ICLEI
Local Governments for Sustainability

South Australian Strategic Action Planning Guide for Sustainable Public Lighting

These guidelines were prepared by
ICLEI-Local Governments for Sustainability-Australia/New Zealand
with funding from the Local Government Association of South Australia Research & Development Scheme.

ACKNOWLEDGEMENTS

The South Australian Strategic Action Planning Guide for Sustainable Public Lighting has been developed with the support of the Local Government Association of South Australia through the Local Government Research and Development Scheme (LGR&DS). The guide draws on work initially undertaken by ICLEI-A/NZ with support from Sustainability Victoria in 2004/05 for the development of the Victorian Sustainable Public Lighting Action Plan Guidelines. Funding for the Victorian Guidelines was provided as a capacity building project under the Sustainable Public Lighting Initiative (SPLI).

The guide was developed in consultation with eleven urban and rural Cities for Climate Protection (CCP) councils in South Australia. ICLEI-A/NZ thanks the following councils for their input through workshops, contribution of case studies and other information, which has been invaluable in ensuring the appropriateness and applicability of the guide to local governments in South Australia:

- Adelaide City Council
- City of Charles Sturt
- City of Mitcham
- City of Port Adelaide Enfield
- City of Unley
- City of Norwood Payneham & St Peters
- City of Marion
- District Council of Mount Barker
- Campbelltown City Council
- Clare & Gilbert Valleys Council
- Salisbury City Council

ICLEI-A/NZ gratefully acknowledges the following organisations that generously contributed their time and information:

- Local Government Association of South Australia
- Public Lighting Steering Committee
- Local Government Corporate Services
- ETSA Utilities
- Department for Transport, Energy and Infrastructure, Energy Division
- Department for Transport, Energy and Infrastructure, Transport Division
- Essential Services Commission of South Australia
- Department of the Premier and Cabinet, Sustainability and Climate Change Division
- Australian Greenhouse Office, Department of Environment and Heritage
- Australian Local Government Association

The project participants and stakeholders at the ICLEI-A/NZ South Australian Recognition & Briefing Breakfast, Friday 20 October.

Back row (from left): Lord Mayor Michael Harbison, Adelaide City Council; Mayor Ivan Brooks, City of Mitcham; Mayor Steve Woodcock, Campbelltown City Council; John McArthur, City of Unley; Ken Potter, Salisbury City Council; Bob Burgstad, Essential Services Commission of South Australia; and Alex Fearnside, Department of the Environment and Heritage.

Front row (from left): Cr Raelene Telfer, Marion City Council; Mayor Fiona Barr, City of Port Adelaide Enfield; Cr John Howland, City of Charles Sturt; Martin Bellamy, ETSA Utilities; Mayor John Rich, President, Local Government Association; and Martin Brennan, ICLEI-A/NZ.

CONTENTS

LIST OF CASE STUDIES

LIST OF TOOLS

INTRODUCTION

Before a local government can develop a sustainable approach to the delivery of public lighting in their municipality, it is important to understand the benefits of, barriers to, and opportunities for such an approach. This introduction provides that context, as well as a basic explanation to the South Australian Strategic Action Planning Guide for Sustainable Public Lighting, why it was created, and how local governments can use it to manage their public lighting in a sustainable manner.

Why should my council act on public lighting?

Across Australia, local governments are taking action to address energy consumption from public lighting for several reasons:

1. *To reduce financial losses.* Local government spending on public lighting ranges from $75,000 to $1.5 million per annum per council in South Australia (source: Data gathered by CCP councils at Milestone 1). Potential efficiency gains of 60-65% (source: Genesis Automation *et. al,* 2006)[1] would mean significant financial savings for councils.
2. *To reduce greenhouse gas emissions*. Cities for Climate Protection (CCP) councils across Australia have reported that public lighting can account for 15-70% of their corporate[2] emissions inventories (source: CCP Software). Most of these councils' local greenhouse action plans identify public lighting as an important area of work, and recognise it will be difficult to achieve their greenhouse reduction goals without reducing emissions from the public lighting sector.
3. *To increase the effectiveness of council's management processes*. Like waste management and planning, public lighting is a service delivered by council to the community. Council's delivery of lighting in public areas should focus on how to provide the service most *effectively*, rather than always using past courses of action. Strategic contract management, infrastructure planning, and service delivery naturally lead to energy efficient public lighting, as they can cost-effectively ensure appropriate lighting levels and light quality. This is particularly important in the context of a deregulated electricity market, where councils have greater decision-making responsibility for meeting the regulatory standards in areas they choose to light, whilst reducing light pollution, managing crime and related fears, improving public amenity, increasing the use of public space, and reducing or controlling the risk of litigation.

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[1] References used in this Guide are referred to by the author and date, and full document details are found in Chapter 4 under Publications.

[2] Councils familiar with the CCP Program will know that the 'corporate' sector refers to a council's own operations, including facilities owned or managed by council. 'Corporate' includes six sub-sectors: buildings; vehicle fleet; employee commute; water/sewage; streetlights and waste. The other sector is 'community' which covers the broader municipality.

Why isn't local government public lighting more energy efficient?

Although some councils across Australia lead the way, and despite significant technological capability to reduce emissions in the sector, council have reported that public lighting is an area in which they often find it challenging to take action. Common barriers experienced by councils are summarised in Box 1.

Box 1: Barriers to Sustainable Public Lighting

National barriers

- **Price disincentives for councils.** Contestable energy has lowered prices, potentially reducing the reasons for councils to act. Depending on the financial model, introducing energy efficiency changes can sometimes involve an upfront capital expenditure to council, higher maintenance costs due to the low economy of scale of new lights (if done individually rather than regionally or in bulk), and/or council liability to maintain the lamps.
- **Price disincentives for distribution businesses and retailers.** As distributors costs are scrutinised and capped by regulators, there is limited incentive for distributors to take risks on new technologies for which they are uncertain of long-term performance and costs. As public lighting uses off-peak rather than peak demand energy, there is less pressure to reduce energy consumption.
- **Complicated public lighting system.** Councils can be unclear about asset ownership, regulations, their role, and energy efficiency options under electricity market deregulation (Full Retail Contestability—or FRC—has been implemented in SA and is at different points in other states).
- **Limited technical knowledge.** Local governments have varying levels of access to technical expertise (internal and external) on the latest lighting technologies and their relevant applications. Within the research field, experts still have inadequate data on the response of the eye under low light conditions, the performance requirements for public lighting, and the performance of blue-white and orange light at night.
- **Limitations to maintenance.** Maintenance levels (under current tariffs) tend to be oriented towards light failures at night versus lights burning during the day.
- **Council difficulties in accurately tracking assets.** Lack of clarity regarding location, tariff type, energy spend, and so on, reduces council ability to manage energy and cost performance.
- **No national standards for energy efficiency.** Energy efficiency is not covered under the Australian Standards for Road Lighting (AS/NZS 1158).
- **Lack of coordination and funding of research and development.**

South Australian barriers

- **Supply monopoly.** As is the case in some other states, having one distributor in SA limits the tariff and financial options for energy efficiency.
- **Few council-owned assets.** As ownership of the majority of public lights was vested in ETSA Utilities as part of it's sale by the State, councils don't own the majority of the assets and therefore have fewer lighting options and less control of the technology.

(Sources: South Australian CCP councils identified the barriers at the CCP SA Regional Meeting October 2005 and SA Sustainable Public Lighting Project council workshops in December 2005 and May 2006; Genesis Automation et. al, 2006; LGA June 2003).

What's possible

A common misconception amongst the CCP councils that work with ICLEI-A/NZ is that, given these barriers, local government is not in a position to influence public lighting. This concern has recurred during the Victorian Public Lighting Forums delivered by the former Sustainable Energy Authority in February 2003, the WA Sustainable Public Lighting Advancing Action Project delivered by ICLEI-A/NZ (2005/06), and this SA Sustainable Public Lighting Project (2005/06). There are, however, many opportunities for local government to influence public lighting, as listed in Box 2.

Box 2: Opportunities for Sustainable Public Lighting

National opportunities

- **Bulk purchasing and increased bargaining power.** Collectively, local government is the largest public lighting customer in Australia. In deregulated markets, councils can use their position to negotiate renewable electricity purchasing, energy efficient lighting, improved maintenance and service levels, and access to public lighting data. Working on a regional level with other councils is a particularly effective strategy to negotiate desired outcomes.
- **Council support.** All CCP councils have politically endorsed greenhouse gas emissions reduction goals and action plans, which often include action on public lighting.
- **Available and emerging technologies and trials.** Includes T5 fluorescents, compact fluorescents, efficient photo-switches, dimming, and a range of other technologies (see Chapter 1 and Case Studies throughout the guide).
- **Reinvestment of financial savings.** Council can use the potential financial savings from lower energy and maintenance costs to finance further sustainable public lighting initiatives.
- **Increasing body of resources, projects and support.** This guide and other materials, projects, networks, and funding opportunities (see Chapter 4) are increasing the options for of councils to take action.

South Australian opportunities

- **State leadership on greenhouse action and acknowledgement of the role of local government** though renewable energy and greenhouse reduction targets, the Premier assuming the role of Minister of Climate Change, and other greenhouse commitments.
- **A building momentum by local government** in SA, demonstrated by lighting policies, trials and other initiaitves by councils; and council participation in this SA Sustainable Public Lighting Project 2005/06 and the SA CCP Plus Sustainable Public Lighting Advancing Action Project 2006/07.
- **Joint state-local government electricity retail contracts,** which include GreenPower options.
- **Proposed trial of T5 compact flourescents by ETSA Utilities** (see Case Study 7), and commitment to energy reductions through a $20million demand management program for projects**.**
- **A range of installation options under the existing tariff structure.**

(Sources: South Australian CCP councils identified these opportunities at the CCP SA Regional Meeting October 2005 and the SA Sustainable Public Lighting Project council workshops, December 2005 and May 2006; Genesis Automation et. al, 2006; LGA April 2003 and circulars (multiple dates); information from stakeholders).

A strategic approach is essential

Through working with councils on specific sustainable public lighting projects in South Australia, Victoria and Western Australia, ICLEI-A/NZ has found that councils can encounter challenges when they try to address individual issues. ICLEI-A/NZ recommends that rather than acting in an *ad hoc* manner, councils take a strategic step-by-step approach to their public lighting work. This allows councils to build their capacity, minimise risks, effectively tackle barriers, leverage opportunities, and maximise potential benefits. The case studies in this Guide show that councils can change their delivery of public lighting services to the community while broadening decision-making considerations to include energy efficiency in addition to community safety and cost considerations. As councils begin to take more control of the management of their public lighting stock, further opportunities to reduce energy spend and greenhouse gas emissions will open up.

How to use this guide

In line with a strategic approach, the *South Australian Strategic Action Planning Guide for Sustainable Public Lighting* has been developed to assist local governments to do this. The guide provides information, advice, templates, tools and case studies that councils can use to develop and implement Sustainable Public Lighting Action Plans (SPLAPs) – a working document developed and used by council to identify and prioritise actions that will increase the sustainability of its public lighting services.

The guide is designed for the use of council staff and elected members working to address public lighting. While different chapters and sections of this guide will vary in relevance according to the reader's role, background and interests, ICLEI-A/NZ has found that each component reinforces the other, so the guide is structured to progressively introduce further detail, and can be read either sequentially or according the reader's interest and needs.

Chapter 1 – Public Lighting Basics, is designed to orient council staff or elected members with the issue of public lighting. It introduces public lights, explains how they work, and outlines the associated energy, financial and greenhouse implications. The chapter then examines how councils typically manage their public lighting and interact with other public lighting stakeholders. Finally, it provides an overview of the technological options for energy efficient public lighting.

Chapter 2 – How to Manage Public Lighting Sustainably, presents a framework for councils to address their public lighting strategically. It explains the foundations and underlying principles that councils can use to guide their approach to sustainable public lighting. The chapter then outlines a step-by-step process for developing and implementing Sustainable Public Lighting Action Plans (SPLAPs). It contains tools, templates, advice, and case studies that councils can use to complete each step and adapt according to their unique needs.

Chapter 3 – Public Lighting Market and Regulatory Structure, overviews the sustainable public lighting opportunities and challenges inherent under Full Retail Contestability (FRC) both nationally and in South Australia. Councils can use this information to prioritise and coordinate their work around meeting the Australian Standards, negotiating electricity contracts and service level agreements, making submissions to relevant State policies, and taking advantage of other current and upcoming issues.

Chapter 4 – Useful Resources, details where to find further information beyond this guide. It contains lists of public lighting tools, references, and further reading. It also outlines the many public lighting stakeholders, their roles, and potential ways local government can interact with them in pursuing sustainable public lighting.

Tools. At the end of the guide is a series of tools councils can use as they progress along the strategic step-by-step framework, including tools for finding information, auditing public lighting assets, conducting a self-analysis of council's capacity, workplanning the development of council's SPLAP, and deciding on actions for the SPLAP.

Chapter 1. PUBLIC LIGHTING BASICS

Before council embarks on managing its public lighting in a sustainable manner, it is important to ensure relevant staff and elected members understand the broad technical, political, greenhouse, and management issues associated with public lighting. Public lighting is a complex area, and although it is certainly not necessary to be an expert in every aspect of the technology and its management, it is essential to know the broad issues and options.

A broad overview is particularly relevant in the local government context where different members of staff and elected members hold expertise in unique aspects of public lighting. For example, in the case of an energy efficient lamp trial, an environment officer may understand the greenhouse implications, a finance manager the contract options, an elected member the community aspirations, and an infrastructure officer the lighting performance implications. In working together – an essential ingredient to the success of a trial or indeed any public lighting work – it is crucial for council to share a common language and understand how the pieces fit together.

This chapter provides a starting point for such an understanding. It begins with an explanation of how public lights work, and then outlines the energy, financial and greenhouse implications. The chapter then examines how councils typically manage their public lighting, and how they interact with the other stakeholders involved. Finally, it overviews the technological options for energy efficient public lighting.

What is a public light?

Public lighting is defined by the Australian Standards — a national standard that regulates the types and number of lights that are to be used in public spaces, described in Chapter 3 — as the lighting provided on major and minor roads (source: Genesis Automation *et.al* 2003). In South Australia street lighting is referred to in retail terms as “12 hour unmetered lighting” and traffic signals as “24 hour unmetered lighting”. Other types of public lights include: car park lighting; flood lighting; lighting in parks and gardens; sign lighting; and marine lighting.

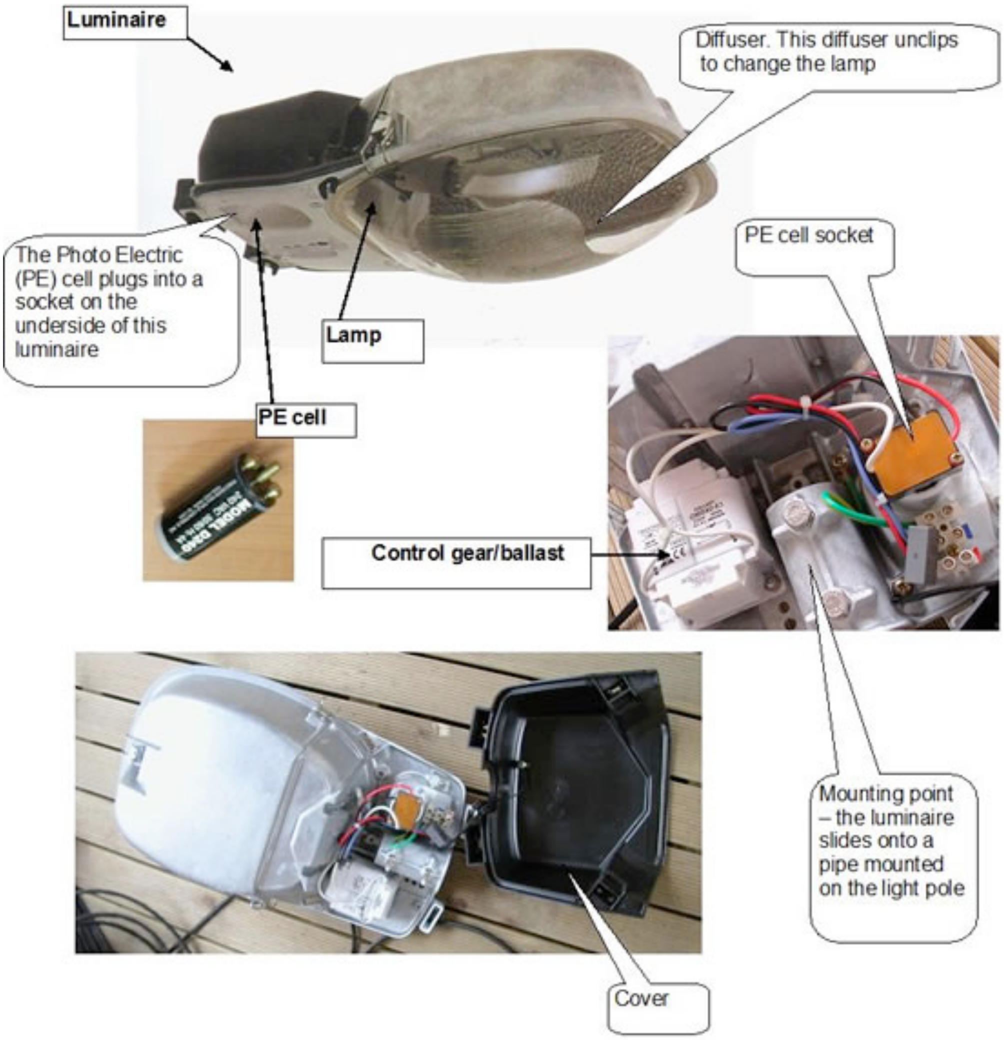
The first electric streetlights installed in South Australia were along King William Street in 1902 (photo courtesy Sir Thomas Playford ETSA Museum).

Other than the pole, public lights are comprised of four main elements:

1. The luminaire, or light fitting, attached to the pole. These generally last 20 years, and protect the rest of the light from rain, hail, dust, temperature, insects, birds and pollution. They also distribute the light using a reflector and lens (symmetric or asymmetric).
2. The lamp.
3. The ballast/control gear. Ballasts help provide the right current and voltage to the lamp. They can be magnetic or electronic, and their energy use varies.
4. The on-off switching control, usually a photoelectric (PE) cell (which responds to light levels), but there can also be: no control gear (permanently on); a manually switched lamp; a ganged PE cell; dimming (during dusk/dawn period, during low traffic period); or intelligent lights – self-monitoring for the hours of use.

These four elements are illustrated in Figure 1. For more information on the components of public lighting, see the “Sustainable public lighting technologies” section of the Sustainable Public Lighting website (http://www.energy-toolbox.vic.gov.au/publiclighting/index).

Figure 1: Components of a public light



(Source: http://www.energy-toolbox.vic.gov.au/publiclighting/index)

Greenhouse and financial implications

A lot has changed in public lighting in Australia since the first electric public light was installed in Tamworth, NSW, more than 116 years ago (source: Genesis Automation *et. al*, 2006). Table 1 compares the public lighting situation in South Australia and Australia as a whole. Australia's 1.94 million streetlights are responsible for 1.15 million tonnes CO_2e, whilst South Australia's 198,670 lights contribute 86,400 tonnes CO_2e to the Australian total. The table shows considerable historical growth and projected future growth in public lighting. It also reveals significant technological potential to reduce energy use in this area.

Table 1: Public lighting in South Australia and Australia

	South Australia	Australia
Public lighting stock	198,670 lights	1.94 million lights
Category breakdown	86% minor roads (category P)	70% minor roads
Electricity use	90 gigawatt hours (gWh)	1035 gigawatt hours (gWh) (0.57% of Australia's total)
Greenhouse gas emissions	86,400 tonnes CO_2e	1.15 million tonnes CO_2e (0.63% of Australia's total CO_2e from electricity)
Costs	(Not available)	$210 million
Growth in electricity use in past 14 years	45%	45%
Projected growth in next five years	(Not available)	35,000 new lanterns, 16-21 gWh, and 18-23kt CO_2e
Potential energy savings	(Not available)	60 to 65% reduction annually through the adoption of energy efficient lighting equipment

(Source: Genesis Automation et. al, 2006. Note statistics cover all councils – including CCP councils – and State and Territory roads authorities.)

South Australian participants in the Cities for Climate Protection (CCP) Program have generated greenhouse inventories that reveal street lighting (the major component of public lighting) is responsible for 15–70% of council's corporate greenhouse gas emissions and costs $75,000–$1.5 million per council per year. These results span rural, regional, urban and fringe councils.

Table 2 compares South Australian and Australian CCP councils. It shows public lighting accounts, on average, for 32% of South Australian CCP councils' annual greenhouse gas emissions and approximately half of their annual corporate energy and waste budget. This is higher than for Australian CCP councils, for whom public lighting accounts for an average 24-25% of their corporate emissions. Table 2 also shows the greenhouse and financial savings from sustainable public lighting actions in both SA and Australia, which CCP councils have quantified.

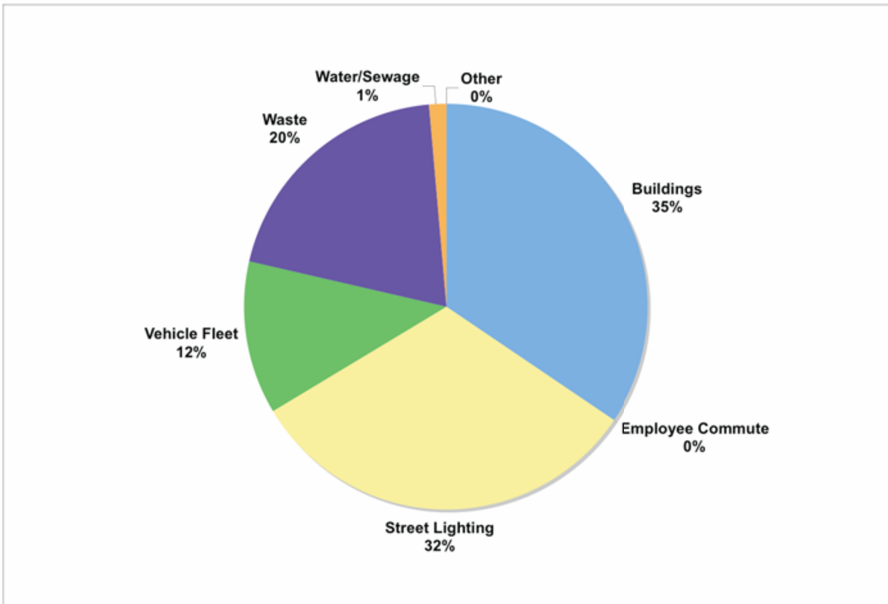
Table 2: Councils' greenhouse and financial costs and savings in public lighting

	South Australian CCP councils	Australian CCP councils
Number of councils	18 (72% of population)	215 (82% of population)
Greenhouse gas emissions per council per year	15–70% of corporate emissions (average ~32%)(1)	15–70% of corporate CO_2e(3) (average ~24–25%)(1)
Costs per council per year	$75,000–$1.5 million (average 50% of their total corporate energy and waste costs)(1)	$1,000–$2.5 million (average 35% of their total corporate energy and waste costs)(1)
Total greenhouse savings from public lighting actions per year	More than 550 tonnes CO_2e(2) (0.03% of total corporate savings)(4)	More than 40,000 tonnes CO_2e(4) (8% of total corporate savings)(4)
Total financial savings from public lighting actions	More than $76,000 per year(2)	More than $365,000 per year(2)

(Sources: (1) Unpublished greenhouse inventory data by CCP councils completed using the CCP for their Milestone 1–(base year– and Milestone 5–reinventory year;.data drawn from multiple years); (2) Unpublished 2004-05 data from ICLEI-A/NZ's CCP Measures database, used to inform the CCP Australia Measures Evaluation Report; (3) ICLEI-A/NZ 2004; (4) ICLEI-A/NZ 2005.)

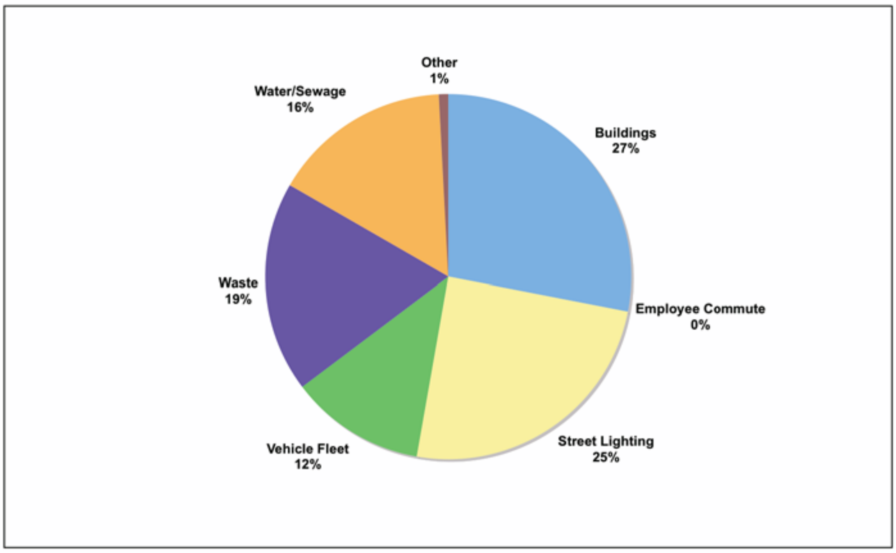
Figures 2 and 3 compare the breakdown of South Australian CCP councils' corporate greenhouse gas emissions to Australian CCP councils.

Figure 2: South Australian CCP councils' average corporate greenhouse emissions



(Source: Data gathered by CCP councils at Milestone 1).

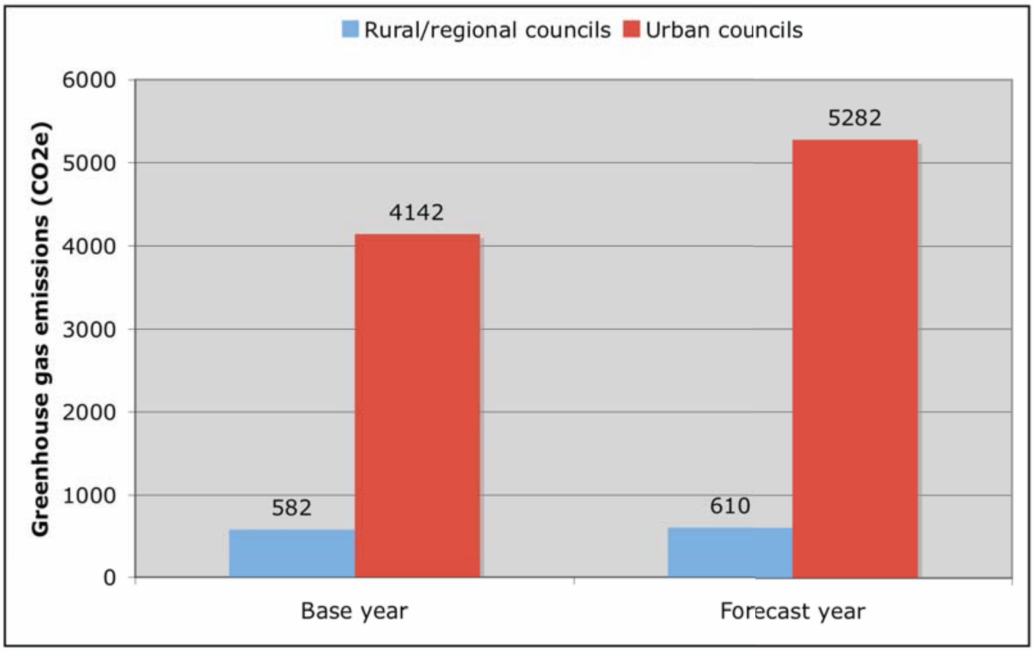
Figure 3: Australian CCP councils' average corporate greenhouse emissions



(Source: Data gathered by CCP councils at Milestone 1).

The proportion of a council's corporate greenhouse emissions attributable to street lighting is usually highest in an urban context and decreases as you move to the outer suburbs and then to a rural/regional context (source: *Data gathered by CCP councils at Milestone 1)*. Urban councils also have greater street lighting emissions in absolute terms, and greater forecasted emissions growth from this sector, as can be seen in Figure 4.

Figure 4: Average urban versus rural and regional public lighting emissions growth



(Source: Data gathered by CCP councils at Milestone 1: average base and forecast year public lighting data for all rural versus all urban Australian CCP councils).

Public lighting management within councils

Local government fulfils several roles in relation to public lighting:

- Planning authority
- Road authority (or coordinating with the responsible road authority)
- Environmental management
- Fiscal responsibility
- Provision of community needs.

(Source: Adapted from presentation by Thomas Kuen to CCP NSW State Forum session on Public Lighting 2003).

Dependant on council size and structure, public lighting is managed by a range of staff members. Management of public lighting generally sits within infrastructure services. Table 3 provides examples of the departments that may have public lighting responsibilities within your council.

Table 3: Departments in council that may have public lighting responsibilities

Business Unit	Public Lighting Responsibilities/Impact Areas
Assets & Maintenance	General public lighting stock information, maintenance of non-standard public lighting as negotiated with distributors.
Finance Department	Public lighting data management, approval and payment of public lighting bills, financial tracking of public lighting accounts, monitoring pay back periods, administration of council's revolving energy fund that could resource public lighting projects.
Elected Members/ Councillors	Conduit to community perceptions on public lighting, leadership on change in the sector, signal of support from council.
Executive	Sends signal of support from council on issue, determines resources available, has knowledge of council structures. May need to be made aware of the management issues relating to public lighting, given the proportion of council's budget that it constitutes, in order to make action a priority.
Planning	Setting standards for lighting types and pole types and approval of new lighting in the community; residential, commercial and industrial planning; contact with developers.
Community Services	Opportunities for community engagement, surveys, safety and perception issues.
Communications	Communications with the broader community, promotion of council work, promotion of strategic responses from council.
Environmental Services	Monitoring greenhouse gas emissions from public lighting. Decisions and planning on issues connected to energy efficiency.

Other stakeholders

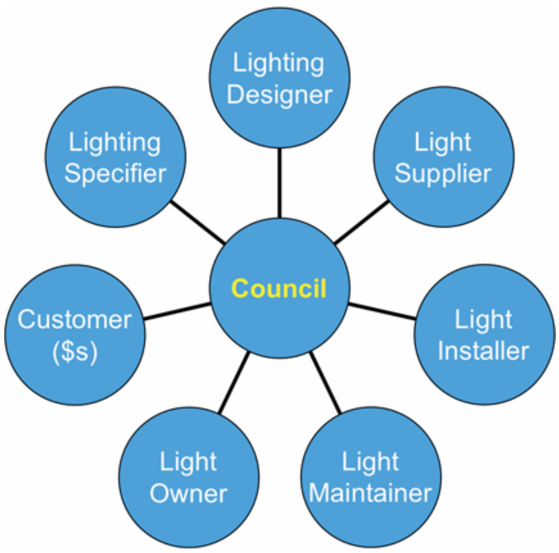
As well as councils, there are many other stakeholders involved in public lighting in Australia, including:

- Other public lighting customers, ie roads authorities
- Distribution businesses
- Public lighting users – pedestrians and drivers
- Local government associations and regional bodies
- Equipment suppliers
- Energy retailers
- Federal and state government bodies responsible for sustainability and/or energy
- Electricity regulators
- Standards Australia
- Peak industry bodies and professional associations.

(Source: Genesis Automation et al, 2006).

Councils typically have some form of relationship with many of these stakeholders, although the nature and extent of these relationships vary between councils according to their size, approach to public lighting management, the market and regulatory framework, and historical factors. A useful way of defining a council's role is as the body that brings the parties responsible for public lighting together (as shown in Figure 5) by liaising with all stakeholders involved in the design, installation, maintenance and replacement of lamps.

Figure 5: Councils' public lighting role



(Source: Thomas Kuen, Glen Eira City Council, Victoria Local government representative on the AS/NZS 1158 committee)

For more information about stakeholders in Australia and South Australia, see Tables 7 and 8, and for an explanation of their specific roles and motivations, read the Australian Greenhouse Office's publication *Public Lighting in Australia – Energy Efficiency Challenges and Opportunities* (Genesis Automation *et al*, 2006).

Sustainable public lighting options

Council can reduce the greenhouse gas emissions caused by its public lighting stock in four main ways: reduce lighting stock; reduce the energy consumption of existing stock; reduce the operating hours of existing stock; and change the energy supply powering its lighting stock. Each option involves different possible actions that can be done at different points, as outlined in Table 4. In addition to greenhouse savings, council can reduce toxic waste pollution from used lamps by reducing their number and improving the method of disposal (e.g. using sealed drums or accredited companies).

Table 4: Energy efficient options and what they involve

Broad option	Specific action involved	When this can be done
Reduce number of lights	• Remove lights from inappropriate locations. • Increase spacing of lights.	• Maintenance. • Upgrades. • Redevelopment.
Reduce energy consumption of lights	• Substitute existing lighting technology for more energy efficient technologies, such as T5 (Triphosphor Fluorescent), high pressure sodium (HPS), metal halide, or compact fluorescent lights; PE cells, electronic control gear, or active reactors. • Use more effective lanterns (e.g. reflector design, diffuser losses, better light distribution). • Improve lamp maintenance routine to ensure lighting levels are effective and lights are not coming on during the day. • Turn lights down (ie dimming), during dusk, dawn, and/or low traffic periods.	• Planned upgrades (individual or bulk) either prior to or at the end of their economic life. • New developments (eg greenfield developments, new roads, undergrounding etc). • One off upgrades (eg to take advantage of budget surpluses).
Reduce operating hours of lights	• Turn lights off after specified times (eg. after midnight), using time clocks or line switching.	• Anytime, particularly during a contract negotiation with the distribution business.
Change energy supply	• Switch to a renewable source of energy (ie Green Power). • Install solar lighting.	• Anytime, especially during budget bids or strategic or environmental planning. • Trials, upgrades or new developments.

(Source: Adapted from Victorian Sustainable Public Lighting Action Plan Guidelines; Genesis Automation et. al, 2006; and "Streetlighting Basics" presentation by the former Energy SA, 2003).

In deciding which option is best for each situation, council should take a number of factors into consideration, including:

- Capital investment
- Staff and management resources
- Ongoing costs or savings (including over what time period and their certainty)
- Expected greenhouse emission reductions
- Risk (of changing and of not changing lighting)
- Lighting performance
- Community needs
- Aesthetics.

A number of resources exist to help councils make decisions that fulfil their needs, including comparisons of the performance of different lights, cost-benefit analysis calculators, case studies of trials by other councils, sources of technical advice, and organisations with technical expertise. A range of these resources are listed in Chapter 4.

Bringing the pieces together

In this short overview of public lighting, we have seen how public lights work, and the significant energy, greenhouse and financial costs they bring to local government and the broader community. We have also seen both the current greenhouse and financial savings of actions implemented by councils in South Australia and Australia, and the potential future savings possible from a range of available and emerging sustainable public lighting options and technologies. We have examined how local governments – who hold primary responsibility for minor road lighting in Australia and South Australia – typically manage their public lighting internally and interact with other stakeholders involved.

The themes of council management and decision-making, data and technologies, and stakeholder relationships emerging from this overview are the main areas where council can work to achieve sustainable public lighting. How council can achieve positive outcomes in each area is explained in the following chapter.

Chapter 2. HOW TO MANAGE PUBLIC LIGHTING SUSTAINABLY

The previous chapter covered information to help you navigate the sustainable public lighting landscape. Having a basic understanding of (and knowing where to find information on) statistics, technologies, stakeholders, key barriers and opportunities is essential to taking effective action on sustainable public lighting.

However, information alone is not enough. Councils encounter challenges when they use this information while attempting to enact individual public lighting changes. Rather than use this information in an *ad hoc* manner, ICLEI-A/NZ recommends councils take a strategic step-by-step approach that generates targeted solutions to the real barriers to sustainable public lighting. This type of approach also serves to build council capacity, minimise risks, effectively tackle barriers, leverage opportunities, and maximise potential benefits.

This chapter introduces ICLEI-A/NZ's approach to sustainable public lighting and provides a step-by-step approach to build council's capacity to develop a public lighting plan, manage technology and enhance key relationships.

The foundations and underlying principles of sustainable public lighting

Through working with CCP councils in Victoria, Western Australia, and South Australia on targeted public lighting capacity building and action planning projects, ICLEI-A/NZ has identified three foundations for the sustainable management of public lighting:

Internal Strategy & Support	**Data & Technology**	**External Relationships**

These are the three key areas that council needs to manage in order to achieve sustainable outcomes in public lighting. The following is a brief overview of what each foundation is, and why it is important:

Internal Strategy & Support

This foundation is about the processes, systems and strategies that underpin public lighting management within council. It is also about the strength of support for energy efficient public lighting within your council, from councillors and senior management.

Building this foundation will involve coordinating council actions in relation to public lighting. It may involve assessing the current public lighting management structure and cultivating internal support for council's public lighting aims amongst senior management, councillors and staff with public lighting responsibilities.

Data & Technology

This foundation is about council's access to public lighting data, ability to analyse and use that data, and access to people with public lighting expertise.

Building this foundation will involve collecting and understanding data on public lighting stock to enable better decision-making. By improving data and technological knowledge, council will be able to present a more robust business case on new lighting types to senior management and council, including greenhouse and energy spending benchmark figures. It may also involve making connections with people who have public lighting expertise, whether within your council or externally, to guide decisions on energy efficient lighting that take full consideration of the Australian Standards and other regulations.

External Relationships

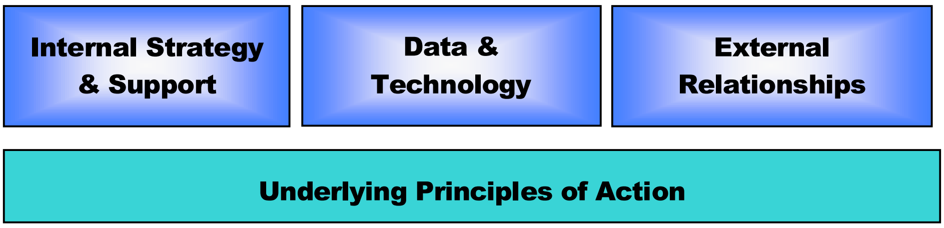
This foundation is about building external relationships with all parties who have some stake in public lighting.

> *"Coming together is a beginning.*
> *Keeping together is progress.*
> *Working together is success."*
> *~ Henry Ford*

Building this foundation will require developing better communication and understanding with your local distribution business. It will also require connections with lighting suppliers, the community and, importantly, other councils.

Underlying principles

Councils need to build capacity in each of the three foundations. Utilising the four underlying principles will assist capacity building and allow council to take advantage of current opportunities, and choose actions which are more effective and are easier to implement.



The four principles are as follows:

1. **Seek actions that build relationships** within council and with external stakeholders. This is how you can build the Internal Strategy & Support and External Relationships foundations.
2. **Seek to coordinate actions** within council and with external stakeholders. Coordinating actions will help you to conserve time and resources, and will also help you to build relationships.
3. **Seek solutions that consolidate existing council systems** rather than create more systems. No one needs more systems or policies that exist in isolation; where possible, make public lighting part of an existing management system so that it becomes part of normal operations. For

example, if your council is updating its general data management system, use that process to get better data management of public lighting.

4. **Seek to implement actions in areas with existing opportunity.** Choose actions complementary to other council processes, efforts by other councils in your region, and to previous actions and achievements. For example, if you have one group of residents already actively involved in becoming sustainable, run public lighting trials in their locality. They are more likely to react positively to the changes, which will pave the way for installation in other localities. Working in areas of opportunity will save you valuable energy.

A step-by-step approach

The complex nature of public lighting means it is important to approach public lighting strategically. The foundations and principles are mutually supportive and need to be built together. A logical step-by-step approach, described in Box 3, can help council do this.

Box 3: Summary of suggested steps for achieving sustainable public lighting

Step 1:	Assess the current public lighting context at council, by conducting a gap analysis of the three foundations – Internal Strategy & Support, Data & Technology, and External Relationships - at council;
Step 2:	Set goals and priorities for sustainable public lighting;
Step 3:	Develop a Sustainable Public Lighting Action Plan (SPLAP) with actions to build council's capacity in each of the foundations;
Step 4:	Implement actions that develop sustainable public lighting, using the principles – build relationships, coordinate actions, consolidate existing systems, and leverage existing opportunities - to guide your prioritisation; and
Step 5:	Review and re-strategise council public lighting emissions and actions.

Councils can follow these steps in one of three ways:

1. CCP Plus councils can apply to participate in a Sustainable Public Lighting Advancing Action Project (AAP), if it is offered in the relevant state. As a part of the AAP, ICLEI-A/NZ offers participating councils a structured framework involving workshops, verification of gap analyses and action plans, one-to-one support, and political recognition. If your council is a CCP participant visit our website for more information: http://www.iclei.org/ccp-au/public-lighting.

2. CCP councils still working through the milestones, and CCP Plus councils not involved in an AAP can still access from ICLEI-A/NZ the online materials and resources, telephone/email liaison, brokering of information, and invitations to events and network meetings.

3. Non-CCP councils can use publicly available online materials to manage their public lighting, including this guide.

Before starting

Time spent in preparation before undertaking the five steps listed in Box 3 can help council achieve a more effective and efficient result:

1. Make sure you are orientated to public lighting issues by reading this guide and other materials (see Chapter 4, Further Resources).
2. CCP Councils should contact their CCP State or Territory Manager to discuss their intentions and options.
3. Workplan how council will approach and progress sustainable public lighting. In particular determine:
    a. How this fits in with your CCP Milestone 3 local action plan, Corporate/Business/Strategic Plan and other plans;
    b. Council roles and responsibilities for working through the framework (including management and staff time); and
    c. Whether there is assistance available from ICLEI-A/NZ, for example through an Advancing Action Project (see above).
4. Establish or work with an existing whole-of-council group of staff members to work on sustainable public lighting with representatives from all the units that have responsibilities for public lighting. See Table 3 in Chapter 1 for potential staff members to invite.

Step 1: Assess the current situation

Assessing council's current public lighting situation is essential before undertaking any action, as it helps council to benchmark its current public lighting management strategy and energy efficiency, and identify strengths and weaknesses. The benchmark informs council's overall direction, goals, priorities and the resulting actions to be included in its Sustainable Public Lighting Action Plan (SPLAP).

ICLEI-A/NZ recommends that, at a minimum, council assess its capacity in each of the three foundations by involving relevant members of staff, preferably through an internal whole-of-council working group.

CCP Plus councils involved in the Advancing Action Project use the CCP Sustainable Public Lighting Gap Analysis Tool, which contains instructions on how to complete a public lighting gap analysis.

There are three tools to help you with this process:

- Tool 1: How to find public lighting information in your council, which council can use to gather information for the self-assessment, audit, and later on when creating SPLAPs
- Tool 3: Council Self-Analysis Checklist, which council can use to undertake a self-assessment it's capacity in each of the three foundations
- Tool 4: How to audit existing lights, which council can use to audit it's public lighting assets

In addition, council may wish to undertake a stakeholder analysis using non-public lighting specific tools. For a manual on stakeholder engagement, try *"The Stakeholder Engagement Manual"* by UNEP, AccountAbility and Stakeholder Research Associates Canada, available from http://www.uneptie.org/outreach/

Case Study 1: Street Lighting Audit, City of Marion, SA

Greenhouse gas emissions from street and public lighting contribute to almost 60% of the City of Marion's corporate emissions and costs council around $1 million per year. The city is currently undertaking a street lighting audit to provide information on the number, type, location and condition of street and public lighting in Marion, in order to create a more accurate database and allow for comparison with ETSA Utilities accounts. Once a clearer understanding of the composition of council's street and public lighting assets is obtained, a policy direction can be developed to guide the management of these assets with the view to improved performance and service delivery.

