General Circular Investment: Nº 15/01

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Purpose

This general circular sets out how the NZ Transport Agency intends to work with road controlling authorities (RCAs) that wish to convert their road lighting to light emitting diode (LED) technology.

It outlines the Transport Agency's investment policies, as they relate to road lighting, including an interim policy designed to help ensure that the plans that many RCAs have to convert road lights to LED can be supported by the Agency.

Advice on the preparation of a business case for an LED conversion programme, and an outline of other specific areas of assistance and advice is presented. Further advice being developed is also discussed.

Transport Agency road lighting investment policy

The Transport Agency's road lighting investment policies are agnostic as to a luminaire's light source. However, LED technology has developed to the point where, on a whole of life cost basis, it is likely to be the lowest cost lighting option in almost any situation. Therefore, the Transport Agency expects that LED will be the 'default' for all future luminaire renewal and road lighting improvement projects, given that it is likely to be the best value for money option.

This general circular does not affect the Transport Agency's investment policies as they relate to true road lighting 'improvement' proposals, for example to light a currently unlit section of road to address a road safety risk problem. Such a proposal will be considered in the same way as at present.

Renewal of luminaires is normally funded by the Transport Agency under work category 222: *Traffic services renewals*. New lighting installations and other road lighting improvements are either funded under work category 341: *Minor improvements* or work category 324 *Road improvements.*

Investing in an 'accelerated renewal LED conversion programme'

The Transport Agency will invest in an 'accelerated renewal LED conversion programme' as an 'improvement' under work category 324 *Road improvements*. Approval will depend on certain conditions being met including receipt of an acceptable business case supporting the proposed investment.

An 'accelerated renewal LED conversion programme' is a programme to convert an existing road lighting installation to LED, before the time at which renewal would have been justified had it not been for the emergence of the opportunity to convert to LED. The economic justification for this early renewal will have been demonstrated. Analysis, using the present value (PV) method, will have compared the options of continued maintenance and operation of the existing installation and the alternative of conversion to LED and shown that conversion to LED will significantly reduce future operating and maintenance costs, to the point where early conversion is the least cost long term option.

For guidance on how to prepare a business case acceptable to the Transport Agency refer to the attachment to this general circular - *Advice on preparation of a business case for an accelerated renewal LED road lighting conversion programme.*

The interim nature of this investment policy

Treatment of an 'accelerated renewal LED conversion programme' as an 'improvement' by the Transport Agency for investment purposes will apply for the 2015-18 three year national land transport programme (NLTP) period. Investing in an LED conversion programme in this way may be extended into the 2018-21NLTP term if circumstances warrant. Conversion programmes that either begin in, or extend into, the 2018-21NLTP term may revert to being funded under work category 222: *Traffic services renewals*.

Investment profile for an 'accelerated renewal LED conversion programme'

The Transport Agency investment profile for an accelerated renewal LED conversion programme, that meets the 'tests' set out in the attachment to this general circular, will typically be 'MH 5+'. That is to say, against the criteria strategic fit and effectiveness the investment will be ranked as 'medium' and 'high' priority respectively and against efficiency it will be given the highest ranking of 5 +. This will be a typical profile, the actual profile for an individual programme will need to be established as required by Transport Agency policy.

Funding assistance rate

An RCA's normal funding assistance rate (FAR) will apply to an accelerated renewal LED conversion programme [1].

Future maintenance spend

Where an RCA converts to LED the Transport Agency will expect to see the savings from reduced energy and maintenance costs reflected in future traffic services expenditure.

Routine road lighting renewals

Where an RCA chooses not to accelerate renewal and instead convert luminaires to LED as and when they reach the end of their useful life, the co-investment will be managed as is usual, as a traffic services renewal, under work category is 222: *Traffic services renewals*.

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[1] Under the new Transport Agency FAR policies this rate will change for some RCAs from year to year until the agreed normal rate is reached.

All RCAs are encouraged to consider accelerating the renewal of existing road lighting installations given that in almost every instance whole of life cost will be reduced.

CMS and 'smart city' opportunities

The Transport Agency is aware that many RCAs, the larger cities in particular, are considering the inclusion of a central management system (CMS) in their LED conversion programme. A CMS is one way to manage the dimming and energy monitoring of road lighting but has other benefits. Many RCAs are also considering what are generally referred to as broader 'smart city' opportunities. Given that a comprehensive LED conversion programme will represent a significant long term investment for any RCA, the Transport Agency expects that all will consider these opportunities when making investment decisions.

