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Birmingham City Council

ECO Lighting
Carpenters Road
Lozells

ECO Lighting

Carpenter's Road

Lozells

Issue and Revision record

Rev	Date	Originator (Print) (Signature)	Checker (Print) (Signature)	Approver (Print) (Signature)	Description
0	13/02/2009	N Parry	H Parry	N Parry	First Issue
1	20/3/2009	N Parry	H Parry	N Parry	Second Issue
2	30/03/2009	N Parry	H Parry	N Parry	Third Issue

Contents

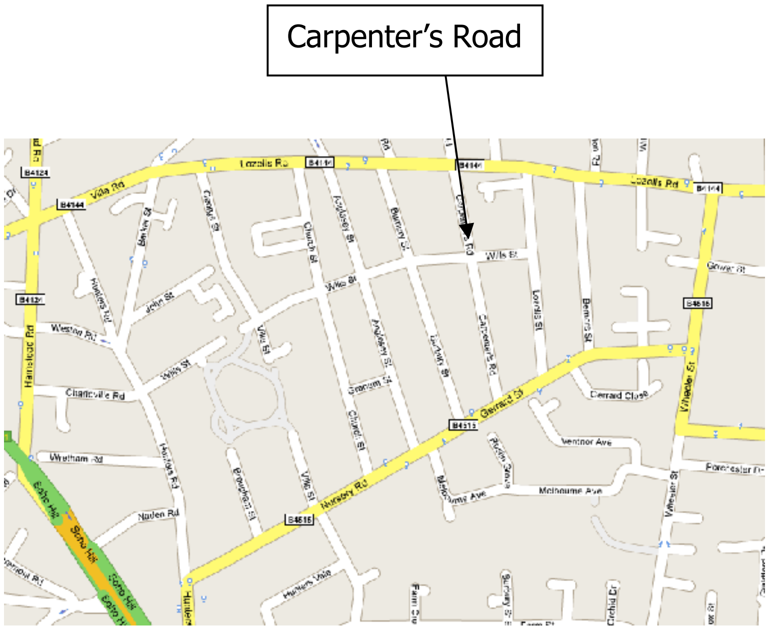
1. Project Brief

The purpose of this report is to assess the potential role that street / public realm lighting can play in delivering the vision for South Lozells (supporting wider 'eco-neighbourhood' works) in particular ensuring high levels of environmental sustainability and public amenity & safety. It outlines aspirational but realistic recommendations for:

a) Reducing the carbon footprint of lighting (in terms of electrical energy use and lifetime footprint of lighting infrastructure)

b) Management of lighting to maintain appropriate levels of lighting at appropriate periods in order to provide a safe and attractive environment

c) Lighting to promote a positive South Lozells image / sense of place



Carpenter's Road – Location Plan

The recommendations will be specific to the study area (typical Victorian terraced streets) but it is anticipated that they will be applicable to other similar areas throughout Birmingham.

2. Street Lighting – Design Factors

A number of factors are driving questions to be asked of street lighting across the UK.

Cost

Accountants are now asking whether all these streets need to be lit and if so does it need to be all night and at what lighting levels. This is resulting in some County Councils switching off sections of street lights in more rural locations. However this has not always been accepted and many are now being switched back on.

Environmental impact

The national agenda to tackle global warming by reducing CO2 emissions has highlighted concerns that street lighting should work efficiently by minimising waste and operating at the right levels, where it's needed, at appropriate times.

Public Safety

Police hold the view that street lighting is one of the best crime deterrents available and tend to be against any reductions in levels or operating hours. The presence of CCTV cameras places more demands on good lighting.

Road Safety specialists recognise that good street lighting reduces the level and severity of night time accidents substantially. For many years the figure of 30% has been used, However the Highway Agency has reduced this to 11% on their trunk road network.

Economic success

Good Lighting is a boost to the area's night time economy; it encourages residents and visitors alike to make full use of the facilities found in Birmingham and their local area.

Light pollution

Astronomers want to reduce the level of glow that significantly reduces the ability to view the night sky. The nature of cities such as Birmingham means that they will glow more than rural areas, but poorly designed or uncontrolled lighting adds unnecessarily to this impact.

Streetscape Quality

The quality of light produced impacts on the night time attractiveness of an area. During the day time, lighting infrastructure (columns, etc) combines with other street furniture to influence the visual quality of streets and the amount of intrusive clutter.

Other functions

Street Lights are also used for a myriad of other functions from mounting traffic signals and festive decorations, to forming a base for mobile/wifi networks and smart metering.

3 New Technology

General

Road Lighting has gently progressed from oil braziers on the frontages of houses in London in the 19th Century through to the introduction of gas lights on ornate cast iron columns through to electric lamps in the early 20th century where they developed to the gas discharge lamps generally used today, whilst now we are viewing Light Emitting Diodes (LEDs) emerging as an alternative light source.

Lamp technology has therefore driven the way road lighting has been delivered and influenced what light levels should be provided on our streets and it remains an important focus for street light development.

However, in more recent years, the emergence of electronics to replace the traditional copper/iron ballasts that are required to control the gas discharge lamps means that this has also become an important factor in determining lighting efficiency and quality. These have enabled greater control of the lamp operation and extended lamp life. They allow the lamp output to be varied, and depending upon lamp type the lamp can be run anywhere between 100% and 1%. In addition, even more recently available are remote monitoring systems using radio frequencies and /or the WiFi network has allowed road lighting systems to be easily monitored and controlled from a central or local point.

Street Lights are also used for a myriad of other functions from mounting traffic signals and festive decorations, to a base for mobile/wifi networks and smart metering.
They have also been used as points for harnessing natural energy from the sun or wind and using it to power the lighting. However in the close urban environment such as in Carpenter’s Road with the proximity of residential houses, it is considered an unrealistic option with current technology and conditions.

The Windela uses a unique wind turbine to power the LED lamp.