For more information contact Ann Gibbons, Environmental Planner on ann.gibbons@marion.sa.gov.au or (08) 8375-6857, or Kimberly Awalt, Unit Manager Technical Services, on kimberly.awalt@marion.sa.gov.au or (08) 8375-6847.

Other councils who have either undertaken or are in the process of undertaking street lighting audits include the Coffs Harbour City Council (see Case Study 11) and in South Australia, the cities of Adelaide, Mitcham, Salisbury, and Unley.

Step 2: Setting priorities

"If you don't know where you're going, how will you know when you get there?" ~ Anon

Identifying and agreeing upon goals and priorities for sustainable public lighting helps council set a direction for its Sustainable Public Lighting Action Plan (SPLAP).

ICLEI-A/NZ recommends the development of goals be: established internally with the whole-of-council working group; relate directly to any gaps identified at Step 1; be achievable within set time frames; and be measurable.

For CCP councils involved in the Advancing Action Project, ICLEI-A/NZ assists them to identify their priorities and goals for public lighting through a workshop.

One possible process for council to establish goals is by following these three, simple steps:

1. As a group, begin to imagine the sustainable public lighting future you want for your council – what would it look like?
2. Using this vision, identify council's sustainable public lighting goals. When setting the goal, remember to consider the key drivers and constraints of sustainable public lighting at your council as identified in your gap analysis.
3. If necessary, break your council's goals down into mini-goals to act as smaller steps along the path to achieving the larger goals.

Possible example goals and mini-goals might include:

- Reduce energy use in the public lighting sector by 20% by 2015 from 1996 levels.
- Achieve a 2% (pro rata) decrease in energy use from public lighting by 2010/11 from 1998/99 levels.
- Reduce toxic waste resulting from mercury light disposal by 10% by 2010.

- Maintain public lighting amenity as per the Australian Standards and Public Lighting Code by 2010.
- Improve the level and quality of public lighting in the City (*e.g.* meet Australian Standards).
- Improve data collection, recording and revision for public lighting.
- Have a public lighting policy in place by 2007/08 (e.g. requiring developers to install energy efficient street lights in all new developments).
- Ensure the future implementation of energy efficient street lighting in the City.
- Establish good external relationships by 2007/08 (e.g. with distribution business and lighting supply companies that specialise in energy efficient street lighting).
- Work collaboratively with all levels of government, lighting suppliers, and distribution companies to develop regional approaches to sustainable public lighting. (e.g. establish a regional Public Lighting Working Group).

The most effective goals will be those that are measurable and have a timeline for achieving a particular action. For examples of sustainable public lighting goals set by other CCP councils, see the example SPLAPs located in the "Sustainable Public Lighting Action Plans" section of the Energy Toolbox at http://www.energy-toolbox.vic.gov.au/publiclighting/.

Step 3: Action planning

A Sustainable Public Lighting Action Plan (SPLAP) is a working document developed and used by your council to identify and prioritise actions that will increase the sustainability of council's public lighting services. It is most commonly an internal rather than a public document. The SPLAP should be based upon the outcomes of steps 1 and 2, as well as other council directions, such as those identified in strategic plans, business plans, or CCP local action plans.

As well as creating individual council SPLAPs, councils can also consider creating regional SPLAPs and sustainable public lighting policies and strategies, described in the following sections.

For CCP councils involved in the Advancing Action Project, ICLEI-A/NZ works with council on its SPLAP development and verification, providing feedback and guidance throughout the process.

How to create an individual council SPLAP

The following step-by-step process outlines how councils can create an individual SPLAP, identifying the tools and resources to help throughout the process.

1. **Workplan the development of your council's SPLAP** using Tool 2.

2. **Develop and write the SPLAP,** using the SPLAP template (located at the "Sustainable Public Lighting Action Plans" section of the Energy Toolbox at http://www.energy-toolbox.vic.gov.au/publiclighting/). The SPLAP template has been developed in collaboration with local government *for* local government so it is a powerful tool to help your council affect change in this sector. It can be filled out and adapted by council and contains instructions for its use. The SPLAP template will walk you through a series of steps, including:
    - **Incorporate council goals** identified in step 2
    - **Choose or create actions that will help your council to achieve your sustainable public lighting goals.** There are several tools to help you do this: the Sustainable Public Lighting Principles (see earlier in this chapter); the case studies throughout this guide; the Action Planning Worksheet [Tool 5]; and Potential Sustainable Public Lighting Actions Checklists [Tool 6]
    - **Identify staff responsibilities for actions**
    - **Set priorities for actions**, ensuring that relevant actions are completed by important dates such as batch replacement dates
    - **Set budget figures for the actions**
    - **Set timelines for actions**. Incorporate key dates identified in the data and technology foundation (for example, batch replacement dates, budget timelines, contract renewal)
    - **Undertake work planning/scheduling for the actions**
    - **Establish a monitoring and review process and timeframe**

    It is worth looking at completed SPLAPs by CCP councils for strategies and action ideas. Copies of these can be found at the Energy Toolbox at http://www.energy-toolbox.vic.gov.au/publiclighting/
3. **Get Mayor or CEO/GM sign off** on the SPLAP and the monitoring and review process.

Case Study 2: Sustainable Public Lighting Steering Committee, City of Melbourne

Based on the success of the City of Melbourne's Greenhouse Steering Committee for ensuring whole-of-council involvement in local action planning, council is applying the same approach to the development and implementation of its SPLAP.

A SPL Steering Committee comprising of representatives from Engineering, Design, Environment, Parks, Community Services and Place Management has been created to improve whole-of council knowledge and management of public lighting. The Committee is responsible for the regular review of SPLAP strategy and actions, and will ensure council gains the appropriate support for SPLAP initiatives. The Committee will also determine the level of capacity building required within council as well as build effective working relationships to deliver to their SPLAP goals.

For more information contact the Greenhouse Projects Coordinator at the City of Melbourne, through their switchboard 03 9658 9658.

How to develop a regional SPLAP

Throughout the process of developing individual SPLAPs, councils often identify that some aspects of sustainable public lighting actions could be managed through regional collaboration. A regional SPLAP is a useful way to structure this work, clarify goals and responsibilities, and ensure high-level support for implementation. A regional SPLAP could be developed in one of two ways:

1. A region of interested councils create individual SPLAPs, then identify commonalities and opportunities for regional collaboration, and use this as the basis of a regional SPLAP. This method is recommended by ICLEI-A/NZ as it can eliminate redundant actions (that individual councils are pursuing) and complement the actions already being undertaken by councils individually.
2. A region of interested councils form a working group to identify, from their existing knowledge, commonalities and opportunities for regional collaboration, and use this as the basis of a regional SPLAP or informal plan of action (see Case Study 3).

Whichever method a region uses, much of the foundations, underlying principles, steps, and tools presented in this chapter can be scaled up for regional application. In addition, councils wishing to develop a regional SPLAP should draw on existing regional work, such as initiatives run under regional CCP Milestone 3 local action plans or through greenhouse or public lighting council networks.

Case Study 3: Street Light Group of Councils, multiple councils, Victoria

The Street Light Group of Councils (SLG), formed in December 2002, now represents 31 Victorian rural and metropolitan municipalities on street lighting issues. The SLG has quarterly regular meetings, with a core group meeting monthly to work on specific projects. The SLG serves as a forum for increasing the knowledge and understanding of public lighting issues and opportunities, and provides a united voice for its members on various sector issues. The SLG's objectives include:

- Achieving fair and reasonable street lighting charges for OMR (Operations, Maintenance and Repair)
- Clarifying roles and responsibilities in the provision of street lighting
- Development of the street light market, e.g. competitive service provision
- A transparent and accountable public lighting regulatory framework.

To date, the SLG has saved money for members on the 2004 OMR review, and is currently working on a revision of the Public Lighting Code, establishing a regulatory framework to achieve TBL outcomes, councils' liability issues with non-standard lights, and public lighting policies that protect the best interests of councils.

For more information on the SLG please contact Craig Marschall, on 03 9418 3907 or cmarschall@tteg.com.au.

As part of the CCP Plus Sustainable Public Lighting Advancing Action Projects, ICLEI-A/NZ assists participating councils to develop regional SPLAPs. For more information please email PublicLighting-anz@iclei.org.

Sustainable public lighting policies and strategies

Some councils find that a public lighting policy or strategy can complement a SPLAP by providing higher level commitment in between the goals identified in Step 2 of this process and the operational (timeline/budget/responsibilities) aspects of the SPLAP identified in Step 3 of this process. It is recommended that the *sustainable* public lighting strategy forms part of a larger public lighting strategy that also incorporates aesthetic, safety, economic and other considerations. Council may have an existing policy it can review.

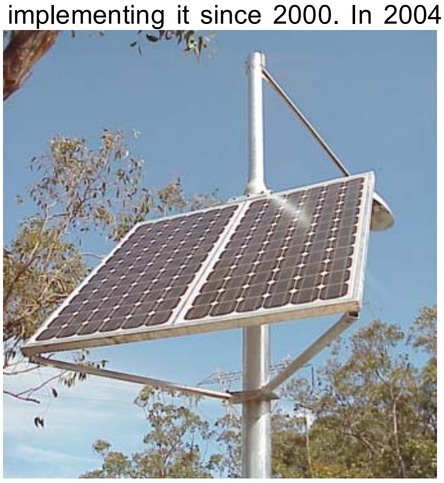
A sustainable public lighting strategy should identify the following:

- The benefits of sustainable public lighting for your council
- The opportunities available for accelerating it's uptake
- Changes needed to accelerate the uptake of sustainable public lighting
- How opportunities identified can be realised
- How and when these opportunities can be delivered, through a SPLAP.

(Source: The "Strategy for sustainable public lighting" section of the Energy Toolbox website http://www.energy-toolbox.vic.gov.au/publiclighting/index)

Case Study 4: Public Lighting Policy, City of Mitcham, South Australia

The City of Mitcham has been working towards a more efficient public lighting network since 1997. In 2000, Council endorsed a "Street Lighting – Energy Efficiency" policy requiring that efficient lamps be used for new developments and spot replacements. Council planners and technical staff are aware of the policy and have been implementing it since 2000. In 2004, nine solar powered lights were erected at traffic control devices in the rural part of the City. Council staff actively promote the issue of energy efficient public lighting to the local government association and the South Australian energy distributor.



Council is also involved in two trials. Ten 50w High Pressure Sodium (HPS) luminaires have been installed in Dudley Avenue, Daw Park. The second component of the trial, of ten 42w Compact Fluoro luminaires are yet to be installed. Performance measurements, in terms of energy efficiency and community acceptance, have not yet been recorded at either site.

For more information contact the Civil Project Engineer at the City of Mitcham on (08) 8372 8131.

Case Study 5: Public Lighting Policy, City of Greater Bendigo, Victoria.

The City of Greater Bendigo is developing a Public Lighting Policy through a Steering Committee comprising representatives from Capital Works, Strategic Planning, Economic Development, Planning and Engineering Services. Origin Energy has provided valuable technical input to the Steering Committee as part of its Climate Care Partnership with the City of Greater Bendigo.

Following consultation with the local developers and Powercor, it is anticipated the Public Lighting Policy will be included in the City's Infrastructure Guidelines and become part of the Council's Planning Scheme. This Policy document is seen as complementary to the development of a Service Level Agreement with Powercor.

For more information contact the Environmental Sustainable Development Officer at the City of Greater Bendigo.

For further examples of sustainable public lighting policies and strategies, see:

a. Adelaide City Council "Council Policy: Lighting Policy" and "Operating Guidelines: Lighting Policy" (2005). Note: Although documents are not available for public viewing, Council has available a Powerpoint presentation of the Lighting Policy. Please contact the Senior Lighting Designer for more information through the switchboard 08 8203 7777.

b. City of Melbourne *Lighting Strategy (2002)* http://www.melbourne.vic.gov.au/rsrc/PDFs/Lightingstrategy.pdf

c. City of Port Philip *Public Lighting Strategy (1999)* http://www.portphillip.vic.gov.au/public_lighting_strategy.html – L4 Note: Council has since developed a new strategy with community consultation and it is past the draft stage, but no document is available to download on web.

d. Bankstown City Council *Bankstown Public Lighting Strategy (2003)* http://www.bankstown.nsw.gov.au/docs/strategies/majorstratdocs.cfm

e. City of Yarra *Draft Public Lighting Policy* (2005) www.yarracity.vic.gov.au/council/meetings/pdf/agenda05/010205pcd/2.3ATT1.pdf Note: Although the Policy available for download indicates it is a draft, it is actually the final version of the Policy that was approved by council.

Step 4: Implement actions

As council progressively implements actions from its SPLAP, keep in mind these points.

- Ensure that responsibilities for SPLAP tasks/actions are built into staff/unit work schedules. Use Tool 5 to help you do this.
- Ensure SPLAP actions are incorporated into council budgets as relevant.
- Progressively build the business case for action within council. The business case for councils is effectively reduced energy and service bills, which can then be used for energy efficient installations and other actions. Getting accurate data to demonstrate greenhouse and financial savings is essential for this.
- CCP councils will be annually quantifying all energy efficient public lighting installations for the CCP National Measures Report, using the ICLEI-A/NZ Quantification Toolkit.
- Continue to identify and actively pursue funding options such as grants, revolving energy funds (REFs), financing facilities that fund initiatives and make loan repayments less than the savings, asset and environment budgets, and partnerships and risk-sharing models[3].

[3] With regard to this last point, remember that the business case for distribution businesses in Australia is lower operations and maintenance costs from new technologies, however there is an initial risk and uncertainty for them to invest in a new technology. To overcome this, they require firmer data on the technologies' performance (which can be developed through trials and working with manufacturers) and/or financial risk-sharing models.

- Regularly identify opportunities for new projects and actions through the SPLAP monitoring and review process.
- Work with other councils and stakeholders to implement actions.
- Ensure political support by keeping councillors up to date.

For CCP councils the effective implementation of the SPLAP and incorporation into council operations and decision-making will be facilitated through CCP program, technical and political support.

Case Study 6: Street Lighting Improvement Program (SLIP), multiple councils, NSW

The South Sydney Regional Organisation of Councils (SSROC) received over $4 million from the DEUS NSW Energy Savings Fund to improve the energy efficiency of street lights in the 29 local government areas. The Program brings together SSROC and EnergyAustralia to improve the energy efficiency of 85% of the street lights in their region. Different technologies will be used for main road and residential lighting.

For more information, visit the SSROC website (http://www.ssroc.nsw.gov.au/projectsissues/streetlighting.cfm), or contact the Program Manager, Graham Mawer, Next Energy on 02 9251 4072 or email gmawer@nextenergy.com.au

Step 5: Review and re-strategise

Through steps 1 to 4, councils will have developed many of the necessary policies, systems and processes for effective implementation of sustainable public lighting. Once council has implemented parts of the SPLAP and developed public lighting actions, it is important to monitor and periodically review its progress. Council will have determined the monitoring and review process in the SPLAP. This should involve a re-assessment of council's situation (ie a repeat of step 1), re-strategising (ie a repeat of step 3), and ensuring actions are still aligned with sustainable public lighting goals (as set out in step 2). To ensure that the SPLAP is being implemented effectively and incorporated into the culture of the council, the review should be conducted by council's workplace public lighting working group, environmental team, or other equivalent body.

Summing up

In this chapter we have overviewed ICLEI-A/NZ's approach to sustainable public lighting. By taking a step-by-step approach and keeping in mind the underlying principles for strategic action, council can produce and implement a targeted sustainable public lighting action plan that builds it's capacity in the three foundations – Internal Strategy & Support, Data & Technology, and External Relationships. Through this council can effectively minimise risks, effectively tackle barriers, leverage opportunities, and maximise potential benefits.

During the first three steps of the process – assessing the current situation, setting priorities, and action planning – council may find it's primary focus is on the first two foundations, and to a lesser extent External Relationships. However, as part of the action planning and implementation steps, it will be important to be aware of the sustainable public lighting opportunities council can leverage within the public lighting market and its regulation. These opportunities are outlined in the next chapter.

Chapter 3. PUBLIC LIGHTING MARKET & REGULATORY STRUCTURE

As discussed in the Introduction, a common misconception by local government is that it is not in a position to influence public lighting, due largely to price disincentives and the distribution of roles and responsibilities between councils and other stakeholders. On the contrary, the current and emerging market and regulatory structure contains many opportunities for local government to influence public lighting. Keeping abreast of technological and market developments will help council to identify and individually and/or regionally leverage opportunities as they arise, as part of council's strategic approach outlined in Chapter 2.

To help council start to navigate the public lighting landscape and target their action planning, this chapter sets out the main areas of opportunities for local government. Depending on council's exisiting capacity, some of the suggested actions can be included in council's SPLAP, whilst others can be added to it later. This chapter is designed to be used in conjunction with Tool 6, the Action Checklist.

The chapter initially explores opportunities at the national level under the Australian Standards. It then focusses on the South Australian context under Full Retail Contestability, and provides an introduction to the market, relevant changes, and a history of public lighting in the state. Within this context, the chapter explores opportunities for renewable energy purchases within electricity contracts; energy efficient lighting installations and other opportunities under current service tariffs and standards; potential energy efficient provisions in cost-sharing arrangements with the road authority DTEI, Transport Division; and growing support for greenhouse actions by the Government of South Australia through it's policies and plans.

Australian Street Lighting Standards (AS 1158)

(Source: Adapted from http://www.energy-toolbox.vic.gov.au/publiclighting/index.php?option=displaypage&Itemid=207&op=page#analysis)

AS/NZS 1158 is the standard that defines the levels of illumination required in public areas and specifies the performance and installation requirements for different categories of road. Recent amendments to AS/NZS 1158 also prescribe limitations to the amount of upwards light that can be emitted by a luminaire. The Standard is set out in a number of sections according to the two broad categories of road lighting:

1. **Category V lighting** – applicable to roads where the visual requirements of motorists are dominant, such as arterial roads and freeways. The Standard identifies five sub-categories with different illumination requirements.
2. **Category P lighting** – deals with lighting for areas intended primarily for pedestrian use or for mixed pedestrian, vehicle and bicycle use. Its primary purpose is to facilitate the safe movement of pedestrians at night. This includes lighting for minor (collector and local) roads and outdoor public areas (eg shopping precincts). The Standard provides specifications for five lighting sub-categories, which have different illumination requirements according to the degree of pedestrian, vehicle or cyclist activity, the risk of crime and the need to enhance the prestige of the locality.

Generally, councils are only responsible for category P (pedestrian) lighting. Category V lighting generally falls under the responsibility of transport authorities. There are supplementary lighting requirements for pedestrian crossings and computer aided lighting design. Adherence to the Standards is not formally legislated through regulatory frameworks.

There are several sustainable public lighting opportunities under the Australian Standards. These include:

- **Deciding if an area will be lit.** The Australian Standards (and State public lighting regulations) only apply to areas council chooses to light; there is nothing in either document that regulates what should and should not be lit. So council can reduce energy consumption by choosing not to light particular areas. This means that council has a responsibility (both socially and environmentally) to think about whether lights are needed or beneficial in particular areas
- **Choosing the category of lighting for their public spaces and roads.** Each public place that is lit is assigned a category that determines the level of illumination that should be provided. The lighting designer will then determine pole heights and spacings for that category of road, based on the light output characteristics of the luminaire, the light output of the lamp, and the maintenance factor. This responsibility gives council the opportunity to choose a category that reduces the number, energy consumption and/or operating hours of lights while meeting the public's lighting needs (safety, etc)
- **Designating a sub category of lighting for each of these areas.** Lighting designers do not need to set the sub-category (and therefore brightness level) of lighting required – it is a council responsibility to select the appropriate category. This means that council is free to reduce lighting levels in an area, or even to change the levels needed after a specific time, as long as the sub-category is selected appropriately using the Australian Standards.
- **Ensuring the installed lights complies with the Standards.** The Standards are designed to provide technical parameters for public areas based on the primary public use of that area. An energy audit can help demonstrate compliance and identify areas that are overlit or inappropriately lit.

For more information, the AS/NZS1158 is available from Standards Australia at http://www.standards.com.au. Training courses on the AS1158 are offered by Australian Standards on an infrequent basis. Councils can contact the Training Department on 1300 727 444 for more information.

Public lighting in South Australia

Beyond the Australian Standards, the majority of opportunities for sustainable public lighting occur at the state level. In South Australia, local governments have undergone significant changes in the way they manage the delivery of public lighting services to the community. This has occurred primarily as a consequence of the deregulation of the electricity market, otherwise known as Full Retail Contestability

(FRC), which changed the role of local government in the public lighting market. Key regulatory changes, changes in ownership, projects, conferences and meetings since the late 1990s associated with FRC and sustainable public lighting efforts more broadly are presented in Box 4.

Box 4: A history of public lighting in South Australia

1998	The LGA formed a Public Lighting Steering Committee (PLSC) to review issues and progress local government options in preparing for Full Retail Contestability.
1998	Electricity Trust of South Australia (ETSA) replaced most 40W fluorescent lights with 80W Mercury Vapour (the majority) and some 50W HPS.
1999-2000	Government sells ETSA Power (retailer) and ETSA Utilities (distributer). Public lighting assets included in sale.
2000	*Public Street Lighting Tarrifs: Final Report* published by SA Independent Industry Regulator (SAIIR).
2000-01	Public Lighting Project, funded by the Local Government Research & Development Scheme (LGR&DS) and delivered by the LGA, investigated the street lighting price regime and service standards, and researched a strategy for negotiations with utilities and submissions to the SAIIRs Inquiry.
February 2002	Energy SA hosted a Streetlighting Forum.
January 2003	Full Retail Contestability (FRC) of the electricity market.
August 2003	Energy SA hosted a second Streetlighting Forum and Workshop.
December 2004	ICLEI-A/NZ "Seize the agenda: implementing greenhouse action" forum in Adelaide, with session on Sustainable Public Lighting.
May 2005	The former Office of Sustainability (OoS) organised multi-stakeholder meeting in response to a letter written by Cr Carol Bouwens from the City of Marion to the Minister for the Environment and Heritage regarding sustainable public lighting.
2005-06	SA Sustainable Public Lighting Guide project funded by the LGR&DS; series of workshops held with CCP councils and meetings with public lighting stakeholders.
2006	Announcement of proposed Climate Change and Greenhouse Emissions Reduction Bill and finalisation of Draft SA Greenhouse Strategy.
2006-2007	CCP Plus Sustainable Public Lighting Advancing Action Project rolled out in SA.

(Sources: Relevant references are found in Chapter 4, Further Resources.)

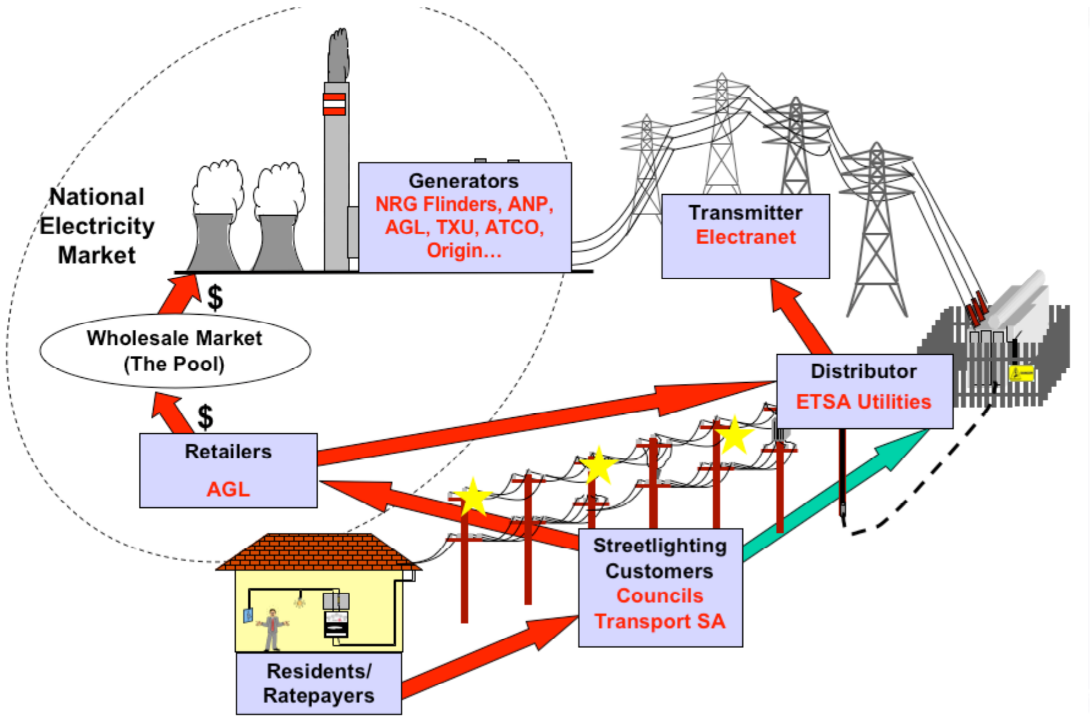
Public lighting has not figured prominently in FRC documentation and debate, and when it has, it has been couched largely in financial terms. This, together with confusion about how public lighting works and ongoing negotiations between local government and stakeholders, has slowed progress on implementing sustainable public lighting in SA. Many of these developments and negotiations, however, have direct or indirect implications and opportunities for sustainable public lighting. Before turning to these opportunities, the market and regulatory structure under FRC is briefly explained.

Full Retail Contestability (FRC) in South Australia

FRC commenced in the South Australian electricity market on 1 January 2003. It involved the sale in December 1999/January 2000 by the South Australian government of ETSA Power (retailer) to AGL (who renamed it AGL SA Pty Ltd), and of ETSA Utilities (distributor or distribution business).

The flow of electricity and money in the public lighting market under FRC in SA is represented in Figure 6. Electricity is generated at power stations by multiple generators and then transmitted through high voltage networks by ElectraNet, whereupon the distribution business ETSA Utilities distributes the energy through the unmetered street lighting network to customers (councils). Financially, councils use funding from ratepayers to purchase electricity from the retailer (currently AGL SA Pty Ltd), and public lighting services (including installment, operation, maintenance, and replacement of assets) to ETSA Utilities. Distribution and transmission services are included in these bills. In addition, some councils pay DTEI, Transport Division for part of the costs of public lighting services and energy of certain Category V (vehicular) lighting (not included in Figure 6).

Figure 6: The South Australian public lighting market under full retail contestability



(Source: Presentation by the former Energy SA to the Metropolitan Adelaide CCP Alliance “Greenhouse friendly street lighting workshop”, 2003. Note the former Transport SA is now the Department of Transport, Energy and Infrastructure, Transport Division).

FRC has had several public lighting implications for councils, such as:

- Billing arrangements. These are described in Figure 6 and relevant opportunities are explained later in this chapter
- Change in tariffs and service standards. Implications and opportunities for this are described later in this chapter
- A 'light handed' approach to price regulation. Public lighting services are an excluded distribution service, meaning councils must negotiate directly with ETSA Utilities on prices and services, and ESCOSA will only step in to arbitrate in the event of a dispute
- Ownership of the majority of local government assets was vested in ETSA Utilities as part of the sale of ETSA by the State Government in order to resolve ambiguity and disputes regarding ownership between local government, the then Transport SA, and ETSA. This has meant a capital loss for councils and lesser control of their public lighting stock
- A consequential change in roles and relationships between councils, the distributor, retailer and the Local Government Association (LGA) (to those described in Chapter 4). In the context of FRC, sustainable public lighting outcomes rely heavily on productive negotiations and partnerships with the distributor. Councils should use their interactions with the distributor to strengthen the distributor-customer relationship for purposes such as energy efficient trials and access to information.

South Australian opportunities

The following three sections outline the key sustainable public lighting opportunities under FRC, whilst the final section explores broader greenhouse opportunities that council can leverage for public lighting.

Electricity: bills, regulation and joint contracts

The first main public lighting cost and area of opportunity for councils is purchasing the electricity to power the lights. Electricity bills are determined through estimations of energy use based on the Public Lighting Load Table (which specifies the energy use of different types of lamps) and the Public Lighting Inventory Table (which lists all lights in SA by type and customer). In a small number of cases electricity use is metered (for more information see the Metered tariff type in Tables 5 and 6).

In 2002 the state government offered councils the option of joining in with their tender specification for (the then) Transport SA's unmetered public lighting. This resulted in joint state and local government retail electricity contracts with AGL SA Pty Ltd from 2003 until 31 December 2006.

The next joint contract is currently being negotiated on behalf of the State Procurement Board by Contract Services in the Department of Administrative and Information Services (DAIS). Councils have been consulted on whether to participate in the new contract and kept informed of the procurement process developments through status reports from Local Government Corporate Services (LGCS) and via the Public Lighting Steering Committee (PLSC).

The Request for Tender involves several ‘parcels’, including:

- Unmetered
  - 12 hour – street lighting
  - 24 hour – traffic signals
- Metered sites
  - 750 Mw pa
  - 160–750 Mw pa
  - <160 Mw pa
  - School and TAFE (state only)

The resultant contract/s will be finalised by the end of 2006 and last up to five years, depending on the outcomes of the contract negotiations.

Sustainable public lighting implications and opportunities for local government from the new contract include:

- Green Power purchases. The new agreement aims to improve Green Power supply options. Council should consider its desired amount of Green Power and how much it wants to spend
- Improved electricity pricing. Council can then use savings for Green Power purchases or to free up budget expenditure for other sustainable public lighting work
- Simpler administration and improved data management. For example, the process may result in consolidated electronic invoicing and reporting.

For more information on the Request for Tender negotiations, please contact the Project Coordinator at Local Government Corporate Services on 08 8223 8540.

Service charges and standards

In addition to electricity charges, councils either pay for or perform parts or all of the installation, operation, maintenance and replacement of street lights. For any given area of street lighting, councils choose from four public lighting tariff options, each with differing payments, distribution of responsibilities, and asset ownership. These differences are summarised in Table 5.

Public lighting services are an excluded service under the Electricity Distribution Price Determination (EDPD), meaning ETSA Utilities set the Standard, CLER (Customers Lantern Equipment Rate), and Energy only tariffs, and advise councils of these tariffs. Local government can object to or negotiate the tariffs and service standards. These tariffs are ‘lightly regulated’ by ESCOSA, meaning ESCOSA will only become involved and arbitrate in the event of an unresolvable dispute over the fairness and reasonability of the tariff. As councils provide their own public lighting services under the Metered option, this process is not applicable.

Table 5: Public lighting tariff options in South Australia

	Streetlighting Use of System (SLUoS)			
	Standard	**CLER (Customers Lantern Equipment Rate)**	**Energy only**	**Metered**
Payment to	ETSA Utilities	ETSA Utilities	ETSA Utilities	N/A (as council manages all aspects of public lighting services)
Payment covers	Operation, maintenance, replacement and installation of public lights on standard brackets	Lamp replacements only, however some conditions apply.	Administrative costs and record keeping	
Council responsible for	Determining road category, providing design brief.	Installation, some maintenance, operation, and replacement	Installation, maintenance, operation, and replacement	Installation, maintenance, operation, and replacement
Asset ownership	ETSA Utilities	Council	Council	Council
How tariff is determined	Different tariff for each light type according to their return of asset and service costs	Different tariff for each light type according to their maintenance and administration costs	Derived from costs to maintain records and administration costs	N/A (as council manages all aspects of public lighting services)
Comments	Most lights in a council's inventory fall under this category. The material and labour cost to install luminaires is currently included in the tariff, and is recovered over the service life of the luminaire rather than as an "up front" charge.	Comprises 13.5% of lighting. Is lower in price than Standard because no capital cost included, and a reduced level of maintenance. Must be of a lamp type that appears on the Load Table and is approved for use on ETSA Utilities' Unmetered Network	ETSA Utilities has no responsibility beyond the point of connection to the ETSA Network. However, ETSA Utilities maintains the records of Energy Only lights and advises the retailer monthly.	Electricity consumption is metered.

(Sources: Based on information from ETSA Utilities' website, and from ETSA Utilities).

Installing energy efficient lighting

There are a range of financial and risk sharing models under the current tariff and service arrangements that councils can use (or in some cases potentially adapt) to install energy efficient lighting. These are outlined in Table 6.

For options using the Standard, Modified Standard, CLER and Energy Only tariffs), the light needs to be included on the Load Table for the purposes of charging electricity retail costs.

Table 6: Energy efficient lighting installation options

	Distributor pays upfront, council pays over time	Council pays upfront, and shares part or all of ongoing costs with ETSA Utilities			Council pays all upfront and ongoing costs
Relevant tariff/s	Standard tariff	Modified Standard tariff ("Full Cost recovery Tariff" or "SLUoS – ETSA Utilities Council Lights")	CLER	Energy Only	Metered tariff
Process	Council asks ETSA Utilities to install from ETSA Utilities' standard range	Council approaches ETSA Utilities to discuss if this might be appropriate and possible			Council works completely independently
Light options	Standard range of luminaires and columns held on ETSA Utilities' stock.	Currently MV 50, MV 80 and HPS 50.	Must appear on Load Table, and be approved for use on Network by ETSA Utilities.	Council choice (currently 50 HPS and 100 HPS).	Council choice (ie can include lights not on Load Table), provided meters are installed to measure its energy use
Financial model	Currently, ETSA Utilities installs and pays upfront capital of luminaire and labour to install luminaire, council pays this over time through SLUoS	ETSA Utilities installs and council pays the upfront capital costs, and pays a lower SLUoS.	Council installs and owns the asset, ETSA Utilities changes lamps only (where Standard ETSA Utilities lamps are used.	Council funded	Council finances completely (installation and all ongoing costs).
Advantages	Lowest risk to council, no up front capital required from council for installation of luminaries. Proposed trials of T5s – see Case Study 7.	Council can increase capital expenditure and reduce ongoing SLUoS and operating expenditure.	Increased choice of luminaire	Not known	Greatest freedom of choice as not reliant on Load Table. Council can maintain and replace for energy efficiency
Disadvantages	Slow process due to testing and trailing light performance and cost.	Model has not been used before. Up front cost involved.	Some councils find council-owned assets uneconomical. Can be difficult to use this tariff	Option has only been used in one council and for a limited number of light types.	Council bears all risk and cost. Metering costs (installation and ongoing).

(Sources: Based on information from ETSA Utilities' website, and from ETSA Utilities).

Case Study 7: T5 Fluorescent Trials with ETSA, multiple councils, SA

ETSA Utilities intends to trial approximately 1,000 T5 fluorescent lights in targeted Council areas across metropolitan Adelaide. These lights may replace certain 40W fluorescent lights. ETSA Utilities have developed a Street Light Use of System (SLUoS) tariff for the T5 lights and added the lamp type to the Load Table. Asset performance of the T5s will be measured, including lumen output, the ability to start in cold conditions, and monitoring failures.

ETSA Utilities will continue to monitor new technologies including the T5 and evaluate suitable luminaires as they become available. ETSA Utilities has a significant number of older fluorescent luminaires targeted for replacement. Once T5's and other trials are completed, ETSA Utilities will determine which luminaires could potentially be used to replace the 40W fluorescent luminaires. ETSA Utilities is also currently trialling 42W CFLs in the City of Mitcham and the District Council of Mount Barker (using Standard and CLER tariff respectively), and may do some further trials.

For more information, contact the Asset Manager Public Lighting, ETSA Utilities (details in Chapter 5, Further Resources).

Case Study 8: T5 trial in partnership with energy retailer, multiple councils, NSW

A number of councils within the energy retailer, Integral Energy, service area requested energy efficient street lights. Integral Energy has been using and trialling two types of T5 fluorescent light globes (2x 24W and 2x 14W T5's) since 2003 with over 4000 lights installed to date. Blacktown City Council has been involved with this move towards greener street lighting, and trialled 1000 new T5 14 watt fluorescent light globes which require 69% less energy than conventional 80 watt Mercury Vapour light globes. During the initial 12-month trial period, only 2-3 lights failed and Blacktown City Council received no complaints from the residents about the lights.

For more information contact Bill Harrigan at Integral Energy on 02 4255 4021.

Case Study 9: T5 trial with distributor, Banyule City Council, Victoria

Banyule City Council has been working closely with technical personnel from distribution business AGL Electricity to make their street lights more efficient. Collaboratively, in 2004, they have trialled four different types of efficient lights and in 2007/08 as part of a batch replacement will install T5 lights as a regular replacement for their older, less efficient technologies. T5 lights are a new generation of fluorescent with a total wattage per light fitting of 28W.

By providing several opportunities for local residents to have input into the process there is a very high level of support locally for a wider refit program. Nine other councils in the Northern Alliance for Greenhouse Action (NAGA) regional group and TXU Electricity have become involved in a Public Lighting Action Program to develop a regional SPLAP, so that it will be a small step to expand this replacement program in the future.

For further information, contact the Greenhouse Officer at Banyule City Council (03) 9457 9825 or Paul Brown at the Shire of Nillumbik (03) 9433 3219.

Case Study 10: Council helps other authorities improve public lighting, Walsall Council, United Kingdom

Walsall Council is helping local authorities across Britain upgrade their public lighting by sharing the experience gained in its innovative and award-winning partnership with Amey Highways. The partnership involves replacing Walsall's 26,000 aging public lights with new greener versions, as part of the council's public lighting Private Finance Initiative (PFI) contract.

Walsall's public lighting PFI is now a path finder and test bed for this type of public private partnership – the first to follow revised Government procedures for local authority PFI's. For further information see http://www.walsall.gov.uk/index/transport_and_streets/road_and_pathway_maintenance/street_lighting.htm

Case Study 11: Bulk replacement in partnership with distribution business, Coffs Harbour City Council, NSW

In partnership with Country Energy and NSW's former energy department, the Sustainable Energy Development Authority (SEDA), council conducted a full streetlight audit. The audit formed the basis of a major street lighting overhaul in Coffs Harbour over a few years. All of Coffs Harbour City Council's mercury vapour street lights (3,500 in the city) have been replaced with high pressure sodium (HPS) lights. All lights were replaced in the 2004/2005 financial year. Coffs Harbour is the first council in Australia to introduce energy-efficient street lighting across its entire area. This will allow council to reduce it's CO_2e emissions by 35%, or 650 tonnes per annum, and made savings of $88,500 in the first year.

The replacement followed trials of energy efficient low pressure and high pressure sodium (HPS) street lighting in two residential areas. The trials were designed to firstly, assess the suitability of energy efficient street lighting and secondly, to assess the community acceptance of energy efficient lighting. Results indicated that the main type of energy efficient street lighting under consideration, HPS lamps, were suitable for the purpose and the lighting produced was acceptable to the community.

Community surveys, though limited to the trial area, showed a high level of acceptance for HPS street lights. Country Energy funded the new capital investment (valued at about $1.25 million); council is funding the payback of the residual capital on the existing lights (to the value of about $400,000) over five years. Financial modelling shows that cost savings of $691,000 will be achieved in the first 10 years.

For more information contact the Manager of Environmental Services at Coffs Harbour City Council, through their switchboard 02 6648 4000.

Other sustainable public lighting opportunities

Other sustainable public lighting opportunities besides replacing existing stock with energy efficient lighting (described above) include:

- Engaging the community for maintenance. Councils can encourage residents to report faults such as day burners (lights on during the day) and drifting (lights switching on/off times changing gradually)
- Using financial savings for budget bids. Councils can put up budget bids to use their financial savings from the reduced energy and service costs from energy efficient lighting for further sustainable public lighting initiatives
- Improving data management. Councils can access information about their public lighting assets from the Inventory Table, purchase more detailed GIS information from ETSA Utilities, and/or undertake an audit of their street lighting assets and advise the distributor of any amendments required [see Tool 4: How to do an audit]. Accurate asset information can save council money on its electricity and public lighting service bills (which can be invested in sustainable public lighting), improve data management, and enable council to identify energy efficient lighting opportunities.

Case Study 11: Service Level Agreement, Central Victorian Greenhouse Alliance, Victoria

A model service level agreement – a variation to the public lighting code negotiated between a public lighting customer and their local distribution business(es) – has been developed by the Central Victorian Greenhouse Alliance (CVGA) under the Sustainability Victoria Sustainable Public Lighting Initiative. The service level agreement is designed to help Victorian councils to clearly define a code of practice between a distribution business and councils, outline the rights, roles and responsibilities of the parties concerned for the provision of public lighting services, and build on the standards outlined in the Victorian Public Lighting Code.

The model service level agreement is available here http://www.energy-toolbox.vic.gov.au/publiclighting/index.php?option=displaypage&Itemid=215&op=page. For further information contact Terry White, CVGA, email: terryw@vic.chariot.net.au

For more information on tariffs and service levels:

- See ESCOSA's website http://www.escosa.sa.gov.au/site/page.cfm?u=163 and http://www.escosa.sa.gov.au/site/page.cfm?u=47
- See ETSA Utilities' website http://www.etsautilities.com.au/content_page_with_downloads.jsp?xcid=138
- Contact Local Government Corporate Services (LGCS) (details in Chapter 4 under Stakeholders section)
- Read the historical and background documents referenced in Chapter 4, Further Resources.

Cost-sharing arrangements with DTEI, Transport Division

Whilst local government is responsible for category P (pedestrian) lighting, in some situations they also share costs for the category V (vehicular) lighting managed by the road authority, DTEI, Transport Division. This happens under Section 26 of the *Highways Act 2000*, where a road gazetted under section 26 will have vehicular needs managed by DTEI, Transport Division, whilst council manages the pedestrian needs. The Commissioner may choose to improve or install lighting on any road and pass on 50% of the cost (for energy and SLUoS) to council if there are benefits to pedestrians and hence council. Due to historical anomalies and disagreement about the distribution of responsibilities and costs between the councils and the DTEI, the Section 26 Committee is currently (at the time of writing, October 2006) developing a Code to clarify the operational responsibilities between the two parties.

Sustainable public lighting opportunities are minimal due to limitations in current category V technologies that are energy efficient, affordable, economic, and meet the Australian Standards. Council cost-shared category V lighting is hence a low priority for immediate action. However, as councils improve their category P lighting they can work towards improvements on the lighting they share costs for by:

- Ensuring energy efficient lighting provisions are included in the consultative draft Code when it is circulated in ~ November 2006, through either the LGA or a council representative on the Committee
- Asking DTEI to light a section of road for which they pay some of the costs with energy efficient lighting, or light it themselves.

For more information, contact the Local Government Association (details in Chapter 4).

South Australian greenhouse policy and action

In addition to the direct public lighting policies and opportunities outlined above, the Government of South Australia has shown leadership on more general greenhouse issues that have implications for councils in regards to sustainable public lighting. The leadership role is evident through the Premier recently assuming the role of Minister for Climate Change, and through several commitments as expressed in *South Australia's Strategic Plan* and *Draft Greenhouse Strategy.* These include:

- Achieving the Kyoto target during the first commitment period (2008-12)
- Setting a target to source 20% of electricity from renewable energy by 2014, and lead Australia in wind and solar power generation within a decade
- Acknowledging the leadership role of local government in engaging local businesses and residents and supporting local government in targeted action in metropolitan and regional industry strategies
- Promoting climate-smart businesses responsive to climate-related market opportunities
- Expanding the use of metering/billing systems to improve information feedback
- An increase in energy technology research and development.

