Street Lighting Energy Efficiency Outline Business Case

West Dunbartonshire Council

November 2012

SCOTTISH FUTURES TRUST

West Dunbartonshire Council
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Executive Summary

Introduction

West Dunbartonshire Council (“WDC”) has identified a need for change within its street lighting service driven by:

- The condition of the existing network and the public and political expectations in relation to standards of street lighting.
- Meeting their 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.

WDC has therefore participated in an initiative with the Scottish Futures Trust (“SFT”) to prepare a Business Case to explore the energy efficiency benefits which may be obtained from an investment within its street lighting network.

WDC’s specific objectives for any investment in its street lighting include:

- Reducing future maintenance costs.
- Reducing energy consumption.
- Meeting the Council’s commitments and demands with respect to sustainable practices and reducing carbon emissions.
- Establishing good practice to encourage partners and developers within the wider community to follow.
- Raising the environmental profile of the Council.

Approach

The Project Team including WDC, SFT and Over 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.* Replace lanterns and control gear on a like for like basis upon failure but including high frequency electronic control gear. No change in existing control strategy.
Option 3	*Replacement of all lamps and installation of a CMS system and increased dimming.* Immediately replace all existing lanterns with conventional light sources within the first two years based upon an anticipated failure rate of lanterns over time: • All sources greater than 70W to be replaced with SON HF light sources. • All sources less than 60W to be replaced with 45-60W Cosmopolis lantern. Upgrade control gear with new dimmable high efficiency technology in new lanterns and control gear replacements. Introduction of CMS to all new lanterns. Increase dimming functionality to all lanterns, assuming dimming of half of residential streets to 50% output between midnight and 6am.
Option 4	*Replacement of all lanterns with LEDs after 3 years.* LED technology replacement for all lanterns after 3 years with all units replaced over a 2 year period. All new LED equipment to be provided with CMS capability. Dimming and trimming settings as per Option 3.

Results

The quantitative and qualitative impact of these options were assessed and the results are summarised within the Table overleaf:

Table 2: Summary of Results

Category	Option 3	Option 4
Financial:		
Initial Investment	£3.3m	£6.6m
Forecast savings/(additional cost) post-financing costs	£1.3m	£12.0m
Forecast savings pre-financing costs	£3.3m	£19.8m
Energy Efficiency:		
Decrease in annual energy consumption	20.4%	58.0%
Tonnes of carbon saved	9.4k	24.8k
Benefits	Benefits arise including 20% 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 58% 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 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.

This table indicates that Option 4 delivers the most cost effective solution requiring a forecast investment of £6.6m and delivering forecast savings of £19.8m assuming that the investment was financed from capital budgets and capital receipts. The savings decrease to £12m if the full investment of £6.6m was financed through SPRUCE (Jessica) funding assuming an interest rate of 2.5% and a 10 year repayment period.

The analysis was subject to sensitivity testing which confirmed that Option 4 provided WDC 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. WDC will continue to monitor these elements of the Business Case whilst preparing for procurement. The business case assumes that LEDs will be installed in 2015-2016 which provides further mitigation of these risks. Option 4 was selected as the preferred option.

Affordability

The affordability implications of the project were also reviewed and the project was confirmed as affordabale.

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

West Dunbartonshire Council ("WDC") 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

In September 2012, WDC published its Strategic Plan 2012 – 2017 which detailed the Council's main priorities for the period, including:

- Improve economic growth and employability.
- Improve life chances for children and young people.
- Improve care for and promote independence with older people.
- Improve local housing and environmentally sustainable infrastructure.
- Improve the wellbeing of communities and protect the welfare of vulnerable people.

Improving the street lighting network within the Council area and improving energy efficiency meets the Council's priority of improving environmentally sustainable infrastructure.

The provision of an enhanced street lighting infrastructure will also contribute to the priorities included within the Single Outcome Agreement by assisting in the creation of attractive town centres; enhancing public service; improving road safety and potentially assisting in the reduction of violent crime. It will also improve West Dunbartonshire's environment and significantly reduce greenhouse gas emissions.

1.3. 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, WDC has an important role to play, by reducing our own carbon emissions and by setting an example for others to follow.

WDC is committed, through various duties, policies and initiatives, to reducing its carbon emissions. There are growing incentives for carbon reduction including the CRC Energy Efficiency Scheme. WDC's Carbon Management Plan sets a target of reducing carbon emissions by one third by 2015. There has been reasonable progress to date and the Council continues to identify new projects which can contribute to meeting this target, including this street lighting project.

The following list indicates the key drivers that now influence the Council's activities in respect of climate change:

- 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)
- WDC's Single Outcome Agreement
- WDC's Best Value responsibilities
- WDC's Sustainable Development Strategy and Action Plan
- WDC's Climate Change Declaration

According to the Department of Energy and Climate Change's Total Emissions 2009 release, the total figure for West Dunbartonshire's "CO2 emissions within the scope of influence of Local Authorities" is 516.2 kt. Carbon emissions from the council's street lighting is a significant portion of this total amount, and therefore implementing this project will look to reduce the Council's overall carbon emissions and climate change impact.

This business case focuses upon the carbon arising from street lighting as part of a SFT pilot project into energy efficiency investment in street lighting.

1.4. Council Objectives

In participating in this project, WDC is aiming to achieve robust and accurate financial data which will assist in informing future investment in our aging street lighting infrastructure. The recent financial climate within the Council has placed a heavy pressure on the Council's revenue budget with significant savings being made year on year and for coming years. The additional demands within the Council of reducing its carbon footprint will help improve the local environment and also achieve additional revenue efficiencies through the reduction in energy usage.

The main factors to be determined through the business case will be:

- The level of capital investment required and timing
- The funding sources available to support the necessary investment
- Spend to save revenue savings generated through energy reduction and payback period
- Maintaining existing high service levels within the street lighting service

The business case to be developed by Scottish Futures Trust which establishes that these requirements can be successfully achieved will assist the Council in meeting its ongoing objectives with respect to:

- Reducing future maintenance costs
- Reducing energy consumption
- Meeting the Council's commitments and demands with respect to sustainable practices and reducing carbon emissions
- Establishing good practice to encourage partners and developers within the wider community to follow
- Raising the environmental profile of the Council

1.5. Current condition of the street lighting stock

Currently our street lighting infrastructure consists of approximately 17,300 columns. As a result of systematic under funding, the existing street infrastructure has now deteriorated to such a condition that it is raising safety concerns. Currently, over 7,000 street lighting columns far exceed their design life expectancy and are in a poor condition.

The number of columns which need to be replaced each year, due to structural failure is increasing.

Our electricity charges are based on an unmetered supply with an outturn wattage of 6,495,087 KWh at 8.81p per KWh as at April 2012.

At present our existing cabling is a mixture of both DNO & local authority cables. The exact split is still to be established but is estimated at 50/50.

The energy consumption at some 23% of the Council’s overall usage is extremely high and to comply with the Council’s energy reduction target and to support the national target, it is essential that a modern, reliable and efficient street lighting infrastructure is funded throughout West Dunbartonshire.

The Lighting section has been replacing yellow light with white light utilising energy efficient control gear. The rate of change however is too slow due to the systematic under funding over many years and this project is of particular importance in directing the Council on how to move forward with future investment in street lighting.

In recent years an increasing number of columns have required to be taken down as a result of severe corrosion. Whilst any column considered to be of immediate structural failure would be removed as a matter of course by the Council, there are some 7,000 columns which now far exceed their design life and will require to be taken down/replaced in the coming years.

This situation has directly influenced the Council’s need to determine the best option to fund the necessary replacement of this failing infrastructure.

The corresponding 18,000 lanterns (which includes signage lights and school flashers as well as street lights) include standard energy efficient electronic control gear (20%), dimmable units (1%) and 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.