The Transport Agency will consider investing, in partnership with an RCA, in technology that enables cost effective dimming. However, the Agency will not co-invest in other technology that has no transport related benefit.

Additional government funding

Government has considered providing additional funding to RCAs, over and above the co-investment assistance that will be provided by the Transport Agency, to further accelerate conversion of road lighting to LED. It has concluded that additional funding is not needed, given the favourable economics of a typical LED conversion proposal. As stated above, in most cases LED will be less expensive than other technologies on a whole of life cost basis.

Reports commissioned by government

The Energy Efficiency and Conservation Authority (EECA) and the Transport Agency have commissioned two reports, prepared by PWC, related to accelerated renewal LED conversion. They are published on the Transport Agency's website. They are: Assessing the potential cost savings from accelerating the roll-out of LED road lights and Review on the likely impact of an uptake in LED road lighting.

The impacts discussed in this second PWC report include the likely reaction of local electricity distribution / lines companies to a reduction in energy consumption. The conclusion drawn being that lines companies will likely alter their charges to maintain present income levels. Consequently the financial advantage from an LED conversion would then depend on a reduction in charges for energy consumed and a reduction in maintenance costs.

Assistance and advice from the Transport Agency and the LGNZ EquiP Road Transportation Unit

The Transport Agency in collaboration with local government, road lighting consultants and the road lighting industry has developed a number of documents and tools to help RCAs that are considering an LED conversion programme.

Work in this area, in collaboration with Local Government New Zealand (LGNZ) through EquiP's Road Transportation Unit, is ongoing.

For more information on the support that the Road Transportation Unit can offer contact Dr Steven Finlay – phone 04 978 1241or email steven.finlay@lgnz.co.nz. Maximising the opportunities for RCAs to benefit from collaboration with others will be a particular focus of the Unit. LED conversion offers many opportunities to obtain better value through collaboration.

M30 - Specification and Guidelines for Road Lighting Design

The Transport Agency has developed the Specification and Guidelines for Road Lighting Design to assist lighting asset owners, design consultants and suppliers capture the maximum benefits from newer lighting technologies, particularly LED road lighting.

This document builds on the significant effort that Auckland Transport and Christchurch City Council have both put into this area of asset ownership and operation, particularly in the area of LED road lighting luminaires and associated equipment.

LED lighting is now proven and technically mature. Investment in LED is low risk. Care is nevertheless needed when designing an LED installation and purchasing LED lighting equipment to ensure suitable quality and performance that meets the requirements of AS/NZS1158 *Road lighting* and international best practice. The M30 specification has been prepared to address these issues.

List of accepted luminaires

The M30 specification references a list of Accepted Luminaires. Accepted luminaires have been independently assessed against the criteria listed in the M30 specification. Those criteria are based on criteria first established by Auckland Transport and Christchurch City Council. RCAs may choose to use a luminaire that is not on the accepted list but need to be aware of that fact and either seek to have the luminaire added to the list or seek appropriate assurance of quality by some other equally rigorous independent process.

Suppliers can submit luminaire information for M30 acceptance. The acceptance process is described in the Luminaire Acceptance Process document.

Advice on preparation of a business case for an accelerated renewal LED conversion programme

Refer the attachment to this general circular, *Advice on preparation of a business case for an accelerated renewal LED road lighting conversion programme,* for a discussion of what the Transport Agency will expect an acceptable business case for an LED conversion programme to cover.

PV method analysis tool

A spreadsheet based PV method analysis tool for an accelerated renewal LED replacement proposal has been developed. Demonstrated savings through conversion to LED are an important part of the business case. This PV method spreadsheet tool allows rapid calculation of savings and can be downloaded from the Transport Agency's website.

Further advice

Further advice will be developed jointly with the LGNZ EquiP Road Transportation Unit in collaboration with RCAs and the industry. Areas where further advice would be helpful include:

- 'Local share' co-investment options.
- Innovative funding and procurement options including private funding.
- Collaborative procurement of equipment, services and installation.

As stated above the Road Transportation Unit is providing advice to RCAs on LED conversions and will help with collaboration amongst RCAs.

Procurement and collaboration

LED conversion programmes lend themselves to innovative approaches to procurement including collaborative procurement arrangements. They also lend themselves to collaboration to develop a single business case for a LED conversion programme covering a group of RCAs.