It is on trial in various locations in the UK

Lamps (Gas-Discharge)

There are a number of gas discharge lamps commonly used in the Street lighting arena to provide the street illumination these are:

A) Mercury vapour (MCF)
B) Low pressure Sodium (SOX)
C) High Pressure Sodium (SON)
D) Fluorescents – compact (PLL)
E) Metal Halide – Cosmopolis being the most recent (CPO)

Each of the above lamp types have certain qualities that are identified by the following means:

1. Lamp Colour
    a. Within this term there are two measures:
        i. Colour Appearance
        ii. Colour Rendering
2. Lamp efficiency – Lumens of light per watt of electrical energy
3. Lumen depreciation – rate that the light output diminishes & overall Lamp Life (average lamp life – usually stated in hours)

1. **Lamp Colour**

The **appearance colour** of the lamp is defined by its colour temperature measured in degrees Kelvin. When first using electric lighting in the street the tungsten lamp, quickly followed by the mercury lamp (MCF) were used, these are both a white light but very poor in terms of lumens of light per watt of energy. It was discovered that Sodium is a very effective producer of light and we have used the sodium lamp for the last fifty years, originally the low pressure (SOX) which is the orange light or more recently high pressure (SON) which is a golden/white light with a warm colour and is about 2000 deg Kelvin. Recently with the introduction of energy saving lamps, we often see whiter lamps – which have a wider spectrum and provide a bluer white feel, operating at temperatures between 2700 to 6000k.

Colour rendering is a measure of how effectively the lamps show true colour with sunshine/daylight providing 100% true colour and for example a low pressure sodium (SOX) lamps providing 0% rendition of colour. As can be seen with the prevalence of SOX lighting across the UK, the lamps colour has never been a major issue as local authorities have focused on delivering a value for money service.

However recent research has shown that colour is important to aid recognition of a friend or foe at night and to recognise colours of parked cars, it is recognised as adding to the quality of the street. At low levels of lighting – typically as on residential roads, it affects the way we see and has been incorporated into the current BS on road lighting allowing a drop of one lighting class when white lights are used.

With the drop of light levels towards a typical moon lit night and within the lower levels of road lighting the eye responsiveness shifts more towards the blue/green end of the spectrum. Therefore the red/yellow light is not so readily absorbed by the eye at night.
This can be exemplified on the streets of Birmingham with examples of existing lighting

- This is a typical side road with a 80watt mercury vapour lamp. These lamps last a very long time, produce a white light but have poor performance in terms of lumens per watt

- Sodium lighting as seen here with both low pressure and high pressure is deemed to be some of the most efficient light sources. However, partculaly with low pressure sodium the light is virtually mono chromatic producing only 'orange' light. The SON is better but still with a restricted spectural element

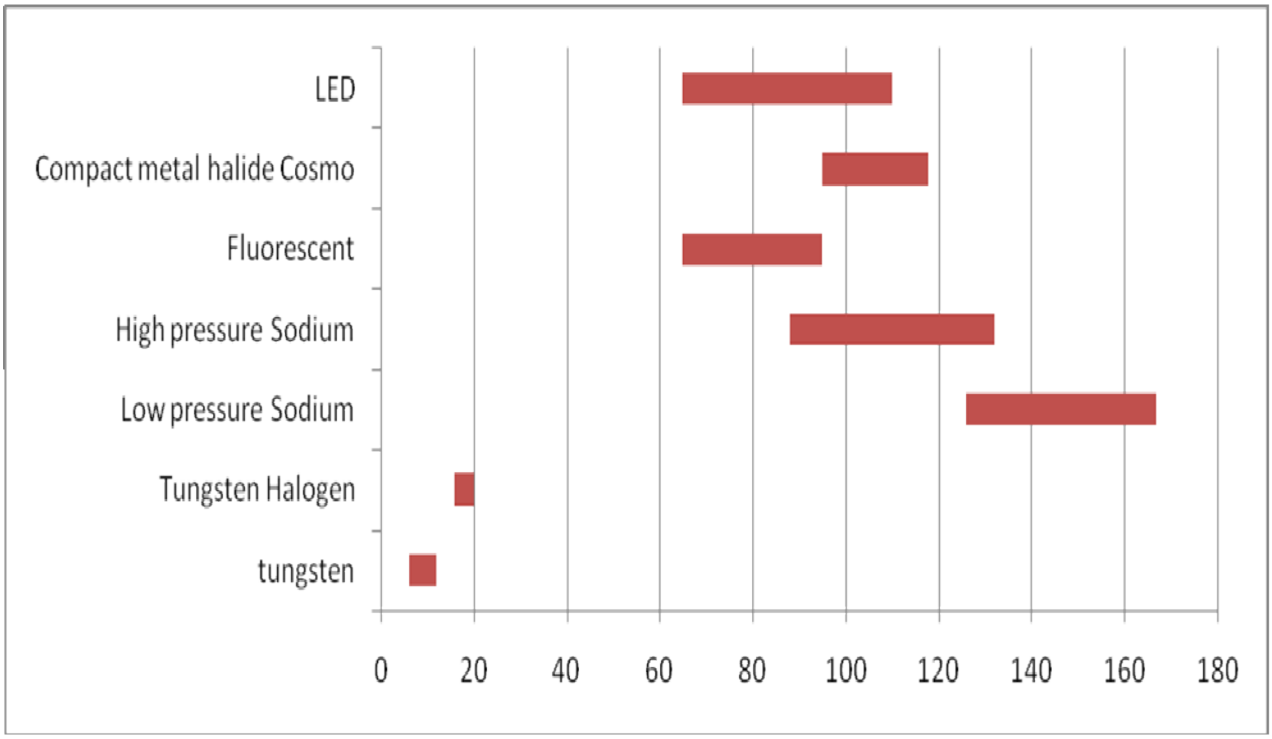
- Metal Halide lamps have developed substantially in the last few years. They produce a high quality sharp white light that is both pleasing in appearance and shows very good colour with a high spectural divergence. The latest development from Philips merges the HPS construction with the metal halide quality to produce long lasting efficinet white lamps.

2. Lamp efficiency

Street Lighting has used gas-discharge lamps for many years as the principal light source. This type of lamp is one of the most reliable and efficient light sources produced. The EU has recently issued guidance on 'Green Procurement' where they stipulate how efficient in terms of lumens of light for watts of power lamps are required to provide. In basic terms, all lamps should be achieving better than 100 lumens per watt by 2012.

The most efficient by this measure are the low pressure sodium lamps (SOX) that emit light in at 590 nm to produce that unique orange colour. The lumen/watt is one of the highest at 165 lm/w for a typical lamp in the range.

The table below indicates the most effective lamps in terms of lumens per watt and although SOX lamps are indeed most efficient, their ability to only produce light in a very narrow part of the visible spectrum and our understanding of how we see in particular at low light levels mean that the any lamp providing a full spectrum is providing a better quality and thus aiding night time visibility.



Lumen per watt per lamp type

3. Lumen Depreciation & Lamp Life

Gas Discharge lamps do last many hours in operation and as part of this operational period we see depreciation in the lumen output of the lamp. Lighting designers will make an engineering decision based upon information similar to the graphs below on when to change the lamps before lamp failures become noticeable.