In addition, the Government is currently working on a Climate Change and Greenhouse Emissions Reduction Bill that will set a target for cutting state greenhouse gas emissions to 60 per cent below 1990 levels by 2050; and set up a voluntary carbon offset program for business and government.

State policy and plans have two main implications and opportunities for sustainable public lighting. The first is that councils can advocate for greater state commitment to and funding for sustainable public lighting by making submissions to the Draft SA Greenhouse Action Plan, and other strategies and processes as they arise. The draft bill also proposes the establishment of a Premier's Climate Change Council in which local government representation will be sought.

For more information see http://www.climatechange.sa.gov.au/ and http://www.stateplan.sa.gov.au/

Summing up

In this chapter we have overviewed sustainable public lighting opportunities for councils within the Australian and South Australian public lighting market and its regulation. Councils can use this information to prioritise and coordinate their work around meeting the Australian Standards, negotiating renewable energy options as part of electricity contracts, installing energy efficient lighting under the tariff structure, making submissions to relevant state policies, and taking advantage of other current and upcoming issues. As well as these opportunities, there will be other emerging opportunities (technical, regulatory, political and/or policy) that council should keep abreast of. The next chapter contains useful resources for staying current with these developments.

Chapter 4. FURTHER RESOURCES

As explained in the Introduction, this guide contains information, advice, templates and tools designed for council to use to build its capacity to manage its public lighting in a sustainable manner. As council progresses along each step of the process, it will be important to keep abreast of new technologies, market opportunities, and what other councils are doing. It will also be strategic to contact various public lighting stakeholders and make use of available tools and resources.

In view of this need, this chapter details where to find further information in support of this guide. It contains: lists of relevant public lighting tools and their applications; case studies and trials in Australia and internationally; and funding opportunities. The chapter also provides an outline of key public lighting stakeholders, their roles, and potential ways local government can interact with them in pursuing sustainable public lighting.

General Public Lighting Resource

Local Government Energy Toolbox – Sustainable Public Lighting

The Toolbox provides:

- Guidance in getting started with strategies and action plans
- Current information about the trials of different technologies and information sharing projects supported by the Sustainable Public Lighting Initiative (SPLI) in Victoria
- The various standards and regulations that govern public lighting in Victoria
- Tools, resources, templates and guidelines to help implement sustainable public lighting
- Information about the different technologies available
- Lists of distribution businesses, suppliers, contacts and other web based resources
- News and events.

The Toolbox was developed originally for Victorian local governments, but much of the content is useful for councils elsewhere in Australia.

http://www.energy-toolbox.vic.gov.au/publiclighting/

Stakeholders

As mentioned in Chapter 1, local government works with, and is impacted by, a wide range of stakeholders in its public lighting work. Tables 7 and 8 briefly explain the roles and responsibilities of the multiple public lighting stakeholders in Australia and South Australia respectively. They also suggest ways to engage each stakeholder and where council can find further information. For a useful explanation of the specific roles and motivations of each of the stakeholders, read *Public Lighting in Australia – Energy Efficiency Challenges and Opportunities* (Genesis Automation *et al.* 2006).

Table 7: National stakeholders (contact details are correct as of October 2006)

Stakeholder	Role in public lighting	How local government can interact with this stakeholder	For more information
Joint Technical Committee LG-002 (Australian Standards Committee)	Prepares standards for the lighting of roads and related public places ie the AS 1158 series (this is explained in Chapter 3, Market & Regulatory Structure).	Local government concerns and needs regarding the AS 1158 series can be communicated to the Committee through the Australian Local Government Association (ALGA).	https://committees.standards.org.au/COMMITTEES/LG-002/
Department of the Environment and Heritage, Australian Greenhouse Office (DEH, AGO)	Delivers the majority of programmes under the Australian Government's climate change strategy, and works with key stakeholders to improve the energy efficiency of public lighting. For major roads, the Ministerial Council on Energy in December 2005 released the 10-year *Greenlight Australia* strategy to reduce the energy consumption of lighting. As part of this strategy, national and all state and territory governments are considering developing and implementing energy performance standards for main roads lighting. For minor roads, the DEH's work is undertaken in partnership with local government, particularly ICLEI-A/NZ. The Cities for Climate Protection (CCP) Australia Program is funded by the Australian Government.	Currently working on a range of tools and case studies that will assist local government to effectively reduce their greenhouse emissions from public lighting. It is anticipated these will be released later in 2006.	Assistant Director, Community Partnerships Team on 02 6274 1022 or see http://www.greenhouse.gov.au Also see the Publications section, for summaries of DEH/AGO publications and tools. A technical report discussing a design energy limit for main roads was released in 2005. See http://www.energyrating.gov.au for a copy. In 2006 the AGO released *Public Lighting in Australia – Energy Efficiency Challenges and Opportunities (Genesis et al, 2006).*
Regional groupings of councils	Regionally pursue sustainable public lighting.	Network and share information.	See case studies throughout this guide.
ICLEI-A/NZ	Builds capacity of local governments to act on greenhouse issues through the Cities for Climate Protection (CCP) program. As public lighting is a major issue for local government, ICLEI-A/NZ has developed specific resources and	CCP Plus councils can apply to participate in a Sustainable Public Lighting AAP, when offered in the relevant state; whilst other CCP councils can access ICLEI-A/NZ's online materials and resources,	http://www.iclei.org/ccp-au/public-lighting PublicLighting-anz@iclei.org

Stakeholder	Role in public lighting	How local government can interact with this stakeholder	For more information
	programs in this area, such as this guide, the Victorian Sustainable Public Lighting Action Plan Guidelines, and CCP Plus Sustainable Public Lighting Advancing Action Projects (AAP).	telephone/email liaison, brokering of information, and invitations to events and network meetings. Non-CCP councils can use all publicly available online materials to manage their public lighting, including this guide.	
Public lighting suppliers	Develops and provides public lighting technologies. Assists councils with conducting trials of new lighting technologies.	Establish or enhance relationships to communicate customer demand and specifications for new and existing energy efficient technologies. Encourage manufacturers to produce stronger evidence of the performance of energy efficient technologies that in particular ensures distributor confidence. Approach suppliers as a regional grouping to bulk purchase energy efficient technologies.	The following suppliers have been used in energy efficient public lighting trials. This is not an exhaustive list. Pierlite – www.pierlite.com.au Sylvania – www.sla.net.au Active Reactor – www.fts.com.au Versalux – www.versalux.com.au Artcraft – www.artcraftpl.com.au Vicpole – www.vicpole.com.au
Australian Local Government Association (ALGA)	Advocates national level climate change and public lighting issues on behalf of councils. Puts interested councils in touch with each other.	Approach Assistant Director, Environmental Policy. Potential to advocate for and progress sustainable public lighting at the national level.	http://www.alga.asn.au Angela Shepard, Assistant Director, Environment Policy, and NRM Local Government Facilitator 02 6122 9433 angela.shepherd@alga.asn.au
Illuminating Engineering Society (IES): The Lighting Society	Provides information (publications, technical meetings and conferences) related to developments in road lighting; sports lighting; daylight and sun effects; environmental impact of lighting, and emergency evacuation lighting. Represents lighting designers on Committee LG-002 (see that entry for details).	Council staff with public lighting responsibilities can become members and access information and feed suggestions into the AS 1158 Series of Road Lighting Standards. Use the IES for networking. Access Lighting Engineers with experience in Public Lighting Design.	http://www.iesanz.org

Stakeholder	Role in public lighting	How local government can interact with this stakeholder	For more information
Lighting Council Australia	Represents the Australian lighting industry to policy-makers and other key stakeholders, influences relevant performance, safety and environmental standards, and advises on lighting issues.	Use their Technical Committee's analysis of technical information.	http://www.lightingcouncil.com
The Energy Networks Association Ltd	Represents distribution businesses and lobbies on government policy and regulation. Minimal public lighting role.	If needed, councils can communicate with the ENA through the Australian Local Government Association (ALGA).	http://www.ena.asn.au
The Astronomical Society of Australia	Educates society on the effect of inappropriate lighting on the ability to see the night sky. Provides information and support for people and organizations with astronomical interests affected by inappropriate lighting. Maintains a list of 'designated optical observatories' of research, educational or community value worthy of protection from obtrusive lighting.	Seek expert advice from the ASA's Lighting Consultant. Use ASA information on 'designated optical observatories'	Web site http://asa.astronomy.org.au/ ASA Council contact information http://asa.astronomy.org.au/contact.html Lighting Consultant and Representative on relevant Australian Standards committees – Reg Wilson FIES - regrw@tpg.com.au

Table 8: South Australian stakeholders (contact details are correct as of October 2006)

	Role in public lighting	How local government can interact with this stakeholder	For more information
ETSA Utilities	Delivers electricity from the generators through the network to point of use, and bill retailers for use of the electricity distribution network. Manages ETSA owned lamps, poles, columns and wires. Maintains a Lighting Asset record and carries out asset audits on a regular basis. Trials energy efficient installations within other commercial and operational limitations. Determines the SLUoS tariffs and billing customers for services provided. Provision, installation and maintenance of security lighting. Advises retailer of number and types of lamps per council, held in ETSA's inventory. Advises ESCOSA if they add new lamp types to the Load Table. Replaces failed lamps. Maintains an asset register of council owned, Energy only lights.	On an individual council basis, such as through negotiating a Service Level Agreement, obtaining asset data, and approaching for trials of energy efficient lamps and partnership projects. Align with other councils to regionally approach for a bulk replacement and trials using energy efficient lighting. Collectively negotiate through the LGA/LGCS, PLSC, and potentially the CEO-Mayors forum. Indirectly influence through the regulatory structure and government policies (*e.g.* through the SA Greenhouse Strategy, and Ministers for Local Government, Environment and Energy). Seek or provide funding to support the cost of installation of energy efficient lighting.	http://www.etsautilities.com.au/content_page_with_downloads.jsp?xcid=138 Martin Bellamy, Asset Manager Public Lighting 08 8404 4127 bellamy.martin@etsa.com.au
Local Government Association of South Australia (LGASA)	Through the LGA Public Lighting Steering Committee, provides a forum for advocacy and representation on public lighting issues. This includes PLEC, across government contracts for supply of electricity, and where required, negotiations with ESTA Utilities (and where required ESCOSA) regarding public lighting tariffs (SLoUS and NoUS). Their R&D Scheme funds public lighting studies.	Through the Manager Finance & Infrastructure LGA. (See also the Public Lighting Steering Committee entry).	http://www.lga.sa.gov.au can be searched for public lighting related circulars, media releases, projects and reports. David Hitchcock, Manager – Finance & Infrastructure 08 8224 2052 david.hitchcock@lga.sa.gov.au

	Role in public lighting	How local government can interact with this stakeholder	For more information
Essential Services Commission of South Australia (ESCOSA)	As Metrology Coordinator, administers and approves any changes to the SA metrology procedures. These procedures cover the "metering installation" requirements for public lighting. Approves the public lighting Load Table and Inventory Tables. Provides administrative support to the Power Line Environment Committee (PLEC). Regulates the price charged by electricity retailers to SA standing contract electricity customers. Arbitrates in the event of a dispute between customers and the distribution business over SLUoS or CLER tariffs.	Obtain clarification of any regulatory aspects of public lighting.	http://www.escosa.sa.gov.au/site/page.cfm?u=47 Bob Burgstad, Director, Technical 08 8463 4353 escosa@escosa.sa.gov.au
Power Line Environment Committee (PLEC)	Assists the Minister responsible for the *Electricity Act 1996* in assessing and recommending the undergrounding of overhead power lines. A high level committee approves council applications for undergrounding public lighting power lines to enhance the aesthetics of a location. Other working groups focus on the implementation and installation of approved applications.	As with any upgrade, replacement or installation, council can choose to use the PLEC undergrounding process to install sustainable public lighting options. The opportunity here is more within council's choice of replacement lighting rather than something mandated within the PLEC process. The Committee is open to being approached by local government (through the LGA) to discuss the potential to include sustainable public lighting provisions in the PLEC Guidelines and process in the future.	http://www.escosa.sa.gov.au/site/page.cfm?u=48&print=1 Stuart McPherson, Executive Officer 08 8463 4352 plec@escosa.sa.gov.au

	Role in public lighting	How local government can interact with this stakeholder	For more information
Local Government Corporate Services (LGCS)	Commercial entity of local government that provides strategic contracting and procurement services to SA councils. Provides secretariat to and undertakes actions as directed by the Public Lighting Steering Committee (see that entry). Represents local government on the 'Across Government Electricity Supply Contracts' tender project (metered & unmetered supplies). Facilitates the review of PLEC Agreements with ETSA, LGA and Local Government Risk Services (Mutual Liability Scheme). Facilitates the development of a Public Lighting Services Agreement with ETSA Utilities in collaboration with LGA and Local Government Risk Services (Mutual Liability Scheme).	Through to the Public Lighting Steering Committee (PLSC) – See entry below for details.	http://www.lgcs.com.au Bruce Wright, Project Coordinator 08 8223 8540 bruce.wright@lgcs.com.au
Public Lighting Steering Committee (PLSC) **Note:** Their role has broadened to take into account metered as well as unmetered sites and has hence changed it's name to "The Metered & Unmetered Electricity Steering Committee" (as of October 2006).	Formed by the LGA in 1998 to review issues and progress local government options in preparing for the full deregulation (Full Retail Contestability) of the electricity market. Provides direction to the LGCS and consultants on the Model Service Level Agreement, SLUoS and other tariffs, joint local government-state electricity contracts, and other public lighting related issues. Discusses energy efficient developments on an *ad hoc* basis.	Attend meetings and raise energy efficient public lighting issues as agenda items. Join the Committee, or if unable to attend, contact a member of the Committee to raise efficient public lighting on behalf of your council. It meets on an as-needed basis and its members are self-nominated representatives from SA councils. Form a sub-committee to progress sustainable public lighting.	http://www.lgcs.com.au

	Role in public lighting	How local government can interact with this stakeholder	For more information
Section 26 Committee	Determines the operational responsibilities (including lighting) between DTEI, Transport Division and local governments with regards to roads in SA under the *Highways Act* and *Local Government Act*.	Either through the LGA or the council representatives serving on the Committee. The Committee consists of representatives from DTEI, Transport Division, councils (rural and urban), the LGA, LG Mutual Liability Scheme (Risk Services), and a local government legal representative.	"Cost-sharing arrangements" section in Chapter 3.
The Department for Transport, Energy & Infrastructure (DTEI), Energy Division	Works in partnership with consumers, industry and government to provide energy policy advice and support, energy industry development, energy resource management, and energy advice and services. In February 2002 and August 2003 held two sustainable public lighting forums and workshops, involving councils and other stakeholders in SA and interstate. Participates in the SA Sustainable Public Lighting Guide Project as observers to council workshops and as informants (2005-2006).	Information on historical sustainable public lighting events and networks in SA.	http://www.energy.sa.gov.au/home/index.htm Richard Day, Community Programs Coordinator 08 8226 5827 richard.day@saugov.sa.gov.au Tina Maiese, Energy Project Officer 08 8226 5534 tina.maiese@saugov.sa.gov.au
The Department for Transport, Energy & Infrastructure (DTEI), Transport Division	As the State Road Authority, installs, maintains and asset manages most Category V (vehicular) lighting on arterial roads in SA, as well as OBarn, some car parking, and marine (jetties) lighting. Participates with councils in joint state-local government electricity contracts and pay SLUoS to ETSA Utilities for replacements. Under the *Highways Act,* installs, operates and maintains road lighting on multi-lane roads in urban environments (and in areas where lighting is considered necessary to ensure proper traffic operation or adequate road safety), then	Share information about the different trials, practices and technologies they have used (eg solar, night checks). Collaborate on bulk purchasing opportunities. Investigate the potential for accessing or adapting their asset database 'Earls'.	http://www.transport.sa.gov.au/ Rick Burt, Unit Manager, Road Lighting and Marine 08 8226 8249 rick.burt@saugov.sa.gov.au

	Role in public lighting	How local government can interact with this stakeholder	For more information
	recovers half this cost from councils where there is amenity to councils.		
State Procurement Board, Department of Administrative and Information Services (DAIS)	Oversees the procurement of both goods and services by state public sector agencies. Negotiates and manages joint electricity purchase contracts between energy retailers and customers (ie DTEI, Transport Division and councils).	On joint energy contracts through the former Public Lighting Steering Committee and LGCS.	http://www.spb.sa.gov.au/
Department of the Premier and Cabinet, Sustainability and Climate Change Division	Implements climate change related actions by the South Australian Government. In May 2005, the former Office of Sustainability (OoS) convened multi-stakeholder meetings to identify barriers to using lower greenhouse technologies in street lighting and discuss ways to facilitate change. Identifies relevant policy responses as part of SA Greenhouse strategy and proposed climate change legislation.	Submissions to strategies, policies, and legislation on the importance of sustainable public lighting and related government support.	http://www.climatechange.sa.gov.au

Case studies and trials

Throughout this guide, we have looked at a number of case studies that could be helpful to councils in mapping their own sustainable public lighting activities. Here we take an in-depth look at a case study from the City of Charles Sturt in South Australia, the Sustainable Public Lighting Initiatives demonstration projects in Victoria and other case study resources.

Case Study 13: Energy Efficient (DIO) Public Path Lighting, City of Charles Sturt, SA

The City of Charles Sturt has a total operating budget of approximately $93 million per annum and serves a predominantly industrial commercial based economy with large capacity for residential infill with a population of 104,000. The City of Charles Sturt's Corporate Emissions Profile in 1997/8 showed 65% of emissions were sourced from the public lighting sector. The Corporate Greenhouse Action Plan (2000) identified the installation of more energy efficient public lighting as a priority measure.

The existing 80-Watt Mercury Vapour lamps at the Station Place, Hindmarsh site required replacement due to yellowing with age or breakage due to vandalism. They were replaced in April 2003 with the more energy efficient DIO lighting (diode emitting) technology to meet the Australian Standard 1158 for park and path lighting. The DIO lights are low voltage – 18V compared to the 240 V used by conventional lights, and therefore consume less energy than conventional lights.

Financial, energy and greenhouse savings of project

Budget Allocation	$16,000 (plus $4,000 grant from the Australian Greenhouse Office)
Energy savings	86.3% power reduction per year
Greenhouse savings	10 tonnes CO_2e per year
Financial savings	$1,495 per year in energy costs
Payback Period	10.7 years
Other environmental benefits	The DIO lights contain no mercury
Community benefits	The pilot has been successful and has the potential for roll out across the city for pathways and reserves.
Other economic benefits	The lamps are expected to last between 100,000 hours and one million hours, which means they may not need to be changed for 20 years. Ongoing decreased operational electricity and maintenance costs.

Council drew on the experience of another council, the City of Port Phillip in installing the diode lighting technology. Based on advice from the City of Port Phillip, the City of Charles Sturt used Showers Pty Ltd to initiate and sustain the process and supply the product, which was then installed by a local contractor. The Station Place lights were metered to allow for pre- and post-retrofit monitoring to determine and verify electricity savings. The City of Charles Sturt utilised its community newsletter to advise the community.

Key success factors in this project included timing the initiative with the federal grant and council budget application process, utilising engineering staff expertise in relation to public lighting standards, and having management support throughout the project. The barrier experienced was the acceptable distance between the poles to meet the Australian Standard AS1185 P category lighting luminance criteria. If other councils wish to undertake a similar project in the future, it is recommended that they engage a lighting consultant to assess this requirement at the start of the project.

For further information please see http://www.charlessturt.sa.gov.au/Default.aspx?tabid=252 or contact Ms Dianne Vivian on dvivian@charlessturt.sa.gov.au or 08 8408 1204.

Action Resources

The **CCP Public Lighting Action Resources** web pages contain links to case studies and how-to guides, which are available to CCP councils at http://www.iclei.org/index.php?id=2252. Resources available on these pages include:

- Hi-tech Foreshore and Park Lighting (Port Phillip, Australia)
- Light Emitting Diodes (LEDs): Traffic Signals and Exit Signs (CCP Australia)

How to update or include your case study

ICLEI-A/NZ keeps a record of the public lighting case studies by CCP councils through our public lighting projects and through the annual Measures reporting process (see http://www.iclei.org/index.php?id=2372 for details). If your case study is featured in this guide and you would like to update any information, simply email PublicLighting-anz@iclei.org.

If you are a CCP council who has implemented a new public lighting initiative or project, or created an innovative process for its implementation, you can complete the CCP Case Study and Initiative of the Month Nomination form (see http://www.iclei.org/index.php?id=action-resources and note you need to log in to the CCP website first) and return it to your CCP State or Territory Manager. Your contributions will help ICLEI-A/NZ to compile our Best Practice Guidelines. Winners of the Initiative of the Month will also be profiled on the CCP website, in the ICLEI-A/NZ Bulletin, Councillor SnapShots, achievement papers and the annual CCP Program Report.

Sustainable Public Lighting Initiative (SPLI) demonstration projects

In November 2003 Sustainability Victoria (formally the Sustainable Energy Authority SEAV) launched the Sustainable Public Lighting Initiative (SPLI). This was done as part of the Victorian Greenhouse Strategy commitment to develop and showcase sustainable energy in public lighting. More than 20 local councils, ten residential developers, all Victorian electricity distribution businesses and other key groups are involved in providing projects and are taking a lead in sustainable energy solutions. A summary of the SPLI projects delivered by multiple councils in Victoria during 2004 and 2005 is given in Table 9.

Table 9: Summary of SPLI demonstration projects

Council and partner	Project details
City of Whitehorse & Active Reactor	Lamp controller to decrease energy use, extend lamp life and reduce maintenance costs
Banyule City Council on behalf of NAGA	High pressure sodiums (HPS) (80 lights) T5 compact fluorescent (40 lights)
City of Port Phillip	Metal halide with electronic ballast and/or sensory system to detect lamp failure (25 lights)
City of Ballarat	High pressure sodiums (HPS) (23 lights)
Casey City & Dennis Family Corporation	42W compact fluorescent amalgam lights (31 lights)
City of Melbourne	20W metal halide catenary lights (40 lights) 28W T5 compact fluorescent (25 lights)
City of Whitehorse	Retrofit of electronic ballast and electronic photoelectric cells to existing 150W metal halide lights 24W T5 compact fluorescent (18 lights) 1W light emitting diode (LED) (15 lights)
Shire of Hepburn	T5 compact fluorescent (12 lights)
Hume City & Delfin Lend Lease	42W compact fluorescent (26 lights in Flinders type luminaires) 42W compact fluorescent (93 lights in Boston style luminaires)
Hume City & Peet & Company	42W compact fluorescent with electronic ballast and electronic photoelectric cells (16 lights)
Hume City & VicUrban	42W compact fluorescent (31 lights) and retrofit of 150W HPS with electronic ballasts (27 lights)
Whittlesea & Villawood Properties	42W compact fluorescent (114 lights)
Whittlesea & VicUrban	50W high pressure sodiums (HPS) (63 lights) 42W compact fluorescent (6 lights)
Melton Shire & Stockland Development	55W metal halide (14 lights)
Whittlesea & Drapac Properties	Compact fluorescent (34 lights)
Wyndham City & Pioneer Homes	50W high pressure sodiums (HPS) (30 lights)
Wyndham City & Dennis Family Corp	42W compact fluorescent (15 and 19 lights)

(Source: The Sustainable Public Lighting website (http://www.energy-toolbox.vic.gov.au/publiclighting/index), which will be updated with trial results as these become available.)

Review of local government sustainable public lighting case studies

Environs Australia (June 2002) ***Public Lighting Case Studies***

This study, produced for the Southern Sydney Regional Organisation of Councils (SSROC) and Sustainable Energy Development Authority (SEDA), NSW, covers 19 local government public lighting case studies, includes twelve case studies from Australia (including case studies from SA, WA, VIC, QLD, ACT, and NSW), and seven case studies from overseas (Sweden, Bulgaria, New Zealand, United Kingdom and the United States). The case studies provide information on energy efficiency, photometrics, lighting output, infrastructure design, maintenance contracts, and tariff structures.

International case studies

A number of international case studies are available on the " " section of the Sustainable Public Lighting website (http://www.energy-toolbox.vic.gov.au/publiclighting/index). These case studies include detail on the following topics:

- Improving councils' ability to tender for lighting provision
- Light control system to reduce cost and liability exposure for councils
- Life cycle cost analysis
- LED traffic signal purchasing strategy
- Electric meters to measure energy cost savings of LEDs

Technical information

Councils can get information on sustainable public lighting technologies through paying for in-house expertise (eg in-house engineers), paying for external expertise (eg consulting engineers such as DPD), and conducting research in these areas:

- Stakeholders: Lighting manufacturers; public authorities from overseas; and national and South Australian organisations including The Lighting Council of Australia Technical Committee, Illuminating Engineering Society (IES) of Australia and New Zealand (the Lighting Society), ETSA Utilities, and DTEI, Transport Division (See Tables 7 and 8 for their role and contact details).
- Technologies: Different street light types, measures of luminaire performance, lamp performance data, and lamp replacement options. The Glossary of this guide explains several technical terms.

  http://www.greenhouse.gov.au/lgmodules/wep/streetlighting/
  http://www.greenhouse.gov.au/lgmodules/wep/toolkit/index.html

  http://www.energy-toolbox.vic.gov.au/publiclighting/index
- *Public Lighting in Australia – Energy Efficiency Challenges and Opportunities* (Genesis *et al*, 2006 – see Publications section for details) has a good description of technical scope and opportunities, and compares the costs and benefits of renewable electricity and energy efficient lighting options.
- The Glossary in this guide.

Publications

Publications are listed alphabetically by author, and contain website links where available.

International

1. International Energy Agency (IEA) (June 2006) "Light's Labour's Lost" – Policies for Energy-efficient Lighting

The comprehensive study is a component of the IEA's response to the G8 Gleneagles Plan of Action (July 2005), which mandated the IEA to identify strategies and scenarios for a more sustainable energy future. It is the first detailed global analysis of the energy used by lighting and includes a thorough review of the technologies and policies that can reduce it.

http://www.iea.org/Textbase/press/pressdetail.asp?PRESS_REL_ID=182

National

1. AS/NZS1158 Road Lighting series is available from Standards Australia at http://www.standards.com.au

2. ICLEI-A/NZ (2005) CCP Australia Measures Evaluation Report 2005. http://www.iclei.org/anz

3. *Bright Sparks: the Sustainable Public Lighting Bulletin.*

Bright Sparks is a forum for councils, developers, distributors and others to identify and discuss any issues on sustainable public lighting. It has a Victorian focus but also some useful national information.

http://www.energy-toolbox.vic.gov.au/publiclighting/

4. Fisher, A (2001) *Energy efficient road lighting – a contribution to greenhouse gas reduction.*

5. Fisher, A (2002) *Facing up to the reality of global warming – a concerted response from the lighting industry.*

6. Genesis Automation, Deni Green Consulting Services, and Kevin Poulton and Associates (June 2006) *Public Lighting in Australia – Energy Efficiency Challenges and Opportunities.* Department of the Environment and Heritage, Australian Greenhouse Office.

This is the first publication in Australia to look at the overall greenhouse gas emissions from public lighting. Summarises the public lighting stock, decision-making process, technologies, best-practice, challenges and opportunities in Australia. It recommends ways the Australian Greenhouse Office can cost-effectively expedite the implementation of these opportunities.

http://www.greenhouse.gov.au/local/publications/pubs/public-lighting.pdf

7. Genesis Automation and Lablight International (1999) *Report on Energy Saving Opportunities in Street Lighting*. Commissioned by the former Energy Efficiency Victoria and SEAV NSW.

Covers an assessment of public lighting technology in Victoria and NSW, and international best practice.

8. Greenlight Australia

The Australian Government is currently developing Greenlight Australia – a 10-year strategy to improve the efficiency of lighting in Australia between 2005 and 2015. Greenlight Australia plans to provide a framework for reducing energy consumption from Australian lighting over the period 2005-2015.

A 2004 discussion paper for the National Appliance and Equipment Energy Efficiency Program (NAEEEP), *Greenlight Australia – Discussion Paper for Improving the Efficiency of Lighting in Australia 2005-2015*, is a precursor to the plan, and is designed to present background and preliminary program ideas for discussion. The Greenlight discussion paper presents a range of lighting 'technology opportunities', based primarily on currently available technologies. The barriers to the uptake of each of these technologies are assessed, and an appropriate 'intervention' is assigned to each. The resulting 'programs' have been assigned a preliminary priority rating based primarily on the perceived ease with which they are able to proceed.

The full discussion paper is available at http://www.energyrating.gov.au

South Australian

1. Department for Environment and Heritage (December 2005) *Tackling Climate Change – South Australia's draft Greenhouse Strategy*, Government of South Australia. http://www.climatechange.sa.gov.au/

2. ESCOSA (2005) *Electricity Distribution Price Determination (EDPD)* http://www.escosa.sa.gov.au/site/page.cfm?u=163 Pricing principles and statement of reasons are in Part A, Chapter 2, including the principles for SLUoS.

3. ESCOSA (November 2005) *Guideline for Excluded Services Regulation - Distribution Draft Report.* http://www.escosa.sa.gov.au/site/page.cfm?u=164

4. ETSA Utilities (n.d.) *Delivering Total Infrastructure Solutions.* CD-ROM available from Peter Dean, Network Business Manager, 08 8404 5964 or Dean.Peter@etsa.com.au

5. Government of South Australia (March 2004) *South Australia's Strategic Plan* http://www.stateplan.sa.gov.au/

6. Government of South Australia (n.d.) Draft *Climate Change and Greenhouse Emissions Reduction Bill 2006* and explanatory paper http://www.climatechange.sa.gov.au/

7. ICLEI-A/NZ (2004) *Local Greenhouse Action: South Australian Councils Participating in the Cities for Climate Protection Campaign*. This report was designed as part of Project Adelaide to highlight the achievements and challenges of CCP Councils in South Australia. http://www.iclei.org/index.php?id=previousprojects

8. Local Government Association of South Australia (14 April 2003) *"Joint Contracts for State and Local Government Electricity Needs*" media release http://www.lga.sa.gov.au/site/page.cfm?u=191&c=4677

9. Local Government Association of South Australia (20 June 2003) *Submission re: Public Lighting Issues.* Submission to ESCOSA regarding 2005 Electricity Distribution Pricing Review and service standard framework for 2005-2010.

10. Local Government Association (LGA), the LGA Public Lighting Steering Committee and ETSA Utilities (July 2003) The Draft Public Lighting Services Model Agreement. http://www.lga.sa.gov.au/site/page.cfm?u=191&c=3805

11. Local Government Association Circulars 6.3, 30.3 and 30.8 (multiple dates) Search http://www.lga.sa.gov.au/

12. PriceWaterhouseCoopers (October 2000) *LGASA Public Streetlighting Inquiry.* Consultancy report to LGASA, assessing whether ETSA Utilities charges were fair and reasonable in response to SAIIRs enquiry. The report informed LGAs and PLSCs work.

13. Public Lighting Load Table http://www.escosa.sa.gov.au/site/page.cfm?u=47

14. Public Lighting Inventory Table http://www.escosa.sa.gov.au/site/page.cfm?u=47

15. SA Independent Industry Regulator (SAIIR) (January 2001) *Public Street Lighting: Proposed changes to the Distribution Code: Public Discussion Paper* http://www.escosa.sa.gov.au/site/page.cfm?u=161&c=694

16. SA Independent Industry Regulator (SAIIR) (November 2000) *Public Street Lighting Tariffs: Final Report.* http://www.escosa.sa.gov.au/site/page.cfm?u=161&c=694

17. Sinclair Knight Merz (2000) *Street Light Benchmarking Study.* August 2000. Benchmarks ETSA Utilities' costs and service performance against other distribution businesses in Australia.

18. Trans Tasman Tariff and Fuel Consultants (June 2002) *Public Lighting Issues Paper for Local Government Association.* http://www.lga.sa.gov.au/webdata/resources/files/Public_Lighting_Issues_Paper_pdf1.pdf

Grants and funding

South Australia's Sustainable Energy Research Advisory Committee (SENRAC) provides energy Research and Development (R&D) grants for competitive proposals that have strong commercialisation prospects, environmental benefits and could potentially reduce costs for SA energy consumers. For more information, see http://www.senrac.sa.gov.au.

For a range of other funding opportunities, see the grants list on the ICLEI-A/NZ website http://www.iclei.org/index.php?id=3910.

State legislation

Public lighting is influenced and regulated by several pieces of state legislation:

- Local Government Act 1999 (SA)
- Highways Act 2000
- Development Act 1993
- Electricity (General) Regulations 1997
- The Electricity Act 1996
- Essential Services Commission Act 2002

Note: most state public lighting legislation and regulations only apply to distributor owned assets. To find the legislation go to the SA Parliament website: http://www.parliament.sa.gov.au/dbsearch/acts-list.htm

Tool 1: How to find public lighting information in your council

Use this table to find relevant information for assessing council's current position on public lighting and identifying basic areas for actions that can be included in the development of a public lighting action plan.

Information required	Who had the information?	How did you access the information?	Did you encounter any barriers?	How did you/could you overcome it?
Public lighting responsibilities at council	Design and culture – projects, strategy, standards. Engineering services. Infrastructure – bills maintenance, projects, developments. Capital works. Project managers.	In job descriptions, work plans. E.g. transportation engineer, construction works, subdivisions officer, CCP officer.	People have left and responsibilities are unclear. Inconsistent information on who owns what (streets, car parks, reserves). No one with overall responsibility for management of public lighting - $750,000 per year of unplanned spending!!	Identify roles on position descriptions.
Dates for batch/ block replacement	Distribution businesses have information on the percentage of lights in their area.	From distribution businesses. Estimated from past batch replacements (average 4 year interval).	No date for replacement, the year given but not the month. Not sure how to confirm that the block replacement has been done. Communicating with distributors has been a problem, however they will provide information. No set/confirmed dates for block replacement. No evidence of 4 yearly block replacement.	Service level agreements. Better communication with distributor.

Information required	Who had the information?	How did you access the information?	Did you encounter any barriers?	How did you/could you overcome it?
Existence of a contract variation negotiated with the distribution business	Environment Department. Infrastructure.	From relevant council departments.	There are no contracts as such. Batch replacement and contracts are out of synch.	Minimum Energy Performance Standards due from the Commonwealth in 2007. Service level agreement.
Data availability and quality	Infrastructure department. Key Staff. Distribution businesses (DB's) Distribution business system: under the amended public lighting code distributor is obliged to provide data upon request. Distributor currently logging in geographic information system GIS. Information rests between ESC, distributor and design and culture department of council.	GIS layer from the DB's. DB's spreadsheet (location, number of lamps, lamp type) OMR charges. Stark (utilities management) database. Energy bills.	No way of validating data. Cumbersome (data entry). Apart from data collected through CCP (including light numbers) there is little data available / accessible / stored. Data can be very sketchy. Data doesn't state whether non standard or standard fittings are in place.	Electronic transfer of energy data or linked with distribution business OMR data. Proposed public lighting audit. Data available from distributor in theory.
Other council public lighting projects	Project Managers (Asset Owners), Subdivision Officer, Infrastructure Staff. Urban design department.	Spoke to relevant staff.	Lack of communication with staff (not overcome at this stage). Council knows when lights are installed, distributor logging lags behind council resourcing and workload are issues.	Need to get support from internal stakeholders – formality. Policies and other SPLI projects will help with work planning.

(Source: Victorian Sustainable Public Lighting Action Plan Guidelines).

TOOL 2: PUTTING THE DEVELOPMENT OF COUNCIL'S SPLAP INTO STAFF WORK PLANS

Use this worksheet either as part of an internal public lighting working group meeting or go around to relevant members of staff to help workplan.

1. Identify key dates and events for the SPLAP that may impact on the work plans of staff involved in developing a SPLAP

Item	Date
SPLAP completion	
Dates for batch replacement of lamps and fittings	
Potential funding for energy efficiency projects	
Public lighting related workshops, seminars, conferences	
Council meetings	
Financial year	
Reporting periods	

2. Key SPLAP tasks that will need to be completed by a staff member in order to develop the SPLAP (see Chapter 3 for a guiding list of tasks)

Task	Time line
Information/data collation (establish current status of council public lighting)	
Internal consultation/workshops with relevant staff	
Preparing the SPLAP, background material as well as action plan	
Submitting the report to the council meeting agenda and confirming a date for submission	
Presenting to council	

3. Allocate responsibility for SPLAP development tasks into staff work plans (work loads)

Task/Chosen Response	Responsibility	Completion date	Budget	
			Staff hours	$

(Source: Victorian Sustainable Public Lighting Action Plan Guidelines).

TOOL 3: COUNCIL SELF-ANALYSIS CHECKLIST

The following checklist outlines, in ICLEI-A/NZ's experience, the attributes leading councils have in regard to sustainable public lighting. This is a tool to help council examine how it compares to leading councils. If council identifies that it is lacking any of these points, the gaps identified through this checklist will form the basis for the council's development of an action plan.

Internal Strategy & Support

☐ A senior manager, key department or public lighting team has overall responsibilities for public lighting management, coordinating the myriad of public lighting decisions.

☐ Public lighting management is included in the corporate plan or equivalent.

☐ Political (councillor/aldermen) and executive level support for actions to establish more energy efficient public lighting as a council priority.

☐ There is whole-of-council support for energy efficient public lighting.

☐ Council has a process for monitoring and reviewing its public lighting management with regard to agreed energy, financial and social outcomes.

☐ Budgets are allocated and/or other sources of financing found for public lighting energy reduction measures.

☐ Staff time is allocated to undertake sustainable public lighting work.

Data & Technology

☐ Relevant council staff have (or have access to) the understanding sufficient to design public lighting, set sub-categories according to the standards, and complete other public lighting tasks.

☐ Key council staff have (or have access to) the technological understanding necessary to make decisions on energy efficient lighting.

☐ Council has a full, accurate inventory of public lighting assets in terms of costs, energy use, lamp/luminaire type and number of lights.

☐ Council is aware of dates planned by distribution businesses for batch replacement of lamps and luminaries.

External Relationships

☐ Active engagement with council's distribution business(es).

☐ Council engages the local community in decisions on public lighting.

☐ Council has established relationships with lighting supplier(s).

☐ Council's public lighting greenhouse gas abatement actions are coordinated with the actions of other councils in its distribution area.

☐ Council is coordinating efforts to promote sustainable public lighting action on a federal/state level with other organisations.

(Source: adapted from the Victorian Sustainable Public Lighting Action Plan Guidelines).

TOOL 4: HOW TO AUDIT EXISTING LIGHTS

Having accurate information about street and public lighting infrastructure is essential for:

- Identifying potential improvements for implementation
- Reducing council budgets for street and public lighting energy costs
- Clarifying (where needed) asset ownership and responsibilities between council, the distribution business(es), and the transport authority.

An audit of the number, type, location and condition of street and public lighting in a municipality is often the starting point in this process and will underpin good data management. Councils should consider doing asset audits/reviews on a regional basis to: achieve economies of scale in engaging consultants; streamline communications with, and requests to, distribution businesses; access potential funding opportunities; develop a central resource of information; and share advice and experiences.

Here are some step-by-step instructions and a checklist for conducting an audit:

1. Access existing public lighting data available within council

In-house information to collect includes:

☐ Your council's public lighting retailer and distributor: ______________________________

☐ Any council staff who have contact with distribution businesses for public lighting: ______________________________

Who their contacts are (name, position, contact details): ______________________________

☐ How/if data is recorded, reviewed, and managed for accuracy. Identifying any staff concerns with the current data (talk to asset management, distribution officers etc) will help inform the audit.

____
____
____

☐ Whether there is an energy management tool in place, such as Utility Tracker: ______________________________

If so, what information is captured with this tool? ______________________________

☐ Whether council has access to the distribution business' geographic information system (GIS) for public lighting: ______________________________

If so, who in council uses it: ______________________________

Tool 1 provides guidance on where to find this information. It is important at this step to engage with all relevant staff across council to ensure that all relevant requirements will be met (e.g. asset management, environment, GIS, etc). An uncoordinated council approach to public lighting data management can make the audit process overly complicated and reduce its accuracy.

2. Audit council's public lighting stock if data is not already available

☐ Either identify in-house staff and resources or engage a consultant to carry out an on-the-ground audit: ______________________________

(Note that in-house skills can be limited, as can be the pool of available lighting specialists from which to select an auditor, which can delay timelines for the project and turn-around times of tender documents, etc.)

Ensure the quote and actual audit covers not only streetlights but all public lighting (ie parks and gardens, car parks), and involves physical checks of:

- ☐ Number of lights
- ☐ Actual location of each light (via GIS positioning)
- ☐ Types of lamp and luminaire at each location
- ☐ Type of pole or bracket at each location
- ☐ Age and value of assets (if possible)
- ☐ Faults such as day burners or lights out

As well, determine for each light:

- ☐ How much energy the lamps use (calculate using the Load Table)
- ☐ Tariff type and what council spends on public lighting (including service charges [by distributor] and electricity use [by retailer])
- ☐ Who maintains stock (council or distribution business)

3. Compare audit data to that provided by distribution business

- ☐ If council does not already have data (as identified in step 1), request this in GIS format from the distribution business. Depending on the distribution business there may be a charge.
- ☐ Compare the information provided by the distribution business(es) with council's audit data and note any discrepancies in location, lamp type and distributors tariff. One approach to conduct this comparison is to load the information into GIS software as two separate layers.

4. Follow up action

- ☐ Advise distribution business of discrepancies for updating the Inventory Table (or equivalent), and clarify (where needed) asset ownership and responsibilities between council, distribution businesses and the transport authority. (Seek an agreed value for any refund where audit indicates overcharging by the distribution business or retailer.)
- ☐ When the lighting data is agreed and finalised, calculate council's greenhouse gas emissions from public lighting (CCP councils should update their inventory in the CCP Software; non-CCP councils can use a consultant or the AGO Factors and Methods workbook).
- ☐ Use the updated energy, asset, financial and greenhouse information to manage the assets for improved performance and service delivery, target energy efficiency improvements, reduce council's energy costs, benchmark and report on current performance, and build a business case for action on sustainable public lighting.
- ☐ Maintain data in asset management system.
- ☐ Remember to obtain an update of distribution business GIS data annually and check all new additions and deletions.

(Sources: Based on information provided by the City of Marion, Adelaide City Council and other SA CCP councils, and some information in the Victorian Sustainable Public Lighting Action Plan Guidelines).

TOOL 5: ACTION PLANNING WORKSHEET

The following worksheet can be used at your council to identify the opportunities, constraints and timelines that will affect your selection of actions for the SPLAP.

1. Identify your council's existing/future drivers and constraints of sustainable public lighting

Key drivers are those things that will encourage and aid in the implementation of sustainable public lighting and may include things like reduction goals, council strategies, opportunities and funding. Key constraints are those things that may limit your council's implementation of sustainable public lighting and may include such things as timelines, budgets and staff resources.

Drivers	Constraints
Opportunity: Greenfield developments / growth areas	No public lighting expertise at council
Batch replacement in council's CBD next year	No funding available for public lighting management in this budget cycle
Funding available from the revolving energy fund in 6 months	New development will need lighting within three months
Infrastructure manager used to work for the electricity regulator	

2. Identify council's current areas of influence / control over public lighting

It is important for you to identify the areas that your council has control over and the areas that you can influence. This will help you clarify your actions in the SPLAP and focus on the areas that your council can control and change, rather than spending all your energy on areas you can only influence.