The Transport Agency expects that many RCAs will obtain investment approval from the Agency, raise the necessary local share and procure the necessary equipment and services in a conventional fashion in collaboration with other RCAs wherever an opportunity to do so exists. However, all RCAs are encouraged to consider more innovative approaches wherever innovation would obtain better value for money.

An innovative approach may, for example, include some form of private finance or use a form of collaborative, shared risk deliver model that does not meet the requirements of a simple 'standard' procurement procedure as set out in the Transport Agency's Procurement manual. Where an innovative approach is being considered RCAs are encouraged to engage in discussion with the Transport Agency early. A procurement procedure approval may be required but if best value for money can be shown then that approval will be forthcoming.

Attachments

There is one attachment - *Advice on preparation of a business case for an accelerated renewal LED road lighting conversion programme*.

Enquiries

All enquiries relating to this circular should be directed to your local Transport Agency Planning and Investment Manager.

For more information on the support that the LGNZ EquiP Road Transportation Unit can offer contact Dr Steven Finlay – phone 04 978 1241or email steven.finlay@lgnz.co.nz.

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Attachment – Advice on preparation of a business case for an accelerated renewal LED road lighting conversion programme

Purpose

This document contains advice to road controlling authorities (RCAs) of what the NZ Transport Agency expects to be covered in a business case to support investment in an accelerated road lighting renewal programme, converting existing road lighting to light emitting diode (LED) technology.

The Transport Agency will invest in an 'accelerated renewal LED conversion programme' as an 'improvement'. under work category 324 Road improvements. Investment approval will depend on certain conditions being met including receipt of an acceptable business case supporting the proposed investment.

LED conversion programmes and the ongoing delivery of road lighting lend themselves to collaborative arrangements involving more than one RCA. Collaborative procurement is discussed elsewhere in this statement of advice. The business case for an LED conversion programme discussed here could be a joint business case from a number of RCAs for a single conversion programme.

This advice is intended to assist RCAs, and Transport Agency staff working with them, to develop an acceptable business case quickly and efficiently.

This advice must be read in conjunction with general circular 15/01 *Conversion of road lighting to LED* to which it is attached.

Introduction

In what can be thought of as a 'technically stable' environment renewal occurs when an asset has reached the end of its life and renewal becomes the lower future cost option than ongoing maintenance.

However, with LED we are not dealing with a 'technically stable' situation. LED represents a technical advance in that it is more energy efficient than previous technologies. It will also require less maintenance throughout its life, when compared to the dominant current technology namely high pressure sodium (HPS), because the lamps do not have to be regularly changed. It therefore can be shown, for many HPS installations, regardless of their age, that the current installation should be renewed now with LED. Hence we, the Transport Agency, are referring to such a programme as 'accelerated renewal', or renewal before the time at which it would have been justified had it not been for the emergence of this 'LED opportunity'.

End of useful life renewal is economically justified when, in Transport Agency economic evaluation manual (EEM) terms, the present value (PV) of renewal is less than the PV of ongoing maintenance. Renewal is the 'do-minimum' option. In the case of an accelerated renewal LED conversion programme, renewal is again the do minimum but is driven by the reduced energy and maintenance costs that come with the change to the new LED technology.

Characteristics of an acceptable business case

For a business case to be acceptable to the Transport Agency, and for the Transport Agency to agree to invest in an accelerated renewal LED conversion programme, certain conditions will need to be met.

An acceptable business case will demonstrate, as a minimum, that the follow 'tests' are met:

1. Contractual arrangements that determine the price paid by the RCA(s) for electricity distribution and for energy supply will be such as to deliver real cash savings upon conversion to LED. To achieve energy cost savings in particular, an up to date road lighting database that complies with electricity regulations for an unmetered supply will almost certainly be required.

2. On the basis of a comparison of options, through PV analysis, conversion now to LED will be shown to be the least PV cost option in terms of an EEM assessment using the approach referred to in the Planning and Investment Knowledge Base (PIKB) as the 'present value (PV) method'.
3. The same EEM assessment will shows that the 'payback' period for the investment in conversion to LED will be short – usually less than 10 years.
4. The business case will clearly identify the renewal component of the cost of the programme and separates it from any improvement component.
5. Any improvement in road lighting included in the programme will be justified in incremental benefit to cost terms[2].