The first use of LED street lighting has now begun in Britain and currently the use of LED street lighting units in West Dunbartonshire is limited to a very few locations such as difficult to access footpaths and some residential roads. The success and reliability of these installations is currently being monitored.

The Council does not have any equipment or current plans in relation to central monitoring systems for its road lighting network but can see merit in the introduction of this technology with respect to maintaining excellent service levels for the community.

Generally the perception of white light is good within our communities.
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 Scottish Power. The ability to rectify these faults lies out-with the Council remit and extended response times from the utilities results in considerable complaints and adverse press / public perception.

1.6. Investment / Replacement Strategy

The capital expenditure budget for street lighting has been significantly reduced over the past few years and at its highest was £500,000. Historically, in 2005/6, the capital budget was sufficient to ensure a stand still approach to the planned renewal of the street lighting infrastructure. In recent years the capital investment has significantly reduced and was nil in 2011/12.

Table 1.1: Capital Expenditure Budget Profile

Year	Budget	Columns replaced
2005/6	£500,000	300
2006/7	£125,000	70
2007/8	£125,000	70
2008/9	£125,000	70
2009/10	£75,000	40
2010/11	£125,000	70
2011/12	0	0

Over the past years it has become increasing necessary to use the maintenance budget to replace failing columns. Some 150 columns have been replaced through revenue funding this year. This approach is unsustainable and is leading to a rapidly deteriorating infrastructure both structurally and electrically as we are unable to fund planned cyclic maintenance. A separate business case was been submitted to Council to fund a 10 year column replacement programme but this is not being funded at this point in time.

In addition, the electricity expenditure is increasing year on year, mainly due to the increase in energy prices.

In summary, the consequence of maintaining the current level of funding is that we are not in a position to undertake any planned renewal schemes and most of all we would be reacting inefficiently to structural failures throughout WDC.

At present, the number of columns which failed structurally in financial year 2010/11 was 70 and this has increased to 150 in 2011/12. However, due to the lack of capital investment, very limited planned replacement schemes have been completed in 2011/12.

The street lighting energy consumption at some 23% of the Council's overall usage is extremely high and to comply with the Council's energy reduction target and to support the national target it is essential that a modern, reliable and efficient street lighting infrastructure is funded throughout West Dunbartonshire.

1.7. The Need for Change

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

- The condition of the existing network and the public and political expectations in relation to standards of street lighting.
- Meeting the Council's 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.

It is essential that these factors are addressed in a manner which makes best use of the limited resources available and achieves value for money and a sustainable outcome. Any significant capital investment will require to deliver significant 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 methodology adopted to assess the energy efficiency implications of various street lighting investment opportunities.
- Appraises a long list of technical options available to WDC 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 WDC 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 future maintenance costs.
- Reducing energy consumption.
- Meeting the Council's commitments and demands with respect to sustainable practices and reducing carbon emissions.
- Establishing good practice to encourage partners and developers within the wider community to follow.
- Raising the environmental profile of the Council.

The Business Case has been developed by:

- WDC street lighting and finance teams.
- Scottish Futures Trust.
- 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 WDC 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 5 technical options were developed with WDC, Arup and SFT which were assessed against the Status Quo. The long list of technical options were appraised financially through analysis of the technical cost elements within a financial model which included consideration of the funding implications of the long list of options. Key outputs on initial investment, 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 against the Status Quo including financial risk and qualitative analysis. A carbon benefits appraisal was also undertaken.

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 short-listed 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 tested as part of this exercise.

The results of the analysis of the long-list 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 WDC 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 Option 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.

WDC currently use a spreadsheet database system 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 and consequently they are in the process of updating their system. The data used in the preparation of this business case is drawn from information collated for a previous business case assessment documented in a report titled 'Proposal for the Refurbishment of Street Lighting within WDC', dated 17th November 2011 and includes:

- Asset register with column type, height, lantern type and date of column installation. – described as being accurate as of 2010/11.
- "Information on Installed Wattage" energy consumption figures (dated April 2011)

WDC has advised that no works have been undertaken in the last 18 months which would significantly change the inventory details. However, they did suggest that the asset register did not accurately reflect the increased use of metal halide light sources and the introduction of high frequency control gear in some SON lanterns.

Information within the database is limited to basic details of each asset, however there were no details of lantern, lamp or control unit replacement dates, asset condition information, predicted asset life or future maintenance requirements.

The data used has been discussed with WDC's street lighting asset team, and their in-depth knowledge of the assets has been drawn upon in order to make assumptions on renewal priorities and sequencing of work.

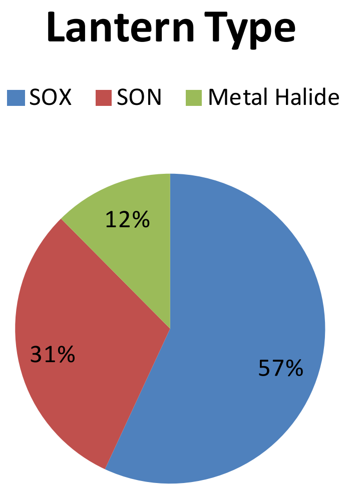
3.2.1. Summary of Street Lighting Assets

The WDC asset register data provided consisted of a spreadsheet itemising each street light, with details of:

- Location and reference number.
- Generic lantern type (SOX, SON, CDMT etc).
- Wattage and circuit wattage.
- Column height.
- Date of original installation.

From the data it was possible to establish an age profile of column infrastructure. As the data did not include last replacement dates of lamps, lanterns and controls, it was not possible to establish similar age profiles for each of these components, particularly where lighting equipment had been recovered from replaced column equipment and re-used. However, the WDC asset team provided general guidance on component ages based on their general knowledge of the assets. The different lantern types are summarised in Diagram 3.1:

Diagram 3.1: Analysis of WDC's lanterns



A more detailed asset sheet is included in Appendix 1.

The WDC asset database indicates that a comparatively small range of lighting types are in use throughout the local authority. Approximately 57% of assets being low pressure sodium SOX lamps (45% of which being higher efficient type control gear), 30% high pressure sodium SON lamps (none of which were identified as containing high frequency electronic control gear). The remaining 13% of lanterns comprising of CDMT metal halide light sources. No data was provided as to the construction of the columns, although the age profile generated from the assets indicated that 15% of all columns were in excess of 35 years old and anticipated to rise to 45% within 10 years if no action is taken.

3.3. Identification of Replacement Solutions

Workshops were held between the study team and WDC officers to discuss WDC'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

WDC has a clear objective to upgrade the column stock, based on safety concerns driven by instances of column failures. However, as specific column condition information is not available 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 100 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.

Clearly WDC could chose to accelerate this column replacement programme with additional Capex should this become available through an Invest to Save programme or other sources. Although this approach is considered reasonable for the purposes of preparing the business case, integrating the lantern and column replacement programmes will be needed in order to deliver the works efficiently.

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 key issues and objectives of WDC that have informed the renewal options are noted below:

- Street lighting assets are currently deteriorating rapidly with more failures occurring every year. Extra funding is required for maintaining and improving street lighting assets which are suffering from a lack of capital investment over a prolonged period. WDC consider that their current budget and resourcing within the department are not sufficient to achieve acceptable and sustainable maintenance service levels in the long term.

- Signage lighting is not considered to be a priority energy consumer and therefore has not been incorporated in the assessment of options.
- There are geographic areas within WDC's boundaries which suffer from high levels of social deprivation where lighting levels are considered important to addressing perceived and actual personal safety issues.
- Removal of street lighting from existing areas is unlikely to be an option that would be politically acceptable and any saving is considered to be minimal due to the small lengths of road where this might be considered technically feasible.
- WDC are very keen to consider the introduction of CMS as they have very limited street lighting staff resources. The integration of a CMS with other WDC maintenance works databases is considered to be advantageous with the potential to streamline work planning.