Areas of control	Areas of influence
Aesthetic lighting	Developers
Internal strategies and policies	Funding available from the revolving energy fund in 6 months
Planning guidelines	State policy

3. Identify key dates and time lines related to public lighting

The following list, whilst not exhaustive, provides examples of things that may impact on the goals chosen by your council; items should be added to or removed from the list as appropriate:

Item	Date
Dates for batch replacement of lamps	
Dates for batch replacement of fittings	
Potential funding for energy efficient lighting projects	
Flagged legislation changes	
Related workshops, seminars, conferences	
Future energy prices increases	

4. What actions might council need to complete to achieve your goals?

Using all the information recorded on the worksheet, devise actions that will help you progress towards your council's public lighting goals.

Goals	Actions	Responsibility	Time Limitations/ Sequence
Council specific goals	Those actions councils will need to complete (including those actions that will help to overcome barriers) in order to achieve goals	Staff within council who should implement these actions	Any time limitations that apply to the goal. An estimated sequence that actions will need to be completed or an indication of parallel actions.

(Source: Victorian Sustainable Public Lighting Action Plan Guidelines).

TOOL 6: ACTION CHECKLIST

The following checklists outline, in ICLEI-A/NZ's experience, what actions leading councils have done to build their capacity in each of the three foundations – Internal Strategy & Support, Data & Technology, and External Relationships. When considering which of these actions to include in council's SPLAP, start with easier actions that produce quick wins, and progressively work towards greater achievements.

In addition to selecting actions from the below checklists, council should:

- Note the results of council's self-assessment and goals (see Chapter 2)
- Determine how to leverage existing opportunities (see Chapter 3 and Tool 5)
- Keep in mind the sustainable public lighting options (see Table 4)
- Consider potential ways to interact with stakeholders (see Tables 7 and 8)
- Be aware of other councils' achievements (see page 5 and Chapter 4)
- Identify further actions to build capacity in each of the three foundations.

Actions to build Internal Strategy & Support

Use some or all of the following methods to build strategic, political and executive support within council, consolidate the overall management of public lighting, and capitalise on any existing support and systems within council.

Consolidate management of public lighting

- ☐ Put overall public lighting management into a senior manager's role.
- ☐ Put overall public lighting management into the work plan of one council unit.
- ☐ Form a public lighting management team.
- ☐ Make sustainable public lighting a key focus for your council's energy management team (or other appropriate body, such as energy component of executive team meetings) [See Table 3, Tools 1 and Case Studies in Chapter 2].
- ☐ Strengthen requests for staff allocation to public lighting management.

Incorporate public lighting into policy and reporting system

- ☐ Develop a sustainable public lighting policy and strategy [see Chapter 2].
- ☐ Incorporate sustainable public lighting into the corporate planning policy (or equivalent).
- ☐ Include public lighting management of in council's corporate plan [see Chapter 2].
- ☐ Establish regular monitoring and review process for public lighting management focusing on monitoring and review of council's SPLAP.

Create the business case for action

- ☐ Prepare a cost benefit analysis of changing existing lighting stock to more energy efficient lamps [see Tool 7].
- ☐ Report to council on public lighting management, costs incurred and greenhouse gas emissions, and savings from any trials implemented [see SPLAP template and Tool 7].

Use existing support to implement actions

- ☐ Develop guidelines; tools or mechanisms to help council planners, urban designers and engineers encourage the installation of energy efficient public lighting.
- ☐ Strengthen budget requests for public lighting work, particularly as savings are identified over time. Ensure that the work is in the SPLAP approved by the CEO/GM or mayor

Actions to build Data & Technology

Use some or all of the following methods to improve council's access to public lighting data, ability to analyse and use that data, and access to people with public lighting expertise.

Find and develop information

- ☐ Talk to asset management about current management of public lighting.
- ☐ Complete a Public Lighting Asset Audit [see Tool 4].
- ☐ Map out what each person/department knows in relation to the technical/legislative requirements of public lighting [see Table 3].
- ☐ Attend seminars and training sessions on energy efficient technology, tariffs, standards, legislation, energy market deregulation and other public lighting topics.
- ☐ Create links with consultants/external bodies that can provide technical information on energy efficiency in public lighting.
- ☐ Train council staff on the Australian Standards for Road Lighting (AS/NZ 1158) with a view to energy efficiency options [see Chapter 3].
- ☐ Monitor and record data on public lighting stock on an ongoing basis (or negotiate for someone within the distribution business to do this).
- ☐ Use the CCP Quantification Toolkit to quantify the greenhouse, energy and financial savings from public lighting actions [see Tool 7].

Share information

- ☐ Centralise the knowledge by running information sharing workshops or sharing information with staff responsible for overall public lighting decisions.
- ☐ Work with other councils or stakeholders to regionally share information and resources, for example establish a regional panel of street lighting consultants, a national/state network of experts, and/or a technical consulting/research service for smaller councils.

Use information to implement actions

- ☐ Use council's knowledge of the Australian Standards, public lighting stock, legislation, tariffs and other public lighting knowledge to identify sustainable public lighting opportunities [see Chapter 3].

Actions to build External Relationships

Use some or all of the following methods to engage and work with distribution businesses, lighting suppliers, other councils, and the community.

Identify existing relationships and plan engagement

- ☐ Conduct a stakeholder analysis [see Step 1 in Chapter 3]
- ☐ Identify which council staff have contact with distribution businesses for public lighting and who their contacts are [see Tool 1].
- ☐ Develop a stakeholder engagement strategy, based on the stakeholder analysis and potential ways to interact with stakeholders (see Tables 7 and 8).

Establish contact

- ☐ Contact your distribution business with a view to creating a positive relationship and identifying opportunities for both organisations. Preferably do this with other councils. Check if they are a member of the Greenhouse Challenge Plus program (see http://www.greenhouse.gov.au/challenge).
- ☐ Hold community information sessions on energy, greenhouse and public lighting alternatives in areas that will have new lighting or trials.
- ☐ Conduct surveys or create working groups to determine community attitudes, perceptions, expectations and awareness of any new sustainable public lighting. Some of the expectations may be conflicting, which is why it is important to recognise them early.

However, working groups will give an opportunity to raise awareness and enable the community to make decisions about whether lighting is actually needed at all. Involve groups such as astronomical societies in this process [see Chapter 4 for details].

- ☐ Contact other local governments in your distribution business' area to assess and build their interest in working together on public lighting goals.
- ☐ Meet with lighting suppliers (preferably as a regional group) and tell them about council's goals and seek solutions – remember you are a big customer.

Build relationships

- ☐ Work as a region to develop symbiotic public lighting policies and goals.
- ☐ Share public lighting staff across the region to maximise knowledge and minimise resourcing issues.
- ☐ Build on or establish a formal regional grouping to focus on public lighting or energy reduction as the broader, long-term primary focus of the group (e.g. public lighting steering committee, CCP council network, etc).
- ☐ Establish a contract variation (known as a Service Level Agreement (SLA) in South Australia and Victoria) with your distribution business [see Case Study 3 for details]. Ensure the Agreement includes sustainable public lighting provisions such as: installation of energy efficient lights; higher maintenance levels to reduce drift and fix day burners; or even specifying minimum energy efficiency levels, or providing an Energy and Performance Review service (for financial, energy and greenhouse costs). Do this individually and/or with other councils.

Use relationships to realise outcomes

- ☐ Choose the same type of alternative lighting as neighbouring councils to increase the economy of scale for distribution businesses.
- ☐ Work with other councils, retailers and any brokering bodies to group/bulk purchase GreenPower for your public lighting.
- ☐ Create an awareness campaign at point of sale of allotments, in consultation with developer.
- ☐ Conduct trials of alternative lighting in partnership with your distribution business, lighting supplier and/or other councils in your region.
- ☐ Encourage residents to report faults, for example brief Neighbourhood night watch on the lighting trials by council and request that they report failures.

Monitor and maintain relationships

- ☐ Record comments/complaints from residents regarding new sustainable public lighting, and ensure you respond to these.
- ☐ Survey the community after the new lighting has been installed to get their input/involvement [See Case Study 11 for an example of this].

(Source: Adapted from the Victorian Sustainable Public Lighting Action Plan Guidelines and work undertaken by Coffs Harbour City Council, NSW, found at http://www.energy-toolbox.vic.gov.au/publiclighting/index.php?option=displaypage&Itemid=220&op=page).

TOOL 7: PUBLIC LIGHTING TOOLS

Several public lighting tools exist that enable councils to organise, analyse, report on and/or make decisions using the information they gather through research. This tool lists key public lighting tools currently available and explains their purpose, as well as how to access and use them. Use this information to decide which tool is suitable for your purposes.

Tool	Use it for	Who created it and where it is
CCP Greenhouse Gas Application (CCP Software)	Benchmarking: Use this to complete an inventory of council's corporate greenhouse emissions, including the energy use, financial spend and greenhouse emissions from public lighting.	ICLEI-A/NZ http://www.iclei.org/ccp-au Note: Available to CCP councils only.
Cost Benefit Analysis Tool	Decision-making: Use this to analyse the sustainable lighting options for council based on the existing mix of lighting types, electricity and maintenance costs and replacement cycles.	Northern Alliance for Greenhouse Action (NAGA), Victoria under Sustainability Victoria's Sustainable Public Lighting Initiative (SPLI), and based on work done by Coffs Harbour City Council, NSW. http://www.energy-toolbox.vic.gov.au/publiclighting/index
CCP Quantification Toolkit	Reporting on initiatives: Use the Toolkit to quantify the greenhouse and financial savings of public lighting initiatives, and report this as part of the annual CCP measures reporting process.	ICLEI-A/NZ http://www.iclei.org/ccp-au Note: Available to CCP councils only.
Car park lighting design concept checklist and design template	Designing installations: Use design concept as an example. Use the checklist to guide the design process of car parking. Use the design template to quantify energy savings for sustainable lighting designs for car parks and pathways.	City of Whitehorse, Victoria and Webb Australia Group under SPLI. http://www.energy-toolbox.vic.gov.au/publiclighting/index
The Land Developers Guide to Solar Public Lighting	Planning installations: Use for engaging or liaising with developers on installing solar public lighting.	Mornington Peninsula Shire Council, Victoria under SPLI. http://www.energy-toolbox.vic.gov.au/publiclighting/index
Sustainable Public Lighting Developers Guidelines and Checklist for new subdivisions	Planning installations: Use to incorporate sustainable public lighting outcomes in the planning process for new subdivisions. Note: adapted to the Victorian context.	Banyule City Council in collaboration with the Northern Alliance for Greenhouse Action (NAGA) under SPLI. http://www.energy-toolbox.vic.gov.au/publiclighting/index

Note: To download tools from the Energy Toolbox: Sustainable Public Lighting website, go to Sustainable Public Lighting Initiatives – Project Updates. The website also contains contact details of council staff involved in the development of the tools.

GLOSSARY

Ballast	Device used with discharge lamps for stabilising the current in the discharge. May be electronic (more efficient) or passive (iron-core). Load tables indicate wattage use by ballasts.
Candela	The candela (cd) is the standard unit of luminous intensity in the International System of Units.
Category P lighting	Lighting designed principally for local roads to provide a safe and comfortable visual environment for pedestrian movement at night, as described in AS/NZS 1158.3.1
Category V lighting	Lighting designed principally for vehicular traffic eg traffic routes, as described in AS/NZS 1158.0
CCP	Cities for Climate Protection
CCP Plus	Cities for Climate Protection Plus
CFL	Compact fluorescent lamp.
CO_2e	Carbon dioxide equivalent units (usually measured in tonnes). CO_2e is a measure of equivalent carbon dioxide relating to the global warming potential of the different greenhouse gases. If methane, for example has a global warming potential that is 21 times stronger than carbon dioxide, a tonne of methane is measured as 21 tonnes of CO_2e.
Colour rendering	A term used to describe the accuracy with which colours are represented when illuminated by particular light sources.
Colour temperature	The colour temperature of a light source refers to the apparent whiteness of the light produced. Higher colour temperatures are referred to as cooler (more blue) sources, while lower colour temperatures are referred to as warmer (more yellow) sources.
CRI	Colour rendering index
DB	Distribution business: Distributors of energy over distribution networks ("poles and wires") in their region, including the provision of public lighting unless otherwise negotiated with public lighting customers.
Direct light	Light that is incident on a point or area having taken a direct path from a source of light, such as a luminaire.
Discharge lamp	A lamp in which the light is produced, directly or indirectly, by an electric discharge through a gas, a metal vapour, or a mixture of several gases and vapours. For example, mercury vapour, high pressure sodium.
Efficiency	The efficiency of the lamp can be evaluated by measuring how many lumens of light produced for a given input of electrical power, i.e. lumens out per watt in.
Fluorescent lamp	Discharge lamp of the low pressure mercury type in which most of the light is emitted by a layer of fluorescent material excited by the ultraviolet radiation of the discharge.
GHG('s)	Greenhouse Gas(es)
GWh	Giga watt hours: 1,000 MWhs
Glare	Light causing discomfort or reductin in visibility
Halogen lamp	Gas filled lamp containing a tungsten filament and a small proportion of halogens.
HID	High intensity discharge. All HID lamps (ie mercury vapour, HPS and metal halide) operate on the principle of an electrical discharge occurring in a closed glass or silica tube containing small quantities of metals that vaporise as an electrical current is passed through the tube. The arc tube, as it is known, is enclosed in an outer glass envelope forming the lamp.

HIR	Halogen infrared
HPS	High Pressure Sodium: high pressure sodium lamps are used in areas where colour rendering ability or appearance is considered more important, but where a yellowish appearance in the emitted light is a desired or acceptable outcome.
ICR	Incandescent reflector.
Illuminance	Illuminance is the measure of the quantity of light incident on a point or a surface. It is measured in units of lux.
kWh	Kilowatt hour: 1000 watt hours.
Lamp	Is the part of a lantern, which emits light and which may require associated control equipment to operate.
Lamp	The name given to the actual light globe that is housed within a luminaire.
Lantern	A complete light fitting containing a lamp and designed to control the output of the light.
LED	Light Emitting Diode: a method of lighting that is becoming increasingly common in public lighting uses such as illuminated signage (traffic signals) and decorative lighting.
LPS	Low pressure sodium. Low pressure sodium lamps have the highest efficacy (efficiency) of all lamp types, coupled with a long life. These lamps are generally located along major arterial roads and have a distinctive yellow light. LPS lights are being phased out in favour of HPS due to HPS's better colour rendition.
Lumen (lm)	The lumen (lm) is the International Unit of luminous flux (lux).
Luminance	Luminance is the measure of what is commonly referred to as brightness. It is a measure of the quantity of light reflected or emanating from a surface. It is referred to in terms of units of candela per square metre.
Luminaire	A complete lighting unit consisting of a lamp or lamps together with the housing designed to distribute the light, position and protect the lamps and connect the lamps to the power supply. The term lantern can also refer to a luminaire.
Lux	Lux (luminous flux) is the International Standard unit of measure for illuminance and is equivalent to one lumen per square metre.
m^2	Square meters
MEPS	Minimum energy performance standards: a regulatory tool used to increase the average efficiency of a product class, in this case public lighting. MEPS regulations remove from sale the least energy efficient models on the market. MEPS programs are made mandatory in Australia by state government legislation and regulations, which give force to the relevant Australian Standards. Regulated by the NAEEEP.
Mercury Vapour	The dominant type of lamp currently used for minor road public lighting (on minor roads commonly 80W mercury vapour lamps). Mercury vapour lamps produce a bluish coloured light.
MH	Metal halide: metal halide lamps have nearly twice the efficacy of mercury vapour lamps. They give a white light with a strong blue-green component.
Mt	Megatonne
MV	Mercury vapour: see above definition
MWh	Megawatt hours: 1,000 kWhs
OMR Charge	Operation, Maintenance and Repair/Replacement Charge: A charge set by distribution businesses for services to public lighting. Approved triennially in Victoria by the ESC.
PE	Photoelectric.

PE Cell	Photoelectric Cell: cell in a street light which determines when the lamp is turned on or off according to ambient light levels. These cells use a small amount of electricity.
Public Lighting	Any infrastructure that provides lighting for public areas including streetlights, park lights and car park lighting.
Reflected/indirect light	Light that is incident on a point or area that has been reflected by at least one surface since emanating from a light source.
Starter	Device for starting a discharge lamp (in particular a fluorescent lamp).
T5	16mm diameter fluorescent lamps or tubes.
TWh	Terawatt hours: 1,000 GWhs
Upward waste light	Light from a luminarie above horizontal (1-4% excellent, 4-10% good, 30-50% poor)
Wh	Watthour: 1 watt operating for 1 hour.

ACRONYMS AND ORGANISATIONS

ABS	Australian Bureau of Statistics
AEEMA	Australian Electrical and Electronic Manufacturers' Association http://www.aeema.asn.au
AGO	Australian Greenhouse Office, Department of the Environment and Heritage
SV	Sustainability Victoria (formerly Sustainable Energy Authority Victoria or SEAV)
SPLI	Sustainable Public Lighting Initiative: An initiative undertaken by Sustainability Victoria to accelerate the uptake of sustainable public lighting in Victoria.
IPWEA	Institute of Public Works Engineering Australia
ICLEI-A/NZ	ICLEI – Local Governments for Sustainability – Australia/New Zealand
NAEEEC	National Appliance and Equipment Energy Efficiency Committee
NAEEEP	National Appliance and Equipment Energy Efficiency Program: Lighting products are regulated by the NAEEEP
NGAC	National Greenhouse Advisory Committee
UNFCCC	United Nations Framework Convention on Climate Change

SAGE CONSULTING ENGINEERS

THE WESTERN AUSTRALIAN LOCAL GOVERNMENT ASSOCIATION AND THE SUSTAINABLE ENERGY DEVELOPMENT OFFICE

WESTERN AUSTRALIAN LOCAL GOVERNMENT ASSOCIATION

Sustainable Energy Development Office
Government of Western Australia

IMPROVED STREET LIGHTING STUDY FOR GREENHOUSE & SAFETY BENEFITS

INSTITUTIONAL AND TECHNICAL REVIEW

JUNE 2007

TOWN OF MOSMAN PARK

PROSPER IN PEACE

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IMPROVED STREET LIGHTING STUDY
FOR
GREENHOUSE & SAFETY BENEFITS

EXECUTIVE SUMMARY

This report covers an Institutional and Technical Review of current street lighting in Western Australia with the primary aim of upgrading street lighting to Australian Standards in the most energy efficient way.

Local Government is responsible for most street lighting in Western Australia. Western Power acts as a service provider to Local Government for the majority of street lighting. Main Roads WA is responsible for street lighting of freeways and major highways. Some major routes are a shared responsibility of Main Roads WA and Local Government.

A large proportion of street lighting in Western Australia is below Australian Standard requirements. Mercury vapour lamps are used for most Local Government street lighting. Mercury vapour lamps have proved reliable for street lighting but the future is likely to lie with a combination of compact fluorescent, metal halide and high pressure sodium lamps that are typically twice as energy efficient as mercury vapour.

Australia and New Zealand Standard 1158 recommends lighting levels much lower than European, British and American standards. Australia enjoys a warmer, drier climate and night vision is not commonly impeded by snow, hail and fog.

A number of initiatives have been taken in Australia to bring street lighting up to standard and reduce energy consumption. Notable examples are Midvale, Mosman Park, Subiaco, and Joondalup in Western Australia and, in the Eastern States of Australia, in Coffs Harbour, Banyule and South Sydney. The Australian Greenhouse Office has had a study undertaken entitled *"Public Lighting in Australia – Energy Efficiency Challenges and Opportunities".*

Appendix E to this report contains details of the Western Australian trial areas of Midvale, Mosman Park and Subiaco. Measurements have been recorded regularly to monitor the performance of the street lighting over two years. A total of 265 streetlights have been monitored every three months over the two year period.

The energy efficient streetlights are performing at least as reliably as the old mercury vapour streetlights.

Appendix G contains a number of scenarios comparing compliance, energy, greenhouse gas emission, lamp cost and lamp life.

It is possible for Local Government to halve energy consumption of street lighting with no drop in performance. An option is to improve street lighting to AS/NZS 1158 and still achieve energy savings.

IMPROVED STREET LIGHTING STUDY
FOR
GREENHOUSE & SAFETY BENEFITS

TABLE OF CONTENTS

REV	DATE	DESCRIPTION	AUTHOR	REVIEW
01	28-09-04	Initial Draft	Mike Sage	Mike Sage
02	29-09-04	Prelim Draft	Mike Sage	Mike Sage
03	30-09-04	Prelim Draft	Mike Sage	Mike Sage
04	11-02-05	Final Draft incorporating WP comments (pages 5, 29, 30 & 31) & SEDO comments (pages 1 & 33) and measurements	Mike Sage	Mike Sage
05	08-03-05	Committee draft incorporating comments from meeting on 22-2-05	Mike Sage	Mike Sage
06	04-05-05	SEDO comments incorporated	Mike Sage	Mike Sage
07	31-01-06	Draft Interim Report	Mike Sage	Mike Sage
08	27-3-06	Interim report	Mike Sage	Mike Sage
09	6-9-06	Revised Interim report	Mike Sage	Mike Sage
09A	26-9-06	Revised Interim report	Mike Sage	Mike Sage
10	16-11-06	Final INTERIM report	Mike Sage	Mike Sage
11	31-12-06	FINAL REPORT	Mike Sage	Mike Sage
11 A	21-05-07	FINAL REPORT May 2007	Mike Sage	Mike Sage
11 B	6-06-07	FINAL REPORT June 2007	Mike Sage	Mike Sage

1 INTRODUCTION

The purpose of this research program is to ensure awareness and encouragement that new and upgraded street lighting, meets not only the requirements of complying with the relevant Australian Standards for illuminance level, safety and cost effectiveness, but also meets or exceeds world best practice in terms of energy efficiency.

Australian Standards for street lighting are appropriate, recommending lighting levels that are adequate without being excessive. Australian Standards require lower lighting levels than European and North American standards because of the clearer weather in Australia.

The Institutional issues relate to Local Government who are responsible for street lighting, the Underground Power Program (UPP) under which new street lighting is installed as part of the undergrounding process, the Office of Energy who is the administrator of the UPP, and Western Power who is the major street lighting service provider to Local Government.

The Technical issues relate to energy efficiency, street lighting meeting Australian Standards, technology options and comparisons of Western Australian practice with national and world practice.

2 BASIS OF REPORT

This report is based on the following sources:

- AS/NZS1158.3.1: 2005 Pedestrian area lighting
- AS/NZS1158.1: 2005 Road lighting
- Austroads: Guide to Traffic Engineering Practice, Part 12- Roadway Lighting: 2004
- IES (NA) Recommendations for Road lighting
- IESNA G-1-03 Guideline for Security Lighting for People, Property, and Public Spaces
- BS/EN 13201 – Road lighting
- State Underground Power Proposals – Guidelines for Round Four Major Residential Projects

3 METHODOLOGY

The methodology used to develop this report includes:

- Liaison with Western Power, Town of Mosman Park, City of Subiaco and City of Swan to identify trial sites.
- Assess current practice in metropolitan and regional Western Australia.
- Identify Australian and worldwide street lighting best practice.
- Review existing street lighting in Mosman Park, Subiaco and Swan against the criteria of greenhouse gas reduction, energy efficiency, safety benefits, economic performance and maintenance (economic cost/benefit).

- Consider appropriate technologies, improvements to tariffs and contracts to reduce energy and improve lighting quality, improvements to tariffs and contracts to improve maintenance, recommended actions to improve lighting services.
- Regular monitoring of the selected trial sites.

4 DEFINITIONS

Average Carriageway Luminance (L) - The average luminance of a given section of the road carriageway when viewed from the observer's position.

Average Illuminance (E) - The average lighting levels at ground level measured in the horizontal plane. For the Category P4 & P5 streets, the results measured and recorded in this column are the average over the whole street.

Average Lamp Life - Time taken until 50% of lamps has reached end of life.

Colour Temperature – An indication of the colour appearance of a lamp measured in degrees Kelvin (K). 2700K indicates a warm colour, 5000K indicates a cool colour.

Depreciation – The loss of light output over time as lamps age and optical surfaces collect dirt and deteriorate.

Disability Glare – Glare resulting in reduced visual performance, often accompanied by discomfort.

Efficacy - A measure of lamp output efficiency, with units of lumen/watt

Flat Glass Luminaires – Luminaires with no light emitting above the horizontal giving low glare & low obtrusive light.

Fluorescent Lamps – Lamps that can give "white light". Compact fluorescent lamps present the ordinary tubular lamp in a small package.

Flange Mounted Pole - a pole manufactured with a flange at the bottom to bolt down to a concrete footing.

Footing - concrete base for a flanged pole.

Glare – Condition of vision in which there is discomfort or reduction of ability to see, or both, caused by an unsuitable distribution or range of luminance, or to extreme contrasts in the field of vision.

Glare Control Mark – A measure of discomfort glare produced by a street light in a particular situation. This mark is on a scale of 1 to 9 with higher numbers being more comfortable.

High Pressure Sodium (HPS) Lamps – Lamps with a yellow colour appearance. Used on freeways.

Illuminance – The amount of lighting at a particular point, measured in lux.

Ingress Protection – or "IP rating", a two digit code that indicates resistance to ingress of solids and liquids, the first digit refers to solids, the second to liquids eg IP55 means dust-protected & water-jet proof. Higher numbers indicate better protection

Illuminance Uniformity (Ue) - This is a measure that relates average illuminance to maximum illuminance. The higher the figure, the greater the problems of excessive contrast of the highest illumination point.

Lamp – a generic term for a man made source of light sometimes colloquially referred to as a "globe" or "bulb".

Light Output – The total luminous flux emitted by a lamp or luminaire.

Luminance – the brightness of an object or surface. Measured in units of cd/m^2 (candela per square metre).

Low Pressure Sodium (LPS) Lamps – Lamps with a distinctive yellow colour. The light emitted by this lamp distorts the colours of blue, green and red, but produced a high quantity of light for the quantity of energy consumed.

4 DEFINITIONS

Longitudinal Luminance Uniformity (UI) – The ratio of minimum to maximum carriageway luminance in a longitudinal line along the road through the observer's position. The closer this figure is to 1, the more even is the luminance.
Luminaire – A light fitting or "fixture" including lamps, optical system and any electrical control gear.
Minimum Illuminance (Emin) - The minimum measured lighting level recorded in the measurement area, the measurements taken at ground level in the horizontal plane
Mercury Vapour (MV) Lamps – Lamps with a blue-white colour.
Metal Halide Lamps – Lamps which can give "white light"- more efficient than mercury vapour.
Mounting Height – The vertical distance between the centre of a luminaire and the surface of the carriageway immediately beneath the lighting.
Nominal Height – The vertical distance between the bottom of the baseplate or ground line (as applicable) and
(a) For columns with outreach arms - a horizontal line at the highest level of the outreach arm centre-line.
(b) For post-top columns – the highest point of the column excluding any fixing spigot.
Observer's Position - A reference position on the road from which theoretical calculations are based. Approximately where a driver would sit when driving down the road.
Obtrusive Light - Spill light causing annoyance distraction, discomfort, or reduction in vision.
Outreach - The distance measured horizontally from the centre of a bracket-mounted luminaire, to the centre of the column or pole, or the wall face to which the bracket is attached.
Overall Luminance Uniformity (Uo) – The ratio of minimum carriageway luminance to the average luminance. The closer this figure is to 1, the more even the luminance.
Peak Intensity - The highest value of luminous intensity from a given luminaire.
Planting Depth - The length of the column that is buried below ground level.
Reliability – in this report reliability is taken as the percentage of street lights working at a given time.
Repair time – the time taken from report of failure to restoration of the street light
Standards – Australian Standards include:

AS1158	Public Lighting
AS1428	Design for Access & Mobility
AS1680	Interior Lighting
AS2293	Emergency Lighting
AS2560	Sports Lighting
AS2890	Off Road Car Parks
AS4282	Obtrusive Light

Spill Light – Light which falls outside the boundary of the property on which the lighting installation is sited
Surround Illuminance Ratio (ES) - The ratio between the average illuminance of the road verge to the adjacent section of carriageway. The higher the ratio, the more effectively will verge details be discernible to drivers.
Threshold Increment – A measure of disability glare produced by a street lighting in a particular situation. The higher numbers correspond to greater disability glare.
Uniformity Ratio – The ratio of maximum illuminance to average illuminance.
Upcast Angle - The angle between the axis of the luminaire fixing and the horizontal.
Uplift - (For pole-mounted bracket arms) - the vertical distance between the intersection of the bracket arm centre-line with the supporting face and the highest level of the bracket arm centre-line.

5 INSTITUTIONAL REVIEW

5.1 BACKGROUND

In Western Australia, as in other states of Australia, Local Governments are responsible for the provision of street lighting. An exception is certain major roads where the responsibility for road lighting lies with Main Roads WA or is shared between Mains Roads WA and Local Government.

The arrangement in Western Australia, where Local Government is responsible for street lighting but employs the electricity supply authority to be the street lighting service provider, is also the case in other parts of Australia and in New Zealand.

In Britain, street lighting is a Local Government responsibility and Local Government; through the County Councils take care of the design, installation, maintenance and ownership of street lighting. The electricity supply authority provides an electricity supply to each light pole via a "service cut out" within the light pole. This service cut out is the dividing line between the supply authority and the County Council. If there is power at the service cut out, the County Council know maintenance is their responsibility. If there is no power at the service cut out, the County Council requests the supply authority to repair.

In Britain there is a need to replace aged public lighting and local authorities can apply for grants from central government to fund lighting improvements.

In Western Australia, there is an historical arrangement where Local Governments have requested Western Power, previously SECWA and SEC, to install streetlights on power poles. Before the formation of the SEC, street lighting was provided by Local Governments who were the local electricity undertakings. During 2006 Western Power was split. "Synergy" is the retial entity that bills local government for street lighting and "Western Power" claims ownership of street lighting equipment. Under the present State Government contestability policy Synergy and Western Power claim that lighting is not contestable.

Early Street lighting in Subiaco [1]

The Western Australian Local Government Association strongly advocates the contestability of street lighting and has published an Infopage 05-001-03-0014

5.2 CURRENT PRACTICE IN WESTERN AUSTRALIA

5.2.1 INTRODUCTION

Western Australia has a stock of 199 552 street lights that consumed 90.2 GWh of energy in 2002/2003. Approximately 40% of these street lights serve major roads and 60% minor roads. In Australia, major street lighting accounts for 30% of the numbers of street lights but 53% of the energy, whereas minor street lights account for 70% of the numbers but 47% of the energy[6].

In accordance with the recognized road hierarchy, minor roads are Local Access Roads and Local Distributor Roads. Major roads are the District Distributors. Principally, minor roads are lit for pedestrian security (AS/NZS 1158 Category P lighting) and major roads for vehicle safety (AS/NZS 1158 Category V lighting).

While the minor roads have a higher number of street lights, they are of lower power than major road street lights.

5.2.2 MINOR ROADS

Most minor roads in Western Australia have substandard lighting. With streetlights spaced 80 m apart, the section of road halfway between the streetlights is a black spot receiving no light. Observation, measurement and calculation have confirmed this.

Typically what was called "half standard" street lighting was installed. This meant streetlights generally installed on every second power pole. The spacing was consequently four street frontages, about 80 m, generally too far apart to achieve compliance with Australian Standards.

For minor roads, 50 W, 80 W, and 125 W mercury vapour streetlights are typical with a mounting height of about 7.5 m with overhead power and 6.5 m with underground power.

Through the 1990's, Western Power upgraded many minor road streetlights to 80 W mercury vapour.

5.2.3 MAJOR ROADS

For major roads, 250 W high pressure sodium and older 250 W and 400 W mercury vapour streetlights are typical with a mounting height of about 9 m with overhead power and 10.5 m, or 12.5 m with underground power.

For the major roads, high pressure sodium lamps are energy efficient. However, a further improvement in energy efficiency can be obtained with bi-level control. Bi-level control of a high pressure sodium lamp halves the energy consumption and the light output. In effect lighting to Category V3 can be reduced to Category V5. This should be acceptable as there appears to be a reduction in traffic flow about 9pm on weeknights. Thus full lighting can be maintained during times of high traffic flow and half lighting when traffic flow reduces.

Bi-level control requires a "supplementary impedance", an extra switching wire, and a 7 day time switch, or similar device.

5.3 UNDERGROUND POWER

With the advent of the State Underground Power Policy in 1990, the Underground Power Program was launched. This programme facilitates the undergrounding of power with funding contributions from Western Power and Local Government. The aim is to have power underground in half of the metropolitan area by 2010.

By necessity, this program has to replace the streetlights mounted to power poles with new streetlights on new steel poles. With the initial trial and stages 1 and 2 of this program, streetlights were replaced on a "like for like" basis, that is, the number of existing streetlights was counted, and then replaced with the same number of new streetlights. If Local Government wanted lighting to achieve Australian Standards, Local Government had to pay for the additional streetlights needed to achieve compliance.

The Round Four Guidelines state:

"Western Power streetlights funded as part of a project will use standard Western Power galvanized poles and luminaires that will provide lighting levels to Australian Standards.

Additional streetlighting requirements such as the use of decorative poles/luminaires or increasing the lighting levels to a higher Australian Standard category may be installed at an additional cost to the local government. ………"

Consequently the Underground Power Program has now moved from "like for like" street lighting to street lighting which meets Australian Standards. The applicable Australian Standard for the lighting of minor roads AS/NZS 1158.3.1 tables five Categories of lighting, from P5 to P1. The standard prescribes four Light Technical Parameters to be met, rather than just one "minimum level". Western Power's Newsletters under "Streetlighting" typically state:

"The new streetlights are designed to conform as closely as possible to the relevant Australian Standard and are located quite differently to the old lights. The new lights will be located one metre from the edge of the roadway, more closely spaced and where possible, placed on the extensions of side boundaries and alternated to both sides of the road". [2]

It is noted that specific Categories of the relevant Australian Standard (AS/NZS 1158) are not quoted in the Office of Energy documentation.

5.4 IMPROVEMENTS

Western Power has been moving forward with more efficient street lighting technology and examples of this include:

- High pressure sodium lamps were used in Stratton in ordinary functional streetlights and in the underground power project in Claremont in decorative "Kensington" streetlights.
- In Midvale, Western Power replaced 80 W mercury vapour streetlights with 70 W metal halide streetlights. The result has seen substandard street lighting raised to Category P4 of AS/NZS 1158.3.1 with lower energy consumption.
- Western Power introduced a range of decorative streetlights in 2000. Initially this range included 80 and 125 W mercury vapour lamps and 70, 150, and 250 W high pressure sodium lamps. The current range of Western Power decorative streetlights includes 70, 150, and 250 W metal halide lamps in addition to 50, 80 and 125 W mercury vapour lamps and 70, 150 and 250 W high pressure sodium lamps.

Western Power is investigating but has not yet trialled fluorescent streetlights. Western Power's concern has been with the reliability of fluorescent technology. These have been available for some years. The 42 W compact fluorescent lamp introduced in 1994 has a similar output to the 80 W mercury vapour lamp but consumes half the energy. The T5 (16 mm diameter) linear fluorescent lamps introduced in 1996 combine high efficacy with long life. A 2 x 24 W T5 streetlight has a similar output to an 80 W mercury vapour streetlight but consumes 55% of the energy.

Modern fluorescent lamps such as the 42 W compact fluorescent lamp and the T5 linear fluorescent lamps are dependent on electronic control gear for their operation. Electronic control gear provides these modern lamps with a stable operating regime. Western Power is concerned about the ambient temperatures in Western Australia that may exceed manufacturer's ratings and shorten the life of the electronic control gear.

The Public Transport Authority is insisting on electronic control gear for all lamps (metal-halide & fluorescent) for the railway stations for the new Mandurah line.

5.5 FUNDING

Western Power and its predecessors SECWA and SEC originally funded the installation of streetlights and then recovered the cost from Local Government through tariffs based on the wattage of the lamp and the burning hours. At present many Local Governments on contract with Western Power pay for street lighting on the basis of an annual "Street Vision" charge that is fixed each year.

Through the Underground Power Program and new residential developments, half of the metropolitan area will have improved street lighting by 2010. However, some of the early underground power project areas have non-conforming street lighting.

6 TECHNICAL REVIEW

6.1 LAMP TECHNOLOGY

Two important characteristics of lamps used for street lighting are the energy efficiency and the lamp life.

The energy efficiency of lamps is measured as "efficacy". This is the ability of the lamp to produce visible light (measured in lumens) from electrical energy (measured in watts). Efficacy is measured in terms of lumens/watt. A lamp with 100% energy efficiency would have an efficacy of 683 lumens/watt. Practical lamps have efficacies in the range 10 to 200 lumens/watt.

The life of lamps may be measured as rated life or as "economic life". Rated life is the time at which 50% lamp mortality has been reached. Economic life is the time at which the light output has depreciated to 70% of the initial light output and should be replaced.

While the mercury vapour lamp has been a reliable source for minor street lighting in many parts of Australia and overseas, its status is now challenged by lamps that are more efficient.

At present, the contenders for replacing mercury vapour lamps are high pressure sodium, metal halide, and fluorescent lamps. Technologies which have not been considered are: low pressure sodium lamps which have poor colour; LED's which are not efficient and have too low power, and induction lamps that are very expensive.

6.2 MERCURY VAPOUR LAMPS

Mercury vapour lamps were developed in the 1930's and their efficacy has not improved since then.

Mercury vapour lamps have:

- A poor efficacy of 40 to 50 lumens/watt.
- A Colour Rendering Index of about 50 with a blue-white output deficient in red that renders skin tones poorly.
- A long life of 16,000 hours typically.
- Have a high mercury content.

One advantage of the mercury vapour lamp is its long and reliable life. Mercury vapour lamps may operate for over a decade, but as each year goes by, its output diminishes. After four years of operation at 4,000 hours per year, a mercury vapour lamp will produce about 65 to 70% of its initial output, but still consume the same amount of energy.

The disposal of mercury vapour lamps should be considered a serious problem. Each 80 W lamp contains 14 mg of mercury.

6.3 HIGH PRESSURE SODIUM LAMPS

High pressure sodium lamps:

- Have high efficacy, around 90-120 lumens/watt.
- Have poor colour rendition with a Colour Rendering Index of 22 and a distinctive golden colour.
- Have long life of 24,000 hours typically.
- Have low mercury content.

High pressure sodium lamps are a reliable light source for road lighting offering high efficacy and long life. The life of high wattage lamps is around 20,000 hours while the life of low wattage lamps is around 12,000 hours. A development of this lamp is the twin arc tube lamp, essentially two lamps in one envelope. This lamp offers double the life.

High pressure sodium lamps are used for lighting minor roads in New Zealand and in England. One disadvantage of these lamps is their poor colour rendition that does not accurately render skin tones, clothing colours, and vehicle paintwork. The primary purpose of minor road lighting is security and high pressure sodium lighting fails to provide colour identification for security.

Under photopic (day) vision, the eye is most sensitive to yellow light. Under scotopic (night) vision, the eye is most sensitive to blue light. Minor road lighting is in the mesopic (between photopic and scotopic) range of vision. What this means is that the predominantly yellow light from high pressure sodium lighting is not as effective as the white light from metal halide and fluorescent lamps. The latest edition of AS 1158.3.1 recognises this and recommends that a de-rating factor of 75% be applied to high pressure sodium lighting for Categories P4 and P5.

High pressure sodium lighting is valid for highway lighting and is used by Main Roads WA and Western Power for major roads.

6.4 METAL HALIDE LAMPS

Metal-halide lamps were developed in the 1960's and may be considered to have evolved from mercury vapour lamps.

Metal-halide lamps:

- Offer high energy efficiencies of around 80 lumens/watt
- Have excellent colour rendering giving "white light" with Colour Rendering Indices between 65 and 80. Their strong blue and green component makes them particularly well suited to night vision.
- Have suffered from short life of about 6,000 hours (1½ years) but developments in recent years have extended life to 12,000 hours for low wattage lamps (3 years) and up to 20,000 hours (5 years) for larger wattage lamps. Philips has a 60W metal halide lamp, branded "Cosmo-white", with a 12 000 hour rated life. Venture have metal halide lamps with long life, claiming 75% survival at 15 000 hours.
- Have low mercury content.

The Lighting Strategy for the City of Perth has designated this lamp for Perth's "White Light". One example is the Eastern Gateway to Perth where the Great Eastern Highway passes Burswood Casino. Other examples are the Thorn "Urbi" luminaires in many of the City of Perth's streets.

6.5 FLUORESCENT LAMPS

Fluorescent lamps:

- Offer high efficacy of between 80 and 100 lumens/watt.
- Offer "white light" with a Colour Rendering Index of 80 giving excellent colour rendering of red, blue and green.
- Have a life varying from 12,000 hours to 36,000 hours.
- Have low mercury content.

T5 (16mm diameter) fluorescent lamps are linear fluorescent lamps but with a smaller diameter to the conventional 26 mm lamps. These lamps run on electronic control gear and have very high efficacy (about 100 lumens/watt) and a long life of about 20,000 hours. A trial of these lamps is being established in Victoria.

One Australian manufacturer, Pierlite has produced a streetlight using two x 14 W and 2 x 24 W, T5 (16 mm diameter) lamps with electronic control gear. These lamps have a rated life of 20,000 hours. The 14 W lamps have an efficacy of 100 lumens/watt and the 24 W lamps 80 lumens/watt. A street lighting trial of T5 lamps is being established in Victoria.

T5 lamps in general are manufactured to give optimal output at 35^0C whereas most fluorescent lamps are optimised at 25^0C. In outdoor applications there is a possibility that the lamps may only give 80% of full output.

Streetlights with compact fluorescent lamps are available from a number of manufacturers. These lamps have an efficacy of 80 lumens/watt and a life of 12,000 hours.

Sylvania have a 42W compact fluorescent lamp with a claimed life of 28 000 hours. This is an "amalgam" type fluorescent lamp.

Old technology fluorescent lamps have been used in Australia, particularly around the Sydney metropolitan area. Twin 18 W linear fluorescent lamps with wire wound ballasts have been typical. These are T8 (26 mm diameter) lamps with a rated life of about 10,000 hours.

6.6 LOW PRESSURE SODIUM LAMPS

Low pressure sodium lamps have been used rarely in the past in Australia for street lighting but are being replaced because of their poor colour characteristics. These lamps have no Colour Rendering Index. These lamps have a monochromatic yellow colour that does not support colour vision, however they do have an extremely high efficiency of 200 lumens/watt.

Low pressure sodium lamps have been used in very few countries with limited success. These lamps have a limited future and are only of historical interest.

6.7 LIGHT EMITTING DIODES

Light emitting diodes (LED's) are a promising light source but the efficacy of white LED's is poor and the power is limited. LED's offer extremely long life.

LED's are a promising light source, but at present are not yet suitable for street lighting because of their low efficacy. LED's have been trialled in Australia but not where compliance with AS/NZS 1158 is required.

At the time of this report, high efficiency LED's are appearing to emerge.

6.8 INDUCTION LAMPS

The induction lamp is a type of fluorescent lamp that offers extremely long life. The cost is very high and makes these lamps appropriate only when maintenance access is extremely difficult.

Induction lamps are not suitable for large scale street lighting as their cost, about $1000, is prohibitive.