For instance with a 70watt SON lamp the choice maybe to change the lamps at 16000 hours, which is approximately 4 years in road lighting terms, and it can be proved that the lumen output has dropped to around 80% of the original output. It is this lumen figure that is used in calculations to ensure the roadway never falls below the acknowledged standard.

It can be seen that this extra light over-lights the road for the time until the lamp is changed and there is an element of energy powering that over lighting. Therefore with the new electronic control gear and remote monitoring systems it is feasible to achieve a Constant Light Output. To do this, a locally stored algorithm will be used to dim a lamp at the beginning of its service period to, say for example 80%, and increase this percentage to 100 as the service period comes to an end.

Light Emitting Diodes - LEDs

LEDs' have been in use since the early 1960s, initially as indicator lamps but only in the last few years as an optional light source. Despite strong rumours to the contrary they are not particularly efficient in terms of light output – lumens per watt. In the table on page 11 it can be seen that in comparison to most gas discharge lamps they are at midway in the league and that is taking a generous view of current available LED figures. However every year there is a marked improvement and it is anticipated that by 2015 they could be achieving 200 lumens per watt, which will then make them predominant as a light source.

LEDs are not naturally white and only appear so by a phosphoresce coating being applied, this technique works well and they have a cool white appearance and excellent colour rendering values. The phosphoresce coating is the currently favoured technique but with the research being carried out, it is possible this may change in the near future.

There are also other advantages in using LED's such as:

- Resistance to physical shock and vibration – two things which can cause catastrophic failure with normal lamps.
- Long Life – typically anywhere from 50,000 hours plus. This of course is dependent upon using quality chips from a quality manufacturer.
- Minimal lumen depreciation – over this period the lumen depreciation may drop down to 70% of the original, but for most of the operational time will remain remarkably constant.
- LEDs housed in a quality product will need no maintenance during their life.
- Instant Light – no warm-up period.
- Fully dimmable for 0 -100% (or even 150% for a short time).

Technically the weak point is the electronic drivers which may only have a 10 - 15 year life and would therefore need to be replaced on a regular basis, however these can be placed remotely at the base of the column and thus provide easy maintenance access. The other issue is cost; at the moment with luminaires for use in Carpenter's Road or similar on the market between £350 - £1500. This compares to approximately £200 for the best performing metal halide/Cosmo lamp fitting or even £100 for a compact fluorescent luminaire.

The market is only just starting to understand the potential of LED's and how they can be used differently to existing light sources. For instance lighting up time is 30 min before sunset in part to allow the gas discharge lamps to warm up to full power, with instant light from the LED this will no longer be required. They may also be used to provide more vertical illumination on the street as they don't have to be clustered together in a luminaire as is the current case.

The UK street lighting sector is recognised as being cautious and thus slow to change, but with the expansion of LED's we may see this approach change with forward thinking clients such as Birmingham being bold in trying new initiatives.

Control Systems

Electronic digital control units replaced the copper/iron ballasts needed to ignite and control the flow of current through an ionising gas tube, which is what is found in gas discharge lamps such as fluorescent lamps in all interior situations in the last twenty years. The characteristics of these discharges is complex and far more so in the type of lights found in the exterior lighting sector than the more common compact fluorescent found both at home and at work. Electronic controllers were developed in the 1980's for these lamps and are now common and generally highly reliable.

A clear advantage with the new electronic control gear is the reduction in energy used in the circuit by the ballast and the need to ensure a power-factor capacitor is operating. The copper/iron(cu/fe) ballast circuits use up to 30% additional power if operating as designed, whereas the new electronic system typically use 10%. In Carpenter's Road the older luminaires will have the traditional cu/fe gear and the newer ones possibly electronic.

The exterior street lighting market is undergoing a similar change to the interior market, as all of the smaller wattage lamps (less than 250watts) now have electronic controllers that can replace the Cu/Fe versions.

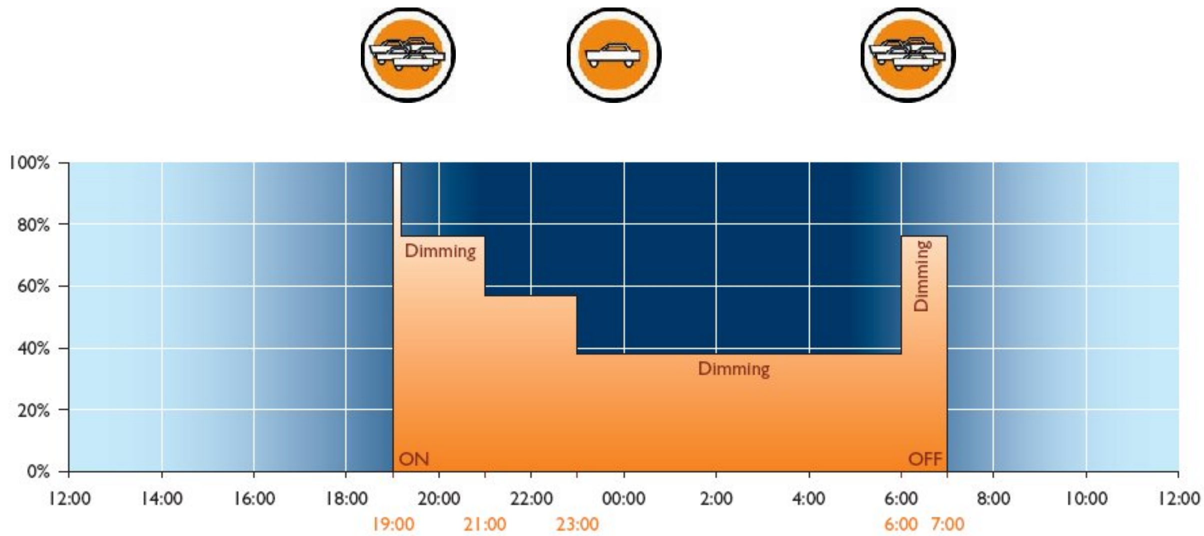
There are a number of advantages of using the electronic control units, these are:

- Operating the lamp circuit with high power factor (near unity), meaning no wasted energy through the ballast – (around 10% but can be up to 30%).
- Extending lamp life as these units will perform a soft start on the lamp (switching on when the voltage is at zero on the sine wave), thereby reducing stress onto the lamp components.
- Working with a broad band of input voltages – it is common in the night that the national grid voltage will creep up towards its maximum limit. Over voltage on a lamp can substantially reduce its life, electronics filter out these variations and keep the lamp at its optimal performance.
- Electronic gear can control the light output from 100% down, so that if the factors that determined the lighting levels have reduced, such as traffic flows, the lighting can be dropped by an appropriate amount. The amount it can be varied depends upon the lamp type:
    - High Pressure Sodium SON from 100% >20%
    - Cosmopolis /Metal Halide CPO from 100% >50%
    - LED's / Fluorescents from 100% >0%
- This dimming will provide both energy savings and reducing the ambient light levels during the set period of the night.
    - There are two basic approaches to achieving this dimming.