3.3.3. Initial Options Analysed

Based upon discussions in the workshops the following long list of technical replacement solutions were agreed and tested:

Table 3.1: Option Definition

Option	Definition
Do Nothing	**A 'theoretical test' option to explore the impact if no investment was made into replacing the ageing column stock and 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 represents continuation of the current asset strategy. Assumptions for the Status Quo option are included within Appendix 6.** Replace lanterns and control gear on a like for like basis upon failure but including high frequency electronic control gear. No change in existing control strategy.
Option 1	**Accelerated replacement of old SOX lamps and energy savings through dimming and trimming.** Immediately replace all existing SOX lanterns with updated conventional light sources within the first two years: • All sources greater than 70W to be replaced with SON HF light sources.

Option	Definition
	• All sources less than 60W to be replaced with 45-60W Cosmopolis lantern. Upgraded control gear to include new dimmable high efficiency technology where new lanterns and control gear replacements are installed. 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. Dimming of half of residential areas by 30% between midnight and 6am.
Option 2	**Replacement of all lamps and increased dimming.** Immediately replace all existing lanterns with conventional light sources within the first two years: • All sources greater than 70W to be replaced with SON HF light sources. • All sources less than 60W to be replaced with 45-60W Cosmopolis lantern. Upgrade control gear with new dimmable high efficiency technology in new lanterns and control gear replacements. Trimming and dimming settings as per Option 1.
Option 3	**As of Option 2 but with a CMS system and increased dimming.** Lantern replacement strategy as per Option 2. Introduction of CMS to all new lanterns. Increase dimming functionality to all lanterns, assuming dimming of half of residential streets to 50% output between midnight and 6am. Trimming settings as per Option 1.
Option 4	**Replacement of all lanterns with LEDs after 3 years.** LED technology replacement for all lanterns after 3 years with all units replaced over a 2 year period. All new LED equipment to be provided with CMS capability. Dimming and trimming settings as per Option 3.

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

3.4. Financial Analysis of Initial Technical 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 WDC 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 options include different phases of investment as detailed within Appendix 6.

- Financing costs have been calculated assuming the Council borrows from the SPRUCE fund at 2.50% for a 10 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.

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

The results of the financial analysis of the long list of technical options are detailed below. The savings are based on the savings (or increased cost) compared to the status quo which broadly equates with WDC's existing street lighting practices.

Table 3.2: Financial Analysis (expressed in nominal terms) of the Long-list of technical options

Option	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	6,885	6,885	58.7%
1	1,747	115	2,156	11.4%
2	2,796	939	4,205	16.0%
3	3,386	1,310	5,264	20.4%
4	6,654	12,019	19,788	58.0%

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.

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	625	6,011	249	6,885
1	(147)	2,186	117	2,156
2	813	3,219	173	4,205
3	813	4,222	228	5,263
4	7,170	11,979	640	19,788

The financial analysis indicates:

- Do Nothing Option – appears to create significant savings against the Status Quo for both maintenance and energy costs and energy consumption. This is due to large reductions in operational columns which is not sustainable and risks WDC not meeting their statutory obligations regarding lighting.

- Option 1 – delivers the lowest level of savings against the status quo with an investment of £1.7m over 25 years delivering £115k of savings post financing costs and £2.2m of savings before financing costs.

- Options 2 and 3 provide WDC with both maintenance and energy savings over the concession period for a smaller initial investment than Option 4. Option 3 has the same lantern replacement programme as Option 2 but also includes a CMS and assumes greater dimming levels, which result in higher investment needs and lower consumption levels. The overall impact on energy consumption is small with option 2 delivering a 16.4% decrease in energy consumption and option 3 a 20.4% decrease.

- Option 4 – includes the implementation of both LED technology and a Central Management System. For an investment of £6.6m it generates savings of £12m before financing costs and £19.8m after financing costs. It also reduces energy consumption by 58%.

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

3.5. Qualitative Analysis of Initial Technical Options

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

Table 3.3: 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 WDC exposed to risk of legal action in the event of an accident. It is also inconsistent with WDC's objective of embedding sustainable practices within its operations.
Status Quo	Minimal capital investment (in line with current expenditure)	No reduction in energy consumption over time, resulting in increased energy and CRC costs as unit charges increase.
1	Gradual improvement in lighting quality through the removal of monochromatic SOX lamps and replacement with CPO light sources within residential areas. Significant energy saving realised through the application of trimming of operational light levels and dimming of residential areas.	The use of conventional technology in replacement of SOX lighting equipment will result in an increase in overall energy consumption masking some of the benefits from the dimming of lanterns.
2	Rapid replacement of SOX with white light sources provides quicker improvement of lighting quality.	This option assumes 30% dimming levels to only 50% of residential streets (similar to Option 1) which results in modest energy cost savings.
3	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.	This option assumes that dimming to 50% would be acceptable to occupants of all residential streets. CMS requires a different approach to managing assets if potential savings are to be realised.
4	LEDs provide a significant reduction in energy consumption and maintenance costs compared to conventional technology sources.	LED technology continues to develop which will influence future price levels and efficiency levels.

3.6. Shortlisting

On the basis of the above financial and qualitative analysis, options 3 and 4 were shortlisted for comparison against the "Status Quo" option as they best meet WDC's objectives as detailed within Sections 1 and 2 of the Business Case.

Option 3 was chosen as it was the "conventional technology" option which aligned with WDC's objectives of significantly reducing energy consumption, rapidly replacing aging assets and having a level of service that's 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. The option delivered total savings and a percentage reduction in energy consumption more favourable than previous options.

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 – The base against which the other options were compared.
- Option 3 – Full investment in conventional technology lamps with CMS and maximising savings from dimming and trimming.
- Option 4 – Complete replacement of current lanterns with LEDs and CMS, with installation commencing in 2015 and complete 2016.

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

4.2. Summary of Technical Costs

The technical costs detailed within Appendix 3 are summarised below in nominal 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)

Issue	Status Quo Option	Option 3	Option 4
Total Capex over 25 years	Nil	3,386	6,654
Total Maintenance over 25 years	8,078	7,265	909
Total Energy Consumption over 25 years (GWh)	165 GWh	135 GWh	84 GWh
Total Energy Cost over 25 years	22,922	18,700	10,943
Total Emissions over 25 years (000's)	55,000 tonnes	45,600 tonnes	30,100 tonnes

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 WDC'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 pre financing and post 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	3,386	1,310	Maintenance:	813	20%
			Energy:	4,222	
			Carbon:	228	
			Total:	5,263	
Option 4	6,654	12,019	Maintenance:	7,169	58%
			Energy:	11,979	
			Carbon:	640	
			Total:	19,788	

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 WDC. 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:

Table 4.3: Sensitivity Testing

Option	Savings pre-financing	Savings post financing	Variation in savings to Base Case	Commentary
Base Case:				
Option 3	5,263	1,310	-	
Option 4	19,788	12,019	-	
Sensitivity 1: Capital costs increase by 5%				
Option 3	5,263	1,112	198	Savings decrease reflecting the increased cost of financing a 5% increase in capex.
Option 4	19,788	11,631	388	
Sensitivity 2: Energy Costs based on 2011/12 outturn				
Option 3	6,232	2,279	969	Savings compared to the base case increase as energy costs increase due to the lower energy consumption following investment
Option 4	22,535	14,766	2,747	
Sensitivity 3: Energy Cost Inflation				
Option 3	7,110	3,157	1,847	As for sensitivity 2
Option 4	25,256	17,487	5,468	

Option	Savings pre-financing	Savings post financing	Variation in savings to Base Case	Commentary
Sensitivity 4: Cost of Carbon				
Option 3 Option 4	5,350 20,038	1,397 12,269	87 250	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.

4.4.2. Sensitivity Analysis – financing the investment

There are a range of approaches available to WDC 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, WDC could also utilise finance from the SPRUCE Fund or the Public Works Loan Board. Table 4.4 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.