6.9 DIMMING

It is possible to dim some types of street lighting lamps. It can be economic, especially with high wattage major road lighting, to dim lamps to about 50% to save energy. Compliance with standards can be maintained, for instance, Category V3 lighting can be dimmed to 50% and Category V5 can still be achieved. The application for dimming would be major roads that are busy in the early evening but have little traffic after 9 or 10pm.

6.10 LAMP COMPARISON

The various lamp families are compared below in Table 1:

Table 1

Lamp Type ❶	**MV**	**HPS**	**MH**	**FL**	**LPS**	**LED**	**IND**
Rated Life (1000 h)	24	24	6-30	10-30	10	100	100
Economic Life (1000 h)	15	24	6-20	10-20	10	100	100
Efficacy Photopic (lumens/Watt)	40-50	90-120	80	80-100	170-200	25	100
Efficacy Scotopic (lumens/Watt)	40-50	50-70	100	80-100	NA	25	100
Power Range (W)	50-400	50-250	35-400	18-57	18-180	1	100-150
CRI ❷	OK	Poor	Good	Good	Very Poor	Good	Good

NOTES
❶ MV = mercury vapour, HPS = high pressure sodium, MH = metal halide
FL = fluorescent, LPS = low pressure sodium, LED = light emitting diode, IND = Induction.
❷ CRI = colour rendering index. An index greater than 50 is good.

The data in Table 1 is derived from lamp manufacturers represented in Australia.

Table 2 shown below compares various lamp technologies in terms of power, power per kilometre (kW/km), greenhouse gas emissions (Tonnes of CO_2 per kilometre per annum), mercury content (milligrams per lamp), life in hours, and estimated annual cost including energy and scheduled maintenance. The table assumes a standard geometry with overhead power of 80 m spacing, 7.5 m mounting height, and a 20 m road reserve.

Table 2

Lamp type ❶	**80 W MV**	**42 W CFL**	**2 x 24 W T5 FL**	**70 W MH**	**50 W HPS❾**	**70 W HPS❾**	**57 W CFL**
Power ❷ (W)	89.5	46	50	77	55	77	63
kW/km ❸	1.2	0.6	0.65	1.0	0.7	1.0	0.8
CO_2/km ❹ (T)	4	2	2.2	3.4	2.4	3.4	2.8
Category ❺	**X**	**X**	P5	P4	**X**	P4	P5
Mercury ❻ (mg)	14	4.5	6	0.01	0.02	0.02	4.6
Lamp Life ❼ (h)	16000	28000	20000	10000	20000	20000	10000
Energy Cost ❽ p.a. per lamp	$38.14	$19.60	$21.30	$32.81	$23.44	$32.81	$26.50

NOTES
❶ MV = mercury vapour, CFL = compact fluorescent, FL = fluorescent, MH = metal halide
HPS = high pressure sodium
❷ Power per lamp measured in Watts.
❸ Power required per kilometre based on a nominal spacing of 80 m.
❹ Tonnes of CO_2 produced per kilometre per annum based on 4 000 h burning and 0.9 kg of CO_2 per kWh.

❺ AS/NZS 1158.3.1 Category, **X** = non-compliant with any Category. The non-compliance refers to the geometry (80 m spacing, 7.5 m mounting height) rather than the technology. In each case compliance could be achieved with better geometry (closer spacing or higher mounting height).
❻ Mercury content in each lamp measured in milligrams.
❼ Lamp life in hours (typical burning hours for all night streetlights are 4,000 per annum)
❽ Based on Western Power tariff Z18 ($1.1676/kW per day).
❾ Twin arc tube versions of the 70 and 50 W high pressure sodium lamps are available. These lamps have twice the life of standard lamps, that is 40 000 hours instead of 20 000 hours. These lamps offer better economy through their long life, but give yellow light that is subject to a de-rating of 75%.

The data in Table 2 is derived from lamp manufacturers represented in Australia [3].

Sample calculations for CO_2 emissions are given in Appendix C.

Where non-compliance is shown against "Category", the non-compliance is due to the minimum illuminance level of AS/NZS 1158.3.1 not being achieved. With this standard geometry 80 W mercury vapour, 42 W compact fluorescent, and 50 W high pressure sodium lamps are non-compliant, but would be compliant at spacings shorter than 80 m.

While mercury vapour lamps have proved reliable for street lighting over 70 years, it is suggested that the future lies with a combination of fluorescent, metal halide, and high pressure sodium lamps that have higher energy efficiencies.

The efficacy of mercury vapour lamps is low, between 40 and 50 lumens watt. The efficacy of fluorescent and metal halide lamps is between 80 and 100 lumens/watt.

The 42 W compact fluorescent lamp will not achieve compliance with AS/NZS 1158 with the standard geometry of 80 m spacing, 7.5 m mounting height, and 20 m road reserve. However it will give performance similar to the common 80 W mercury vapour lamp while consuming half the energy.

Two 24 W T5 fluorescent lamps can achieve compliance with AS/NZS 1158 Category P5 with an energy reduction of 37.5% compared with the non-compliant 80 W mercury vapour lamp. The 70 W metal halide and 70 W high pressure sodium lamps can achieve compliance with AS/NZS 1158 Category P4 with an energy reduction of 14% compared with the non-compliant 80 W mercury vapour lamp.

The efficacy of high pressure sodium lamps is between 90 and 120 lumens/watt in the photopic (day light) range of vision and between 50 and 70 lumens/watt in the scotopic (night) range of vision. For street lighting the range of vision lies between the photopic (daylight) and scotopic (night). High pressure sodium lamps have the highest efficacy when used for street lighting at high illuminance levels, that is, towards the photopic range, and lower efficacy at low illuminance levels.

Mercury vapour lamps have about half the efficacy of the fluorescent, metal halide and high pressure sodium lamps.

Table 3 shown below compares the annual running costs of specific lamps relative to their light output.

Table 3

Lamp type ❶	**80 W MV**	**42 W CFL**	**2 x 24 W T5 FL**	**70 W MH**	**50 W HPS**	**70 W HPS**	**57 W CFL**
Lamp Life ❷ (years)	4	5	5	2.5	5	5	2.5
Lamp cost ❸ ($)	2.95	6.99	12.50	33.00	15.00	14.50	24.60
Labour cost ❹ ($)	32.50	32.50	32.50	32.50	32.50	32.50	32.50
Plant cost ❺ ($)	42.50	42.50	42.50	42.50	42.50	42.50	42.50
Cost per re-lamp❻ ($)	77.95	81.99	87.50	108.00	90.00	89.50	99.60
Re-lamp cost pa ❼ ($)	19.49	16.40	17.50	43.20	18.00	17.90	39.84
Power ❽ (W)	89.5	46.0	50.0	77.0	55.0	77.0	63.0
Energy Cost ❾ p.a.	38.14	19.60	21.30	32.81	23.44	32.81	26.50
Running cost ❿ p.a. ($)	57.63	36.00	38.80	76.01	41.44	50.71	66.34
Light output lumens	3600	3200	3500	4900	4400	6500	4300
Running cost per kilo-lumen ($) p.a.	**16.00**	**11.25**	**11.09**	**15.51**	**9.42**	**7.80**	**15.43**

NOTES

❶ MV = mercury vapour, CFL = compact fluorescent, FL = fluorescent, MH = metal halide HPS = high pressure sodium

❷ Lamp life in hours divided by 4,000 hours per annum.

❸ Lamp cost based on lamp manufacturers' information

❹ Labour cost based on ½ hour re-lamp time @$65/hour (electrician/linesman)

❺ Plant cost based on ½ hour re-lamp time @$85/hour (plant and operator)

❻ Sum of lamp cost, labour cost, and plant cost

❼ Cost per re-lamp divided by lamp life in years

❽ Power per lamp measured in Watts

❾ Based on Western Power tariff Z18 ($1.1676/kW per day).

❿ Sum of re-lamp cost pa and energy cost pa.

Table 3 assumes that the existing street light luminaires need to be replaced and that the cost of replacement luminaires will be the same regardless of the selected technology. This assumption is based on most existing street lights being due for replacement as they would have exceeded their expected life. Prior to 2005, Australian Standards specified a life of 15 years for street light luminaires. AS/NZS 1158 – 2005 now specifies 20 years.

The running cost per kilo-lumen p.a. for the 80 W mercury vapour lamp is calculated as follows:

Re-lamp cost p.a. =	($2.95 + $32.50 + $42.50) ÷ 4 years	= $19.49
Energy cost p.a	(89.5 W ÷1000 x $1.1676/day x 365	= $38.14
TOTAL COST p.a.		= $57.63
TOTAL COST PER kilo-lumen p.a. =	$57.63 ÷ 3.6 kilo-lumens	= $16.00

6.11 COMPARISON OF PRACTICES

6.11.1 ENGLAND

In England low pressure sodium lamps have historically been preferred for both minor and major roads. This lamp was originally selected because of its high efficacy (up to 200 lumens/watt).

The lamp produces yellow monochromatic light that does not support colour vision. These lamps are being replaced by high pressure sodium lamps on major and minor roads for their superior colour characteristics.

Where there is a perceived security risk or where security cameras are in use, white light sources, such as metal halide, or compact fluorescent lamps, are favoured.

In discussion with lighting engineers from Surrey and Hampshire [4], a preference for 57 W compact fluorescent lamps was expressed. Trials had been undertaken with this lamp, high pressure sodium, and 35 W metal halide. The perception from this trial was that the 35 W metal halide lamp with its small envelope was very glary compared with the 57 W compact fluorescent lamp with its larger envelope and thus lower lamp brightness.

Mercury vapour lamps are not used for street lighting in England because of their poor efficiency.

6.11.2 NORTH AMERICA

In North America, mercury vapour lighting has been used for minor roads and high pressure sodium lighting for major roads. There is a tendency towards metal halide for its white light and high efficacy both for upgrading minor and major roads. The City of New York selected metal halide lighting for 40th Street to provide "white light" [5].

6.11.3 SOUTH AFRICA

In South Africa, a mixture of mercury vapour and high pressure sodium lamps is used for minor road lighting. Generally, mercury vapour lamps are being replaced with high pressure sodium lamps.

The lowest output lamp used is the 125 W mercury vapour. These are being replaced with 70 W high pressure sodium lamps.

With major roads, historically a mixture of high pressure sodium, low pressure sodium and mercury vapour has been used. Mercury vapour and low pressure sodium lamps are being replaced with high pressure sodium.

The national standard is NRS 10098 Part1: The lighting of public thoroughfares and Part 2: The lighting of certain specific areas of streets and highways. The City of Cape Town insists that the national standard is applied to all new street lighting. [6]

6.11.4 NEW ZEALAND

In New Zealand, high pressure sodium streetlights are preferred for major and minor roads.

6.11.5 AUSTRALIA

In Australia mercury vapour lamps have been preferred for minor road lighting. Some fluorescent lighting has also been used, particularly around the Sydney metropolitan area. More recently there have been a number of initiatives to change lamp technologies to achieve better energy efficiency.

In Western Australia there has been a number of energy efficiency driven street lighting initiatives in Midvale, Mosman Park, Subiaco and Joondalup.

In **Midvale**, 70 W metal halide streetlights have replaced 80 W mercury vapour streetlights. These streetlights are mounted on timber power poles at a spacing of 80 m. Not only has energy consumption been reduced by 14% but the lighting levels increased from substandard to AS/NZS1158.3.1 Category P4 thus enhancing security for the community.

In **Mosman Park** a combination of compact fluorescent, metal halide and high pressure sodium streetlights have replaced 80 W mercury vapour streetlights. These streetlights have been installed on steel poles as part of an Underground Power Program. The new lighting complies with AS/NZS 1158 whereas the previous lighting was substandard.

In **Subiaco**, 42 W compact fluorescent streetlights on 3.5 m and 4.5 m steel poles have replaced 80 W mercury vapour streetlights on overhead power poles. This has either been part of City installations or of an Underground Power Program. The new lighting complies with AS/NZS 1158.3.1 Category P4 whereas the previous lighting was substandard.

In **Joondalup** City Centre, the City of Joondalup proposes replacing the 1980's decorative road lighting with more energy efficient road lighting. The proposal can reduce the energy consumption by 60%. The new lighting will comply with AS/NZS 1158 whereas the old lighting was patchy and substandard.

The following techniques will be used in Joondalup:
- Efficient metal halide lamps
- Effective optical systems
- Low energy loss electronic ballasts
- Bi-level switching reducing lighting levels in the late evening when traffic decreases

Coffs Harbour in New South Wales has replaced all of their mercury vapour lamps with 50 W high pressure sodium lamps [7]. This program was initiated to save energy and thus greenhouse gas emission and was completed in September 2005. Coffs Harbour chose the high pressure sodium lamp as it was established technology and the luminaires could be upgraded to metal halide or compact fluorescent when those technologies were more mature. The luminaires have proven to be reliable and community feedback has been positive.

In **Canberra**, compact fluorescent lamps have been retrofitted to existing incandescent street lights. These lamps are 28 W self ballasted with E27 screw bases. Problems of short life have been experienced. This is being addressed with better specification to obtain lamps of better manufacture. The cold weather in Canberra may be a contributing factor to the short life of these lamps.

Banyule City Council in Victoria is trialling the Pierlite "Greenstreet" luminaire with high efficiency T5 (26 mm diameter) fluorescent lamps [8]. Twin 14 W luminaires have replaced 80 W mercury vapour luminaires on existing power poles spaced 80 m apart. Over two years these luminaires have worked well with a reduction of two thirds of the energy and greenhouse gases and positive community feedback. The luminaires have proven to be robust, reliable and with no insect or water ingress.

In Victoria, **Integral Energy** has installed about 3000 Greenstreet luminaires with success.

The **South Sydney Regional Organisation of Councils** (SSROC), through their service provider Energy Australia, from 2004, stopped installing 2 x 18 W fluorescent streetlights and installed 80W mercury vapour Sylvania Suburban streetlights as an interim measure for two years[9]. On behalf of SSROC, the consultant Next Energy is evaluating two candidate luminaires: the Pierlite 2 x 14 W and 2 x 24 W T5 Greenstreet Mark III luminaire; and the Sylvania 32 W and 42 W compact fluorescent Suburban Eco luminaire. The NSW State Government is intending to contribute $4.2 million from their Energy Saving Fund to SSROC for residential and major road lighting upgrades. From October to December 2006, the major road lighting upgrade should commence as well as pilot trials of minor road lighting to test the candidate luminaires. Large scale replacement is due to start early in 2007.

The **City of Adelaide** is converting all of its street lighting to metal halide. The reasons for this conversion are energy efficiency and the community security provided by the white light of metal halide lamps.

The **Australian Greenhouse Office** engaged Genesis to undertake a study entitled "*Public Lighting in Australia – Energy Efficiency Challenges and Opportunities".* This study required:

- An overview of public lighting in Australia.
- As assessment of the total public lighting stock in Australia.
- Assessments of the state of play in Australia regarding the timing of batch re-lamping.
- A review and assessment of significant public lighting trials in Australia & overseas.
- A range of best practice scenarios for public lighting decision makers.
- A range of robust "scenario calculators".

This report was published late in 2005 and released on 9 February 2006. [10]

The Australian Greenhouse Office is producing a guide towards energy efficient street lighting. This guide will encourage local government to consider alternatives to the 80W mercury lamp.

ICLEI, the International Council for Local Environmental Initiatives, is encouraging energy efficient street lighting through the Cities for Climate Protection program.

ICLEI ran a forum in May 2005 and in March 2006 covering many sustainability issues including street lighting.

The Cities of Armadale, Bunbury, Cockburn, Gosnells, Nedlands, Perth, the Shire of Serpentine/Jarrahdale, and the City of Subiaco have been participating in these workshops.

MEPS, Minimum Energy Performance Standards, are generally Australian Standards documents that apply to components, such as lamps and lamp control gear, rather than systems. However the MEPS document, "Minimum Energy Performance Standards, Design Energy Limits for Main Road Lighting" covers lighting systems [11]. This document applies only to Category V lighting and lists power limits per metre for different road geometries and different lighting categories.

Table 4 lists two common categories and geometries, where the following power limits are specified:

Table 4

CATEGORY	GEOMETRY	POWER LIMITS (W/m)	
		Mandatory	High Efficiency
AS/NZS 1158 V3	7m, dual carriageway	7.3	5.5
AS/NZS 1158 V5	7m, dual carriageway	6.2	5.5

6.11.6 TRENDS

Internationally there appears to be a general trend away from low pressure sodium (poor colour) and mercury vapour (poor efficacy) lamps towards better colour and higher efficacy lamps.

This trend is outlined below:

ENGLAND	LPS → HPS and some MH and CFL
NORTH AMERICA	MV → MH
SOUTH AFRICA	MV & LPS → HPS
NEW ZEALAND	MV → HPS
AUSTRALIA	MV & HPS → CF/MH/HPS

6.12 LIGHTING STANDARDS

6.12.1 NATIONAL STANDARDS

AS/NZS 1158.3.1-2005 is the current national standard covering lighting of minor roads. Changes from the 1999 edition include:

- Consideration of energy consumption and efficiency.
- Recommendations on de-rating of sodium lamps for Categories P4 and P5.
- Reductions in the maximum Upward Wasted Light Ratio (to reduce light pollution and energy wastage).
- Revisions and clarifications on lighting of local area traffic management devices, curves and intersections, and car parks.

This standard contains 12 Categories of lighting of which 5 Categories, P1 to P5 cover most minor roads and pathways. The other Categories cover town squares, transport terminals, car parks, etc.

Category P5 generally should only be applied to replacement of luminaires on existing power poles. (Refer footnote e) on page 11 of AS 1158.3.1:2005).

This standard is largely performance based and recommends a number of Light Technical Parameters to be achieved. These parameters are average lighting level (lux), minimum lighting level (lux), uniformity, and for higher Categories, vertical lighting level (lux) at face height.

The standard does not specify lighting equipment or energy consumption, but the currently published draft does require an "Energy Audit". This audit is required in general rather than specific terms.

Most lighting of minor roads in Western Australia is below the lowest Category of AS/NZS 1158.3.1. Local Government may be exposed to litigation if they have facilities that do not comply with a national standard even when that standard is not mandatory.

The Inquest dated 1 April 2004 on the death of Leon Russell Coomerang on 28 February 2002 emphasised the contribution of substandard street lighting to the death.

The State Coroner stated:

"I recommend that all Local Government bodies ensure that new roads constructed are adequately illuminated and that the illumination is at least in excess of Australian/New Zealand Standards and that in the case of existing roads regular reviews are conducted to ensure that all relevant standards are met and effective maintenance programs are in place" [12]

6.12.2 INTERNATIONAL STANDARDS

Appendix A contains a summary of the Australian & New Zealand Standard, the British and European Standard, and the North American Standards.

The comparison of Standards in Appendix A shows that South African, European and North American Standards demand higher lighting levels for pedestrian areas than AS/NZS 1158.3.1.

Category P3 of AS/NZS 1158.3.1 corresponds to the lowest Category B3 of SABS 098. AS/NZS 1158.3.1 offers Categories P4 and P5 below this level. The South African standard is thus two steps higher than the Australian Standard.

Category P3 of AS/NZS 1158.3.1 corresponds approximately to the lowest Category S6 of BS/EN 13201 in terms of average illuminance, but the minimum illuminance of Category P3 is half that of BS/EN 13201 category S6. The European standard is thus two steps higher than the Australian Standard.

Category P2 of AS/NZS 1158.3.1 corresponds to the lowest Category of the North American standard for "Residential" street lighting. AS/NZS 1158.3.1 offers Categories P3, P4, and P5 below this Category. The North American Standard is thus three steps higher than the Australian Standard.

AS/NZS 1158.3.1 therefore cannot be viewed as excessive or "gold plated" when compared to the standards of other countries. Australia enjoys a warmer, drier climate than most parts of Europe and North America and night vision is not commonly impeded by snow, hail and fog. This can possibly explain the lower lighting levels of the Australian Standard.

6.12.3 ENERGY EFFICIENCY

As previously mentioned, AS/NZS 1158.3.1:2005 does mention energy auditing, but it treats energy auditing in a qualitative rather than quantitative way. The standard states that the audit is in three parts:

- i) Hardware used (with a view to minimizing the use of capital equipment which itself requires high energy inputs during manufacture).
- ii) Electricity use in the lamp and control gear.
- iii) Energy (electricity and other) used in the maintenance of the system commensurate with ensuring reliability and the efficiency of the scheme.

Appendix E of AS/NZS 1158.3 gives the required documentation if an energy audit is requested.

6.13 OBTRUSIVE LIGHT

Western Power reports they receive as many complaints about obtrusive light as they do about poor lighting. Obtrusive light is spill light that causes annoyance, discomfort, distraction or reduction in the ability to see essential information.

Obtrusive light can affect:

- Residents, **-** Difficulty in sleeping may be experienced due to light entering bedroom windows or due to the direct view of bright light sources.

- Transport System Users, **-** Disability glare reduces the ability to see objects in the environment and reduces the visibility of transport signalling systems. Marine and air navigation are also affected by obtrusive light.

- Astronomical Observation, **-** Sky glow from lighting systems lightens the dark sky and reduces the ability to see the night sky. To the community this is a general loss of amenity but to astronomers this is a particular concern. In the vicinity of observatories there are guidelines that need to be followed to avoid obtrusive light.

Obtrusive light and energy efficient lighting go hand in hand. Obtrusive light is not only a nuisance but also a waste of energy. Raising the standard of street lighting does not necessarily mean "too much light", or obtrusive light. Efficient optical systems direct the light where it is needed and reduce obtrusive light.

AS/NZS 1158 addresses the control of obtrusive light from road lighting in terms of the maximum Upward Waste Light Ratio from roadlighting luminaires.

7 LONG TERM FIELD STUDY

7.1 MEASUREMENTS

Illuminance levels in lux are being recorded in Midvale, Mosman Park and Subiaco in Western Australia in an area that has been re-lit with energy efficient lighting and in a control area lit with existing mercury vapour streetlights. Readings are being taken under each streetlight and directly opposite the streetlight at the edge of the road. Readings are being taken on nights when the moonlight does not interfere with the readings. Readings will be taken regularly over two years commencing at the end of 2004, and being completed at the end of 2006.

The locations of the trial are recorded in Appendix D. The measurements of the trials are recorded in Appendix E.

7.2 ECONOMIC IMPACT

In Western Australia, the cost of street lighting to Local Government is of the order of $20 million per annum. This cost includes an energy component and a maintenance component. In a large Local Government area, the cost of street lighting is about $1 million per annum.

Present indications are that while modern lamps can halve energy consumption and cost, the maintenance cost may increase. The increase in maintenance cost would be due to the shorter life of some of the modern lamps and the higher purchase cost of some modern lamps compared with mercury vapour lamps.

7.3 ENVIRONMENTAL IMPACT

Street lighting is a major component of Local Government energy consumption. The metropolitan area has about 10 000 km of sealed roads and if these are lit with 80 W mercury vapour street lights at 80 m spacing, burning 4,000 hours per annum, the energy consumption is 44,750 kWh (89.5 W (including ballast losses) ÷ 1,000 x 10,000,000 m ÷ 80 m x 4,000 = 44,750 kWh).

Assuming 0.9 of CO_2 per kWh street lighting causes CO_2 emissions amounting to 40 million kg per annum or 40,000 tonnes per annum.

Synergy does not break down their street lighting accounts into energy, maintenance and ownership components. If the common 80W mercury vapour street light is considered, the ZE02 tariff is 23.53 cents per day. The ZE02 tariff includes the cost of energy, maintenance and ownership. However, at the Z18, energy only tariff, the energy cost is 9.34 cents per day. This hypothetical comparison indicates that the energy cost component is 40% of the total cost. If energy could be halved without an increase in maintenance and ownership costs, there is a potential to reduce the total cost of street lighting by 20%.

7.4 RESULTS & RECOMMENDATIONS

7.4.1 MEASUREMENTS

The measurement data sheets are presented in Appendix E.

Three maintenance criteria are stated in the Electricity Supply Association of Australia.

- DEPRECIATION – Light Technical Parameters shall not fall below 70%.
- REPAIR TIME – Luminaire failures should be repaired within 5 days.
- RELIABILITY – No less than 95% of luminaires shall be operational at any time.

Depreciation is defined as the loss of light output over time as lamps age and optical surfaces collect dirt and deteriorate. The field trials address depreciation and reliability.

The average depreciation over the period of the field trials is shown in Table 5 below:

Table 5

SITE	TECHNOLOGY	DEPRECIATION
SUBIACO	Compact Fluorescent	81%
	Mercury Vapour	83%
MIDVALE	Metal Halide	73%
	Mercury Vapour	63%
MOSMAN PARK	Compact Fluorescent	61%
	Metal Halide	77%
	High Pressure Sodium	87%
	Mercury Vapour	88%

The reliability for the period of field trials is shown in Table 6 below:

Table 6

SITE	TECHNOLOGY	RELIABILITY
SUBIACO	Compact Fluorescent	97%
	Mercury Vapour	94%
MIDVALE	Metal Halide	90%
	Mercury Vapour	80%
MOSMAN PARK	Compact Fluorescent	81%
	Metal Halide	96%
	High Pressure Sodium	80%
	Mercury Vapour	75%

A 97% reliability indicates that over the four field trials 3% of the streetlights were not working. The poorest reliability was that of the mercury vapour streetlights in the southern part of Mosman Park where 25% of the streetlights were not working.

The greenhouse gas emissions are indicated in Table 7 below:

Table 7

SITE	TECHNOLOGY	AS/NZS 1158 COMPLIANCE	ENERGY PER km p.a.	GREENHOUSE GAS PER km p.a.
SUBIACO	CFL	P4	1.32 kW	4.8 T *
	MV	**X**	1.12 kW	4 T
MIDVALE	MH	P4	1.0 kW	3.4 T
	MV	**X**	1.12 kW	4 T
MOSMAN PARK	CF	P5	0.57 kW	2.1 T
	MH	P4	1.13 kW	4 T
	HPS	P3	1.37 kW	4.9 T
	MV	**X**	1.12 kW	4 T

* Greenhouse Gas Emissions in Subiaco increased because the previous mercury vapour lighting was well below standard and the new lighting aimed to comply with Australian Standards.
X The lighting does not comply with AS/NZS1158**.**

7.4.2 DISCUSSIONS ON MEASUREMENTS

Depreciation

The depreciation results indicate:

- In Subiaco there are similar rates of depreciation for compact fluorescent and mercury vapour lamps.
- In Midvale there is a higher depreciation rate for mercury than metal halide lamps.
- In Mosman Park there is a higher depreciation rate for compact fluorescent and metal halide lamps when compared with high pressure sodium and mercury vapour lamps. The high pressure sodium & mercury vapour lamps in Mosman Park have similar depreciation rates.

Reliability

The reliability results have to be weighed against the following considerations:

In Subiaco, many compact fluorescent lamps have been replaced as a result of water ingress into the luminaires. The water ingress is a luminaire problem rather than a lamp technology problem.

In Midvale, the City of Swan discontinued their Bulk Globe Replacement (BGR) program with Western Power on 1 July 2005. This was due to a lack of funding rather than any dissatisfaction with the BGR program.

In Mosman Park, there were initial problems with poor quality manufacture of compact fluorescent lamps. This was rectified by sourcing lamps of better quality.

The reliability figures reflect observations at the time of the field trials. Lamps may have had to be replaced in between the times of the field trials.

The poorest reliability in the field trials is that of the mercury vapour street lights in Mosman Park. What is encouraging is that the newer technologies are exhibiting better reliability than mercury vapour. This is surprising as it has been claimed that mercury vapour, despite its poor energy efficiency, has a long reliable life.

In both Midvale and Mosman Park, the reliability of the mercury vapour street lights is so poor, 80% and 75%, as to present a safety and security hazard. With these streetlights normally spaced 80 m apart, there is a blackspot of about 20 m in between. With failed streetlights the spacing could extend to 160 m resulting in a blackspot of 100 m with no lighting.

At this stage, the field trials are indicating that the newer technologies of compact fluorescent, high pressure sodium and metal halide lamps are performing similarly to mercury vapour lamps in terms of depreciation and reliability.

Greenhouse Gas Emissions

In Subiaco the emissions have increased 20% mainly because the lighting has been improved to comply with Category P4 of AS/NZS 1158 which required a significant number of new streetlights whereas the old lighting was below standard spacings of 80 m and more.

In Midvale the emissions have dropped 15% even though the lighting has been improved to Category P4 of AS/NZS 1158. It is noted that there are no additional streetlights.

In Mosman Park, emissions have remained the same where metal halide lighting to Category P4 of AS/NZS 1158 has been installed to replace below standard lighting. Emissions on Local Distributor roads have increased 22% where high pressure sodium lighting has been installed to the higher Category P3 of AS/NZS 1158, replacing previously below standard lighting. Similar to Subiaco, there was also a significant increase in the number of streetlights.

7.4.3 RECOMMENDATIONS

This report submits the following recommendations:

- **Standards**
  WALGA encourage Local Government to adopt AS/NZS 1158 as a policy for technical design of streetlight networks. AS/NZS is appropriate, and should not be considered as excessive. There is a risk to Local Government if they do not comply with a national standard.
- **Efficient light technologies**
  WALGA encourage Western Power and Local Government to use the more efficient lamp technologies in new and replacement street lights.
- **Underground Power Program**
  The Office of Energy encourages energy efficient street lighting for Underground Power Projects, and specifies appropriate AS/NZS 1158 Categories.
- **Synergy/Western Power Invoicing**
  Synergy provides a price breakdown listing maintenance, replacement, energy, and administrative costs to individual Local Government clients.
- **Mercury**
  On overhead power systems, the 80 W mercury street light at 80 m spacing does not comply with AS/NZS 1158. Mercury vapour lamps have half the efficiency of modern lamps. Consequently the use of mercury vapour lamps should be phased out by responsible authorities.
- **Western Power**
  WALGA request Synergy and Western Power to include fluorescent lamps such as compact fluorescent and T 5 fluorescent lamps in their available stock.
- **Energy Efficient Street Lighting Technologies**
  For minor road lighting two technologies are available to Local Government:
  - 42 W compact fluorescent
  - 2 X 24 W T5 fluorescent

Both lamps are mature, not emerging technologies. The compact fluorescent lamp has been available since 1982 and the 42 W version since the early 1990's. T5 fluorescent lamps have been available since the mid 1990's. Both lamp technologies are available in Australian made street lights.
These technologies are equivalent in light output to the common 80 W mercury vapour lamp and offer a halving of energy consumption and greenhouse gas emissions.

8 REFERENCES

1 A History of Subiaco, Ken Spillman, 1985

2 State Underground Power Proposals Guidelines for Round Four, Office of Energy, undated.

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5 New Notions of Night Light, Henri Bérubé, Security Management, December 1994.Toronto

6 Email correspondence with the City of Cape Town Public Lighting Manager & staff, January 2006.

7 Telephone discussions with Rob Fletcher of Coffs Harbour (02 6648 4415) August 2004. CD available entitled "Coffs Harbour City Council Energy Efficient Street Lighting Info".

8 Telephone discussion with lighting manufacturer Pierlite who supplied streetlights to Banyule, 2004, and with Paul Brown (03 9433 3219) ex Banyule environmental officer.

9 An article entitled "Street lighting review", Engineers Australia, October 2002.

10 Public Lighting in Australia – Energy Efficiency Challenges and Opportunities, Australian Government Department of Environment and Heritage, Australian Greenhouse Office Final Report 2005 (prepared by Genesis Automation, Kevin Poulton & Associates, and Deni Greene Consulting Services).

11 Minimum Energy Performance Standards, design Energy Limits for Main Road Lighting, National Appliance and Equipment Energy Efficiency Program, Report No: 2005/18.

12 Inquest of the Western Australian State Coroner on the death of Leon Russell Coomerang on 28 February 2002, 1 April 2004

9 TABLE OF ANNEXURES

1 TABLE OF APPENDICES

APPENDIX A

LIGHTING STANDARDS

AS/NZS 1158.3.1: 2005- ROAD LIGHTING- Pedestrian Area Lighting
AS/NZS 1158.1:2005- ROAD LIGHTING- Vehicular Traffic Lighting
BS EN 13201 – Road Lighting
IES North America Recommendations for Road lighting
IES North America Guidelines for Security
Lighting for People, Property and Public Spaces.
South African SABS 098
Comparison of Standards

AS/NZS 1158.3.1:2005 Pedestrian area lighting

Roads & Pathways

Lighting Category❷		P1❸	P2❸	P3	P4	P5	P6	P7	P8
Type Of Road Or Pathway				MIXED VEHICLE & PEDESTRIAN TRAFFIC Pedestrian or cycle orientated pathways, eg footpaths, including along arterial roads, walkway, lanes, park paths, cycle paths (P1 to P4 apply) Collector roads or non-arterial roads which collect and distribute traffic in an area, as well as serving abutting properties Local roads or streets used primarily for access to abutting properties including residential properties. Common area, forecourts of cluster housing			GENERALLY PEDESTRIAN MOVEMENT ONLY • Areas primarily for pedestrian use, e.g. city, town, suburban centres, including outdoor shopping precincts, malls, open arcades, town squares, civic centres MIXED PEDESTRIAN & VEHICLE TRAFFIC • Transport terminals and interchanges, service areas		(similar to P1)
Selection Criteria ❶❸	Activity	n/a	High	Med	Low	Low	Ped only N/A Mixed - High	Med	Low
	Risk of crime	High	Med	Low local roads -	Low	Low	High	Med	Low
	Need to enhance prestige	n/a	High	Med	n/a	n/a	High	Med	n/a
1.1.1.1.1.1 Light Technical Parameters									
Maintained Average Horizontal Illuminance (lux)		7	3.5	1.75	0.85	0.5	21	14	7
Maintained Horizontal; Illuminance (lux)		2	0.7	0.3	0.14	0.07	7	4	2
Maximum Horizontal lluminance Uniformity E_{max}/E_{ave}		10	10	10	10	10	10	10	10
Maintained Vertical Illuminance ❹ (E_v) lux		2	0.7	0.3❺	n/a	n/a	7	4	2

Connecting Elements and Outdoor Car Parks

Lighting Category	P9	P10	P11a	P11b	P11c	P12
Type Of Road Or Pathway	Steps, ramps, footbridges, pedestrian ways.	Subways, including associated ramps or steps ❻	Parking spaces, aisles and circulation roadways ❼			Parking spaces for people with disabilities ❼
Night time vehicle or pedestrian movements	N/A	N/A	High	Medium	Low	N/A
Night time occupancy			>75%	>25%, <75%	<25%	
Risk of crime			High	Medium	Low	
1.1.1.1.1.2 Light Technical Parameters						
Maintained average horizontal Illuminance (lux) Eh	Same as for highest lighting category applying to adjacent connected areas but, where forming part of a road or pathway, to not less than Category P8	35	14	7	3.5	-
Maintained horizontal; Illuminance (lux)		17.5	3	1.5	0.7	>14 & >Eh
Maximum horizontal Illuminance Uniformity E_{max}/E_{ave} (U_p)		10	10	10	10	-
Maintained vertical Illuminance ❹ (E_v) lux		17.5	3	1.5	-	-

NOTES:

❶The highest level of selection criteria that is deemed appropriate for the road or pathway will determine the applicable lighting category.
❷P3, P4 & P5 apply across the whole road reserve. P1 & P2 apply only to the formed footpath
❸Where there are good vertical reflecting surfaces alongside the pathway, the next lower lighting category may be selected
❹Applies at 1.5m above the surface of the area.
❺The vertical illuminance requirement for Category P3 applies to pathways not local roads
❻Subway walls should have a light colour
❼Luminaires should be located to highlight obstruction and hazards. For indoor car parks refer to AS1680.2.1

AS/NZS 1158.1.1: 2005 - ROAD LIGHTING - Vehicular Traffic Lighting

Lighting Category	V1	V2	V3		V4	V5
1.1.2 APPLICATIONS Note: for all applications the upward waste light ratio should not exceed 6%	Arterial or main roads in central and regional activity centres of capital and major provincial cities, and other areas with major abutting traffic generators	Arterial roads that predominantly carry through traffic from one region to another, forming principal avenues of communication for traffic movements with major abutting traffic generators	Arterial roads that predominantly carry through traffic from one region to another, forming principal avenues of communication for traffic movements	Freeways, motorways and expressways consisting of divided highways for through traffic with no access for traffic between interchanges and with grade separation at all intersections	Sub-arterial or principal roads which connect arterial or main roads to areas of development within a region, or which carry traffic directly from one part of a region to another part.	
1.1.2.1.1.1 Light Technical Parameters						
Minimum Average Luminance L(cd/m^2) (maintained)	1.5	1.0	0.75		0.5	0.35
Min Overall Uniformity U_o	0.33	0.33	0.33		0.33	0.33
Min Longitudinal Uniformity Ul	0.5	0.5	0.5		0.5	0.5
Max Threshold Increment TI(%)	20	20	20		20	20
Min Surround Illuminance ES(%)	50	50	50		50	50
At Intersections - Min Point horizontal Illuminance E_{min}, lux (maintained)	15	10	7.5		5	3.5
Max Illuminance Uniformity E_{max}/E_{min}	8	8	8		8	8
Max Upward Waste Light Ratio %	3	3	3		3	3

Notes on reflectance characteristics:
R1 = light diffuse road (eg concrete)
R2 = diffuse & specular (eg asphalt with artificial brightener in aggregate)
R3 = slightly specular, typical highways and MRWA design standard
R4 = mostly specular, very smooth texture

RECOMMENDATIONS OF BS EN 13201:2003 ROAD LIGHTING

CATEGORY	LIGHT TECHNICAL PARAMETERS	
Conflict areas, shopping streets complex intersections, roundabouts, queuing areas	**Horizontal Illuminance**	
	E (ave) lux	Uniformity min
CE0	50	0.4
CE1	30	0.4
CE2	20	0.4
CE3	15	0.4
CE4	10	0.4
CE5	7.5	0.4
Paths and residential roads:	**Horizontal Illuminance**	
	E (ave) lux	E (min) lux
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	
Paths and residential roads:	**Hemispherical Illuminance**	
	E hs(ave) lux	Uniformity min
A1	5	0.15
A2	3	0.15
A3	2	0.15
A4	1.5	0.15
A5	1	0.15
A6	Performance not determined	
Pedestrian areas to reduce crime:	**Semi-circular illuminance**	
	E sc, (min) lux	
ES1	10	
ES2	7.5	
ES3	5	
ES4	3	
ES5	2	
ES6	1.5	
ES7	1	
ES8	0.75	
ES9	0.5	

E (ave) = Average illuminance of vehicular and pedestrian surfaces (maintained)
E (min) = Minimum illuminance of vehicular and pedestrian surfaces (maintained)
Esc, (min) = Semi-cylindrical Illuminance (maintained)

IES NORTH AMERICA RECOMMENDATIONS FOR ROAD LIGHTING

ROAD & AREA CLASSIFICATION	Freeway		Expressway			Major			Collector			Local		
	Class A	**Class B**	**Commercial**	**Intermediate**	**Residential**	**Commercial**	**Intermediate**	**Residential**	**Commercial**	**Intermediate**	**Residential**	**Commercial**	**Intermediate**	**Residential**
Average Luminance L_{ave} (cd/m^2)	0.6	0.4	1.0	0.8	0.6	1.2	0.9	0.6	0.8	0.6	0.4	0.6	0.5	0.3
Luminance Uniformity L_{ave}/L_{min}	3.5		3	3	3.5	3	3	3.5	3	3.5	4	6		
Luminance Uniformity L_{max}/L_{min}	6	6	5	5	6	5	5	6	5	6	8	10		
Veiling Luminance Ratio (maximum)❶ L_v/L_{ave}	0.3		0.3			0.3			0.4			0.4		
Average Maintained Illuminance, lux														
Road Surface Classification ❷ R1	6	4	10	8	6	12	9	6	8	6	4	6	5	3
Road Surface Classification ❸ R2 & R3	9	6	14	12	9	17	13	9	12	9	6	9	7	4
Road Surface Classification ❹ R4	8	5	13	10	8	15	11	8	10	8	5	8	6	4
Illuminance Uniformity E_{ave}/E_{min}	3		3			3			4			6		

Notes:

❶ L_v = veiling Luminance
❷ R1 = light diffuse road (eg concrete)
❸ R2 = diffuse & specular (eg asphalt with artificial brightener in aggregate), R3 = slightly specular, typical highways
❹ R4 = mostly specular, very smooth texture

IES (NORTH AMERICA) GUIDELINES FOR SECURITY LIGHTING FOR PEOPLE, PROPERTY AND PUBLIC SPACES

		E_h	E_v	U (ave/min)
Unoccupied Spaces (acceptable losses): - storage yards, industrial equipment areas and container terminals		5-20	-	8
Unoccupied Spaces (unacceptable losses): - storage yards, industrial equipment areas and container terminals		10-20	-	6
Building Façade		-	5-20	8
Building Interior		10	-	6
Facial Identification		-	5-8	4
Guarded Facilities:	Entrances & gatehouse inspection	100		3
	Guardhouse interior	❷	❶	
A.T.M.'S (Exterior):	Face of ATM	-	150	3
	Within 3.5m	100	-	-
	3.5 to 15.2m	20	❶	3
	Supported Parking 18.5m			
	Side of building out to 12.2m when ATM within 3.5m of corner			
A.T.M.'S (Interior):	Face of ATM	-	150	3
	Preparation of ATM	150	❶	3
	Other areas of enclosure	100	❶	-
Parking Facilities Garages & Covered Parking Spaces	On pavement	60	❶	4
	Gathering points (stairs, elevator, ramps)	50		
Parking Garages for the Elderly	Entrance	500	❶	4
	Exterior walkways around senior facilities			
Parking Lots, Areas for Public Parks	Open parking spaces	30	❶	4
	Park trails and walkway	6		
	Likely loitering areas	10		
Supermarket, Major Retail Parking	Parking lot	30	❶	4
	Low activity – close-in parking	50		
Fast Food Restaurants	General Parking	30	❶	3
	Drive up window out to 9.1m	60		
	Refuse area	30		
Convenience Stores & Gas Stations	Pump Island	60	❶	4
	Sidewalks, refuse areas & grounds	30		
	Interior of store	300		
Single Family Residences	Exterior doorways	-	8	-
Multi-family Residences	Common areas	30	❶	4
	Mail box areas	100		
Senior Housing	Hallways/Room Entrances (Active hours)	300	❶	-
	Hallways/Room Entrances (Sleeping hours)	100		
Schools & Institutions	General Parking	30	❶	4
	Sidewalks & footpaths	10		
Law enforcement, Fire, Ambulance & other Emergency Service Facilities	Within 18.2m of all vehicle and pedestrian movement areas	80	❶	3
	General parking and walkways	30		
Hotel & Motels	General Parking	30	❶	4
	Sidewalk and grounds	10		

❶ Ev 5 to 8 lux or ≥ 25% Eh

❷ Interior illuminance should be minimum recommended for specific task performance.