An acceptable business case is also likely to propose that the LED conversion programme will start with the category 'P' roads. AS/NZS1158 *Road lighting* categorises roads as either 'P' or 'V'. Vehicular traffic (category V) lighting is used on generally more heavily trafficked roads. Pedestrian area (category P) lighting is used on low traffic volume roads. The economics for conversion from HPS to LED in P category areas is often compelling but this is not always so for V category roads. It will be acceptable to the Transport Agency for any straight forward accelerated renewals programme business case to be prepared as a single stage business case covering, to the depth that is warranted, initiation, strategy, programme and activity.

Identifying the problem, opportunity or issue

As with any business case the problem, opportunity or issue needs to be correctly identified, based on evidence. In the case of an accelerated renewal LED conversion programme the problem, etc will present as an opportunity in the first instance, to reduce the whole of life cost of providing the current road lighting level of service. The programme may coincidentally address minor issues or problems which will also be set out in the business case.

The proposed programme must meet all the 'tests' referred to above and the RCA(s) must have considered the problem, etc in broad terms from a customer perspective. Customer level of service considerations would include – is the level of service in every area to be covered by the programme appropriate, are there areas that are currently lit but do not need to be, can some lights be turned off at certain times, to what extent can lights be dimmed and at what times and should some current lighting in some specific areas be improved?

Identifying the benefits of the accelerated renewal programme

For a straightforward accelerated renewals programme there will be no quantifiable benefit in the EEM sense. The customer level of service will be generally unchanged in that lighting levels will not change. Neither will the new lighting deliver more light than required by AS/NZS1158 for the particular class of road. The 'benefit' will be a long term service delivery cost saving. How that cost saving should be quantified and documented is discussed below.

If the conversion programme includes lighting improvements, for example to mitigate a road safety risk at a point of conflict, then the business case must at a minimum identify the benefit from investing in the improvement and compare that benefit with the incremental cost.

Economic efficiency assessment using the present value method

The PIKB describes a number of 'alternatives to benefit cost analysis'. The first listed being the 'present value (PV) method: https://www.pikb.co.nz/assessment-framework/efficiency/ The PIKB description of the method states that "The present values of future costs are used to establish the long term least cost option". This method is typically used to determine if renewal is more cost effective than ongoing maintenance.

[2] For a programme component that is to be treated as a minor 'improvement' the incremental benefit may not need to be quantified.

Every accelerated renewal LED conversion proposal business case will include a PV method analysis comparing the option of continuing to operate and maintain the existing installation and the alternative option(s) of replacing with LED.

A spreadsheet based PV method analysis tool for an accelerated renewal LED conversion programme can be downloaded from the Transport Agency's website.

Determination of a payback period is not typically part of a PV method analysis but in the case of an LED conversion proposal that statistic is very informative and therefore should be calculated and quoted in the business case. The above tool calculates the payback period.

An accelerated renewal LED conversion programme business case will typically include a number of separate PV method analyses, each one will typically cover a continuous geographical area, a route or a continuous network of similar streets. The group of lights included in one PV method analysis for one part of the road lighting network will usually all be currently using similar luminaires and be lighting roads in the same AS/NZS1158 lighting category. The same LED luminaire will usually be a suitable replacement for all current luminaires in that part of the network.

Dimming LED lights and 'smart city' opportunities

The Transport Agency is aware that many RCAs, the larger cities in particular, are considering the inclusion of a central management system (CMS) in their LED conversion programme. A CMS is one way to manage the dimming and energy monitoring of road lighting but has other benefits including automated failure reporting, remote control and inventory management. Many RCAs are also considering what are generally referred to as broader 'smart city' opportunities.

Given that a comprehensive LED conversion programme will represent a significant long term investment all reasonable opportunities should be considered in any proposed LED conversion programme.
Dimming, referred to above, is one such opportunity and one that will likely show significant tangible financial advantage to both the RCA and the Transport Agency through energy cost savings.

Given that dimming, possibly even turning lights off from say 11 pm to 5am, will save energy the Transport Agency expects that every proposed LED conversion programme will have considered the option of dimming and examined the additional cost (in PV terms) of including dimming and compared this to the value of energy savings. The business case should show the PV cost of dimming plus the PV of energy cost savings and the payback period for the additional cost of dimming capability.