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 Case: SPRUCE Funding at 2% over 10 years			
Option 3	5,263	1,310	3,953
Option 4	19,788	12,019	7,769
Public Works Loan Board Finance @ 3.31% over 20 years			
Option 3	5,263	468	4,795
Option 4	19,788	10,365	9,423
Sensitivity: Public Works Loan Board Finance @ 4% over 20 years			
Option 3	5,263	145	5,118
Option 4	19,788	9,730	10,058
Sensitivity: Public Works Loan Board Finance @ 5% over 20 years			
Option 3	5,263	(340)	5,603
Option 4	19,788	8,777	11,011

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 £19.8m if capital budgets, capital receipts or reserves were used to finance the investment. These savings decrease to £8.8m over a 25 year period if funded through PWLB borrowing at 5%[2] or £12.0m if funded through SPRUCE funding at 2.5%.

The sensitivity analysis indicates that such an investment would provide significant protection to WDC 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 savings of £2.7m.

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 £3.4m resulting in forecast savings of £5.3m before financing costs, and a forecast saving of £1.3m 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.

[2] WDC recharge interest to projects at their blended rate which varies over time but approximates to 4.5%. The 5% sensitivity therefore indicates a worst case scenario.

5. Technical Option Appraisal – Evaluation of Benefits

5.1. Introduction

In appraising the options for qualitative benefits, the following criteria were 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 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 in the options in 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 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 can be quantified.

5.2. Evaluation of Benefits

Table 5.1 summarises the main benefits that an investment in energy efficiency street lighting is expected to deliver. A detailed review of these benefits 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 removes the need for night scouting	Marginal Beneficial: the introduction of a CMS facilitates more efficient planning of maintenance and removes the need for night scouting

The following section 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 within Section 4.4 of the 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 Business Case. Comment Greater actual tendered data will become available over the next 12-24 months which can be used to verify the assumptions made within the Business Case.

Risk	Issue, Impact and Commentary
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. Appendix 4 details the assumptions made regarding forecast LED efficiencies. 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 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 8 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** **Forecast savings/(additional cost) post-financing costs** **Forecast savings pre-financing costs**	£3.3m £1.3m £3.3m	£6.6m £12.0m £19.8m
Energy Efficiency: **Decrease in annual energy consumption** **Tonnes of carbon saved**	20.4% 9.4k	58.0% 24.8k
Benefits	Benefits arise including 20% 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 58% 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	Provides maximum protection to the Council regarding future

Category	Option 3	Option 4
	energy cost rises.	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 in terms of timing 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 WDC would require to undertake. This will 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: WDC's Objectives and the Preferred Option

WDC Objective	Commentary
Reducing future maintenance costs	The introduction of LED technology under Option 4 results in a significant reduction in maintenance costs of £7.2m in comparison to the Status Quo.
Reducing energy consumption	Based on 2011/12 budgeted costs option 4 will result in energy savings of c.£12m. Based on 2011/12 actual costs this saving increased to £14.7m indicating the potential benefits of such an investment. This is a 58% decrease in energy consumption.
Meeting the Council's commitments and	Street lighting currently accounts for c.23% of

WDC Objective	Commentary
demands with respect to sustainable practices and reducing carbon emissions	the Council's energy bill and c.23% of their carbon emissions. An investment in energy efficiency street lighting would have a material impact upon both these variables.
Establishing good practice to encourage partners and developers within the wider community to follow	WDC 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 associated toolkit will be made available to other Authorities to consider and, where appropriate, take forward similar initiatives.
Raising the environmental profile of the Council	

8. Affordability

8.1. Introduction

This section reviews the affordability implications of the preferred technical option against existing WDC 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 West Dunbartonshire Council: Annual Street Lighting Budget (1012/3)

	Council Budgets Available to Fund an energy efficiency project (£)
Supplies & Services	420,000
Electricity	660,770
Total	1,080,770
Add: future budget required for carbon	38,143
Total Total inflated to 2014/15	1,118,913 1,232,952

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.

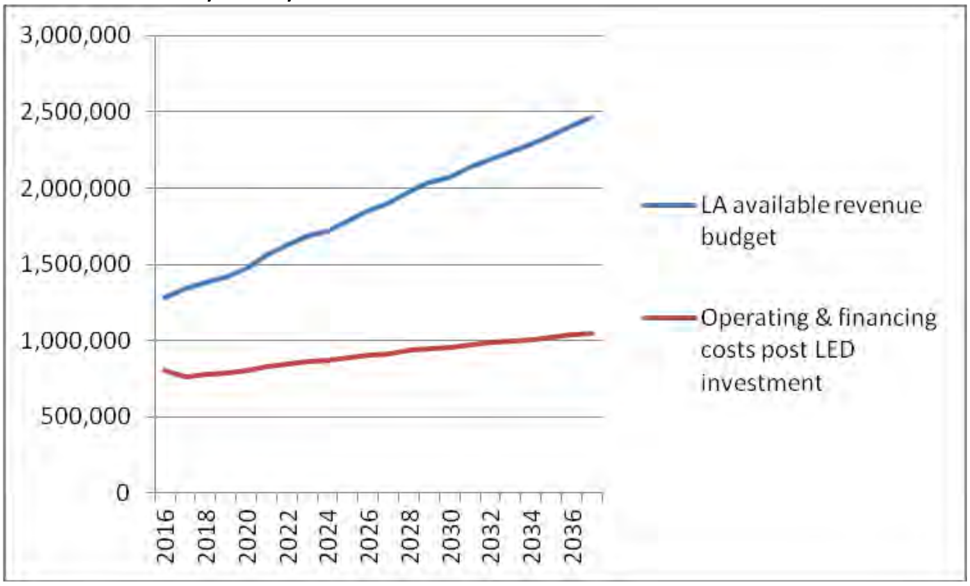
8.3. Affordability

In considering affordability, WDC have taken cognisance of:

- the forecast costs of the preferred option as detailed within Section 4 and Appendix 6.
- The need to invest within a column repair and replacement programme. A separate submission for capital funding of £1.1m per annum over a 10 year period had been made however this is not being funded at this point in time.

The affordability analysis is summarised within the Diagram 8.1:

Diagram 8.1: Affordability Analysis



The diagram indicates that following implementation period there are significant cost reductions against budget which provides significant protection 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 £21.6m 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	2024/25	2029/30	2034/35
LA available revenue budget	42,411	1,281	1,338	1,383	1,413	1,474	1,786	2,072	2,347
Forecast cost of LED	20,805	809	767	778	786	802	886	958	1,022
Budget Impact	21,606	472	571	605	627	672	900	1,114	325

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.

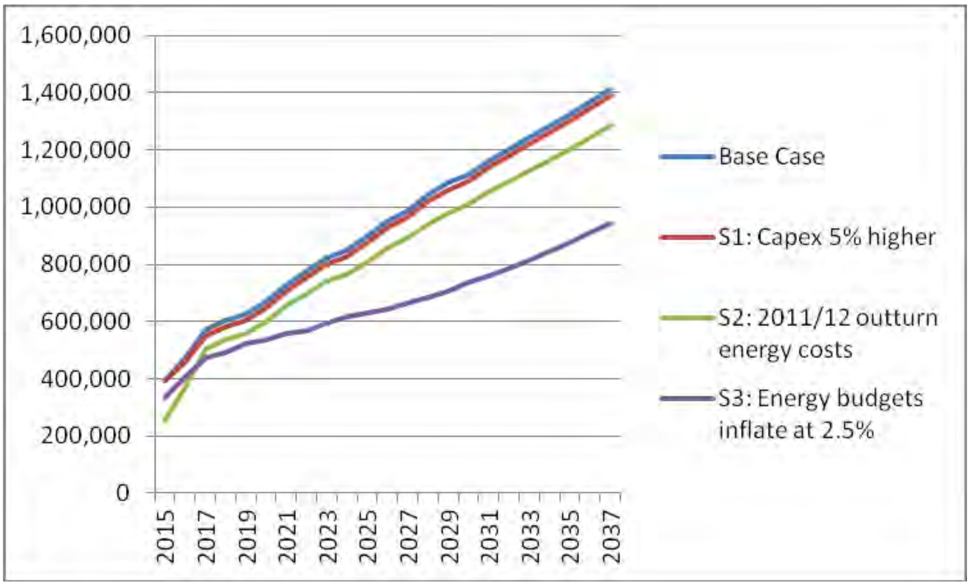
The results of this analysis are summarised within Table 8.3:

