracies	Cost estimates wrong as the specification is incorrect and the Council are subject to claims for variations in the contract	Updating and auditing of asset records prior to developing the specification.
Delays in approval		Timetable will slip. Development and project costs may escalate and savings be eroded	

Procurement Risks

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
Underestimation of costs at Business Case stage, resulting in tender prices being higher than expected	Cost underestimation	Adverse impact on affordability	Technical and Financial due diligence and surveys by the Council pre-procurement to test business case assumptions. Refine estimates

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
			through soft market testing.
Design Warranties **Lack of scope definition** **Over specification of output requirements** **Third party claims** **Intellectual Property disputes**	Contract	Adverse impact on costs or reliable delivery	Supply due diligence Use of best practice contract documents Appropriate legal advice
Insolvency of supplier or party providing the warranties/guarantees on the LED technology	Financial robustness	If it occurs during installation may lead to contract terminations.	Robust financial tests. Councils to monitor the financial viability of companies providing guarantees