➢ The simple method is to have the electronic gear preset to dim during an agreed time slot. The diagram at below outlines the process and indicates the variation possible.

➢ The more complex method is to have a central management system that communicates with each lamp from a central or local point. This will give greater flexibility to the hours of dimming plus a number of additional benefits such as:

- Remove the need for a separate photocell on each lamp
- Remove the need for a regular lighting scout
- Audit trail of lamp operation
- Predict lamp failure
- Meters the energy usage
- Constant Light output – as highlighted previously
- Allow greater flexibility in dimming variation



To make the most of remote monitoring systems they need to be fully integrated into the local management database. This enables the comprehensive data being produced to be fully understood and managed. This would ideally be able to provide a management dashboard where it will indicate how many lamps are approaching failure criteria across the network and thus a decision about lamp changes can be more precisely made.

In the road lighting field this is relatively new technology and is still being developed. Therefore we may see substantial step changes in development during the next few years and it may be best to keep a watching brief and if possible carry out a number of small trials to get familiar with the technology for the next two to three years.

Columns

Unless building mounted, lighting columns will be required to support the lamp luminaire in its optimum position. A variety of materials have been used over the years and are used today to carry out this function. These are the ornate cast-iron columns and brackets, wooden poles, concrete columns, steel and aluminium. In addition a variety of plastic columns have been tried and are in use as passively safe columns on high speed roads where they may be required to improve road safety.

Building mounted luminaires keeps the streets clear of furniture and improve the open vista, however the building owner will need to provide permission and in reality this proves to be a time consuming process. Building mounted equipment is usually preferred in town or city centres where the opportunity to open up the pedestrian area is deemed key to the area.

In residential roads such as Carpenter's Road there are a limited number of options for column materials, these being:

- **Steel Columns** - these can be sub categorised into:
    - Stainless Steel – these are expensive but are made from approximately 85% re-cycled materials
    - Galvanised Steel with option to paint on-site – The basic type with galvanising providing sufficient protection in 'clean air- low pollution' areas
    - 'Pre-Painted' Galvanised Steel – these are the same columns but treated with specific paint finishes that will extend the life of the columns as they offer the galvanizing excellent protection, especially at ground level where road salt and dog urine can cause severe corrosion.

    All of these can be supplied as parallel sided or as a tapered column. There are more artistic designs and these are often used as an aid to local identity through shape and colour. With modern luminaire optics there is no need for a bracket to project the lamp over the road, so the lamp can be mounted directly atop of the column shaft

- **Aluminium Columns** are generally tapered in section and do not require any additional protection such as galvanising or painting as they have a life of at least 60 years. They are significantly lighter than the steel columns and thus easier to handle and also have some generic passive safety features.

An approximate cost comparison is tabled below for a 6 metre tall column.

Type	Cost	Life	Additional Treatment through/extend life
Plain Galvanised Steel	100	35	Paint after 20 years then every 8 years
Painted Version	140	45	Specialist Factory applied type finish 35 years + Painted versions from 15 years onwards
Aluminium	210	65	none
Stainless Steel	400	70	none
Plastic	350	35	none

Maintenance

Recent research has confirmed that the maintenance factors used in street lighting design and to set maintenance regimes is over rigorous. This is outlined in the recently published CSS 'Review of luminaire maintenance factors'

These maintenance factors take into account both the lamp lumen depreciation covered earlier and a factor for the condition of the luminaire. This factor considers the optical purity of the luminaire, and the main feature that can affect the luminaires efficiency is a build up of dirt. The build up of dirt on the bowl or reflector will tend to diffuse the light. The air in the UK is much cleaner than it was 30 years ago when the tables were formulated.

Following the research it is proposed that the maintenance factors are amended and possibly included in a future BS5489 update. This, combined with new materials in use within the luminaires and being designed/constructed with a high ingress protection rating, typically IP65 mean the units stay cleaner longer and the sight of a street light bowl filling up with water after a downpour is now a very rare sight. The progressive extending life of the lamps themselves means that it may only be essential to visit a lighting column every four or five years. If LEDs were to be used then a visit every 25 years may only be required, with a local LED company now offering a guaranteed 30 year life. Obviously a regular check on the structural and electrical integrity will be required but this can seriously impact on the number of staff required and their operating schedules, leading to a reduction in the CO2 used to maintain the stock.

Self cleaning glass does not rely upon the rain washing off the dirt but rather the ultra-violet light emitted from the lamp to dispel the dirt, and paint finishes that the dirt doesn't adhere to. Both are now easily available at a minimal cost and should be applied to reduce simple day to day maintenance

Therefore potentially Birmingham could:

Go from a three year lamp change to five year on SON lamps by simply ensuring they purchase the long life versions

All new luminaires would be IP65 and have self cleaning glass so that the clean is only required every five years and only the exterior requires a clean to take it back to as new.

Technology Horizon

In the above sections we have highlighted the progress of lamps and lighting and how light sources are becoming more efficient and lasting longer with LEDs set to make real changes over the next twenty years.

We have also looked at renewable energy and how being able to control the lighting can reap benefits in terms of reducing lighting output and saving energy.

There are some ideas on the fringe of Lighting that may come to fruition with the right backing and opportunity. They are the ones that are directly interlinked with providing the lighting and those utilising the lighting network to make improvements elsewhere.

Firstly those linked to delivering the lighting on the streets:

Remote sensors

Various companies are trying to develop suitable sensors which are able to monitor traffic flow so that the feedback can automatically raise or drop the lighting as required. It may be appropriate that the lighting is on full power only during the rush hours and automatically dims until activated to raise the levels once again. This would apply to pedestrians as well as vehicles.

Combined with sensors are miniature light sensors that automatically adjust the lighting levels to the correct level and therefore do not over light the streets wasting energy.

Solar PV panels/ Intelligent roads

Solar Photo Voltaic development is progressing rapidly and the energy output is rising from the current 15% towards a promised 30% which will make it much more usable in these northern climes; however the most interesting aspect could be the way the Solar PV can now be made. In essence it can be formed to most shapes and therefore could easily be the canopy of the luminaire itself providing power directly to the lamp.