Table 8.3 Affordability Sensitivity Analysis

Sensitivity	Total	2015/16	2016/17	2017/18
LED costs 5% higher than anticipated				
Council Budgets	42,411	1,281	1,338	1,383
LED Cost	21,300	820	790	801
Budgetary Saving	21,111	461	548	582
Forecast electricity costs based on 2011/12 outturn				
Council Budgets	42,411	1,281	1,338	1,383
LED Cost	23,063	910	830	845
Budgetary Saving	19,348	371	508	538
Council energy budgets only inflate by 2.5%				
Council Budgets	35,917	1,213	1,241	1,269
LED Cost	20,805	809	767	778
Budgetary Saving	15,112	404	474	491

Diagram 8.2 summarises the different impact on budgets 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 £21.6m to £19.3m.

    - 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 £15.1m. 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 £21.6m to £21.1m.

9. Procurement

9.1. Introduction

Option 4 has been 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 the Council adopting a general policy of dimming lights in around half the residential areas 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. Preferred 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. WDC currently out-source the maintenance of their street lighting estate and will give further consideration into the incorporation of maintenance within such a contract.

The Council will undertake further analysis regarding the most appropriate approach to financing such an arrangement either through a series of staged payments as the energy efficiency technology is installed – these may be funded through capital budgets, capital receipts, capital reserves or borrowings from either the Public Works Loan Board or SPRUCE (Scotland's JESSICA fund).

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

WDC is currently updating their street lighting database and migrating onto a new asset register . This register will require to be tested for robustness, completeness and integrity prior to WDC developing a street lighting specification. Prior to entering into any procurement process, WDC 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 approach was adopted.

9.4. Risk Management and Mitigation

WDC has indicated that their preferred procurement approach is to contract for the supply and installation of the lights and control systems. Appendix 8 includes a risk register of the key delivery risks involved in taking forward this procurement and who would be responsible for managing and mitigating these risks under this procurement approach. The key risks which will be retained by WDC are summarised in the Table below together with the proposed mitigation of these risks:

Table 9.1: Summary Risk Analysis and Mitigation

Risk	Mitigation Strategy
Specification is inaccurate or incomplete	WDC currently updating their asset registers for street lighting which will form the basis of any specification. A programme of auditing and verifying the specification will be undertaken pre-procurement.
LED cost savings and efficiencies are not realized	WDC are not planning to procure the project until 2014 and as part of the pre-procurement work they will verify and confirm the market position around such areas.
Delays are incurred during installation	WDC will 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 will be managed on a risk register.
Cost of finance	WDC will manage the financing associated with their capital plans and will track the cost of any finance required, managing it as part of their wider Treasury function.

Risk	Mitigation Strategy
Savings are not realised	Savings may not be realised for a number of reasons such as WDC 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. WDC will develop a live risk register to allow these risks to be tracked and managed.

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

9.5. Project Management and Governance

Project Management

WDC would require to establish a Project Delivery Team which includes 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.

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

Governance

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

APPENDICES

Appendix 1: Schedule of Existing Lantern Types

(Excludes signage lighting and school flashers)

West Dunbartonshire Council

Existing Lantern Schedule

Existing Lanterns

Type		Power (W)	Cct (W)	2012
CDMT	CDMT	70	84	308
CDMT	CDMT	70	86	1,194
CDMT	CDMT	100	114	6
CDMT	CDMT	150	172	335
SON	SON-T	50	62	15
SON	SON-T	70	84	2,624
SON	SON-T	100	114	119
SON	SON-T	150	172	837
SON	SON-T	250	279	920
SON	SON-T	400	434	60
SOX	SOX	35	65	355
SOX WL	SOX	35	48	28
SOX	SOX	55	84	2,688
SOX WL	SOX	55	67	2,836
SOX	SOX	90	123	987
SOX WL	SOX	90	104	836
SOX	SOX	135	175	733
Total Number of Existing Lanterns				14,881

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)

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.

Capex, Maintenance, Energy and Carbon Model

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 later in this Appendix, 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 /MWh based on the 2011/12 budget figure. Real prices for future years 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 WDC's own assessed costs, adjusted and benchmarked against industry norms. A Capex allowance is required for all options for the replacement of 100 columns per year. As it is common to all options it has not been included within the analysis.

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 not covered in the model. However, the impact on these items is discussed in a later section of this report and the impacts considered as a sensitivity assessment for the options which include a CMS.

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.

LED Systems

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). 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. The number of suppliers is also increasing and scaling of the market means that the unit costs of LED are 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. Our approach to deriving energy consumption and pricing forecasts along with source references are described further in Appendix 4.

CAPEX

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 Nominal £'000
Status Quo	0	0	0	0	0	**0**	**0**
Option 3	3,336	0	0	0	0	**3,336**	**3,386**
Option 4	6,426	0	0	0	0	**6,426**	**6,654**

The key features are:

- The Status Quo does not include any Capex.

- Option 3 includes £3.336m (in 2012 prices) for the replacement of 14,782 of the 14,881 lanterns between years 2013 and 2014. Existing lanterns are replaced with 5,921 CPO (40-60W) lamps and 8,861 SON-HF lanterns. All new lanterns have dimming capability and a CMS system.

- In 2012 prices, Option 4 includes approximately £5.7m for replacement of 14,881 lamps with LED units at an average installed cost of £381 per unit. A full CMS is also installed at a cost of £744k.

Maintenance

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 in the section below on 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 cost rates have been applied to this based on the WDC's estimates which have been reviewed against industry averages. Details of the failure and units cost rates are included in Appendix 3.1.

Using this bottom up approach, for the Status Quo option in 2013, we have included for the replacement of approximately 2,850 lamps, 500 lanterns and 1,440 control gear units at a cost of £273k. This compares to WDC's estimated total budget of £377k which would imply that around £104k would be spent on other activities such as inspections and central office costs etc. This has been discussed with WDC and it has been acknowledged that the there is a significant under spend on these activities currently due to a lack of resources and budget. WDC have advised that they have cut back their scouting activities substantially, with the primary means of fault finding being through notification from the general public.

Mandatory routine inspections are currently below sustainable levels.

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 Nominal £'000
Status Quo	1,260	1,299	1,244	1,084	1,091	**5,978**	**8,078**
Option 3	722	598	657	1,621	1,421	**5,019**	**7,265**
Option 4	672	37	37	37	37	**820**	**909**

The key features are:

- The Status Quo includes ongoing lantern, gear and lamp replacement upon failure. The model includes for on average 415 lanterns, 1,150 control units and 2,700 lamps to be replaced per annum.

- Option 3 includes a reduced replacement rate of lanterns due to refresh of equipment stock.

- Option 4 includes continued lamp replacement, prior to investment in LED technology in 2015/16. Ongoing allowance for the replacement of 0.1% LED lanterns due to failure each year.

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.

Other benefits 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 costly night time inspections of installations can be avoided (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.

- Reduced need for night scouting inspections.

Other features and advantages/disadvantages are included in Appendix 5.

CMS – Qualitative Benefits

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 WDC, given the current budget and resourcing levels within the department, it was felt that a CMS would not enable further cost reductions, but would bring the maintenance service levels back up to an acceptable long term sustainable level. It was therefore agreed that this would be treated as a qualitative benefit.