RECOMMENDED LIGHTING VALUES OF SABS 098 (amdt 1996)

Part 1 STREETS AND FOOTWAYS

Lighting Category	Type of Street	Min. average horizontal illuminance	Min. horizontal illuminance	Min. semi-cylindrical illuminance
B1	Residential streets in high density residential areas and medium to high traffic volume traffic	5	1	2
B2	Residential streets in medium density residential areas and medium volume traffic	3	0.6	1
B3	Residential streets in low density residential areas and low volume traffic	2	0.4	0.6
C1	Wholly pedestrian in city centre	10	3	7.5
C2	Wholly pedestrian in local shopping malls	7.5	1.5	3

Part 2: Roadway Lighting

Lighting Category	Type of Road	Without Median												With Median											
		Max traffic volume during darkness (motor vehicles per hour)																							
		>600				300				100				>900				600				200			
		L_n	U_o	U_l	TI	L_n	U_o	U_l	TI	L_n	U_o	U_l	TI	L_n	U_o	U_l	TI	L_n	U_o	U_l	TI	L_n	U_o	U_l	TI
A1		2	0.4	0.7	15	1.5	0.4	0.7	20	1	0.4	0.6	20	2	0.4	0.7	15	1.5	0.4	0.7	20	1	0.4	0.6	20
A2		1.5	0.4	0.7	20	1	0.4	0.6	20	0.8	0.4	0.5	20	1.5	0.4	0.7	20	1	0.4	0.6	20	0.8	0.4	0.5	20
A3		1	0.4	0.6	20	0.6	0.4	0.5	20	0.5	0.4	0.5	20	1	0.4	0.6	20	0.6	0.4	0.5	20	0.5	0.4	0.5	20
A4		0.75	0.4	0.5	20	0.5	0.4	0.5	20	0.3	0.3	0.5	25	0.75	0.4	0.5	20	0.5	0.4	0.5	20	0.3	0.3	0.5	25

L_n = min Luminance cd/m^2
Uo = Overall luminance uniformity
Ul = Longitudinal luminance uniformity
TI = Threshold Increment %

COMPARISON OF STANDARDS

LIGHTING LEVEL	Australia and New Zealand AS/NZS 1158.3.1			South African SABS 098 Pt 1			Britain and Europe BS/EN 13201			North America IESNA ❶		
	Cat.	Ave Lux	Min Lux	Cat.	Ave Lux	Min Lux	Cat.	Ave Lux	Min Lux	Cat.	Ave lux	Min lux
							S1	15	5			
							S2	10	3			
	P1	7	2	B1	5	1	S3	7.5	1.5	C ❷	9	❸
	P2	3.5	0.7	B2	3	0.6	S4	5	1.0	I ❷	7	❸
	P3	1.75	0.3	B3	2	0.4	S5	3	0.6	R ❷	4	❸
	P4	0.85	0.14				S6	2	0.6			
	P5	0.5	0.07				S7	Not specified				

NOTES

❶ Assumes R2 or R3 reflectance characteristic of road
❷ C = Commercial, I = Intermediate, R = Residential.
❸ Uniformity of 6:1 (average to minimum).

APPENDIX B

COMPARISON OF NATIONAL PRACTICES

COMPARISON OF NATIONAL PRACTICES

COUNTRY	EXISTING TECHNOLOGY	TREND TECHNOLOGY
ENGLAND	LPS	HPS and some MH and CFL
NORTH AMERICA	MV	MH
SOUTH AFRICA	MV & LPS	HPS
NEW ZEALAND	MV	HPS
AUSTRALIA	MV & HPS	CF/MH/HPS

Notes
CF = compact fluorescent
HPS = high pressure sodium
LPS = low pressure sodium
MH = metal halide
MV = mercury vapour

APPENDIX C

GREENHOUSE GAS SAMPLE CALCULATION

GREENHOUSE GAS – SAMPLE CALCULATIONS

Assumptions:

1. 80 W mercury vapour lamp – energy consumption with ballast losses 89.5 W.
2. 80 m street light spacing.
3. Street lights burn 4 000 hours per annum.
4. CO_2 emissions in Western Australia = 0.9 kg/kWh.

Sample calculation for one 80 W lamp (per annum)

CO_2 emission = lamp power (W) ÷ 1000 x burning hours x CO_2 coefficient (kg/kWh)

= 89.5 W ÷ 1000 x 4 000 h x 0.9 kg/kWh = **322 kg**.

Sample calculation for one kilometre of street lighting (80 W @ 80 m) per annum

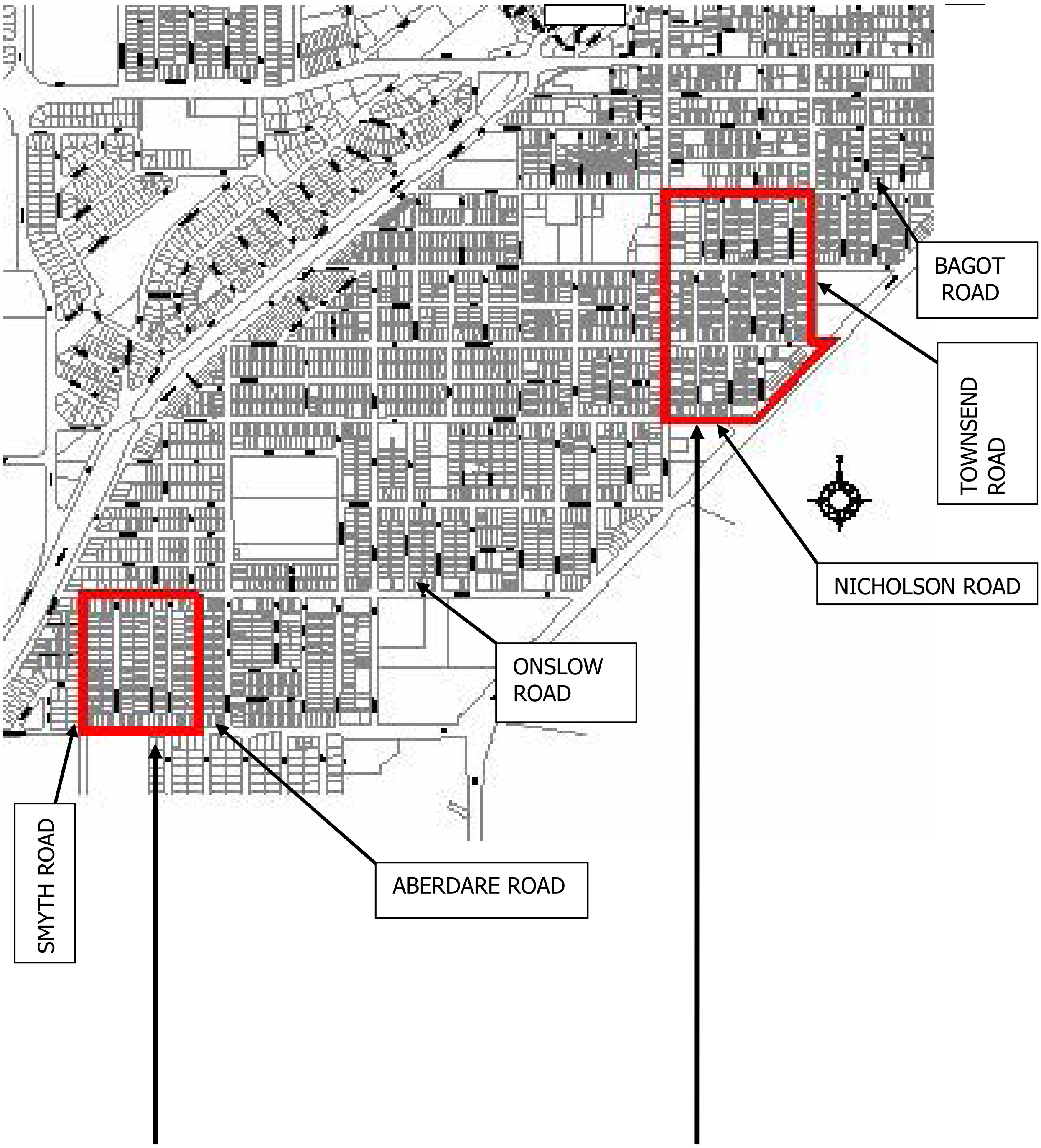
CO_2 emission = lamp power (W) ÷ 1000 ÷ spacing (m) x 1000 x burning hours x CO_2 coefficient (kg/kWh)

= 89.5 W ÷ 1000 ÷ 80 m x 1000 x 4 000 h x 0.9 kg/kWh = **4 027 kg** = **4T**.

APPENDIX D

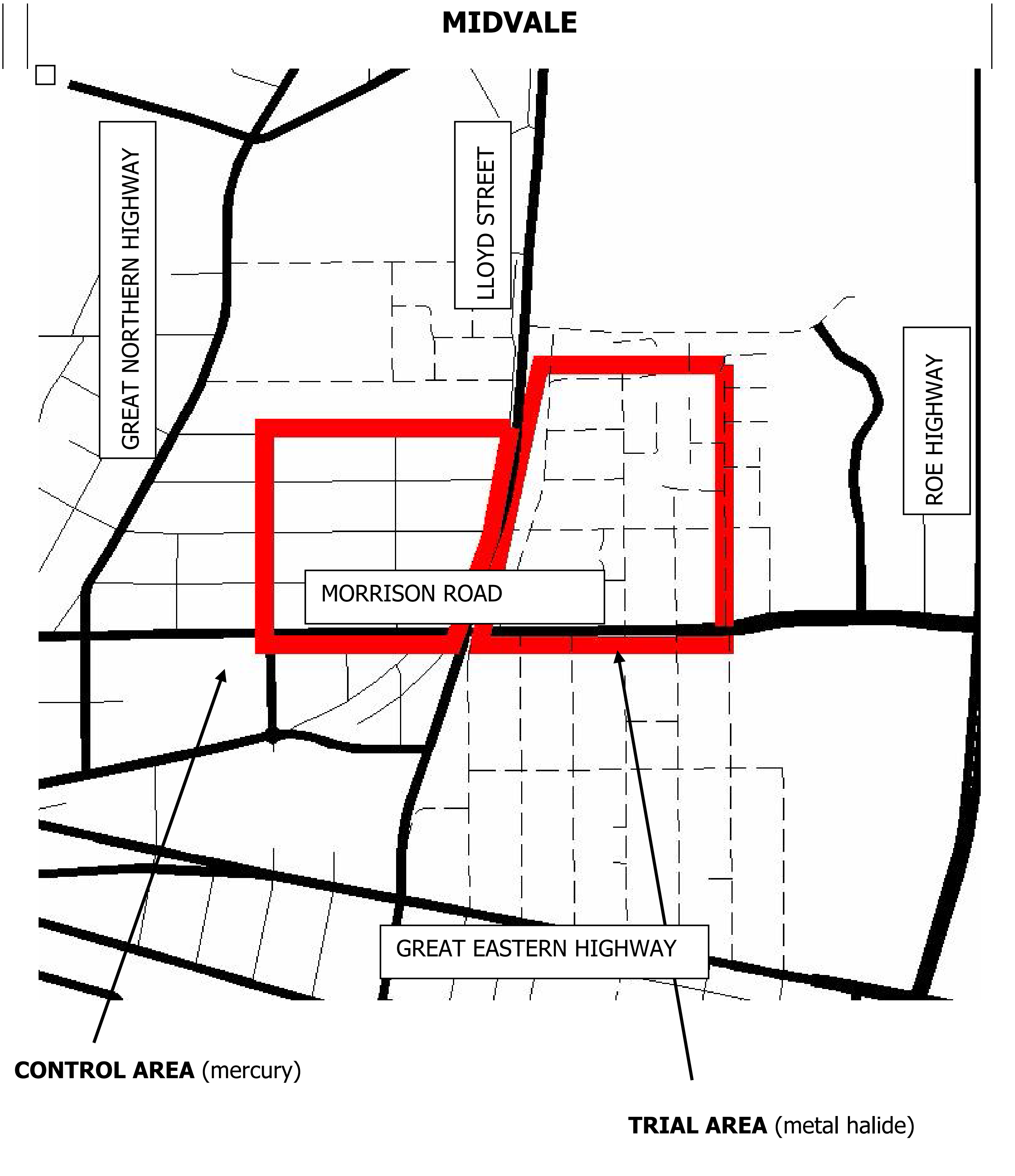
LOCATIONS OF FIELD TRIALS

SUBIACO

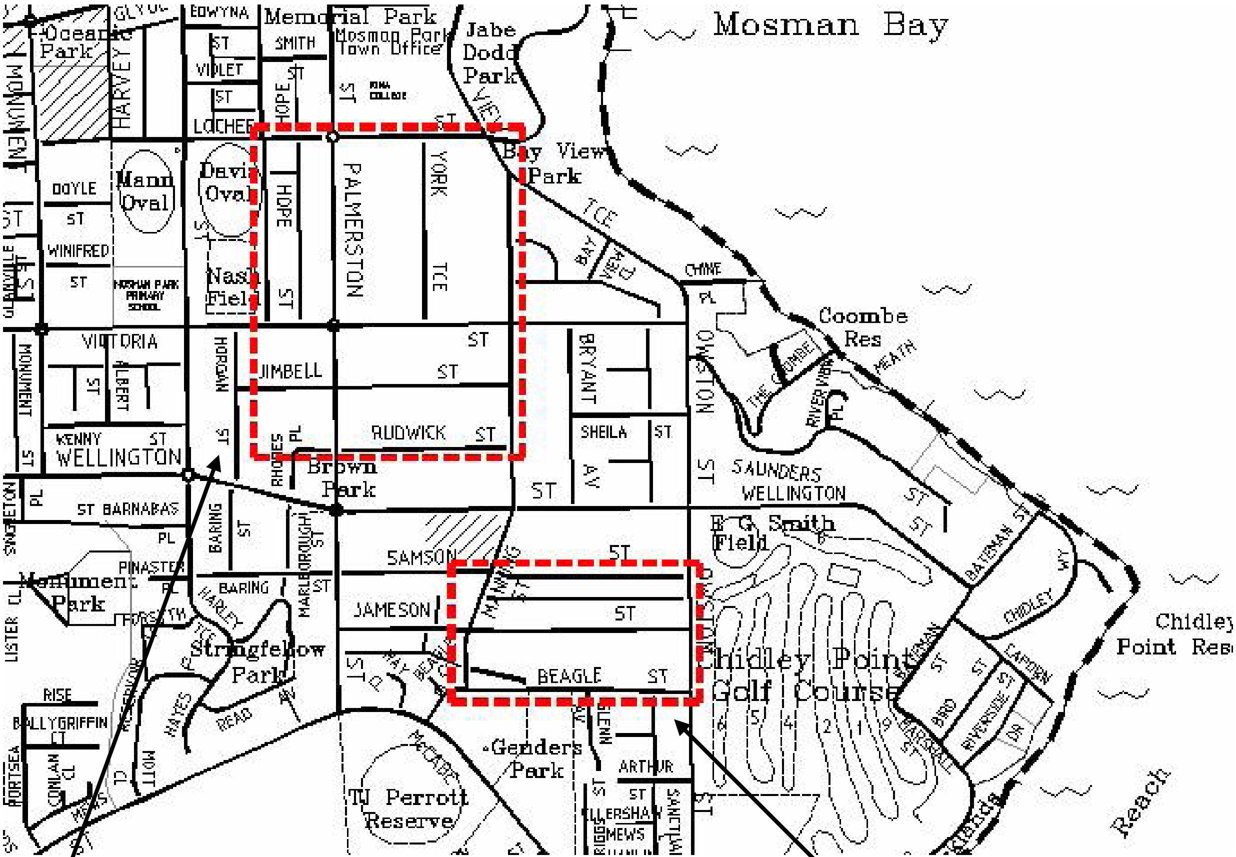


CONTROL AREA (mercury) **TRIAL AREA** (compact fluorescent)

MIDVALE


GREAT NORTHERN HIGHWAY
LLOYD STREET
ROE HIGHWAY
MORRISON ROAD
GREAT EASTERN HIGHWAY
CONTROL AREA (mercury)
TRIAL AREA (metal halide)

MOSMAN PARK



CONTROL AREA (mercury)

TRIAL AREA (metal halide/high pressure sodium/compact fluorescent)

APPENDIX E

FIELD TRIAL MEASUREMENTS

SUBIACO

LUMINAIRE TYPE	STREET	POLE NUMBER	ILLUMINANCE UNDER STREETLIGHT				ILLUMINANCE ACROSS ROAD				DEPRECIATION
			Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4	
CF	Hamersley Road	P1	12.90	13.00	12.00	11.00	0.40	1.00	1.20	1.50	14.73
CF		P2	15.40	13.00	15.00	13.80	0.70	1.00	1.00	1.00	10.39
CF		P3	8.00	8.20	17.00	14.00	0.50	0.64	1.60	3.00	17.65
CF		P4	10.00	9.90	0.00	8.00	0.15	0.34	0.00	0.50	20.00
CF		P5	13.50	15.00	14.00	13.00	0.20	0.50	1.10	0.70	3.70
CF		P6	12.30	12.00	11.00	8.50	0.30	0.49	0.50	0.40	30.89
CF		P7	12.20	12.00	11.00	11.00	0.20	0.60	0.70	1.30	9.84
CF		P8	13.00	13.00	12.00	13.00	0.30	1.00	1.10	1.10	0.00
CF		P9	11.80	10.00	10.00	9.90	0.20	0.36	0.40	0.40	16.10
CF	Heytesbury Road	P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
CF		P2	12.80	14.00	13.00	13.00	0.20	4.90	0.60	0.45	0.00
CF		P3	13.70	7.00	17.00	13.00	0.60	0.71	2.60	1.40	5.11
CF		P4	15.00	18.00	14.00	14.00	0.20	0.40	0.50	0.50	6.67
CF		P5	10.20	9.50	9.30	8.60	0.20	0.45	0.80	0.50	15.69
CF		P6	6.60	7.10	14.60	12.70	0.30	0.37	1.20	0.90	13.01
CF		P7	12.10	13.00	12.00	0.00	0.15	0.45	0.50	0.00	NA
CF		P8	11.10	13.00	11.00	9.60	0.10	0.55	0.40	0.50	13.51
CF		P9	12.40	13.00	10.00	9.20	0.40	0.70	0.80	0.10	25.81
CF	Rupert Street	P1	17.30	19.00	15.90	13.00	0.40	1.80	2.30	2.10	24.86
CF		P2	10.00	12.00	8.10	7.60	0.30	1.40	1.40	1.10	24.00
CF		P3	11.20	12.00	11.00	11.00	11.20	1.70	1.90	0.90	1.79
CF		P4	10.90	11.00	10.00	11.00	10.90	1.70	2.30	2.00	9.09
CF		P5	12.50	12.00	12.00	19.20	0.30	2.00	2.00	4.00	4.00
CF		P6	13.60	15.00	13.00	12.00	0.50	1.50	0.40	1.20	11.76
CF		P7	10.30	8.90	8.00	3.20	0.40	1.10	1.10	0.80	68.93
CF		P8	7.80	8.70	7.80	6.70	0.20	1.10	1.10	1.20	14.10
CF		P9	7.80	8.70	7.30	7.00	0.30	1.10	1.00	7.00	10.26
CF		P10	5.60	5.80	5.70	5.10	0.20	0.60	0.90	0.90	8.93
CF		P11	13.50	15.00	12.20	12.00	0.75	2.40	1.80	2.20	11.11
CF		P12	12.60	12.00	7.60	11.00	0.40	2.00	2.00	2.00	12.70

CF		P13	9.00	8.40	7.30	6.40	0.40	1.10	1.20	1.20	28.89
CF		P14	8.80	7.90	11.00	11.00	0.30	1.20	2.50	2.10	10.23
CF		P15	8.70	6.50	17.30	10.00	0.20	0.70	1.40	1.01	42.20
CF		P16	11.40	10.10	10.30	9.20	1.10	8.84	1.10	0.70	19.30
CF	Salisbury Street	P1	10.90	14.00	0.00	0.00	0.45	2.40	0.00	0.00	NA
CF		P2	10.40	11.00	9.90	10.00	0.40	2.00	2.10	1.50	3.85
CF		P3	0.40	6.70	7.10	7.00	0.40	1.50	1.80	1.40	1.41
CF		P4	7.60	8.50	7.50	7.70	0.40	1.20	1.60	1.30	9.41
CF		P5	10.60	12.00	2.60	6.60	0.06	1.30	0.10	1.00	37.74
CF		P6	12.50	15.00	14.00	13.00	0.90	1.20	0.70	0.90	13.33
CF		P7	16.10	18.00	16.00	17.00	0.60	1.90	3.10	1.50	5.56
CF		P8	8.50	10.00	8.10	9.10	0.10	0.25	1.10	1.10	9.00
CF		P9	10.50	9.40	8.50	5.00	0.50	1.50	1.70	1.60	52.38
CF		P10	9.00	0.53	5.40	4.90	0.40	0.70	1.00	0.40	45.56
CF		P11	16.70	16.00	14.00	11.20	0.90	2.30	2.80	2.00	32.93
CF		P12	11.60	12.00	11.00	9.70	0.50	1.90	1.60	1.40	16.38
CF		P13	7.80	8.00	7.20	5.60	0.20	1.50	1.40	1.30	28.21
CF		P14	6.10	6.20	6.80	6.30	0.30	1.00	1.30	1.10	7.35
CF		P15	11.50	12.00	10.00	8.00	0.40	2.00	2.10	2.10	30.43
CF		P16	13.20	14.00	13.00	8.50	0.80	2.00	2.20	1.80	35.61
CF	Finlayson Street	P1	5.70	7.10	16.50	6.30	0.20	1.80	3.00	1.80	61.82
CF		P2	9.90	10.00	18.90	6.50	0.30	1.80	1.60	1.70	34.34
CF		P3	8.50	8.90	8.70	7.60	0.30	1.80	1.70	1.50	10.59
CF	Chester Street	P1	10.70	11.00	9.30	8.00	0.40	1.20	1.60	1.70	25.23
CF		P2	10.50	12.00	10.00	6.40	0.50	1.50	2.00	2.00	39.05
CF		P3	12.40	13.00	9.40	17.00	0.60	2.50	1.50	3.10	24.19
CF		P4	9.90	11.00	9.50	8.70	0.60	1.70	2.00	1.90	12.12
CF		P5	9.20	9.70	20.00	17.00	0.40	1.50	3.30	2.60	15.00
CF	Kershaw Street	P1	9.50	10.00	4.70	6.50	0.20	0.30	0.30	0.60	31.58
CF		P2	8.20	8.40	7.70	6.80	0.40	1.30	1.30	0.10	17.07
CF		P3	17.80	19.00	17.00	17.00	0.80	1.80	2.20	1.80	4.49
CF		P4	11.60	13.00	11.00	21.00	0.50	1.00	1.60	3.10	5.17
CF		P5	10.40	11.00	9.20	7.90	0.30	1.30	1.60	1.30	24.04
CF	Robinson Street	P1	13.80	13.00	12.10	11.00	0.70	1.70	2.00	1.10	20.29
CF		P2	11.00	10.00	8.20	4.10	0.60	1.75	1.50	1.50	62.73
CF		P3	8.80	9.20	8.60	7.90	0.30	1.20	2.00	1.70	10.23

CF		P4	12.60	14.00	12.00	12.00	0.50	2.00	2.30	2.40	4.76
CF		P5	8.00	7.70	7.30	6.60	0.40	1.60	1.60	1.50	17.50
CF	Proclamation Street	P1	12.40	12.00	18.80	17.00	0.40	1.50	3.00	2.70	9.57
CF		P2	8.30	11.00	8.10	7.20	0.30	1.10	1.20	1.20	13.25
CF		P3	9.30	10.00	0.00	20.00	0.40	1.20	0.00	2.90	NA
CF		P4	10.80	13.00	22.00	18.00	0.40	1.30	1.30	2.50	18.18
CF		P5	9.20	10.00	9.00	8.30	0.20	1.10	3.70	1.50	9.78
CF	Townsend Road	P1	8.00	8.80	7.80	7.40	0.15	0.25	0.60	0.50	7.50
CF		P2	11.70	13.00	11.00	12.00	0.15	0.17	0.70	0.80	7.69
CF		P3	31.60	19.00	13.00	13.00	19.30	5.60	1.40	0.80	58.86
CF		P4	11.80	12.00	11.00	11.40	0.09	0.32	0.50	0.40	3.39
CF		P5	10.40	9.60	15.00	13.10	0.14	3.80	0.70	0.70	12.67
CF		P6	0.00	0.00	7.30	5.50	0.00	0.00	0.70	0.25	NA
CF		P7	8.50	7.00	7.30	7.30	0.15	0.33	0.70	0.70	14.12
CF		P8	8.60	8.20	7.00	6.60	0.15	0.45	0.40	0.52	23.26
CF		P9	12.10	13.00	12.00	11.40	0.20	4.50	0.50	0.38	5.79
										AVERAGE DEPRECIATION	81.32
	PERCENTAGE SURVIVAL		97.60	97.60	96.30	96.30					
				AVERAGE SURVIVAL		96.95					
MV	Smyth Road	P1	0.13	0.74	2.70	0.40	0.13	0.72	1.00	3.50	85.19
MV		P2	2.80	3.80	5.90	2.70	0.35	1.10	1.80	1.60	3.57
MV		P3	4.00	4.30	11.00	12.00	0.15	0.91	2.50	2.50	NA
MV		P4	3.40	3.70	12.00	10.00	0.15	0.74	2.90	2.10	16.67
MV		P5	5.00	5.10	11.00	7.00	0.30	1.00	2.20	2.20	36.36
MV		P6	3.50	3.80	7.40	14.00	0.40	0.90	2.00	0.30	NA
MV		P7	4.90	0.00	14.00	37.00	0.40	0.00	2.30	18.00	NA
MV	Hopetoun Terrace	P1	1.70	0.11	4.90	2.90	0.20	0.59	1.50	2.10	40.82
MV		P2	0.70	0.94	6.30	7.00	0.03	0.25	1.80	2.50	NA
MV		P3	0.15	0.12	1.00	0.80	0.13	0.19	1.80	0.80	20.00
MV	Commercial Street	P1	1.50	1.50	0.00	6.10	0.20	0.49	0.00	1.20	NA
MV		P2	6.10	6.30	10.00	11.00	0.13	0.92	1.40	1.60	NA
MV		P3	5.40	5.20	6.80	7.20	0.16	1.00	1.30	1.90	3.70
MV		P4	5.80	6.10	7.60	7.80	0.40	1.10	1.70	1.70	NA
MV		P5	8.70	9.90	10.00	10.00	1.00	2.10	2.20	2.40	0.00

MV	Murchison Street	P1	1.70	4.90	1.40	1.80	1.40	1.20	1.90	0.30	63.27
MV		P2	4.50	4.50	8.70	8.50	1.40	1.30	1.90	2.60	2.30
MV		P3	4.80	5.40	8.10	7.60	1.10	1.60	2.70	2.20	6.17
MV		P4	7.00	7.00	9.00	8.10	1.80	2.00	2.70	2.40	10.00
MV		P5	4.50	4.90	7.90	7.80	1.80	1.70	3.00	2.70	1.27
MV		P6	5.80	6.10	9.20	8.60	1.80	1.40	2.40	2.60	6.52
MV		P7	6.70	8.10	8.80	8.30	2.00	1.80	1.80	1.90	5.68
MV		P8	6.60	6.60	0.00	0.00	2.30	2.30	0.00	0.00	NA
MV	Yilgarn Street	P1	7.90	7.80	0.00	13.00	1.00	2.10	0.00	3.60	NA
MV		P2	6.00	5.70	5.70	5.80	1.20	2.00	1.90	2.40	3.33
MV		P3	6.00	6.30	6.00	7.30	1.00	1.70	1.90	2.40	4.76
MV		P4	6.20	1.40	0.00	0.40	0.65	0.12	0.00	1.80	NA
MV		P5	5.90	6.10	0.00	8.80	0.80	1.80	0.00	3.20	NA
MV		P6	5.50	5.50	8.60	9.10	0.80	1.40	2.40	2.60	0.00
									AVERAGE DEPRECIATION		82.80
	PERCENTAGE SURVIVAL		100.00	96.6	82.80	96.6					
				AVERAGE SURVIVAL		94.00					

MIDVALE

LUMINAIRE TYPE	STREET	POLE NUMBER	ILLUMINANCE UNDER STREETLIGHT				ILLUMINANCE ACROSS ROAD				DEPRECIATION
			Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4	
MV	Hamersley street	P1	13.00	11.60	8.50	0.00	2.36	2.31	1.80	0.00	NA
MV		P2	5.72	4.96	3.90	3.50	1.25	1.28	0.80	0.80	38.81
MV		P3	9.85	9.58	7.40	7.00	2.10	2.20	1.70	1.60	28.93
MV		P4	11.45	10.24	16.80	15.30	2.87	3.02	3.50	3.40	10.57
MV		P5	8.64	0.00	0.00	0.00	3.25	0.00	0.00	0.00	NA
MV		P6	4.15	3.24	1.70	1.40	1.14	0.92	0.50	0.40	66.27
MV	North Street	P1	5.34	0.00	0.00	0.00	0.97	0.00	0.00	0.00	NA
MV		P2	6.63	6.23	5.00	4.80	2.40	2.01	1.60	1.20	27.60
MV		P3	8.40	8.05	1.00	6.10	2.62	2.55	1.70	1.60	27.38
MV		P4	5.18	4.72	4.00	3.30	1.50	1.52	1.00	0.80	36.29
MV		P5	8.68	7.41	6.80	6.80	2.00	1.75	1.50	1.40	21.66
MV		P6	7.50	7.52	6.10	6.40	1.53	1.63	1.30	1.30	14.67
MV		P7	0.11	2.21	4.20	5.50	1.19	0.20	1.40	1.60	NA
MV		P8	0.00	0.00	7.50	7.40	0.00	0.00	1.60	1.20	NA
MV		P9	4.05	0.00	12.60	11.50	0.91	0.00	3.60	2.00	NA
MV	Charles Street (west)	P1	5.62	4.63	3.50	3.60	1.57	1.36	1.00	1.10	35.94
MV		P2	4.59	3.91	2.70	2.70	1.25	1.24	0.80	0.80	41.18
MV		P3	8.30	0.00	0.00	0.00	2.13	0.00	0.00	0.00	NA
MV		P4	8.84	8.04	6.50	5.80	2.58	2.31	1.90	1.20	34.39
MV		P5	4.71	4.22	2.70	2.50	1.45	1.19	0.80	0.80	46.92
MV		P6	3.40	2.88	1.00	0.90	3.40	0.90	0.30	0.90	73.53
MV		P7	6.12	0.00	8.40	8.80	1.62	0.00	1.70	1.90	NA
MV		P8	5.23	0.00	8.30	8.90	1.55	0.00	2.40	2.40	NA
MV		P9	0.70	2.40	1.00	0.50	0.86	0.86	0.50	0.50	28.57
MV	Gartell Street	P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
MV		P2	5.18	5.25	2.90	3.30	0.90	1.16	0.60	0.50	36.29
MV		P3	5.85	5.37	0.00	0.00	0.79	0.84	0.00	0.00	NA
MV	George Street	P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
MV		P2	9.35	0.00	7.30	6.10	2.02	0.00	1.60	1.40	34.76
MV		P3	3.93	3.29	1.90	1.30	0.96	0.95	0.60	0.40	66.92

MV		P4	0.00	3.93	7.00	6.00	0.00	1.92	1.70	1.40	NA
MV		P5	8.39	7.56	6.60	6.40	1.84	1.70	1.70	1.40	23.72
MV		P6	5.34	5.25	3.80	3.00	1.49	1.55	1.00	0.80	43.82
									AVERAGE DEPRECIATION		63.09
	PERCENTAGE SURVIVAL		87.9	69.7	81.8	81.8					
				AVERAGE SURVIVAL		80.3					
MH	Charles Street (east)	P1	3.11	2.10	1.70	1.00	0.86	0.60	0.50	0.30	67.85
MH		P2	10.11	9.90	12.00	10.40	1.43	1.50	1.60	1.40	2.08
MH		P3	3.05	2.80	2.30	1.90	0.92	0.88	0.80	0.60	37.70
MH		P4	5.95	12.00	10.50	9.60	1.25	2.50	1.90	1.90	20.00
MH		P5	0.62	3.50	2.80	2.60	1.20	1.10	0.70	0.80	25.71
MH		P6	4.60	3.90	3.00	2.60	1.05	1.10	1.00	0.80	43.48
MH		P7	2.92	2.30	3.60	3.50	0.44	0.47	0.60	0.70	21.23
MH	Wroxton Street	P1	16.92	15.00	13.00	15.00	1.62	1.50	0.93	2.70	11.35
MH		P2	5.12	12.00	10.10	10.40	1.87	2.90	2.10	2.10	13.33
MH		P3	6.05	4.70	3.70	3.40	1.48	1.20	0.91	0.70	43.80
MH		P4	5.17	4.50	3.70	0.00	1.60	1.20	1.10	0.00	NA
MH		P5	7.85	7.75	12.00	10.50	0.98	1.40	1.10	1.20	1.27
MH		P6	1.29	0.00	7.00	7.80	1.22	0.00	1.80	2.40	NA
MH		P7	5.38	4.80	4.00	2.40	1.69	1.50	1.00	0.60	55.39
MH		P8	6.68	5.50	4.12	0.00	3.17	2.50	2.30	0.00	NA
MH		P9	5.98	0.00	11.60	11.50	1.43	0.00	2.40	2.40	NA
MH		P10	9.07	8.90	7.80	2.50	2.58	2.80	2.20	0.60	72.44
MH	Henry Street	P1	4.56	3.80	0.00	0.00	1.10	1.00	0.00	0.00	NA
MH		P2	8.85	7.80	7.30	6.60	1.74	1.60	1.20	1.10	25.42
MH		P3	6.24	5.70	4.50	0.00	1.45	1.30	1.00	0.00	NA
MH		P4	3.45	2.80	2.30	2.00	0.92	0.86	0.80	0.60	42.03
MH	Ferguson Street	P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
MH		P2	4.68	9.30	6.40	6.80	1.20	2.60	1.30	1.90	26.88
MH		P3	3.89	3.50	0.00	0.00	1.26	1.20	0.00	0.00	NA
MH		P4	10.05	10.00	9.90	8.80	2.03	2.00	2.00	1.50	12.44
MH		P5	5.28	11.00	6.50	6.70	1.48	3.10	2.00	1.70	39.09
MH		P6	5.91	14.00	11.00	9.30	1.88	3.80	2.60	2.50	33.57
MH		P7	0.00	12.00	5.70	9.50	0.00	2.40	2.30	1.40	NA
MH		P8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA

MH		P9	4.68	10.00	8.90	9.50	1.11	2.40	2.00	2.00		5.00
MH	Wellaton Street	P1	4.94	0.00	8.80	7.90	1.70	0.00	2.50	1.70		NA
MH		P2	3.26	3.90	7.90	2.30	1.59	1.20	1.10	0.60		29.45
MH		P3	10.03	9.60	3.00	7.80	2.45	2.20	2.20	1.80		22.23
MH		P4	5.38	4.70	3.50	3.00	1.29	1.07	0.10	0.80		44.24
MH	Warde Street	P1	6.89	5.60	5.70	4.90	2.52	1.50	4.40	3.50		28.88
MH		P2	5.37	4.70	10.00	9.50	1.26	1.30	1.70	2.00		12.48
MH		P3	8.72	8.10	7.50	0.00	1.73	1.90	1.20	0.00		NA
MH		P4	9.15	9.40	7.20	8.90	1.82	1.90	1.10	1.70		2.73
MH	Eric Street	P1	8.48	8.40	7.50	7.40	2.21	2.40	1.90	1.30		12.74
MH		P2	6.31	5.30	4.30	2.60	1.48	1.30	1.00	0.60		58.80
MH	Roger Street	P1	4.93	4.10	18.00	18.70	1.03	1.10	2.90	2.90		16.84
MH		P2	8.14	11.00	9.80	19.40	1.54	2.10	1.90	2.40		10.91
MH		P3	5.70	0.00	0.00	15.40	1.48	0.00	0.00	3.40		NA
MH		P4	0.00	9.60	7.30	19.10	0.00	1.90	1.30	3.50		NA
MH		P5	5.42	10.00	8.10	8.30	1.25	2.50	1.80	1.80		17.00
MH		P6	7.96	7.70	6.10	6.60	1.51	1.70	1.30	1.50		17.09
MH	Kingston Place	P1	5.98	13.00	9.90	8.50	1.72	4.20	2.80	2.40		34.62
MH		P2	5.66	4.70	4.40	0.00	0.57	0.70	0.60	0.00		NA
MH		P3	5.08	4.40	12.90	10.30	1.75	1.70	9.40	3.20		20.16
MH		P4	6.61	5.80	4.80	5.10	0.25	0.50	0.70	1.00		22.84
MH	Egan Place	P1	6.04	11.10	8.70	2.70	2.10	3.40	2.90	2.60		55.30
MH		P3	10.92	10.15	8.10	8.30	1.43	0.92	1.10	1.10		23.99
MH		P3	0.00	15.00	12.20	11.80	0.00	4.24	2.50	2.20		21.33
MH		P4	9.05	9.40	7.70	7.40	3.74	3.60	3.00	2.70		18.23
MH		P5	8.78	8.10	6.90	7.00	3.04	2.60	2.50	2.30		20.27
MH		P6	6.51	0.00	13.30	11.80	0.43	0.00	0.70	1.60		NA
MH	Ewart Grove	P1	10.38	11.00	9.40	8.90	3.26	2.80	2.90	3.00		14.26
MH		P2	4.22	7.40	5.60	5.20	1.50	2.10	1.80	1.30		29.73
MH		P3	9.53	7.40	12.00	10.30	0.78	1.40	2.00	1.80		22.35
									AVERAGE DEPRECIATION			72.87
	PERCENTAGE SURVIVAL		93.20	88.10	91.50	86.40						
				AVERAGE SURVIVAL		89.80						

MOSMAN PARK

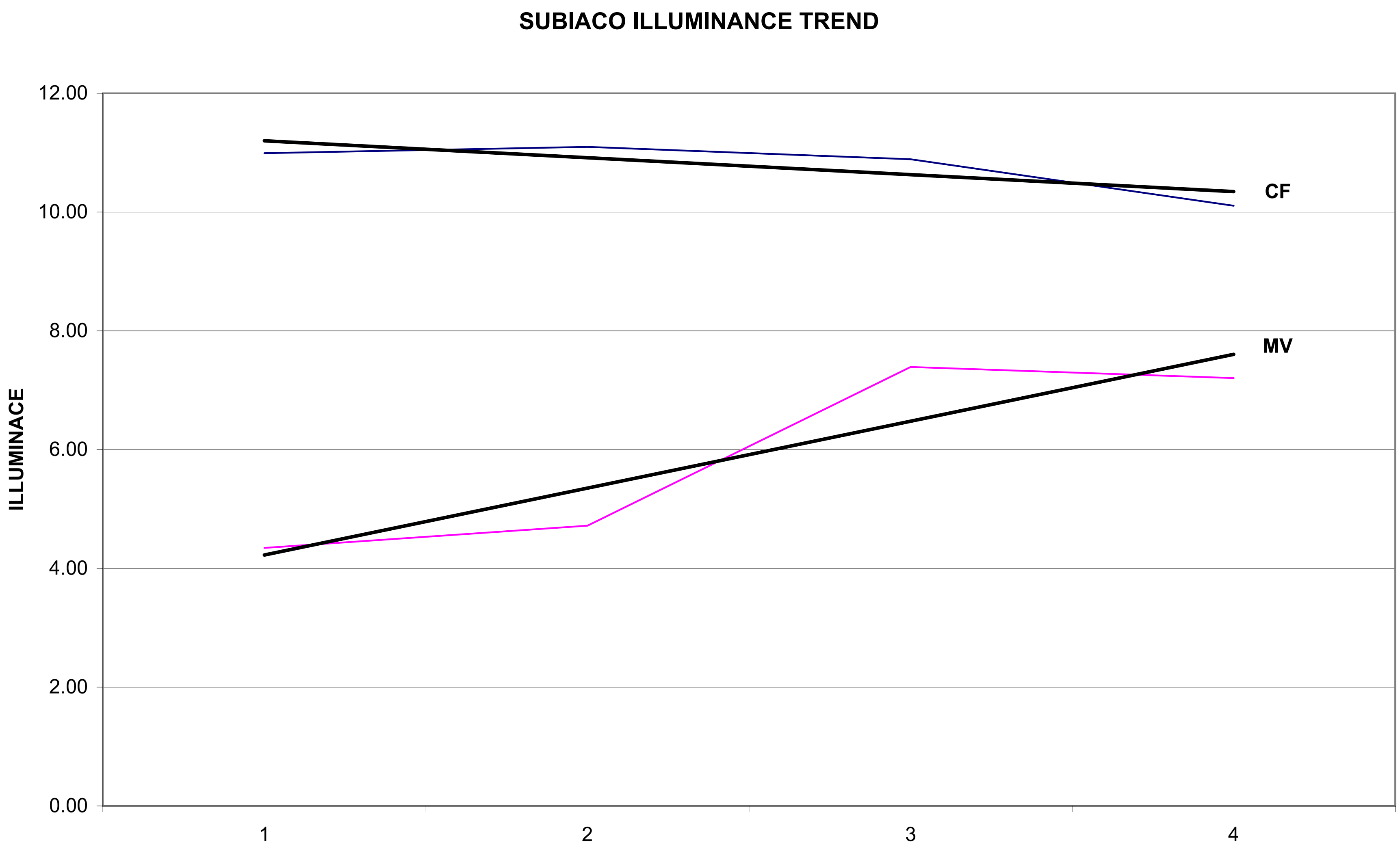
LUMINAIRE TYPE	STREET	POLE NUMBER	ILLUMINANCE UNDER STREETLIGHT				ILLUMINANCE ACROSS ROAD				DEPRECIATION
			Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4	
HPS	Glyde Street	P1	20.00	19.10	19.70	22.00	1.00	4.72	5.60	5.90	1.50
HPS		P2	19.00	17.18	20.10	21.00	0.70	4.98	5.40	5.30	9.58
HPS		P3	15.00	13.75	11.70	14.00	0.50	2.50	2.70	2.60	6.67
HPS		P4	19.00	19.50	0.00	0.00	1.40	6.20	0.00	0.00	NA
HPS		P5	22.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	NA
HPS	Palmerston Street	P7	22.50	20.30	18.50	21.00	1.50	5.68	4.70	6.20	6.67
HPS		P8	24.20	21.60	20.00	0.00	1.50	5.36	2.60	0.00	NA
HPS		P9	22.00	23.30	0.00	0.00	1.00	5.08	0.00	0.00	NA
HPS		P10	20.50	14.70	14.70	14.00	1.30	2.22	4.10	4.30	31.71
HPS		P11	21.20	22.70	18.30	15.00	1.20	5.20	4.50	4.30	29.25
HPS		P12	0.00	20.60	20.40	19.00	1.60	5.67	6.40	5.90	7.77
									AVERAGE DEPRECIATION		86.70
	PERCENTAGE SURVIVAL		90.90	90.90	72.70	63.60					
				AVERAGE SURVIVAL		79.53					
MH	Edwyna Street	P1	20.00	10.40	18.30	19.00	3.80	2.06	10.10	11.00	5.00
MH	Hope Street	P1	22.60	21.60	19.70	19.00	10.00	14.40	13.00	12.00	15.93
MH		P2	18.00	16.80	12.90	13.00	3.50	10.40	7.20	7.60	27.78
MH		P3	19.00	16.55	14.20	12.00	4.00	5.65	5.50	4.60	36.84
MH		P4	19.00	23.30	12.40	20.00	4.00	13.50	2.20	11.00	14.16
MH		P5	23.00	21.20	18.60	20.00	11.30	12.50	9.80	12.00	13.04
MH	Solomon Street	P1	21.50	19.40	18.50	18.00	0.09	5.07	5.40	4.70	16.28
MH		P2	21.00	17.40	16.70	16.00	1.20	3.58	4.00	3.70	23.81
MH		P3	24.00	19.50	18.70	19.00	1.20	5.00	5.70	5.10	20.83
MH		P4	20.00	19.50	17.40	17.00	0.04	2.90	3.00	3.20	15.00
MH		P5	25.10	21.80	20.50	19.00	1.60	5.86	5.60	5.40	24.30
MH	Violet Street	P1	22.20	21.30	8.80	25.00	3.10	10.47	2.20	12.00	60.36
MH	Smith Street	P1	20.50	18.70	16.90	16.00	1.20	5.21	4.50	4.90	21.95
MH	Lochee Street	P4	0.00	0.00	19.40	0.00	0.00	0.00	7.00	0.00	NA