The lowest PV cost 'do-minimum' option will commonly include dimming. The PV method analysis tool referred to above includes calculation of dimming cost savings.

The Transport Agency will consider investing, in partnership with an RCA, in any opportunity that has a transport related benefit, however, the Agency may not wish to co-invest in an opportunity that has no transport related benefit.

Knowledge of the existing lighting installation and of operating contracts

To complete a PV method analysis for any one part of the road lighting network a significant amount of data is required, both data describing the current installation in that part of the network and data describing the situation post any LED conversion.

Data required that relates to the existing installation will include:

1. number and type of luminaires and the power consumption of each
2. frequency and cost of lamp replacement and cleaning for existing luminaires
3. energy supply contractual details to establish existing energy supply charge

4. lines charges contractual details to establish existing lines charges
5. other maintenance contractual arrangements to establish cost of any other maintenance.

Data required that relates to the installation post conversion to LED will include:

1. number and type of luminaires and the power consumption of each
2. frequency and cost of cleaning
3. energy supply contractual details to establish future energy supply charge including any possible change in contractual arrangements – beyond normal inflation adjustment
4. lines charges contractual details to establish future charges including any possible change in contractual arrangements – beyond normal inflation adjustment
5. cost of installing LED luminaires plus other additional costs, for example the cost of an electrical wiring upgrade, that are necessary as a direct consequence of converting to LED
6. other maintenance contractual arrangements to establish cost of any other maintenance.

Without sound knowledge of the current lighting installation, plus current and future costs based on contractual arrangements, an accelerated LED conversion programme should not be contemplated. Existing contractual arrangements in particular may make accelerated LED conversion unviable until those arrangements are changed.

Particular care needs to be taken to establish likely future lines company charges, preferably over the next 10 or more years. Future lines company charges, or uncertainty about future charges, is expected to make some accelerated LED conversion programmes unviable. Sensitivity testing should be undertaken to determine the effect of varying future charges on the investment decision.

Care also needs to be taken to ensure that the method of calculating energy consumption for a road lighting installation will give an immediate reduction in the energy charge post an accelerated renewal LED conversion. The fact that most road lighting installations are unmetered heightens the need for care here. Similarly each RCA needs to be confident that its contract for energy supply will allow it to capture the cost savings from the installation of a system to dim lights.

Many installations have a separate circuit for road lights, referred to as a 4th wire. Where a '4th wire' is used, maintenance contractual arrangements related to the 4th wire need to be considered. Given that the 4th wire is separate – it does not serve other consumers - repair can be a very low priority for a lines company when the circuit develops a fault[3].

Electricity regulations, that apply to distributed unmetered loads and therefore apply to almost all road lighting installations, demand that information on road lighting assets must be kept, including information on when and how much power is consumed. If an RCA has access to such a database, and the database is up to date and meets the standard required by regulation then asset knowledge should meet the standard discussed above.

Inclusion of 'improvements' in the LED conversion programme

If a proposed LED conversion programme includes expenditure to deliver more light in some locations then the marginal cost of that 'improvement' must be identified.

The scope of the lowest PV 'base case' will typically be no more extensive than simply replacing all current luminaires with LED luminaires to deliver lighting to a standard no worse than is currently provided. No additional poles will be installed and no poles will be moved. Neither will there be any proposal to make targeted improvements to lighting at, for example, intersections or other points of conflict.

[3] Where a 4th wire is used a higher lines charge may be used, reflecting the fact that the 4th wire is dedicated to road lighting.

Any element of improvement included in an accelerated renewal LED conversion programme must meet the investment criteria appropriate to an improvement. The criteria will either be those appropriate to work category 341: *Minor improvements* or work category 324 *Road improvements* depending on the scale of the improvement.

'Improvements' that should be considered

No proposed LED conversion programme should proceed without first understanding the customer level of service being delivered by the current system and then considering where change may be warranted. For any improvement to be warranted there must be supporting evidence. In a P category area in particular the fact that the P category design standard is not met by the current installation is not of itself evidence to support change. It would be difficult to justify improving lighting that is currently delivering an acceptable customer level of service.

One example of a matter that should be considered, in either a category P or V area, is improving lighting at intersections or other points of potential conflict. As discussed above such an improvement would typically be treated as a minor improvement for Transport Agency investment purposes - where the scale is appropriate to a minor improvement benefit obtained in return for the additional investment cannot necessarily be quantified but can be described and judged to be good value for money.