Energy Consumption and Expenditure

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)

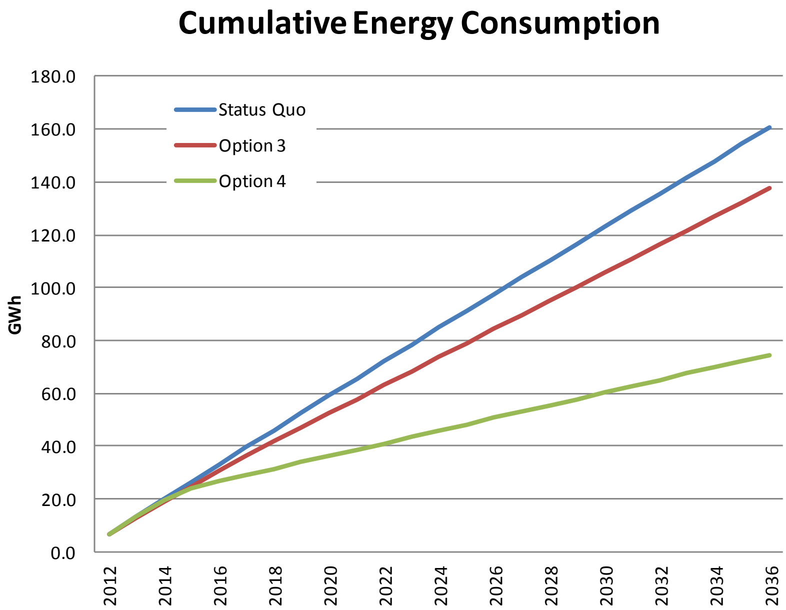
Energy Consumption/ (Expenditure)	2012-2016	2017-2021	2022-2026	2027-2031	2032-2036	Total Real	Total Nominal £'000
Status Quo	33.0 (2,798)	32.4 (3,026)	33.2 (3,428)	33.0 (3,608)	33.0 (3,632)	**164.6 (16,492)**	**(22,922)**
Option 3	28.8 (2,422)	26.6 (2,493)	26.6 (2,747)	26.6 (2,912)	26.6 (2,931)	**135.2 (13,505)**	**(18,700)**
Option 4	27.6 (2,317)	14.1 (1,315)	14.0 (1,449)	14.1 (1,537)	14.0 (1,547)	**83.8 (8,165)**	**(10,943)**

The key features are:

- The Status Quo includes the gradual 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 98% of current levels. Annual energy costs will increase as unit prices inflate.

- Option 3 includes the immediate replacement of 94% of lanterns (excludes some existing recently replaced SON-T lamps) with modern conventional technology incorporating increased dimming and CMS technology. The trimming and dimming is the main contributor to the drop in energy consumption, which at the end of the 25 year period is around 80% 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 11% 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 58% compared to existing levels.

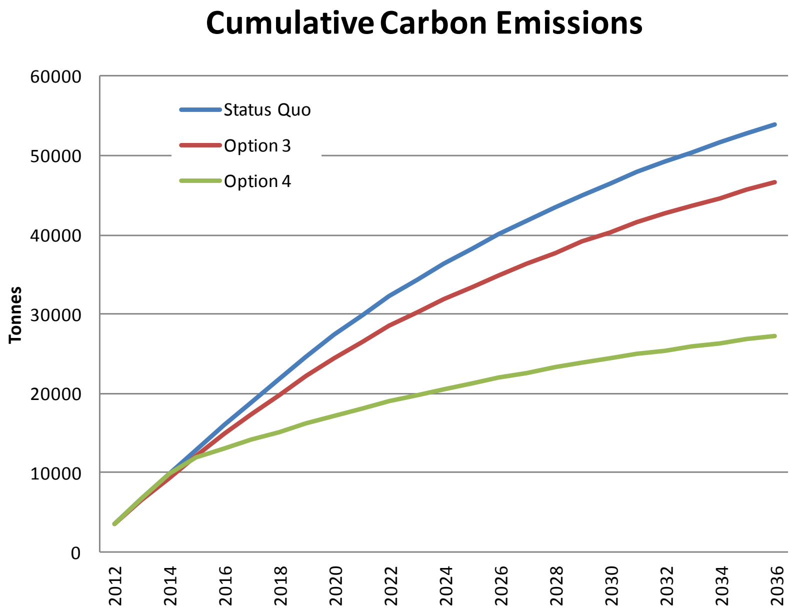


From the energy consumption estimates, DECC CO2 emissions factors have been applied to derive annual emission estimates.

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

CO2 Emissions	2012-2016	2017-2021	2022-2026	2027-2031	2032-2036	Total
Status Quo	16.0	13.8	10.5	8.3	6.4	**55.0**
Option 3	13.9	11.4	8.4	6.7	5.2	**45.6**
Option 4	13.5	6.1	4.4	3.5	2.7	**30.2**

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.


Cumulative Carbon Emissions
60000
50000
40000
30000
20000
10000
0
Tonnes
Status Quo
Option 3
Option 4
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036

Appendix 3.1: Technical Model Cost Assumptions

Model Assumptions

Energy Prices	Base Electricity Tariff 2012 Future years inflation based on DECC IAGGuidance for Policy Appraisal Toolkit, Tables 4-9: Energy prices - Central, 2011 prices: ELECTRICITY - retail: commercial	79.00	[£/MWh]
Carbon Emissions Conversion Factor	DECC IAGGuidance for Policy Appraisal Toolkit, Table 1: Electricity emissions factors to 2100, kgCO2/kWh		
Component Replacement Cycles	Lanterns - conventional	15	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

West Dunbartonshire Council - Status Quo Lantern Schedule

Type		Power (W)	Cct (W)	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Existing Lanterns																			
CDMT	CDMT	70	84		308	308	308	308	308	308	308	308	308	308	308	308	308	308	308
CDMT	CDMT	70	86		1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194	1,194
CDMT	CDMT	100	114		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
CDMT	CDMT	150	172		335	335	335	335	335	335	335	335	335	335	335	335	335	335	335
SON	SON-T	50	62		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
SON	SON-T	70	84		2,624	2,624	2,624	2,624	2,624	2,624	2,624	2,167	1,667	1,167	667	167	-	-	-
SON	SON-T	100	114		119	119	119	119	119	119	119	119	119	119	119	119	119	119	119
SON	SON-T	150	172		837	837	837	837	837	837	837	837	837	837	837	837	837	837	837
SON	SON-T	250	279		920	920	920	920	920	920	920	920	920	920	920	920	920	920	920
SON	SON-T	400	434		60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
SOX	SOX	35	65		355	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX WL	SOX	35	48		28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
SOX	SOX	55	84		2,688	2,543	2,043	1,543	1,043	543	43	-	-	-	-	-	-	-	-
SOX WL	SOX	55	67		2,836	2,836	2,836	2,836	2,836	2,836	2,836	2,836	2,836	2,836	2,836	2,836	2,836	2,836	2,836
SOX	SOX	90	123		987	987	987	987	987	987	987	987	987	987	987	987	987	887	387
SOX WL	SOX	90	104		836	836	836	836	836	836	836	836	836	836	836	836	836	836	836
SOX	SOX	135	175		733	733	733	733	733	733	733	733	733	733	733	733	400	-	-
Total Number of Existing Lanterns					14,881	14,381	13,881	13,381	12,881	12,381	11,881	11,381	10,881	10,381	9,881	9,381	8,881	8,381	7,881

Type		Power (W)	Cct (W)	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
New Lanterns																			
CPO	CPO	45-60	56.7		-	500	1,000	1,500	2,000	2,500	3,000	3,043	3,043	3,043	3,043	3,043	3,043	3,043	3,043
SON-HF	SON-T	70	79		-	-	-	-	-	-	-	457	957	1,457	1,957	2,457	2,624	2,624	2,624
SON-HF	SON-T	100	110		-	-	-	-	-	-	-	-	-	-	-	-	-	100	600
SON-HF	SON-T	150	158		-	-	-	-	-	-	-	-	-	-	-	-	333	733	733
Total No. of New Lanterns					-	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500	6,000	6,500	7,000