Although of limited application in residential area such as Carpenter’s Road, the road markings can be illuminated so that they can give guidance to drivers on routes etc. LEDs set into the kerb edge have been tried in Scotland to highlight roundabouts to approaching drivers and provide simple edge guidance

Associated Ideas

Likely to uses for the street lighting infrastructure:

- Lighting Columns could become access for re-charging your electric car with sockets externally fixed at the base and a quick call from your mobile will activate the power.
- With a wireless network in place through the remote monitoring it may be possible to sell spare capacity on the system to say utilities to be able to read the home meters directly.
- They are used now for carrying mobile networks transmitters and with a 4G mobile network about to be rolled out it will be an opportunity to raise funds and keep the streets clear.

4 Carpenter's Road - Existing Scenario

A survey of Carpenter's Road street lighting was carried out and the details of the condition of the equipment, and the energy and maintenance implications, are described below.

The locations of the existing 11 columns in Carpenter's Road are marked on the following plan. They are spaced at some 35 metres apart, positioned at the front of the footway.

There is a mixture of older cast iron and newer steel lighting columns with a similar mixture of luminaires mounted atop of the columns. The road is lit using 70watt high-pressure sodium lamps in the different luminaires to achieve the desired lighting levels as defined in BS5489.

Lighting in Carpenter's Road

The main section of the street was refurbished in the early 1990's where the existing cast iron/steel columns were retained and repainted. The improvement work replaced the existing luminaires with a new Philips basic luminaire. These luminaires use traditional lamp control gear consisting of a copper/iron control gear (similar in construction to electrical transformer), a lamp ignitor that produces an electrical impulse of upto 5,000 volts to 'strike' the lamp to switch the lamp on and a power factor capacitor to improve the power factor of the circuit thereby reducing lost power.

The means of controlling the light from the luminaire is reliant upon basic louvers in the plastic bowl protecting the lamp. This does not provide the best type of control and tends to put a pool of light on the street. Within a terraced road this type of general distribution of light is reflected from the building frontages thereby providing quite a 'well-lit' street. However by the nature of the bowl there is a relatively high percentage of light directed up into the night sky adding to the City's sky glow and wasting electrical energy.

The newer lighting columns located in the section closer to Lozells Road were recently installed and use new steel 6 metre high columns with new WRTL Vectra luminaires that have much improved light control mechanism within the luminaire. This again uses a 70 or 100 watt High-Pressure sodium lamps to achieve the current BS5489:2003 requirements as defined for Birmingham by the Street Lighting Team.

Survey results

The structural assessment of the columns is summarised in the table below. It follows the guidance in the ILE Technical Report 22 'Guidance for the Assessment of the Condition of Street Lighting Supports' to assess the columns' condition as:

1- Good, 2 – Fair, 3- Poor, 4 – Bad.

Location	ref No	Column		
		Height	Type	Condition 1-4
Jnc Gerard Rd	1	5	Step Cast	3
o/s 120/122	2	5	Step Cast	3
o/s 109/111	3	5	Step Cast	3
o/s 89/91	4	5	Step Cast	3
o/s 66/68	5	5	Step Cast	3
o/s 53/55	6	5	Step Cast	3
jnc Wills St	7	5	Step Cast	3
jnc wills St	8	6	Steel	1
o/s 18A/20	9	5	Step Cast	3
o/s 11/13	10	6	Steel	2
jnc Lozells Rd	11	6	Steel	1

Full survey information for the columns, luminaires, lamps and control mechanisms is set out in **Appendix 3**. The survey did not find any areas of grave concern (category 4) equipment in the street.

Based upon the Carpenter's Road survey results, it is estimated that a lighting level of 5 lux with a minimum of 2 lux is currently being achieved. This aligns with a BS5489 light class of S3

For the existing 11 lighting columns, the electrical energy load being generated can be estimated based on the following assumptions/criteria:

- 70 watt SON lamp = 90watt (Including internal circuit losses)
- 4037 hours of darkness per annum (photocell switching on at 70lux and off at 35lux)
- 8p per kilowatt-hour

This is costing approximately £328 per annum

Producing 2,200kg CO_2

In terms of maintenance, Birmingham City Council scout (check for lamp outages) by driving down the road once a fortnight in the winter and once a month in the summer.

Maintenance operations in line with national good practice for this type of equipment in this type of location are:

- Electrical testing once every six years
- Bulk lamp clean & change every three years
- General visit once a year
- Direct costs per location are difficult to estimate for a particular location but assumed 20 scout visits per annum.
- 1 maintenance visits per annum (including percentage of lamp clean, change and electrical test).

5 Carpenter's Road - Design Standards

National Design Standards

The British Standard for Road Lighting BS 5489 was substantially updated in 2003, as it was part of a new European Code EN13201, and was recently amended in 2008. This update of the code introduced substantial change to the previous approach to lighting on the highway. Much of the street lighting on our streets dates back to the 1950s & 60s where a simple recipe method was used that for a given width of road the street lights were placed so many yards apart – typically 35 yards.

However since then the development of lamps and importantly the reflectors they sit within has enabled the designs to become much more precise and today complex computer software accurately produces designs to the last metre.

Hence the new code reflects this approach and introduces three bands of requirements for street lighting. It also provides guidance on choosing the correct level of lighting for any given location. Factors to take into account when deciding upon a lighting class include traffic flow, crime data, and environmental zones.

The three lighting bands are:

- Conflict Areas
    - where vehicles and pedestrians are intersecting and hence the risk of collision is high. These typically are roundabouts, pedestrian crossing points, and mixed traffic surfaces
- ME -Traffic routes
    - providing minimum targets for luminance (reflected light) on the highway with minimum uniformity values
- S - Residential routes
    - more variation with lighting classes from S1 – S6 and, introducing uniformity values and allowing the lighting level to be dropped by one class when using white lights.

Carpenter's Road as a residential road will require lighting within the S- Class requirements. The current British Standard now encourages the use of white lighting (Ra>60) on residential streets by allowing the reduction of lighting level by one class. Therefore if the guidance indicates the appropriate lighting class is S3 then by using a white light source the road can be lit to S4.