The timing of any improvement must be considered. Some improvements will have a lower cost if completed at the same time as the LED conversion. Others may be able to be delayed without incurring additional cost.

Compliance with AS/NZS1158 Road lighting

A number of parts of AS/NZS1158 are listed in the Transport Agency's Register of Network Standards and Guidelines. They either have the status of a 'guideline' or an 'other reference'. The Transport Agency's expectation in relation to compliance with AS/NZS1158 is therefore that it will be followed unless the RCA has a sound value for money reason not to do so. However, as stated above it would be difficult to justify improving lighting on a P category road that is currently delivering an acceptable customer level of service.

RCAs can therefore expect that in most instances the Transport Agency will:

1. not co-invest in lighting to a higher standard than that proposed by AS/NZS1158
2. expect compliance with the standard on 'V' category roads, unless a sound value for money case for not doing so can be mounted
3. question any proposal to raise the standard of lighting on a 'P' category road, however, as discussed above there may be a rational value for money argument to make targeted improvements to lighting at points of traffic, including pedestrian, conflict.

Prioritising within an accelerated renewal LED conversion programme

Where an LED conversion is shown to save money long term the case to convert without further delay is also made. However, there are many reasons to want to control the speed of LED conversions, the first being to not overstretch the supply markets involved and thus drive prices up. RCAs need to coordinate to prevent this. All RCAs are encouraged to keep the LGNZ EquiP Road Transportation Unit informed of their LED conversion plans, who will help to ensure coordination.

Priority should be given to the best cases for immediate conversion. The spreadsheet based PV analysis tool referred to above calculates a payback period, which gives a quick way to help identify those parts of a road lighting network that should be given priority.

Outlook for electricity prices

New Zealand electricity prices are expected to fall, in real terms. Refer the MBIE report on this matter from June 2013: http://www.med.govt.nz/sectors-industries/energy/energy-modelling/modelling/new-zealands-energy-outlook-electricity-insight

This provides a further reason to prioritise the short payback period parts of a network for accelerated renewal LED conversion.

M30 Specification and Guidelines for Road Lighting Design

The Transport Agency has developed the M30 Specification and Guidelines for Road Lighting Design to assist RCAs, design consultants and suppliers capture the maximum benefits from newer lighting technologies, particularly LED road lighting.

The specification and guidelines are still to be formally finalised but are expected to be given the status of a guideline in terms of the Transport Agency's Register of Network Standards and Guidelines.

Procurement and collaboration

All RCAs are encouraged to team up with their neighbours to jointly develop a multiple RCA LED conversion business case, jointly purchase and jointly contract for services to maximise economies of scale. LED conversion programmes and the ongoing delivery of road lighting lend themselves to collaborative arrangements. Auckland Transport has offered its luminaire buying power to all RCAs.

Some RCAs are considering innovative approaches which may, for example, include some form of private finance or use a form of collaborative, shared risk deliver model that does not meet the requirements of a simple 'standard' procurement procedure as set out in the Transport Agency's Procurement manual. Where an innovative approach is being considered RCAs are encouraged to engage with the Transport Agency early. A procurement procedure approval from the Transport Agency may be required but if best value for money can be shown then that approval will be forthcoming.

The LGNZ EquiP Road Transportation Unit is providing support and advice in relation to LED conversion programmes and in particular will assist with collaboration. To register an interest in, or explore collaboration options contact Dr Steven Finlay at the Road Transportation Unit - phone 04 978 1241 or email steven.finlay@lgnz.co.nz.

The benefits of white light

Note that the above discussion does not mention the fact that an LED conversion programme will in most cases deliver more white light than is currently the case – this will be especially so where LED is replacing HPS lighting.

White light does deliver a number of benefits including vehicle and pedestrian safety benefits, mostly through better colour rendition. At this time these benefits cannot readily be quantified in monetary terms and therefore the economic evaluation of options would not be expected to include them. RCAs may, however, give unquantified value to these non-standard non-market benefits.

The benefits of dark skies

Note that the above discussion does not mention the fact that an LED conversion programme will in most cases reduce light pollution. This will be especially so where LED is replacing HPS lighting.

Reduced light pollution benefits cannot readily be quantified in monetary terms and therefore the economic evaluation of options would not be expected to include them. RCAs may, however, give unquantified value to these non-standard non-market benefits.