Total Lanterns															
Total No. of Lanterns	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**

West Dunbartonshire Council - Option 3 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	2026
CDMT	CDMT	70	84		308	154	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CDMT	CDMT	70	86		1,194	597	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CDMT	CDMT	100	114		6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CDMT	CDMT	150	172		335	168	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SON	SON-T	50	62		15	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SON	SON-T	70	84		2,624	1,312	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SON	SON-T	100	114		119	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SON	SON-T	150	172		837	419	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SON	SON-T	250	279		920	920	920	920	920	920	920	920	920	920	920	920	920	920	920	-
SON	SON-T	400	434		60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	-
SOX	SOX	35	65		355	178	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX WL	SOX	35	48		28	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX	SOX	55	84		2,688	1,344	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX WL	SOX	55	67		2,836	1,418	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX	SOX	90	123		987	494	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX WL	SOX	90	104		836	418	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOX	SOX	135	175		733	367	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Number of Existing Lanterns					14,881	7,931	980	980	980	980	980	980	980	980	980	980	980	980	980	-

New Lanterns

Type		Power (W)	Cct (W)	Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2026
CPO	CPO	45-60	56.7		-	2,961	5,922	5,922	5,922	5,922	5,922	5,922	5,922	5,922	5,922	5,922	5,922	5,922	5,922	5,922
SON-HF	SON-T	70	79		-	2,063	4,126	4,126	4,126	4,126	4,126	4,126	4,126	4,126	4,126	4,126	4,126	4,126	4,126	4,126
SON-HF	SON-T	100	110		-	974	1,948	1,948	1,948	1,948	1,948	1,948	1,948	1,948	1,948	1,948	1,948	1,948	1,948	1,948
SON-HF	SON-T	150	158		-	953	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905	1,905
																				980
Total No. of New Lanterns					-	6,951	13,901	13,901	13,901	13,901	13,901	13,901	13,901	13,901	13,901	13,901	13,901	13,901	13,901	14,881

Total Lanterns

Total No. of Lanterns	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**	**14,881**

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

These figures are based upon an anticipate 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 Arup’s have used which takes the current published trade prices of good quality LED units as the starting point. We have then consider 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 (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 required.

- 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.

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.

- 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).

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 – financial assumptions

The Status Quo broadly follows WDC'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 £nil reflecting current budgets.
- Maintenance Costs – have been calculated on the basis of the age profile of WDC's existing asset base. It has been flexed to reflect the roll out of the existing replacement policies – for example, light and lantern replacements met from existing budgets.
- Energy Costs - have been based on the schedule of individual lighting assets along with their circuit wattages and multiplied by the operational hours to derive an overall estimate of the annual energy consumption. To estimate the annual energy cost, this has then been multiplied by the electrical unit cost rate of 7.9 per KWh for 2012 and subsequent years escalated using the Central DECC Energy Price Forecasts prepared by the Inter-departmental Analysts' Group (IAG)

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

Financial Analysis of Long List of Options

The long list of technical options are defined within Section 3.3.3 of the Business Case. Within this section we review, the initial investment associated with each option and the savings which may be generated if the investment is funded from capital budgets, capital receipts or reserves.

Option 1

Option 1, as identified in Section 3.3.3, is to replace all existing SOX lanterns with conventional low energy lanterns. Key outputs and graphs from the financial model for Option 1 are as follows:

Key Output	Value
Initial Investment (£) and phasing:	1,747,398 2013-2016: £1,747,398 2017-2020: £0 2021-2024: £0
Total Savings compared to Status Quo pre financing (£)	2,156,323
Finance Route	SPRUCE funding at 2.5%, payable over 10 years
Total Savings compared to Status Quo post financing (£)	114,743
Tonnes of carbon saved over the concession (tonnes)	4,793
Energy reduction over concession (%)	11.4%

From these results, the following can be inferred:

- The initial investment creates energy savings over the concession period, but only c.£430k more than the initial investment.
- Annual savings decrease after year 2027 due to an increased amount of lanterns needing to be replaced annually.
- There are increased maintenance costs over the concession of £150k, due to replacing all the lanterns within the network, rather than when each lantern fails.

Option 2

Option 2, as identified in the technical section, is to replace all existing lanterns with conventional low energy lanterns. Key outputs and graphs from the financial model for Option 2 are as follows:

Key Output	Value
Initial Investment (£) and phasing	2,796,168 2013-2016: £2,796,168 2017-2020: £0 2021-2024: £0
Total Savings compared to base case pre financing (£)	4,205,464
Finance Route	SPRUCE funding at 2.5%, payable over 10 years
Total Savings compared to base case post financing (£)	939,419
Tonnes of carbon saved over the concession (tonnes)	7,130
Energy reduction over concession (%)	16.0%

From these results, the following can be inferred:

- Initial annual savings of c.£250k pa can be achieved from the more energy efficient lamps
- In 2027, there is a large increase in annual lantern replacements (from 65pa to 927pa). This increased maintenance cost then offsets any energy savings.

Option 3

Option 3, as identified in the technical section, is to replace all existing lanterns with conventional low energy lanterns and to introduce a control management system that allows dimming and trimming. Key outputs and graphs from the financial model for Option 3 are as follows:

Key Output	Value
Initial Investment (£) and phasing	3,386,450 2013-2016: £3,386,450 2017-2020: £0 2021-2024: £0
Total Savings compared to base case pre financing (£)	5,263,686
Finance Route	SPRUCE funding at 2.5%, payable over 10 years
Total Savings compared to base case post financing (£'m)	£1.3m
Tonnes of carbon saved over the concession (tonnes)	9,402
Energy reduction over concession (%)	20.4%

From these results, the following can be inferred:

- Initial annual savings of c.£300k pa can be achieved from the more energy efficient lamps
- Maintenance savings are similar to Option 2, as it assumed the operations and dynamics of the Council's maintenance team will not change because of the CMS introduction.
- The ability to have additional dimming and trimming from the CMS system increases the energy savings over the concession period.

Option 4

Option 4, as identified in the technical section, is to replace existing lanterns with LED technology, and to include a control management system as part of the LED solution. Key outputs and graphs from the financial model for Option 4 are as follows:

Key Output	Value
Initial Investment (£) and phasing	6,653,772 2013-2016: £3,310,334 2017-2020: £3,343,438 2021-2024: £0
Total Savings compared to base case pre financing (£)	19,787,568
Finance Route	SPRUCE funding at 2.5%, payable over 10 years
Total Savings compared to base case post financing (£m)	12m
Tonnes of carbon saved over the concession (tonnes)	24,809
Energy reduction over concession (%)	58.0%

From these results, the following can be inferred:

- Consistent nominal annual savings above c.£800k pa can be achieved from LED energy efficient lamps
- Initial savings are significantly reduced by the finance costs for the first ten years. After the debt has been paid off in year 2027, total nominal savings amount to c.£1m per year.
- The LED solution shows a marked reduction in energy consumption, compared to previous options

Appendix 7: Financial Model and Assumptions

Financial Model

The financial model is structured so that the costs savings for the option 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. However, within the affordability sheet there is an option to include a cost for column replacement financed either through capital or through borrowing.

The relevant sub headings of the 'comparison cashflow' 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 modeling.

Option Costs

The option costs are formed from the energy, maintenance and carbon costs for the option, which 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 cashflow' 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.

Financing Costs

Financing costs are derived from market rates as at Spring 2012 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.