The tables below are extracts from EN13201 -2 and BS5489:

Table B.4 — lighting classes for subsidiary roads (pedestrians and cyclists)

Crime rate	R_a value	Lighting class					
		Low traffic flow		Normal traffic flow		High traffic flow	
		E1/E2[d]	E3/E4[d]	E1/E2[d]	E3/E4[d]	E1/E2[d]	E3/E4[d]
Low	R_a <60 R_a > 60	S5 S6	S4 S5	S4 S5	S3 S4	S3 S4	S2 S3
Moderate	R_a <60 R_a :>60	S4 S5	S3 S4	S3 S4	S2 S3	— —	S1 S2
High	R_a <60 R_a :>60	S2 S3	S2 S3	S2 S3	S1 S2	— —	S1 S2
NOTE 1 Crime rates are relative to the local area, not national. Assistance can be obtained from the local crime prevention officer. NOTE 2 The lighting levels shown in this table may be increased by one lighting class in the vicinity of traffic calming measures. _							
[A] Low traffic flow refers to areas where the traffic usage is of a level equivalent to a residential road and solely associated with the adjacent properties. [b] Normal traffic flow refers to areas where the traffic usage is of a level equivalent to a housing estate access road and can be associated with local amenities such as clubs, shopping facilities, public houses, etc. [c] High traffic flow refers to areas where the traffic usage is high and can be associated with local amenities such as clubs, shopping facilities, public houses, etc. [d] Environmental zone, as given in the ILE publication *Guidance notes for reduction of light pollution* [16].							

Table 3 — S-series of lighting classes

Class	Horizontal illuminance	
	$\overline{E}$ in lx [a] [minimum maintained]	E_{min} in lx [maintained]
S1	15	5
S2	10	3
S3	7,5	1,5
S4	5	1
S5	3	0,6
S6	2	0,6
S7	performance not determined	performance not determined

[a] To provide for uniformity, the actual value of the maintained average illuminance may not exceed 1,5 times the minimum $\overline{E}$ value indicated for the class.

Following this logic would indicate that Carpenter's Road is a Low Traffic Road, within a Medium Crime area and being in environmental Zone E3/E4 with high ambient light.

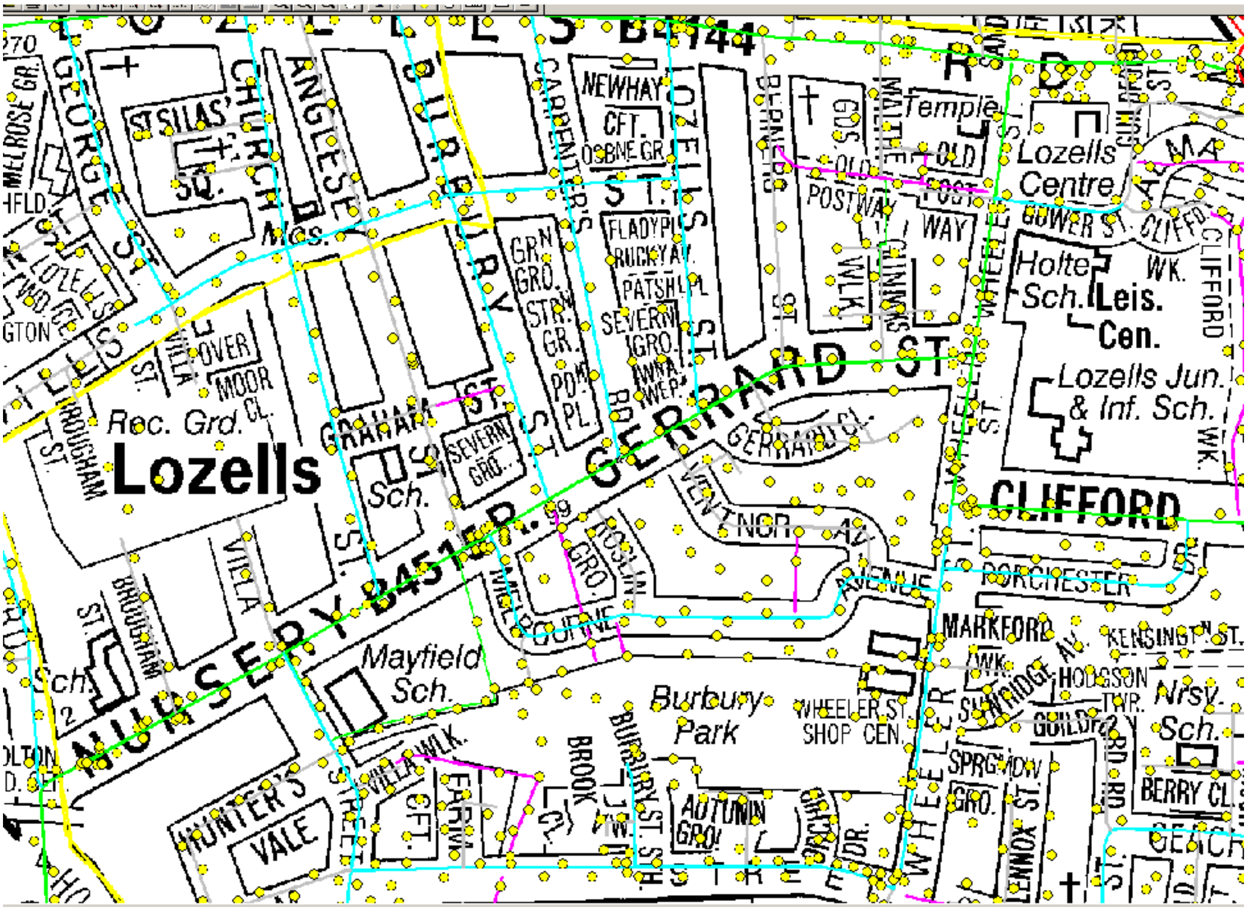
Therefore if using a white light source it would define lighting to S4 which will mean an average of 5 lux with a minimum point of 1 lux

Local Design Standards

Birmingham City Council Highways Department Street Lighting team have carried out an assessment of every road within the City and set a given lighting class for that location. They have made this available through a map based system.

The map below indicates the colour coding to the lighting class: with green for Gerrard Street and Lozells Rd both requiring Traffic Route Lighting to ME3 class Lav 1.0 cd/m^2

The Residential Roads such as Carpenter's and Burbury St. are coloured blue, this indicates a residential 'link' road – that is a road linking two traffic routes and requires lighting to S2. Anglesey Road is in grey and is classified as a local road and requires lighting to S3.



Consideration will be given to residential streets lit with a white source to drop a lighting class e.g.

S2 $\Longrightarrow$ S3
S3 $\Longrightarrow$ S4

6 Carpenter's Road - Options

This section sets out options for a sustainable approach to street lighting in the Carpenter's Road area.