MH		P5	21.00	19.20	18.10	17.40	1.20	5.84	5.70	5.10	17.14
MH		P6	21.20	19.20	18.90	18.10	1.00	3.75	3.90	4.00	14.62
MH		P7	21.00	20.30	18.80	19.00	1.00	5.26	5.10	4.80	9.52
MH		P8	0.10	16.00	14.10	7.00	0.10	5.82	4.40	3.50	56.25
									AVERAGE DEPRECIATION		76.89
	PERCENTAGE SURVIVAL		94.40	94.40	100.00	94.40					
				AVERAGE SURVIVAL		95.80					
CF	Black Lane	P1	6.00	2.66	0.00	5.60	4.40	1.96	0.00	3.80	NA
CF		P2	0.00	4.88	2.60	0.00	0.00	3.32	1.60	0.00	NA
CF	Birchley Lane	P1	6.80	3.25	2.70	3.10	4.70	2.61	1.90	2.10	54.41
CF		P2	5.60	5.00	2.80	3.00	1.90	4.30	2.20	1.10	46.43
CF	Sibbald Lane (South)	P1	4.60	3.60	6.80	6.60	2.40	2.21	3.70	4.10	2.94
CF		P2	6.00	3.35	6.50	6.50	3.20	1.96	3.90	3.80	44.17
CF	Sibbald Lane (north)	P1	4.60	2.49	0.00	0.00	3.40	2.20	0.00	0.00	NA
CF		P2	0.00	0.00	5.30	4.00	0.00	0.00	4.00	2.60	NA
CF		P3	4.30	2.40	3.30	2.20	3.00	1.26	1.20	1.10	48.84
									AVERAGE DEPRECIATION		60.64
	PERCENTAGE SURVIVAL		77.80	88.90	77.80	77.80					
				AVERAGE SURVIVAL		80.58					
MV	Lochee Street	P1	0.00	0.00	7.90	0.00	0.00	0.00	1.30	0.00	NA
MV		P2	0.00	0.00	22.30	0.00	0.00	0.00	7.10	0.00	NA
MV		P3	0.00	0.00	18.90	0.00	0.00	0.00	7.50	0.00	NA
MV	York Terrace	P1	3.60	0.00	4.30	4.30	0.50	0.00	1.30	1.50	0.00
MV		P2	3.60	3.70	3.90	3.70	0.44	1.04	1.40	1.30	5.13
MV		P3	1.70	1.70	2.10	1.70	0.24	0.43	0.90	0.50	0.00
MV		P4	3.50	3.11	3.00	3.40	0.01	1.02	1.10	0.80	2.86
MV	Manning Street	P1	3.70	3.77	2.50	3.70	0.60	0.90	1.00	1.00	0.00
MV		P2	0.80	0.82	1.10	1.00	0.02	0.15	0.20	0.30	9.09
MV		P3	0.60	0.00	1.90	2.50	0.02	0.00	0.20	1.00	NA
MV		P4	3.50	0.00	1.70	1.60	0.01	0.98	0.90	0.90	54.29
MV	Victoria Street	P1	2.40	2.80	2.60	2.60	0.20	0.67	0.80	0.80	7.14
MV		P2	0.02	0.00	0.00	0.00	0.10	0.00	0.00	0.00	NA

MV		P3	3.20	3.72	2.90	3.00	0.15	0.73	1.00	0.90	6.25
MV		P4	5.60	4.71	5.60	5.40	1.10	1.78	2.10	2.00	3.57
MV		P5	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	NA
MV	Palmerston Street	P1	2.00	1.96	2.00	2.00	0.25	0.90	1.10	1.00	0.00
MV		P2	2.60	2.35	3.00	2.20	0.25	0.90	1.10	1.10	15.38
MV		P3	1.80	1.28	1.50	1.50	0.20	0.63	0.70	0.80	16.67
MV		P4	0.60	0.00	0.00	0.00	0.10	0.00	0.00	0.00	NA
MV		P5	6.00	4.87	4.70	3.40	1.90	4.00	3.50	1.00	43.33
MV		P6	0.00	0.00	18.20	0.00	0.00	0.00	4.10	0.00	NA
									AVERAGE DEPRECIATION		88.31
	PERCENTAGE SURVIVAL		81.80	63.60	86.40	68.20					
				AVERAGE SURVIVAL		75.00					

APPENDIX F

ILLUMINANCE DEPRECIATION GRAPHS


SUBIACO ILLUMINANCE TREND
ILLUMINACE
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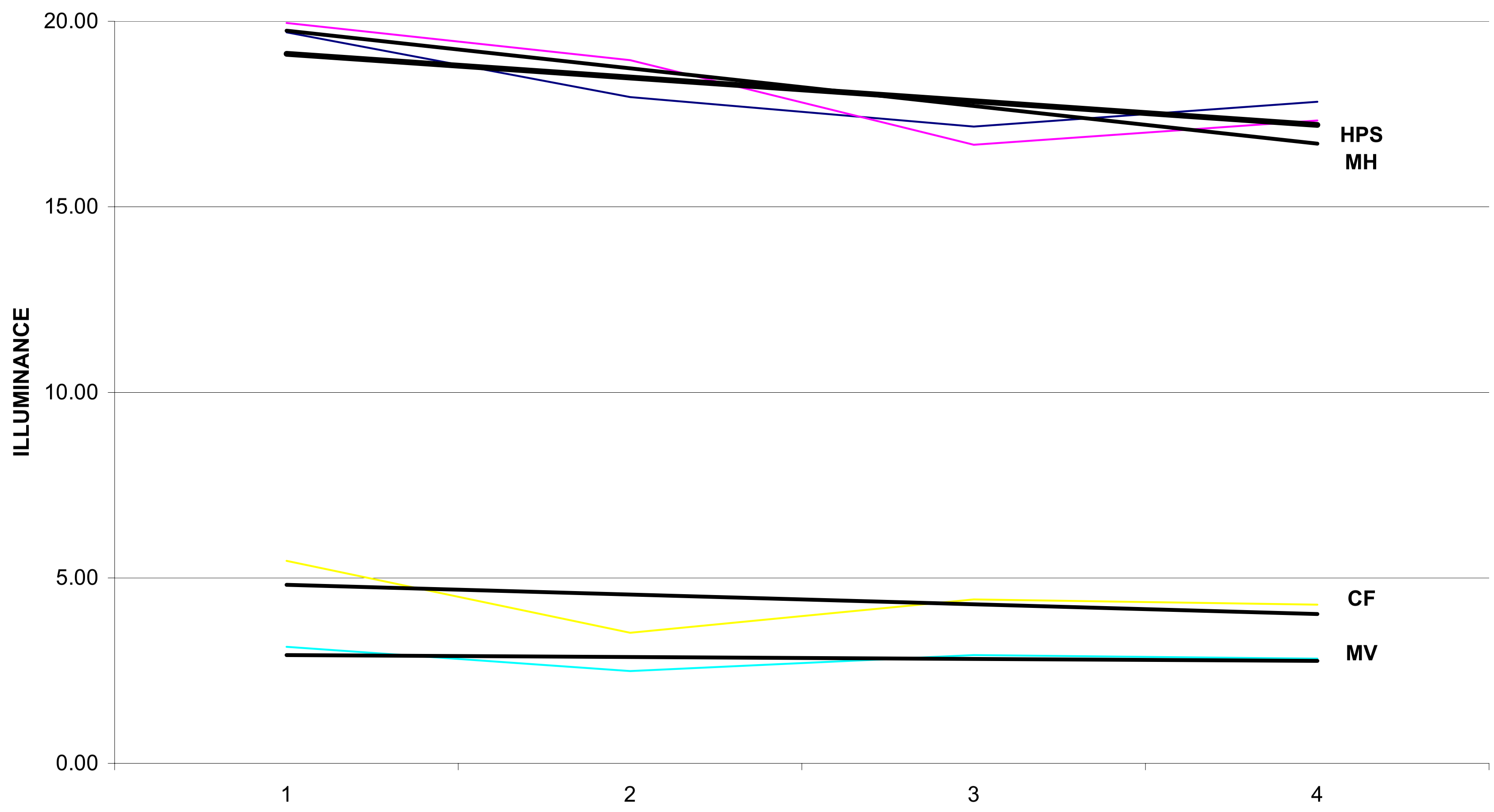
10.00
8.00
6.00
4.00
2.00
0.00
1
2
3
4
CF
MV

MOSMAN PK ILLUMINANCE TREND



MIDVALE

LUMINAIRE TYPE	STREET	POLE NUMBER	ILLUMINANCE UNDER STREETLIGHT				ILLUMINANCE ACROSS ROAD				DEPRECIATION
			Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2	Trial 3	Trial 4	
MV	Hamersley street	P1	13.00	11.60	8.50	0.00	2.36	2.31	1.80	0.00	NA
MV		P2	5.72	4.96	3.90	3.50	1.25	1.28	0.80	0.80	38.81
MV		P3	9.85	9.58	7.40	7.00	2.10	2.20	1.70	1.60	28.93
MV		P4	11.45	10.24	16.80	15.30	2.87	3.02	3.50	3.40	10.57
MV		P5	8.64	0.00	0.00	0.00	3.25	0.00	0.00	0.00	NA
MV		P6	4.15	3.24	1.70	1.40	1.14	0.92	0.50	0.40	66.27
MV	North Street	P1	5.34	0.00	0.00	0.00	0.97	0.00	0.00	0.00	NA
MV		P2	6.63	6.23	5.00	4.80	2.40	2.01	1.60	1.20	27.60
MV		P3	8.40	8.05	1.00	6.10	2.62	2.55	1.70	1.60	27.38
MV		P4	5.18	4.72	4.00	3.30	1.50	1.52	1.00	0.80	36.29
MV		P5	8.68	7.41	6.80	6.80	2.00	1.75	1.50	1.40	21.66
MV		P6	7.50	7.52	6.10	6.40	1.53	1.63	1.30	1.30	14.67
MV		P7	0.11	2.21	4.20	5.50	1.19	0.20	1.40	1.60	NA
MV		P8	0.00	0.00	7.50	7.40	0.00	0.00	1.60	1.20	NA
MV		P9	4.05	0.00	12.60	11.50	0.91	0.00	3.60	2.00	NA
MV	Charles Street (west)	P1	5.62	4.63	3.50	3.60	1.57	1.36	1.00	1.10	35.94
MV		P2	4.59	3.91	2.70	2.70	1.25	1.24	0.80	0.80	41.18
MV		P3	8.30	0.00	0.00	0.00	2.13	0.00	0.00	0.00	NA
MV		P4	8.84	8.04	6.50	5.80	2.58	2.31	1.90	1.20	34.39
MV		P5	4.71	4.22	2.70	2.50	1.45	1.19	0.80	0.80	46.92
MV		P6	3.40	2.88	1.00	0.90	3.40	0.90	0.30	0.90	73.53
MV		P7	6.12	0.00	8.40	8.80	1.62	0.00	1.70	1.90	NA
MV		P8	5.23	0.00	8.30	8.90	1.55	0.00	2.40	2.40	NA
MV		P9	0.70	2.40	1.00	0.50	0.86	0.86	0.50	0.50	28.57
MV	Gartell Street	P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
MV		P2	5.18	5.25	2.90	3.30	0.90	1.16	0.60	0.50	36.29
MV		P3	5.85	5.37	0.00	0.00	0.79	0.84	0.00	0.00	NA
MV	George Street	P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
MV		P2	9.35	0.00	7.30	6.10	2.02	0.00	1.60	1.40	34.76
MV		P3	3.93	3.29	1.90	1.30	0.96	0.95	0.60	0.40	66.92

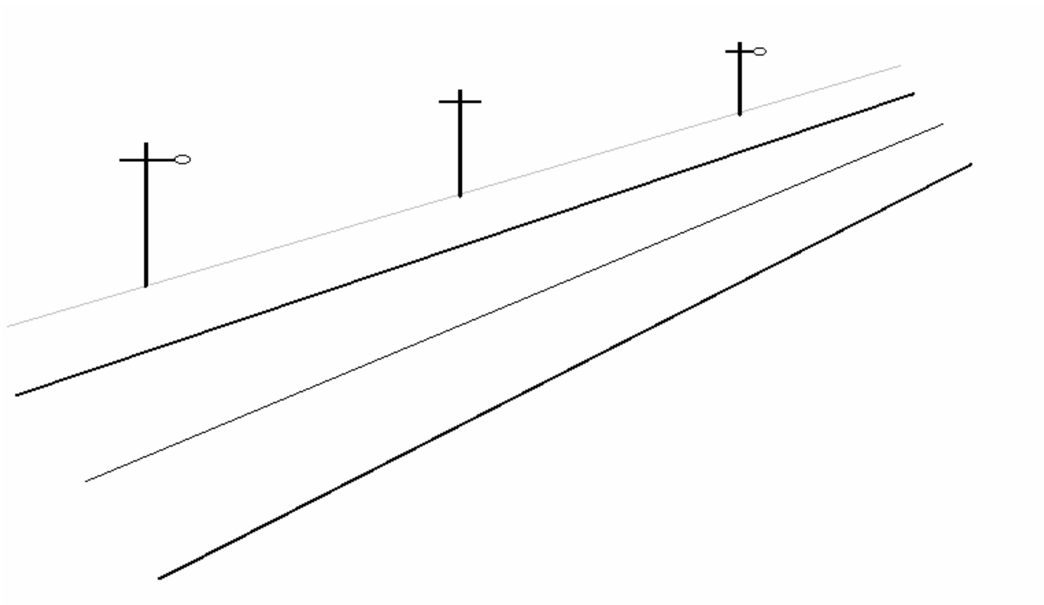
MV		P4	0.00	3.93	7.00	6.00	0.00	1.92	1.70	1.40	NA
MV		P5	8.39	7.56	6.60	6.40	1.84	1.70	1.70	1.40	23.72
MV		P6	5.34	5.25	3.80	3.00	1.49	1.55	1.00	0.80	43.82
									AVERAGE DEPRECIATION		63.09
	PERCENTAGE SURVIVAL		87.9	69.7	81.8	81.8					
				AVERAGE SURVIVAL		80.3					
MH	Charles Street (east)	P1	3.11	2.10	1.70	1.00	0.86	0.60	0.50	0.30	67.85
MH		P2	10.11	9.90	12.00	10.40	1.43	1.50	1.60	1.40	2.08
MH		P3	3.05	2.80	2.30	1.90	0.92	0.88	0.80	0.60	37.70
MH		P4	5.95	12.00	10.50	9.60	1.25	2.50	1.90	1.90	20.00
MH		P5	0.62	3.50	2.80	2.60	1.20	1.10	0.70	0.80	25.71
MH		P6	4.60	3.90	3.00	2.60	1.05	1.10	1.00	0.80	43.48
MH		P7	2.92	2.30	3.60	3.50	0.44	0.47	0.60	0.70	21.23
MH	Wroxton Street	P1	16.92	15.00	13.00	15.00	1.62	1.50	0.93	2.70	11.35
MH		P2	5.12	12.00	10.10	10.40	1.87	2.90	2.10	2.10	13.33
MH		P3	6.05	4.70	3.70	3.40	1.48	1.20	0.91	0.70	43.80
MH		P4	5.17	4.50	3.70	0.00	1.60	1.20	1.10	0.00	NA
MH		P5	7.85	7.75	12.00	10.50	0.98	1.40	1.10	1.20	1.27
MH		P6	1.29	0.00	7.00	7.80	1.22	0.00	1.80	2.40	NA
MH		P7	5.38	4.80	4.00	2.40	1.69	1.50	1.00	0.60	55.39
MH		P8	6.68	5.50	4.12	0.00	3.17	2.50	2.30	0.00	NA
MH		P9	5.98	0.00	11.60	11.50	1.43	0.00	2.40	2.40	NA
MH		P10	9.07	8.90	7.80	2.50	2.58	2.80	2.20	0.60	72.44
MH	Henry Street	P1	4.56	3.80	0.00	0.00	1.10	1.00	0.00	0.00	NA
MH		P2	8.85	7.80	7.30	6.60	1.74	1.60	1.20	1.10	25.42
MH		P3	6.24	5.70	4.50	0.00	1.45	1.30	1.00	0.00	NA
MH		P4	3.45	2.80	2.30	2.00	0.92	0.86	0.80	0.60	42.03
MH	Ferguson Street	P1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA
MH		P2	4.68	9.30	6.40	6.80	1.20	2.60	1.30	1.90	26.88
MH		P3	3.89	3.50	0.00	0.00	1.26	1.20	0.00	0.00	NA
MH		P4	10.05	10.00	9.90	8.80	2.03	2.00	2.00	1.50	12.44
MH		P5	5.28	11.00	6.50	6.70	1.48	3.10	2.00	1.70	39.09
MH		P6	5.91	14.00	11.00	9.30	1.88	3.80	2.60	2.50	33.57
MH		P7	0.00	12.00	5.70	9.50	0.00	2.40	2.30	1.40	NA
MH		P8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA

MH		P9	4.68	10.00	8.90	9.50	1.11	2.40	2.00	2.00	5.00
MH	Wellaton Street	P1	4.94	0.00	8.80	7.90	1.70	0.00	2.50	1.70	NA
MH		P2	3.26	3.90	7.90	2.30	1.59	1.20	1.10	0.60	29.45
MH		P3	10.03	9.60	3.00	7.80	2.45	2.20	2.20	1.80	22.23
MH		P4	5.38	4.70	3.50	3.00	1.29	1.07	0.10	0.80	44.24
MH	Warde Street	P1	6.89	5.60	5.70	4.90	2.52	1.50	4.40	3.50	28.88
MH		P2	5.37	4.70	10.00	9.50	1.26	1.30	1.70	2.00	12.48
MH		P3	8.72	8.10	7.50	0.00	1.73	1.90	1.20	0.00	NA
MH		P4	9.15	9.40	7.20	8.90	1.82	1.90	1.10	1.70	2.73
MH	Eric Street	P1	8.48	8.40	7.50	7.40	2.21	2.40	1.90	1.30	12.74
MH		P2	6.31	5.30	4.30	2.60	1.48	1.30	1.00	0.60	58.80
MH	Roger Street	P1	4.93	4.10	18.00	18.70	1.03	1.10	2.90	2.90	16.84
MH		P2	8.14	11.00	9.80	19.40	1.54	2.10	1.90	2.40	10.91
MH		P3	5.70	0.00	0.00	15.40	1.48	0.00	0.00	3.40	NA
MH		P4	0.00	9.60	7.30	19.10	0.00	1.90	1.30	3.50	NA
MH		P5	5.42	10.00	8.10	8.30	1.25	2.50	1.80	1.80	17.00
MH		P6	7.96	7.70	6.10	6.60	1.51	1.70	1.30	1.50	17.09
MH	Kingston Place	P1	5.98	13.00	9.90	8.50	1.72	4.20	2.80	2.40	34.62
MH		P2	5.66	4.70	4.40	0.00	0.57	0.70	0.60	0.00	NA
MH		P3	5.08	4.40	12.90	10.30	1.75	1.70	9.40	3.20	20.16
MH		P4	6.61	5.80	4.80	5.10	0.25	0.50	0.70	1.00	22.84
MH	Egan Place	P1	6.04	11.10	8.70	2.70	2.10	3.40	2.90	2.60	55.30
MH		P3	10.92	10.15	8.10	8.30	1.43	0.92	1.10	1.10	23.99
MH		P3	0.00	15.00	12.20	11.80	0.00	4.24	2.50	2.20	21.33
MH		P4	9.05	9.40	7.70	7.40	3.74	3.60	3.00	2.70	18.23
MH		P5	8.78	8.10	6.90	7.00	3.04	2.60	2.50	2.30	20.27
MH		P6	6.51	0.00	13.30	11.80	0.43	0.00	0.70	1.60	NA
MH	Ewart Grove	P1	10.38	11.00	9.40	8.90	3.26	2.80	2.90	3.00	14.26
MH		P2	4.22	7.40	5.60	5.20	1.50	2.10	1.80	1.30	29.73
MH		P3	9.53	7.40	12.00	10.30	0.78	1.40	2.00	1.80	22.35
									AVERAGE DEPRECIATION		72.87
	PERCENTAGE SURVIVAL		93.20	88.10	91.50	86.40					
				AVERAGE SURVIVAL		89.80					

APPENDIX G

SCENARIOS

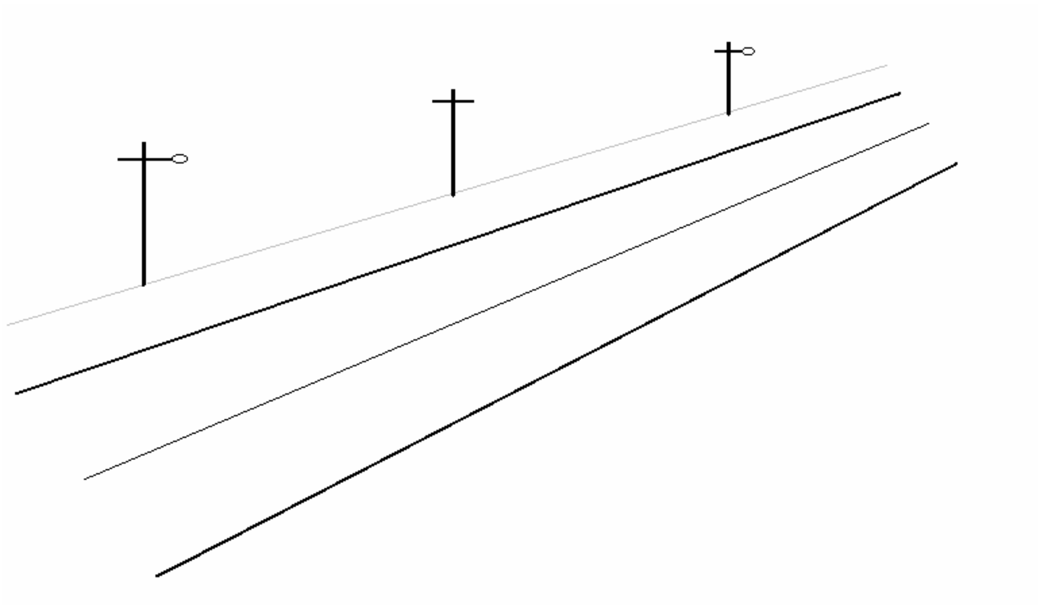
OVERHEAD POWER - 80 W MERCURY AT 80 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		✖
ENERGY ❶	1.12	kW/km
GREENHOUSE GAS ❷	4.0	T/km
LAMP COST ❸	$ 4.50	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	$86	
Running cost per kilolumen	$16.00	

NOTES:
❶ Based on circuit power of 89.5 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

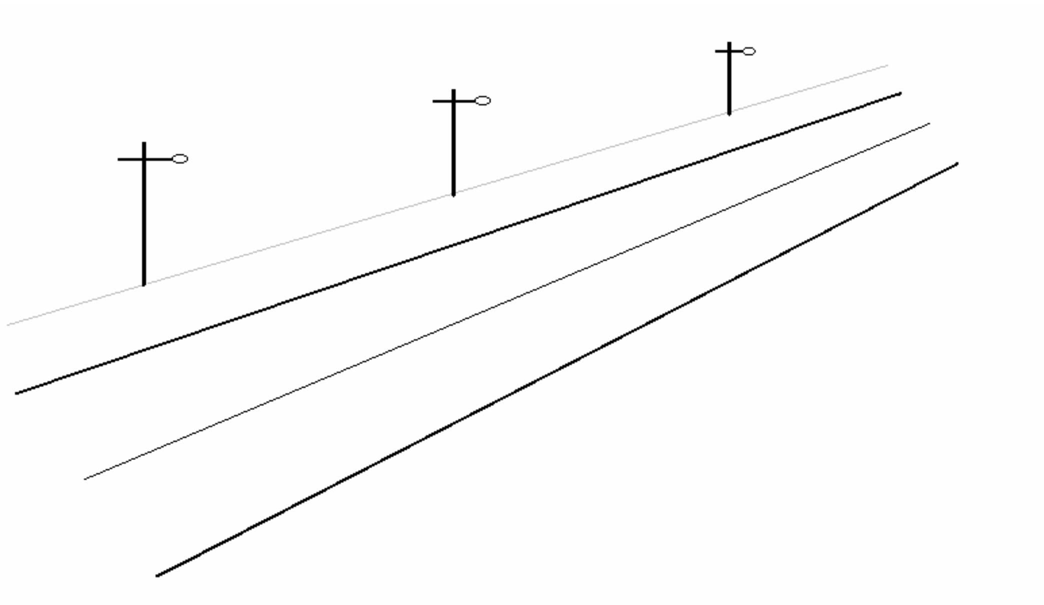
OVERHEAD POWER - 42 W COMPACT FLUORESCENT AT 80 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		✖
ENERGY ❶	0.6	kW/km
GREENHOUSE GAS ❷	2.0	T/km
LAMP COST ❸	$ 13	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	N/A	
Running cost per kilolumen	$11.25	

NOTES:
❶ Based on circuit power of 46 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

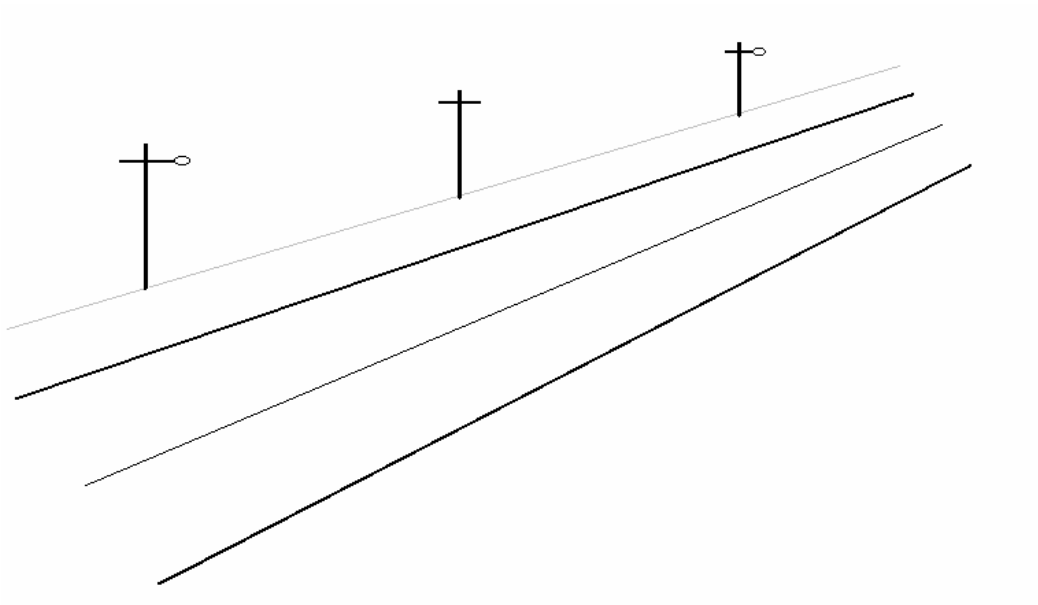
OVERHEAD POWER - 42 W COMPACT FLUORESCENT AT 40 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		**Category P4**
ENERGY ❶	1.2	kW/km
GREENHOUSE GAS ❷	4.1	T/km
LAMP COST ❸	$ 13	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	N/A	
Running cost per kilolumen	$11.25	

NOTES:
❶ Based on circuit power of 46 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

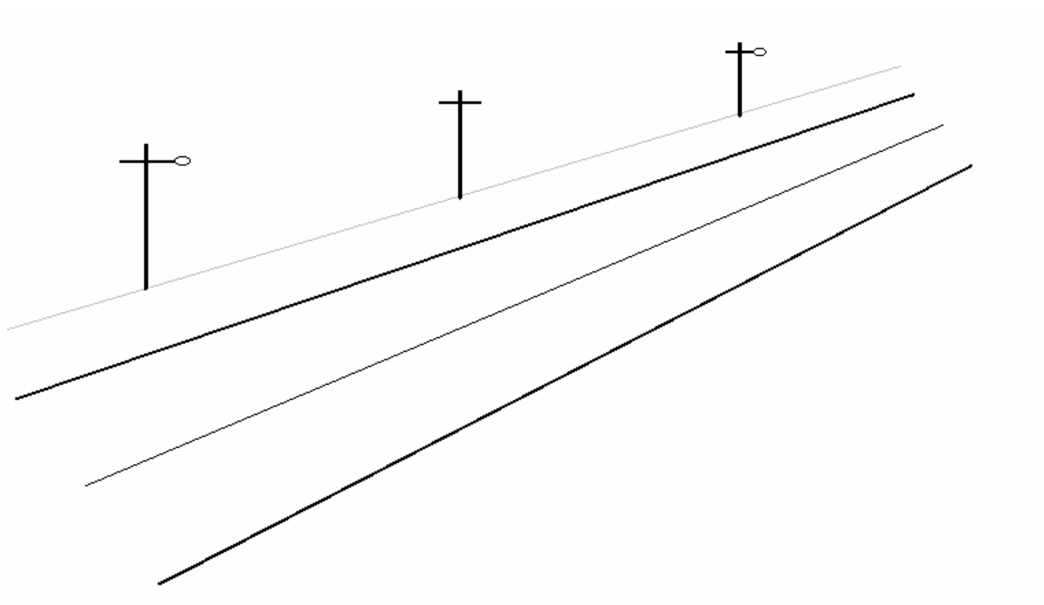
OVERHEAD POWER - 70 W METAL HALIDE AT 80 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		**Category P4**
ENERGY ❶	1.0	kW/km
GREENHOUSE GAS ❷	3.4	T/km
LAMP COST ❸	$ 40	
LAMP LIFE ❹	3	years
SYNERGY TARIFF p.a.	$129	
Running cost per kilolumen	$15.51	

NOTES:
❶ Based on circuit power of 77 W
❷ Based on 0.9 kg of CO_2 2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

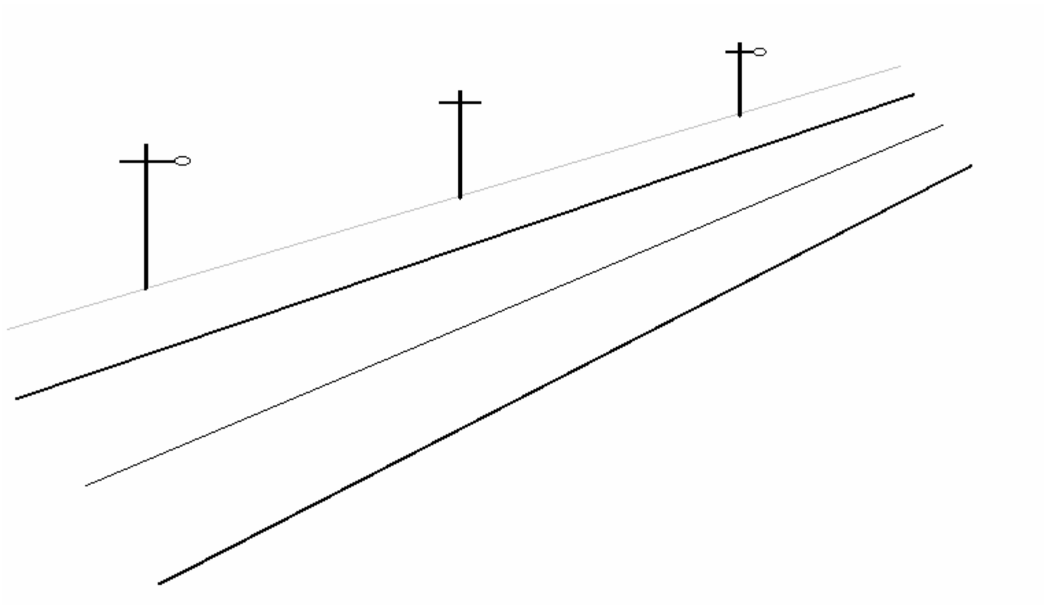
OVERHEAD POWER - 70 W HIGH PRESSURE SODIUM AT 80 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		**Category P4**
ENERGY ❶	1.0	kW/km
GREENHOUSE GAS ❷	3.4	T/km
LAMP COST ❸	$ 21	
LAMP LIFE ❹	5	years
SYNERGY TARIFF p.a.	$82	
Running cost per kilolumen	$7.80	

NOTES:
❶ Based on circuit power of 77 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

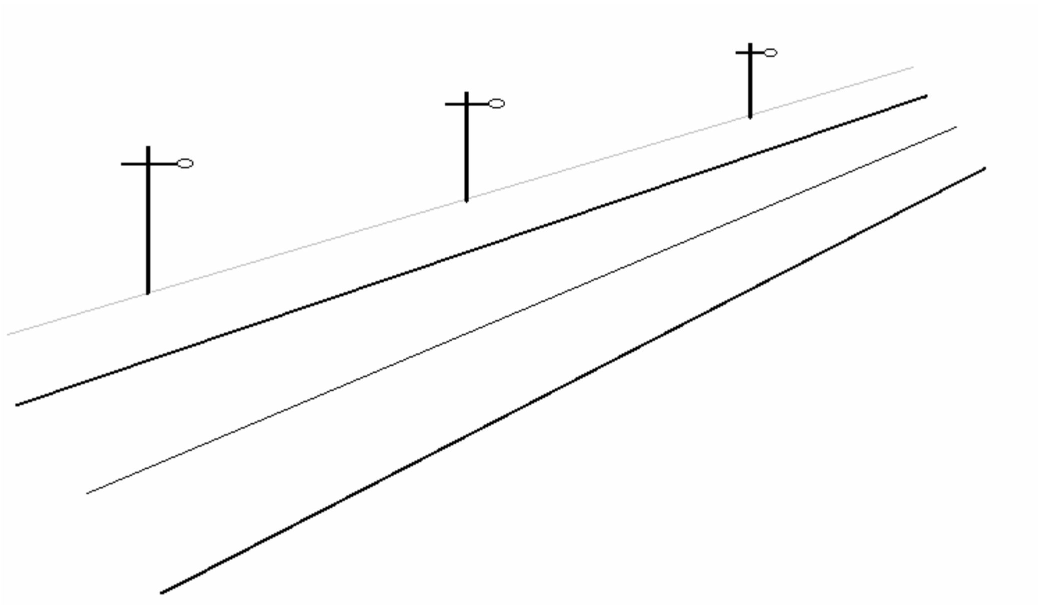
OVERHEAD POWER - 50 W HIGH PRESSURE SODIUM AT 80 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE	✖	
ENERGY ❶	0.69	kW/km
GREENHOUSE GAS ❷	2.5	T/km
LAMP COST ❸	$ 21	
LAMP LIFE ❹	5	years
SYNERGY TARIFF p.a.	N/A	
Running cost per kilolumen	$9.42	

NOTES:
❶ Based on circuit power of 55 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

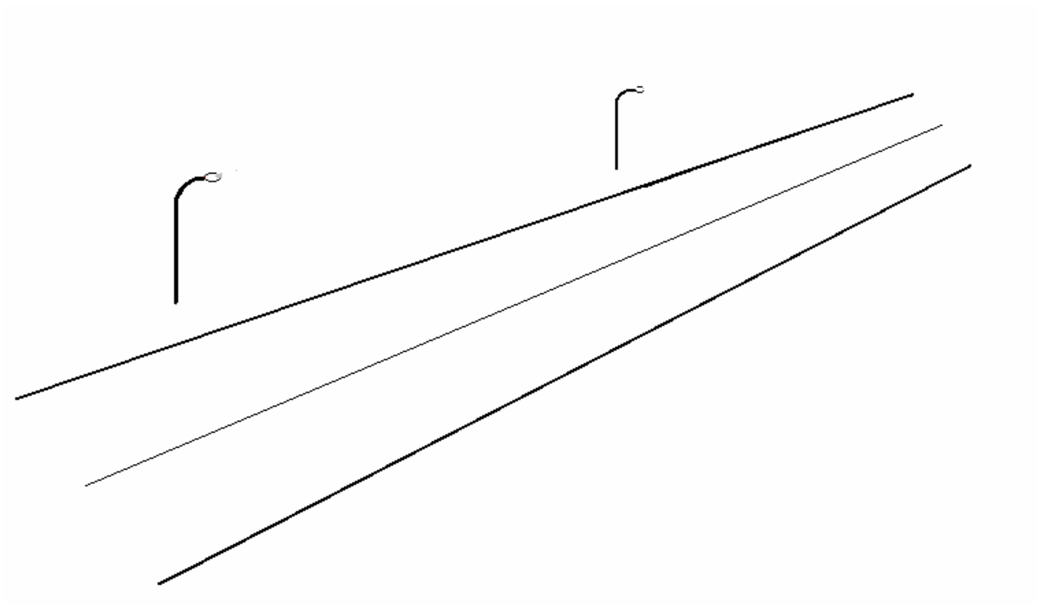
OVERHEAD POWER - 50 W HIGH PRESSURE SODIUM AT 40 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		**Category P4**
ENERGY ❶	1.38	kW/km
GREENHOUSE GAS ❷	4.95	T/km
LAMP COST ❸	$ 21	
LAMP LIFE ❹	5	years
SYNERGY TARIFF p.a.	N/A	
Running cost per kilolumen	$9.42	

NOTES:
❶ Based on circuit power of 55 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

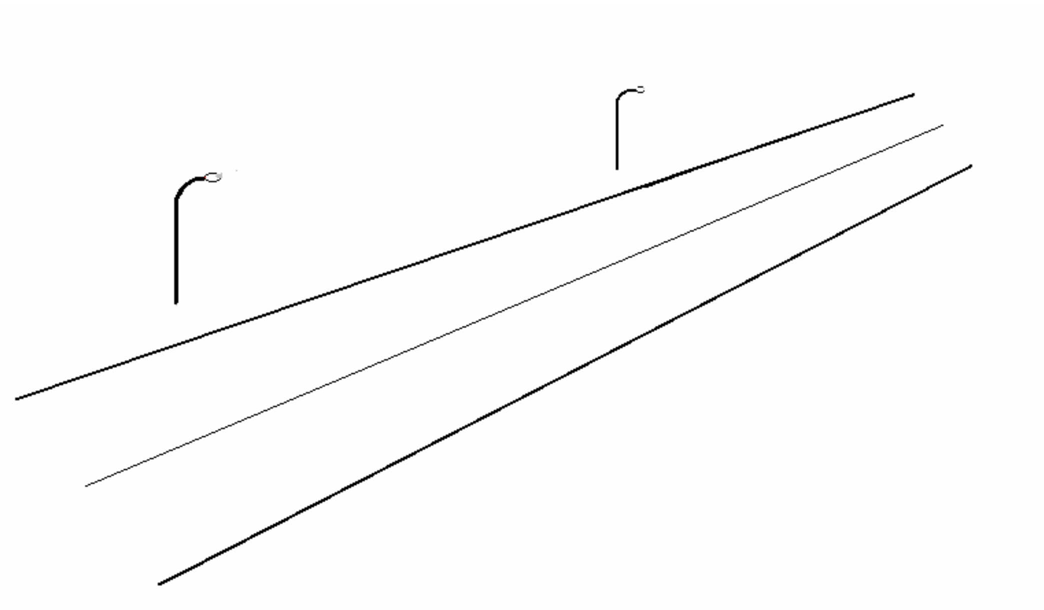
UNDERGROUND POWER - 80 W MERCURY AT 60 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		**Category P4**
ENERGY ❶	1.49	kW/km
GREENHOUSE GAS ❷	5.4	T/km
LAMP COST ❸	$ 4.50	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	$86	
Running cost per kilolumen	$16.00	

NOTES:
❶ Based on circuit power of 89.5 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

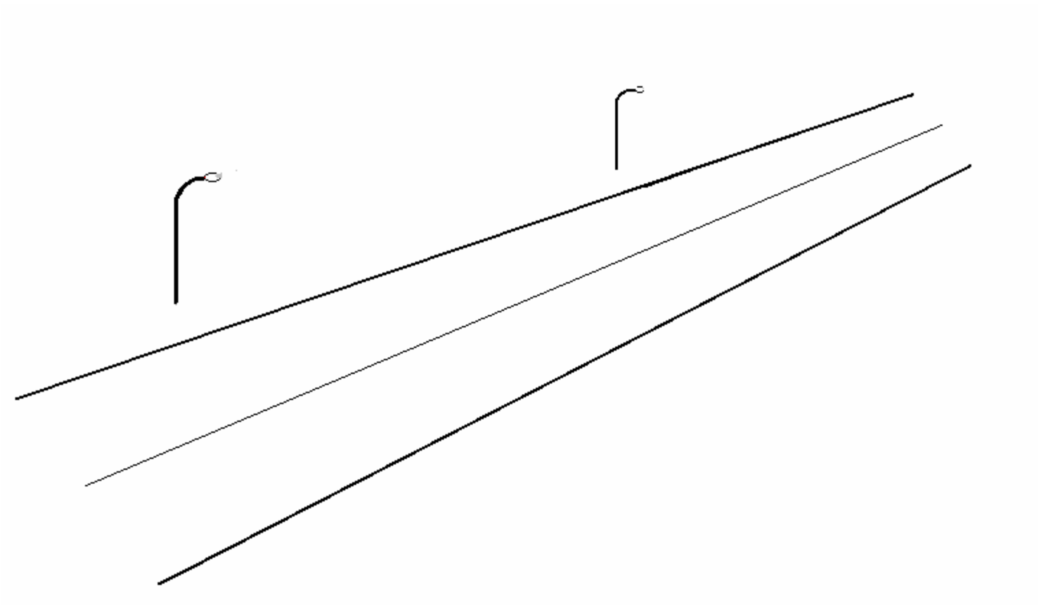
UNDERGROUND POWER – 42 W COMPACT FLUORESCENT AT 60 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		**Category P4**
ENERGY ❶	0.77	kW/km
GREENHOUSE GAS ❷	2.7	T/km
LAMP COST ❸	$ 13	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	N/A	
Running cost per kilolumen	$11.25	

NOTES:
❶ Based on circuit power of 46 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