Variable	**Assumption modelled**
Timings	The Contract period for the street lighting project is modelled at 25 years from 1 April 2012.
Capital Expenditure ("Capex")	The Capex costs for the project are in today's prices provided by Arups and inflated at 1% per annum.
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.
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 CO_2 (per government announcements). However, from 2013, carbon prices will be market driven. After discussion with industry experts, and publicly available information, it has been

Variable	Assumption modelled
	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.
Stock replacement	It is assumed that the business case concentrates on energy efficiency elements. Therefore, stock replacement programmes have been omitted from the analysis. It is assumed that the councils current stock replacement strategy and programme will be sufficient in replacing life expired columns. As the stock replacement costs would be the same for the 'status quo' scenario and any other 'option' scenario, they have been omitted from the comparison cashflows.
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.

SPRUCE Funding

As the Council is within a designated area, SPRUCE (JESSICA) funding is available for energy efficiency projects. After discussions with the fund managers, information on indicative funding terms was provided, which detailed that councils could directly borrow from the fund at an all-in interest rate of 2.5%. The term on the commercial loan would not be longer than 12 years. Therefore, a more prudent 10 year loan length was modelled.

Prudential Borrowing Loan Term

Although not selected as the funding route for the financial modelling base case, one of the deliverable financing routes for the Council, established as part of the financial workshop, is through prudential borrowing. As a sensitivity, some of the short-listed technical options developed have been financially modelled through prudential borrowing.

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.

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 purpose as to whether a route is lit or not, therefore any proposed alterations to WDC'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 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 phenomenon, very little scientific research has been carried out to verify 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).

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 light sources with good colour rendering properties 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. WDC has expressed concerns about the acceptability of reducing lighting levels within some residential areas due to antisocial behaviour. The use of a CMS would allow selection/review of dimming provision in areas where enhanced light levels may be desirable/necessary. The trimming of lighting level activation at sunset and sunrise theoretically reduces the provision of lighting as an amenity, in reality lighting levels will remain above that specified within the British Standard.	There is some evidence that the use of white light within foggy environments can increase the experienced brightness of the environment, marginally reducing 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. Remote CMS control could be used to instantly increase lighting levels within an area in response to a particular incident if deemed necessary.

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.

WDC expressed concern as to the acceptability of dimming of lighting in some residential areas with elected members of the council, particularly at a time where the local authority is actively increasing light levels in some wards on the grounds of improving perceived personal security. The appraisal of the business model options has been undertaken with appropriate consideration given to these issues.

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	Neutral impact on pedestrian safety
Notes and comments	The use of light sources with improved colour rendering properties (CPO lamps) on pedestrian routes will give the perception of a better lit and brighter environment, although is unlikely to result in a tangible improvement in pedestrian safety.	The dimming of residential areas could result in a reduction in pedestrian safety due to reduced visibility during the off-peak dimmed hours. 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. Similarly the application of CMS will allow for appropriate selection of residential streets suitable for dimming down to individual columns.	The dimming of residential areas could result in a reduction in pedestrian safety due to reduced visibility during the off-peak dimmed hours. 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 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 direct affect of improved lighting provision on the impact of crime and security within areas, 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 is 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 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. Particular consideration has been given to the concerns raised by WDC and current requests by elected councillors to increase lighting levels in some wards and therefore the anticipated objection to proposals of reduced light levels.

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 light sources with improved colour rendering properties 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 impact on crime and security; however it is unlikely that the proposals will be so significant as to be noticeable to the casual observer. Dimming of lighting in all areas has not been considered appropriate and the cost model reflects these requirements with only 50% of residential streets having the reduced lighting level applied. The application of CMS allows the dimmed levels to be optimised as appropriate on a column by column basis to meet requirements and fault diagnostics may speed up fault rectification.	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 revised lighting scheme. The application of CMS allows the actually dimmed levels to be optimised as appropriate on a column by column basis to meet requirements and fault diagnostics may speed up fault rectification.

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 habitable rooms.

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

	Status Quo Option	Option 3	Option 4
Appraisal Summary	Base Case	Marginal beneficial impact to visual impact and light pollution.	Marginal beneficial impact to visual impact and light pollution.
Notes and comments	The replacement of SOX light sources will reduce the visual impact of the illuminated streets. SON and CPO sources are often considered to provide a warmer comfortable light. 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 Skies often prefer the use monochromatic SOX light for astronomical purposes.	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 sources are currently significantly less efficient. The overall success of an LED scheme requires

	Status Quo Option	Option 3	Option 4
			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 sources (including metal halide sources) 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 metal halide based technology, such as CPO lamps, is considered to impact on the behaviour of flora and fauna due to the enhanced UV component of source. 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 CPO 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. The ability to control lighting allows the potential for altering the lighting to take account of changing conditions and increasing knowledge of the affects of lighting on natural systems.	LEDs are generally considered by ecologists to have a beneficial impact on the lit environment due to their negligible output in the UV 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 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** **Implementation Issues to comply with planning legislation** **Industrial Action** **Traffic Management** **Programming of works**	Installation	Increase in cost Delay to timetable Project uncertainty	Experienced delivery team
LED Costs greater than expected **LED Efficiencies not realised**	Changes in technology	Potential weakening of the business case	Monitor market progress including soft market testing

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
LED Lifecycle less than expected LED not as reliable as claimed CMS systems prove unreliable CMS information underutilised and no management savings realised		if predicted unit cost reductions are not realised.	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 Electrical Safety of all Apparatus & Equipment Installed Health & Safety Case Legislative/Regulatory Change Local Authority Policy Changes Site Security and Safety	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.
Access Agreements and Consents Planning Approvals/Consents / Permissions Easements required	Consents	Delay to timetable	
Environmental Liabilities/Damage	Environmental	Adverse publicity	Environmental risk assessment prior to

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
Pollution **Change in appearance of new lighting source has greater impact on environment than anticipated**			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 less savings 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 energy prices. **CRC charges escalate higher than forecast**	Financial	Variation in forecast savings from the project	Inflation and energy prices to be tracked during the development of the 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 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

Operational Risks

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
Change in cost of providing the service **Changes in Local Authority Policy** **Changes in National Policy** **Apparatus obsolescence/Availability of Spare Parts** **Changes in Design Codes of Practice**	Contractor recharges	Delays. Extra costs. Delayed benefits. Poor perception.	Identification of milestones and effective project management. Commercial agreement covers the impact of changes arising from these sources and who is responsible for funding them.
Commercial Viability **Health & Safety (including CDM)** **Parking Obstructions affecting operations** **Interface between repairs and the network results in inefficient working practices** **Permits and Approvals** **Security of Apparatus, Equipment and Vehicles** **Technological Refresh** **Technological Obsolescence of Equipment** **Third Party Liability** **Uninsurable Risks** **Volume Changes - Energy Consumption**	Operations	Services deteriorate. Cost for extra work.	Operations management Ensure up to date records. Project and contract management plan put in place. Covered by performance regime included within the contract.
Lamp Cleaning and Replacement **Depot maintenance** **Detection of Outages** **Electrical Safety of all Apparatus** **Electrical Supply and Connections**	Maintenance	Unmaintained assets Quicker deterioration. Less savings	Commercial responsibility of maintenance contractor to be covered by the Performance Regime.

Risks	Type of Risk	Risk Impact	Risk Mitigation / Control
Electrical, Mechanical and Structural Testing **Energy Supply and Usage** **Maintenance service standards**			
Non-Performance of Apparatus **Power Supply failure** **Lighting Failures** **Fault Rectification** **Adequacy of all Cabling**	Faults	Service interruption Adverse public perception	Fault reporting system. Covered within the commercial agreement and performance requirements.
Accident Damage & Knock-downs **Third Party Damage** **Vandalism** **Storm Damage** **Other Damage**	Damage	Service interruption Increased costs	Commercial agreement should allocate risk share.
Legislative / Regulatory Change	Regulatory	Potentially reduced public and political support.	Effective change mechanism. Contract flexibility. Stakeholder management.
Maintenance & Repair Costs **Monitoring Costs** **Operating Costs**	Costs	Increased costs	Transferred under the maintenance contract. WDC to have clear understanding of when these risks may require to be shared with the Council.