Options to improve the environmental sustainability of the street lighting (while ensuring that it continues to perform to standard in terms of its key functions, particularly public safety) relate to:

- Type and number of columns
- Type of luminaires and lamps
- Control of lamp operations
- Power supply
- Additional functions

Columns

The anticipated operational lifespan of the columns in Carpenter's Road is that the older 5m tall cast iron columns are reaching the end of their operational life but is approximately 30 years for the newer steel columns.

There is limited information about the carbon footprint of different types or materials of replacement columns due to the variety of steel sources, the manufacturing methods and country of origin. The most widely used across the UK are the types that are presently used in Birmingham i.e. galvanized steel or, in increasing numbers, aluminum.

To achieve the same standard of lighting the number of columns could be reduced by using 6m tall rather than existing 5m columns so reducing the amount of materials needed. But we need to consider impact on local character and whether it retains "pedestrian-scale" lighting in the predominately residential area. Savings in materials would be small at the local level of one street, but obviously more significant if applied to a wider area. However, there are costs associated with changing positions of columns.

The tables at **Appendices 1** and **2** shows the maximum spacing of the main existing columns / lamps and the maximum and minimum spacings for alternative street lighting suitable for Carpenter's Road.

Luminaires and Lamps

The existing basic luminaires have an anticipated operational life of around 20 years, and the 70w high pressure sodium (SON) lamps are likely to need replacing every 3 – 4 years.

In the table at **Appendix 1**, the first two rows indicate the existing lighting type and levels probably currently being achieved, which is lighting class S3 for the 6m columns and between S3 and S4 for the 5m columns. Study of the guidance within British Standard would indicate that Carpenter's Road may be over lit and a more sustainable solution would be to drop the level by one to light class S4 and use white light.

For comparison, the table indicates the performances of the best lighting solutions available and suitable for this location. Three white light sources (including an LED) are included and compared at a lower class of S5 as they will not be able to provide the slightly higher S4.

It is a social/engineering judgment call to decide whether S4 or S5 is most appropriate as there is very little difference between the minimum values of 1 and 0.6 lux which are very difficult to measure on site and virtually impossible to distinguish between the two by the human eye. However, dropping to S5 provides more opportunity to make greater energy and carbon savings.

If retained at S4 but in line with national guidance, the lighting can then be dimmed one class to S5 when the streets are quiet between midnight and 5 am, thereby saving energy and reducing the sky glow over the City.

Appendix 2 also gives an indication as to costs, although it should be noted that there are a number of variables that can have some effect on the longer term costs.

Therefore to reduce the carbon/energy usage a number of factors need to be addressed:

- Review of BCC lighting policy to set lighting levels across the City
- Replace existing lighting stock with new light sources and control gear
- Dim the lighting during quiet periods – either as part of unit or through central management system across the City

Control of Lamp operations

Existing Carpenter's Road luminaires control gear are copper/iron ballast type which waste some 20% of the energy and changing to electronic gear would reduce the lost energy to some 3%. However this may not be easily achieved in the older luminaires and a replacement luminaire would be required, with the associated benefits of better light distribution.

When changing to new electronic gear there are at least two options:

1. Gear that will dim the light at set times (e.g. midnight to 5am) for example, half power thereby saving some 25% on energy/carbon usage.
2. Using a remote management system that communicates with the electronic gear, which can:
    a. Switch lamp on & off
    b. Monitor performance/energy usage through life
    c. Dim at set times or be linked to interactive support system to vary dimming period to suit local needs.
    d. Replace need to scout once a fortnight, thereby reducing carbon usage and pollution.

A simple step is to replace the existing photo-electric cells (PEC) that switch the lights on & off with cells that switch at lower levels , saving some 100 hours per annum (existing annual hours = 4037hrs). Not a lot for one unit, but when combined across the city will be significant. Also PECs can switch the lights to go off at midnight and back on again for the early rush hour.

Potential savings can be:

Trimming the hours of operation by PEC may save 2.5% on the energy bill

Dim for half the night to say 50% power may save 25% energy and Co_2

Switch off lights for half the night may save 50% energy and Co_2

Power Supply

The existing power supply to the street lights is from the underground mains supply at 230 volts and all things considered still the best option. Within the close urban environment the opportunity to use large Solar PVs or even a wind-turbine on each column is extremely limited and would seriously impact on the appearance of the residential street.

In the future with the potential of LEDs to improve their effective lights output and operate at just at very low voltage, combined with advancements in Solar PV systems and batteries will probably see freestanding lighting units on the streets in 10 years.

Additional functions

There are a number of additional functions the street lights can now deliver, which include:

- Festive decorations
- Mobile phone antenna
- Traffic signs and information
- De-cluttering the street – waste bins etc

In the future they could also:

- Carry wifi technology - -capable to rent out network to utilities to measure meters in houses
- Street sensors
- Communication – live local buses/train timetables
- Emergency points
- CCTV points
- Advertising/Local information

Summary

There are two paths to reducing the carbon usage of street lighting in Birmingham.

Firstly to consider the lighting levels currently being employed and whether these high levels are required in all locations. The European and National standards are to be reviewed and this may provide a greater opportunity to drop levels and stay within guidelines.

Secondly is to invest in new technology to make carbon and energy savings. This is demonstrated in the comparison tables. Where existing street lighting is under review, the opportunity to implement the new savings should be recognized. The new technology both uses less energy and allows greater control to reduce the light levels during an agreed period in the night and further reduce demand.

Therefore it is proposed that the existing lighting system in Carpenter's Road is replaced with a lighting system that will provide lighting in full accordance with BS 5489:

EQUIPMENT

- 6 metre high lighting columns (coated galvanized steel or aluminum)
- Luminaires with electronic control gear and high performance optics
- CosmoPolis (CPO) lamps (WHITE LIGHT)
- Central Management system to monitor and control lights to minimize operating period (or a fixed dimming system)

LIGHT LEVELS

S4 which is an average of 5 lux and minimum of 1 lux, dimming to
S5 average of 3lux and 0.6 lux during the night (12 – 5am).

Lighting could be dimmed from 8pm until 6am by one level (say 33%) and further reductions from midnight to 5am (approx 50%)

COSTS & ENERGY SAVINGS

The estimated capital cost to carry out this work, based upon a cost for a new complete street light at £800 and allowing some £200 to remove each of the existing 11 units and replace with 8 new units, is approximately £8600.

Assuming the cost of energy remains constant (possible but unlikely) the annual energy cost comparison for the street could be:

- Existing (11 no 70watt SON street Lights)= £323 per annum
- New (8 no 60 watt CPO street lights- dimmed) = £132 per annum

The payback period is therefore significant unless carried out as planned replacement works.

Note that this does not take into account **maintenance savings** to be found through reduced scouting, longer equipment life and less lighting stock to maintain.

If looked at in terms of energy use and CO_2 production, changing to new technology and lowering the lighting standard would lead to reductions in residential areas.

Dropping lighting class from:
S3 – approx 1100 kw / 2200kg co_2 ⇒ **S4** – approx 500 kw / 1200kg co_2

leading to 45% reduction.

In addition, dimming during the quiet period could save a further 33% of the balance

⇒ **S5** – approx 350 kw / 790kg co_2

leading to 65% reduction.

By investing in new technology, Birmingham could reduce its street lighting energy budget and associated CO_2 for residential areas by approximately 65% whilst delivering the desired lighting

2200 kg CO_2 ⇒ 790kg CO_2 pa

APPENDICES

1. **Comparison of existing and alternative lighting equipment, light levels and CO2**

2. **Comparison of existing and alternative lighting equipment and costs**

3. **Site Survey of existing equipment**

Appendix 1.
Comparison of existing and alternative lighting equipment, light levels and CO2

Class	E Av	E Min
S2	10	3
S3	7.5	1.5
S4	5	1
S5	3	0.6

Height m	Lamp (Lantern)	Lamp Watt	Lamp Type	Lamp Ra	Electrical Load watts	Spacing Max m	Spacing Min m	Average Illuminance - lux	Minimum Illuminance - lux	BS Level	Approx No Req'd	Electrical Load watts	Approx Kg CO2 pa
Carpenter's Road – existing equipment													
5	WRTL 2600	70	Son	20	90	33		8.9	1	Lies between S3 and S4 and with reflectance's from adjacent buildings will move towards S3	11	1000	2169
6	WRTL Vectra	100	Son	20	128	41		11	2.5	In S3 band	9	1152	2307
Possible alternative types of lamps													
6	WRTL Vectra	100	Son	20	128					**Cannot achieve S4 as source is too powerful**			
6	WRTL Vectra	70	Son	20	90	46	35	5.6	1.02	In S4 band	8	720	1578
6	WRTL ARC ASR Bowl	60	CPO	65	68	42	34	5.9	1	In S4 band	9	612	1341
6	Philips 451	60	CPO	65	68	44	30	5.05	1.64	In S4 band	8	544	1341
6	Philips 451	45	CPO	60	51	41	28	5.05	1.68	In S4 band	9	459	1006
6	Philips 451	45	CPO	60	51	57	42	3.31	0.6	In S5 band	6	306	783
6	Philips Residium	55	PLL	80	62	36	25	3	0.67	In S5 band	11	682	1494
6	WRTL Stella LED	36	LED	80	40	43	42	4.4	0.6	In S5 band	9	360	790

Appendix 2.
Comparison of existing and alternative lighting equipment and costs

BS5489:2003 Light Class	Height (m)	Luminaire reference	Lamp Watt	Lamp Type	Lamp Cost (£)	Luminaire Cost (£)	Lamp Change Period (years)	Maintenance Visit (15 min)	Electrical Load (watts)	Spacing Max (m)	Column Cost in Aluminum	Column Cost in Steel +Paint	Approx No Req'd	Electrical Load (watts)	**Approx Kg CO2 pa**	**Annual Energy Cost at 8p per KWH**	Annual Maintenance	Capital Cost Materials Only Alu Col		Annual Maintenance Inc Energy and regular lamp Change ex Elec/ Structural Testing	Capital + Maintenance Over 20 years
Carpenter's Road – existing equipment																					
S3	5	WRTL 2600	70	Son	5		5	10	90	33			11	1000	**2169**	**£323**	£33			£356	
S3	6	WRTL Vectra	100	Son	5		5	10	128	41			9	1152	**2307**	**£372**	£27			£399	
Possible alternative types of lamps																					
S4	6	WRTL Vectra	100	Son	6				128												
S4	6	WRTL Vectra	70	Son	5	175	5	10	90	46	200	140	8	720	**1578**	**£233**	£24	£3,000		£257	£ 8,130
S4	6	WRTL ARC ASR Bowl	60	CPO	25	175	4	10	68	42	200	140	9	612	**1341**	**£198**	£79	£3,375		£276	£ 8,903
S4	6	Philips 451	60	CPO	25	175	4	10	68	44	200	140	8	544	**1341**	**£176**	£70	£3,000		£246	£ 7,913
S4	6	Philips 451	45	CPO	25	175	4	10	51	41	200	140	9	459	**1006**	**£148**	£79	£3,375		£227	£ 7,914
S5	6	Philips 451	45	CPO	25	175	4	10	51	57	200	140	6	306	**783**	**£ 99**	£53	£2,250		£151	£ 5,276
S5	6	Philips Residuum	55	PLL	3	90	4	10	62	36	200	140	11	682	**1494**	**£220**	£36	£3,190		£256	£ 8,310
S5	6	WRTL Stella LED	36	LED	0	550	21	10	40	43	200	140	9	360	**790**	**£116**	£4	£6,750		£121	£ 9,163

Appendix 3.
Site Survey of Existing Equipment

Location	ref No	Column			Electrical		Luminaire		Lamp		PEC Control
		Height	Type	Condition 1-4	Type	Condition 1- 4	Type	Condition 1- 4	Type	Wattage	
Jnc Gerard Rd	1	5	Step Cast	3	DNO	2	BVI 39000	2	SON	70w	1pt
o/s 120/122	2	5	Step Cast	3	DNO	2	BVI 39000	2	SON	70w	1pt
o/s 109/111	3	5	Step Cast	3	DNO	2	Philips MI57	3	SON	70w	1pt
o/s 89/91	4	5	Step Cast	3	DNO	2	Philips MI57	3	SON	70w	1pt
o/s 66/68	5	5	Step Cast	3	DNO	2	Philips MI57	3	SON	70w	1pt
o/s 53/55	6	5	Step Cast	3	DNO	2	Philips MI57	3	SON	70w	1pt
jnc Wills St	7	5	Step Cast	3	DNO	2	BVI 39000	2	SON	70w	1pt
jnc wills St	8	6	Steel	1	DNO	1	WRTL Vectra	1	SON	70/100w	1pt
o/s 18A/20	9	5	Step Cast	3	DNO	2	Philips MI57	3	SON	70w	1pt
o/s 11/13	10	6	Steel	2	DNO	1	WRTL Vectra	1	SON	70/100w	1pt
jnc Lozells Rd	11	6	Steel	1	DNO	1	WRTL Vectra	1	SON	70/100w	1pt