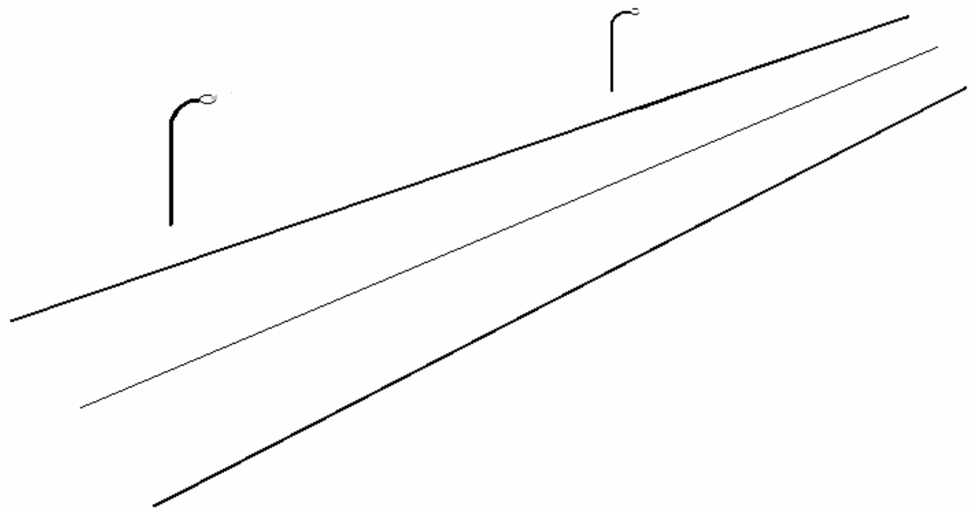
UNDERGROUND POWER - 70 W METAL HALIDE AT 70 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		**Category P4**
ENERGY ❶	1.1	kW/km
GREENHOUSE GAS ❷	4.0	T/km
LAMP COST ❸	$ 40	
LAMP LIFE ❹	3	years
SYNERGY TARIFF p.a.	$129	
Running cost per kilolumen	$15.51	

NOTES:
❶ Based on circuit power of 77 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

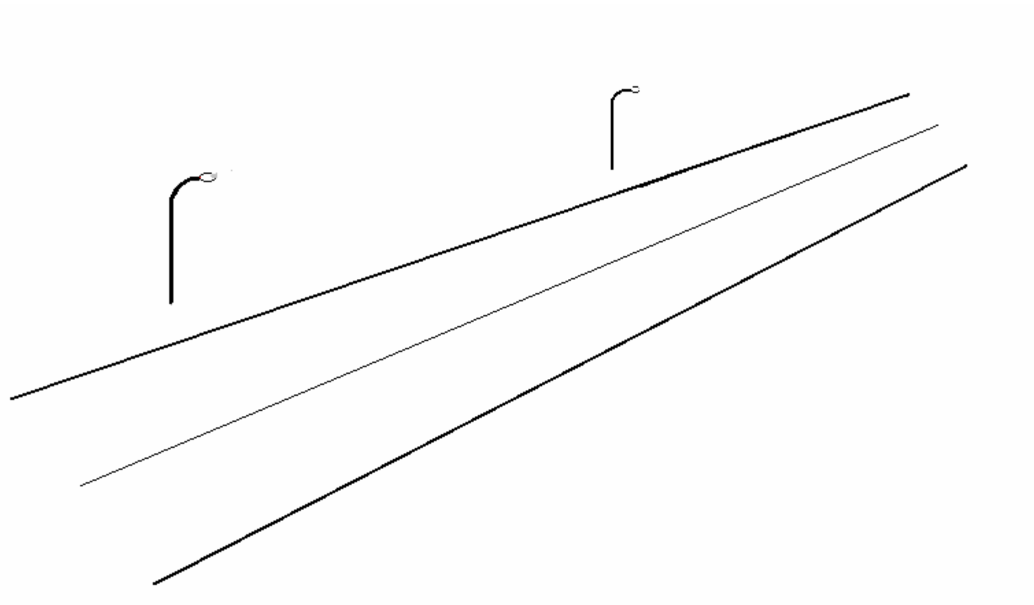
UNDERGROUND POWER - 70 W HIGH PRESSURE SODIUM AT 60 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		**Category P4**
ENERGY ❶	1.28	kW/km
GREENHOUSE GAS ❷	4.7	T/km
LAMP COST ❸	$ 21	
LAMP LIFE ❹	5	years
SYNERGY TARIFF p.a.	$82	
Running cost per kilolumen	$7.80	

NOTES:
❶ Based on circuit power of 77 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

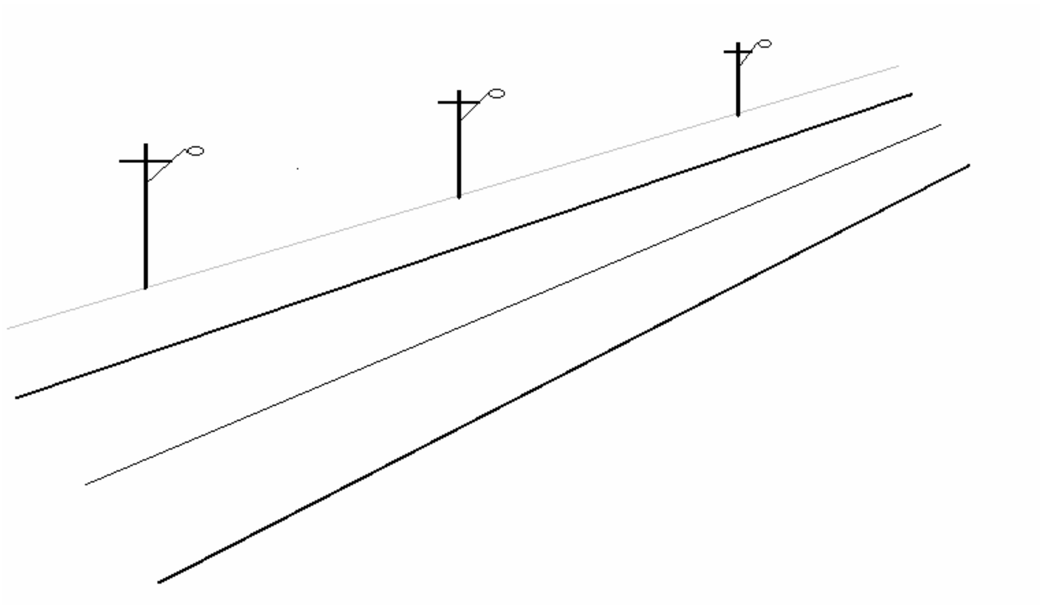
UNDERGROUND POWER - 50 W HIGH PRESSURE SODIUM AT 60 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		✖
ENERGY ❶	0.92	kW/km
GREENHOUSE GAS ❷	3.3	T/km
LAMP COST ❸	$ 21	
LAMP LIFE ❹	5	years
SYNERGY TARIFF p.a.	N/A	
Running cost per kilolumen	$9.42	

NOTES:
❶ Based on circuit power of 55 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year

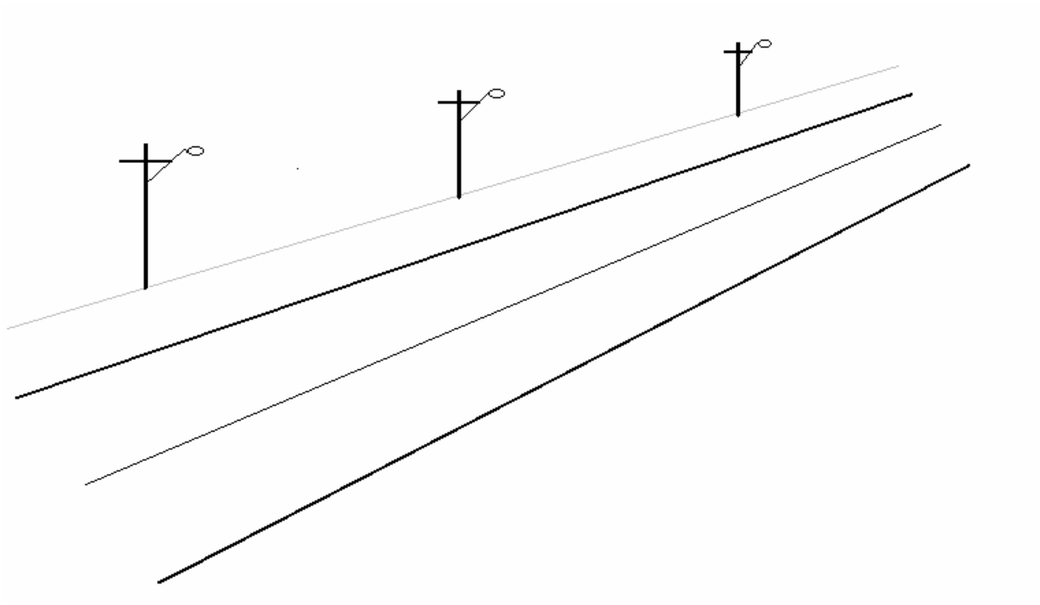
OVERHEAD POWER - 250 W HIGH PRESSURE SODIUM AT 40 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		Category V3
ENERGY ❶	6.9	kW/km
GREENHOUSE GAS ❷	25	T/km
LAMP COST ❸	$ 20	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	$161	
Running cost per kilolumen	$5.05❺	

NOTES:
❶ Based on circuit power of 276 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year
❺ Based on 4 year lamp life, lamp cost of $20.00, the labour and plant costs listed in Table 3, circuit power of 276 W, energy cost at ZE18 tariff, and lamp output of 28 000 lumens.

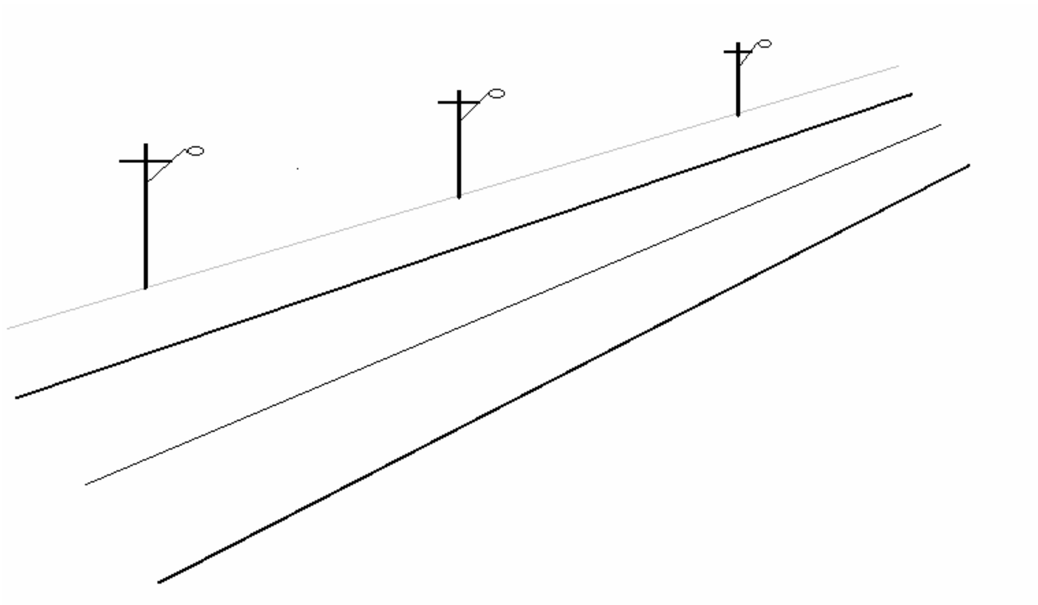
OVERHEAD POWER - 400 W MERCURY AT 40 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		Category V3
ENERGY ❶	10.7	kW/km
GREENHOUSE GAS ❷	39	T/km
LAMP COST ❸	$ 10	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	$232	
Running cost per kilolumen	$8.50❺	

NOTES:
❶ Based on circuit power of 429 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year
❺ Based on 4 year lamp life, lamp cost of $10.00, the labour and plant costs as listed in Table 3, circuit power of 429 W, energy cost at ZE18 tariff, and lamp output of 24 000 lumens

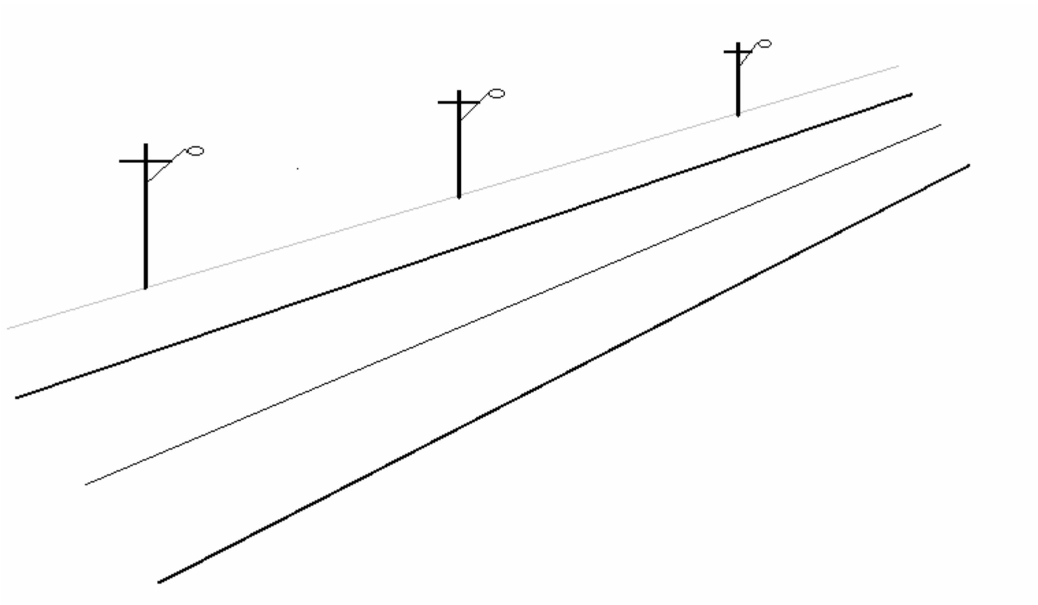
OVERHEAD POWER - 150 W HIGH PRESSURE SODIUM AT 40 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		Category V5
ENERGY ❶	4.2	kW/km
GREENHOUSE GAS ❷	15	T/km
LAMP COST ❸	$ 22	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	$125	
Running cost per kilolumen	$6.61❺	

NOTES:
❶ Based on circuit power of 168 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year
❺ Based on 4 year lamp life, lamp cost of $22.00, the labour and plant costs as listed in Table 3, circuit power of 168 W, energy cost at ZE18 tariff, and lamp output of 14 500 lumens

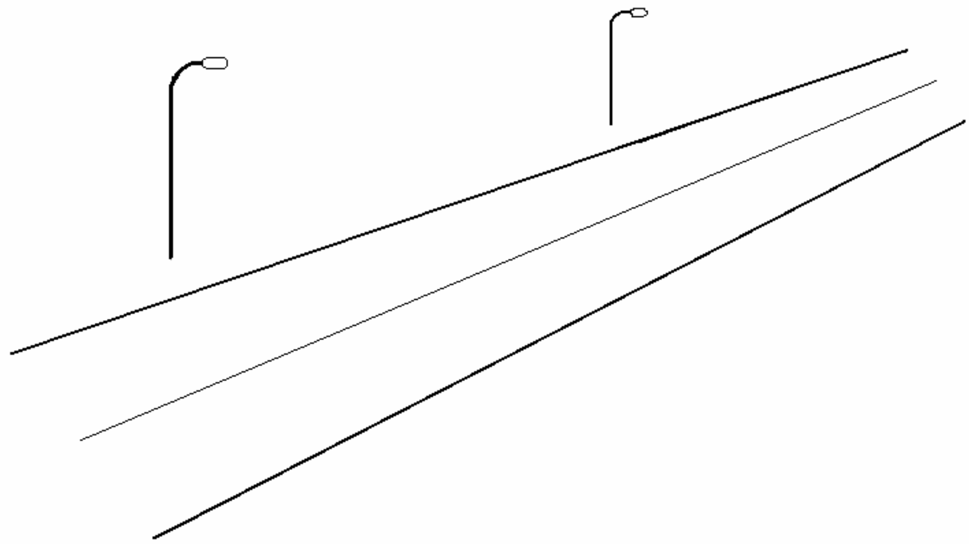
OVERHEAD POWER - 250 W MERCURY AT 40 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		Category V5
ENERGY ❶	6.9	kW/km
GREENHOUSE GAS ❷	25	T/km
LAMP COST ❸	$ 10	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	$173	
Running cost per kilolumen	$9.77❺	

NOTES:
❶ Based on circuit power of 276 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year
❺ Based on 4 year lamp life, lamp cost of $10.00, the labour and plant costs as listed in Table 3, circuit power of 271 W, energy cost at ZE18 tariff, and lamp output of 14 000 lumens

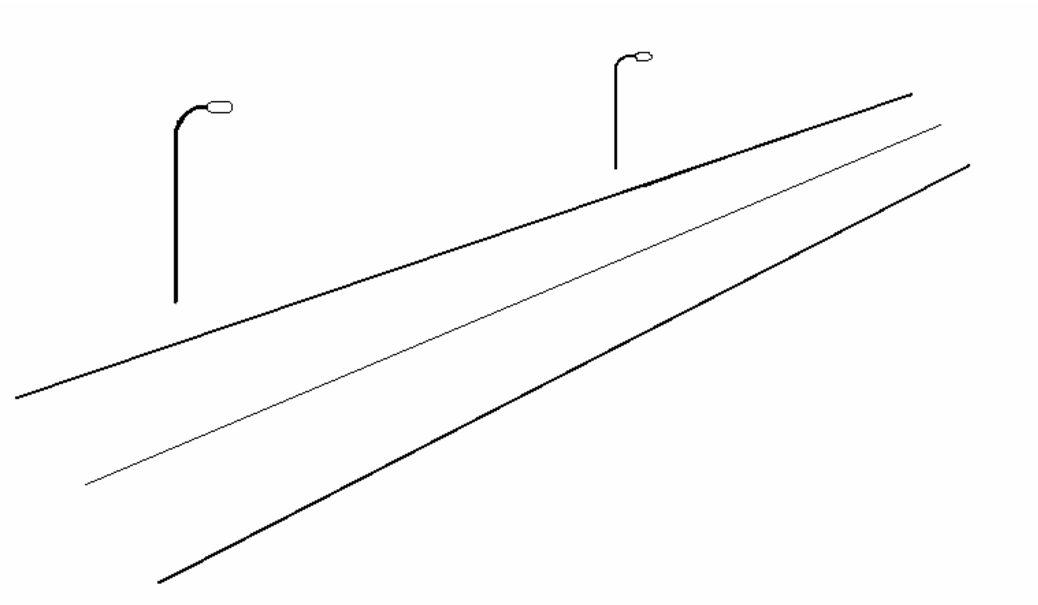
UNDERGROUND POWER - 250 W HIGH PRESSURE SODIUM AT 60 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		Category V3
ENERGY ❶	4.6	kW/km
GREENHOUSE GAS ❷	16.6	T/km
LAMP COST ❸	$ 20	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	$161	
Running cost per kilolumen	$5.05❺	

NOTES:
❶ Based on circuit power of 276 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year
❺ Based on 4 year lamp life, lamp cost of $20.00, the labour and plant costs as listed in Table 3, circuit power of 276 W, energy cost at ZE18 tariff, and lamp output of 28 000 lumens

UNDERGROUND POWER - 150 W HIGH PRESSURE SODIUM AT 60 M



KEY PERFORMANCE INDICATORS		
AS/NZS 1158 COMPLIANCE		Category V3
ENERGY ❶	2.8	kW/km
GREENHOUSE GAS ❷	10	T/km
LAMP COST ❸	$ 22	
LAMP LIFE ❹	4	years
SYNERGY TARIFF p.a.	$125	
Running cost per kilolumen	$6.61❺	

NOTES:
❶ Based on circuit power of 168 W
❷ Based on 0.9 kg of CO_2 per kWh
❸ Based on manufacturer information
❹ Based on 4 000 hours of operation per a year
❺ Based on 4 year lamp life, lamp cost of $22.00, the labour and plant costs as listed in Table 3, circuit power of 168 W, energy cost at ZE18 tariff, and lamp output of 14 500 lumens

APPENDIX H

BRIEF

BRIEF September 2004

Improved Street Lighting Study for Greenhouse and Safety Benefit – Project Brief

Institutional and Technical Review

a. Conduct an Institutional and Technical review of the current situation in Western Australia. The institutional issues would relate to Western Power, the Office of Energy, the State Underground Power Programme and a comparison between Council owned street lights and Streetvision. The Technical issues would include luminaire choices and adherence to the Australian Standards and comparisons of efficiencies with other Australian States as well as World's best practice.

b. Prepare a report on outcomes of the Institutional and Technical Review. The Report will include recommendation on how the efficiency of street lighting could be improved in Western Australia.

c. Prepare a seminar designed and conducted on the outcomes of the Institutional and Technical Review.

2. Monitoring Programme

2.1 The monitoring will cover about 200 new streetlights in each of Mosman Park North, Subiaco Underground Power Area, and Midvale and about 50 control old mercury vapour streetlights in each of Mosman Park South, Subiaco overhead power area, and Midland adjacent Midvale.

2.2 Prepare an initial report (2004) outlining the area of the study with maps showing location of streetlights and then submit report to WALGA. Each local government will provide GIS information to the consultant in AutoCAD format.

2.3 Develop monitoring methodology with the Streetlighting Steering Group. Monitor by means of twelve bimonthly by night visits to each streetlight. Each Local Government will report to the consultant any streetlights burning during the day ie. (faulty PE switches). Submit data to WALGA.

2.4 Prepare interim Report (2005) on the outcomes of Monitoring and Reporting for Three Study Sites at 12 Months. The Interim Report should draw on and include outcomes and finding of 1.2 and 1.3 in establishing interim recommendations.

2.5 Prepare final report on the 24 month monitoring trial including link to recommendations from Institutional and Technical Review. Submit to WALGA.

2.6 Prepare a seminar designed and conducted to report project outcomes to stakeholders. Subject to level of interest, this may be conducted in parallel with the Institution and Technology seminar.

APPENDIX I

LIGHTING MEASUREMENT MAPS

LEGEND

22.0	ILLUMINANCE LEVEL IN LUX
OUT	INDICATES STREETLIGHT OUT OF ORDER
•○	STREETLIGHT

NOTES

FOR EACH STREETLIGHT, TWO ILLUMINANCE READINGS ARE SHOWN, ONE DIRECTLY UNDER THE STREETLIGHT, THE OTHER AT THE ROAD RESERVE BOUNDARY PERPENDICULAR TO THE STREETLIGHT.

Western Australian Local Government Association

Field Trials 1

Midvale - Area 1

Sage Consulting Engineers Pty. Ltd.

DRAWN: A.G.R. DATE: 5/1/2005 SCALE: 1:2000 @ A3

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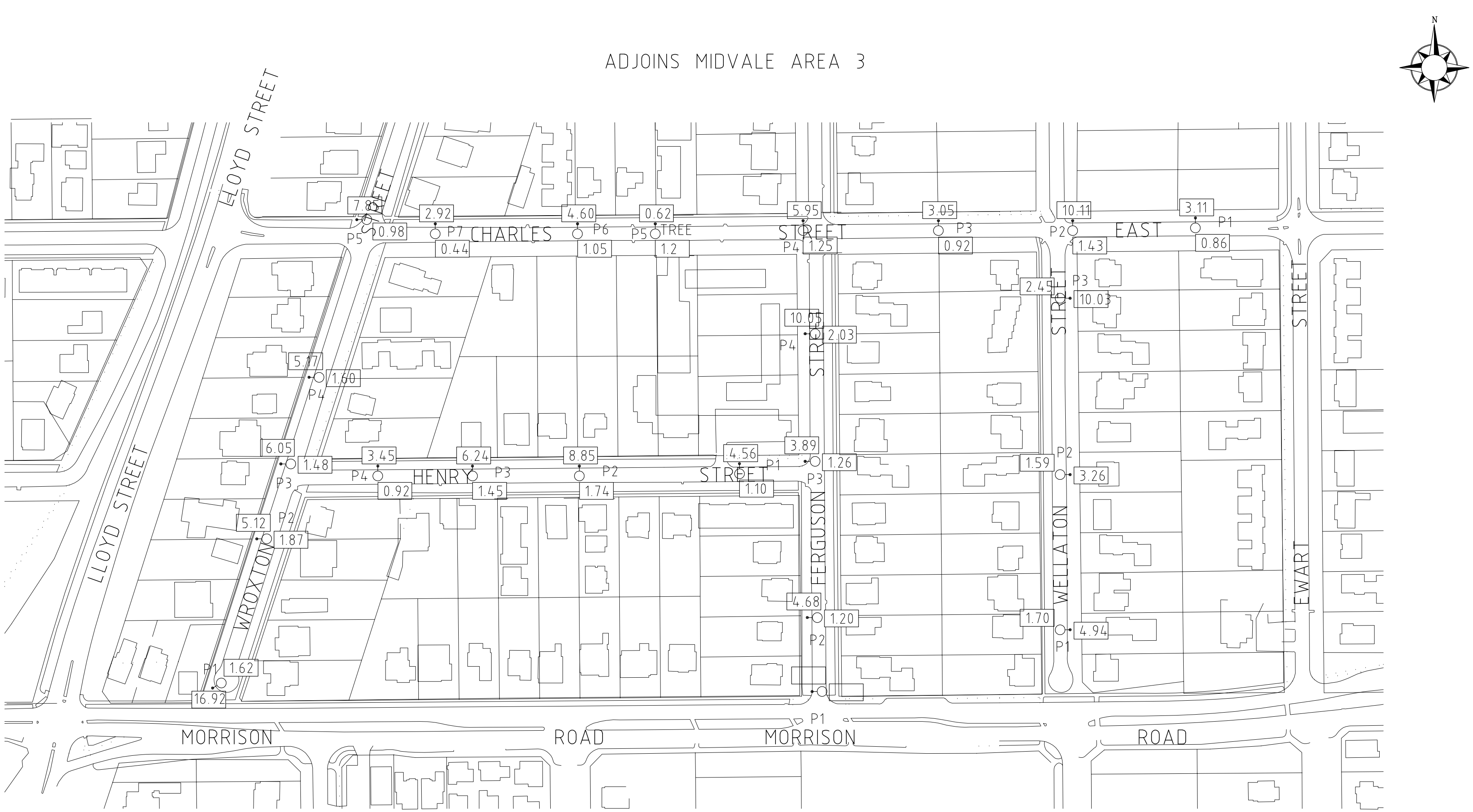
A3



LEGEND

22.0	ILLUMINANCE LEVEL IN LUX
OUT	INDICATES STREETLIGHT OUT OF ORDER
-○	STREETLIGHT

NOTES

FOR EACH STREETLIGHT, TWO ILLUMINANCE READINGS ARE SHOWN, ONE DIRECTLY UNDER THE STREETLIGHT, THE OTHER AT THE ROAD RESERVE BOUNDARY PERPENDICULAR TO THE STREETLIGHT.

Western Australian Local Government Association

Field Trials 1

Midvale - Area 2

Sage Consulting Engineers Pty. Ltd.

DRAWN: A.G.R. DATE: 5/1/2005 SCALE: 1:2000 @ A3

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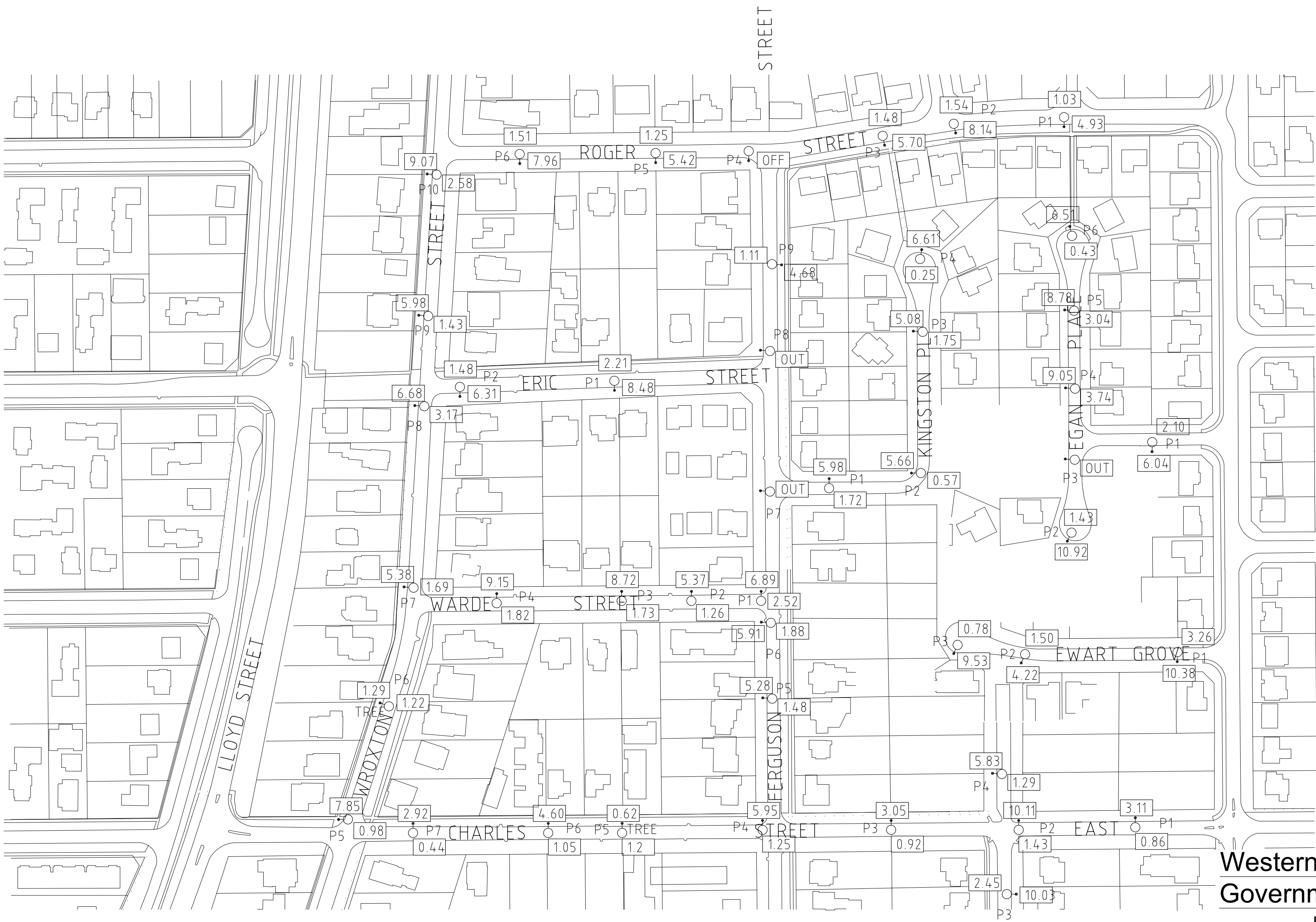

Western Australian Local Government Association

Field Trials 1

Midvale - Area 3

Sage Consulting Engineers Pty. Ltd.

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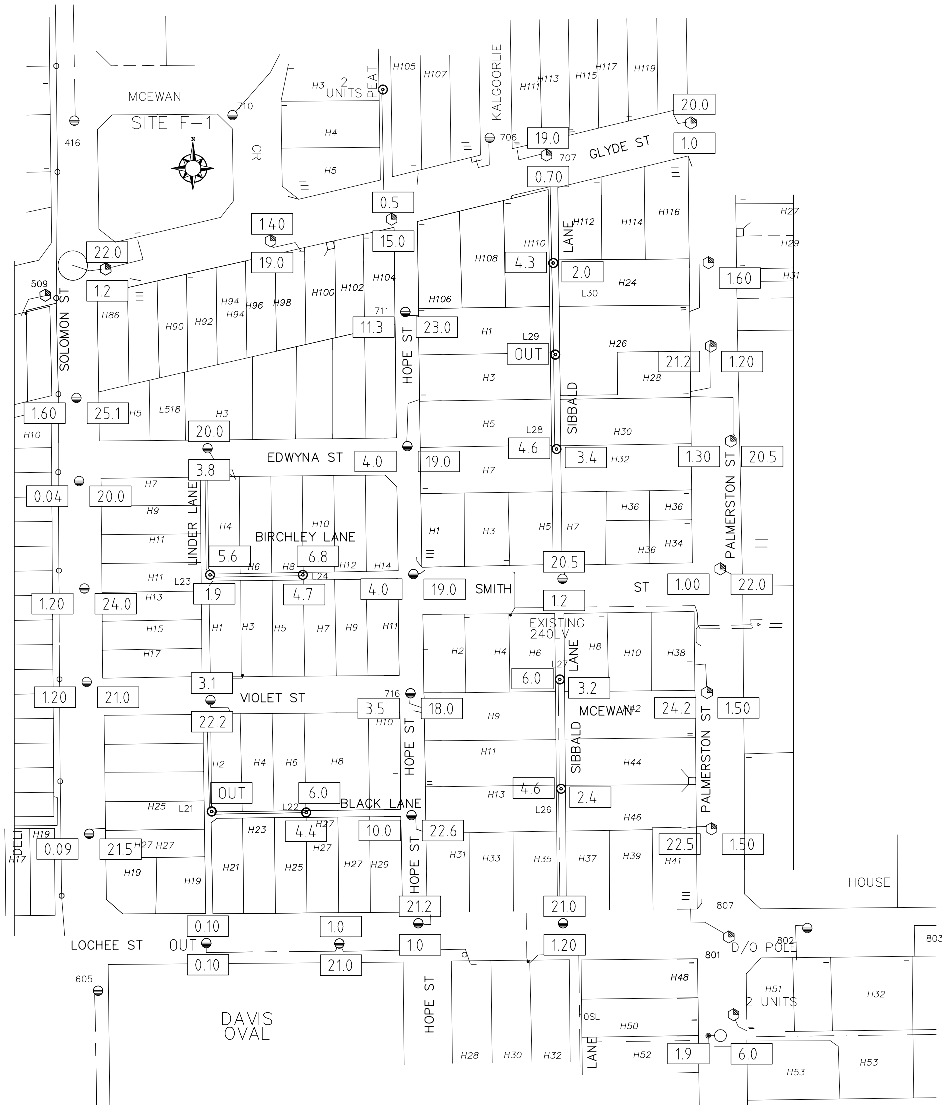
LEGEND

22.0	ILLUMINANCE LEVEL IN LUX
OUT	INDICATES STREETLIGHT OUT OF ORDER
•○	STREETLIGHT

NOTES

FOR EACH STREETLIGHT, TWO ILLUMINANCE READINGS ARE SHOWN, ONE DIRECTLY UNDER THE STREETLIGHT, THE OTHER AT THE ROAD RESERVE BOUNDARY PERPENDICULAR TO THE STREETLIGHT.



Area 1

REFER DRAWING Mosman Park LR2
FOR CONTINUATION OF AREA 2

LEGEND

22.0	ILLUMINANCE LEVEL IN LUX
OUT	INDICATES STREETLIGHT OUT OF ORDER
⊙	LANEWAY STREETLIGHT
◒	STREETLIGHT

NOTES

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Western Australian Local Government Association

Field Trials 1

Mosman Park - Area 1

Sage Consulting Engineers Pty. Ltd.

DRAWN: A.G.R. DATE: 11/2/2005 SCALE: 1:2000 @ A3

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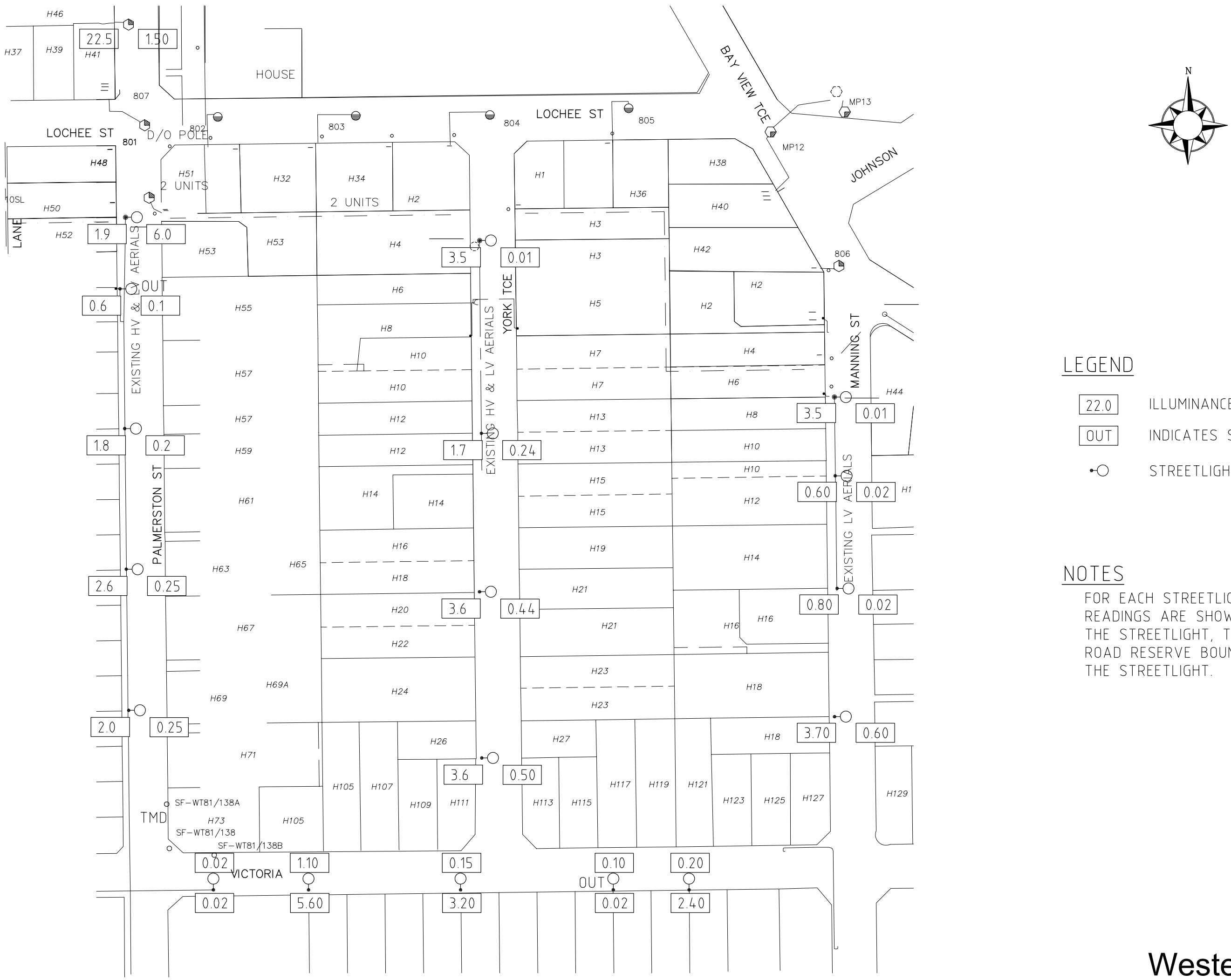
A3

REFER DRAWING Mosman Park LR1
FOR CONTINUATION OF AREA 1



Area 2

LEGEND

22.0	ILLUMINANCE LEVEL IN LUX
OUT	INDICATES STREETLIGHT OUT OF ORDER
•○	STREETLIGHT

NOTES

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Western Australian Local Government Association

Field Trials 1

Mosman Park - Area 2

Sage Consulting Engineers Pty. Ltd.

DRAWN: A.G.R. DATE: 14/2/2005 SCALE: 1:2000 @ A3

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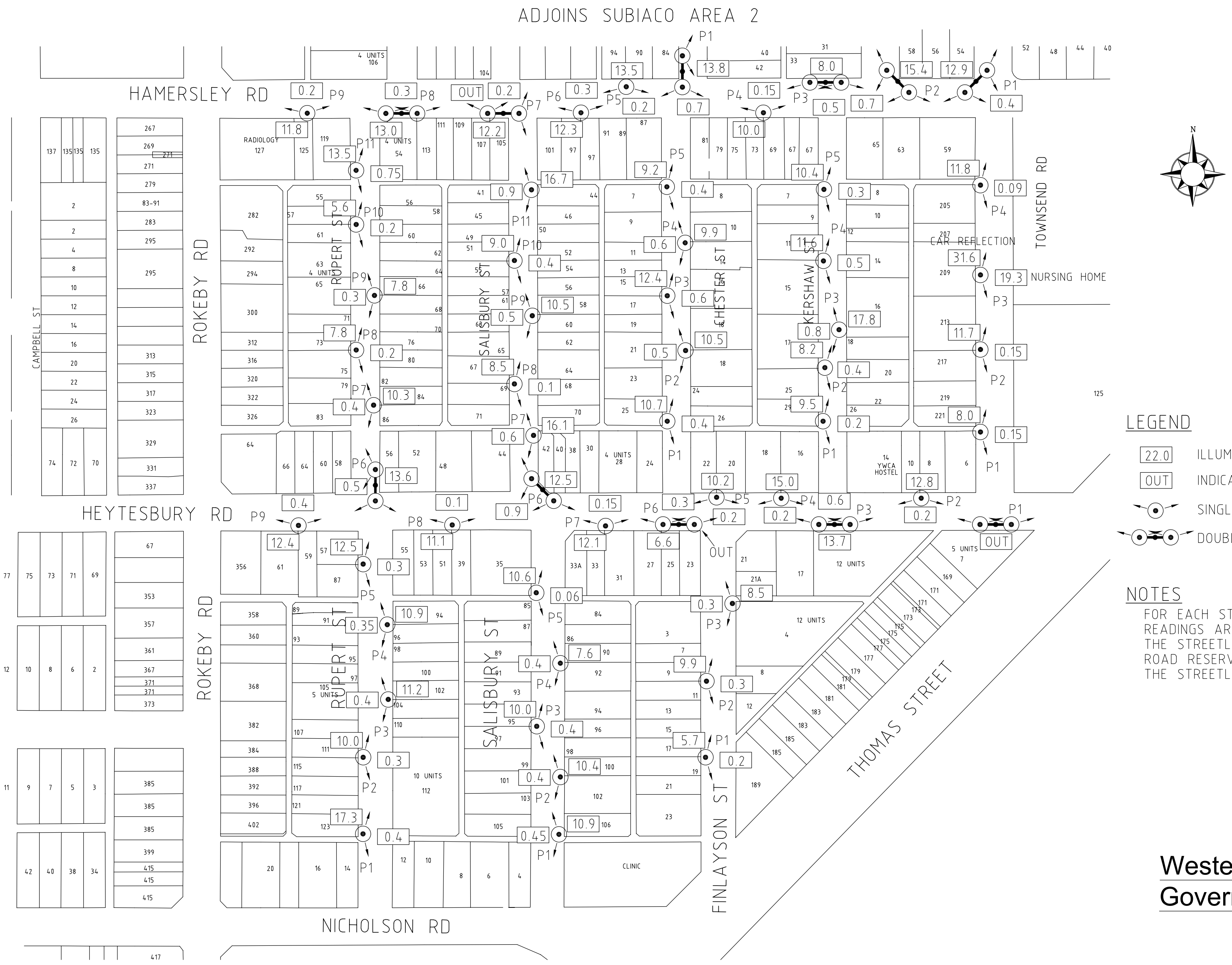

LEGEND

22.0 — ILLUMINANCE LEVEL IN LUX

OUT — INDICATES STREETLIGHT OUT OF ORDER

SINGLE STREETLIGHT

DOUBLE STREETLIGHT

NOTES

FOR EACH STREETLIGHT, TWO ILLUMINANCE READINGS ARE SHOWN, ONE DIRECTLY UNDER THE STREETLIGHT, THE OTHER AT THE ROAD RESERVE BOUNDARY PERPENDICULAR TO THE STREETLIGHT.

Western Australian Local Government Association

Field Trials 1

Subiaco - Area 1

Sage Consulting Engineers Pty. Ltd.

DRAWN: A.G.R. DATE: 10/2/2005 SCALE: 1:2000 @ A3

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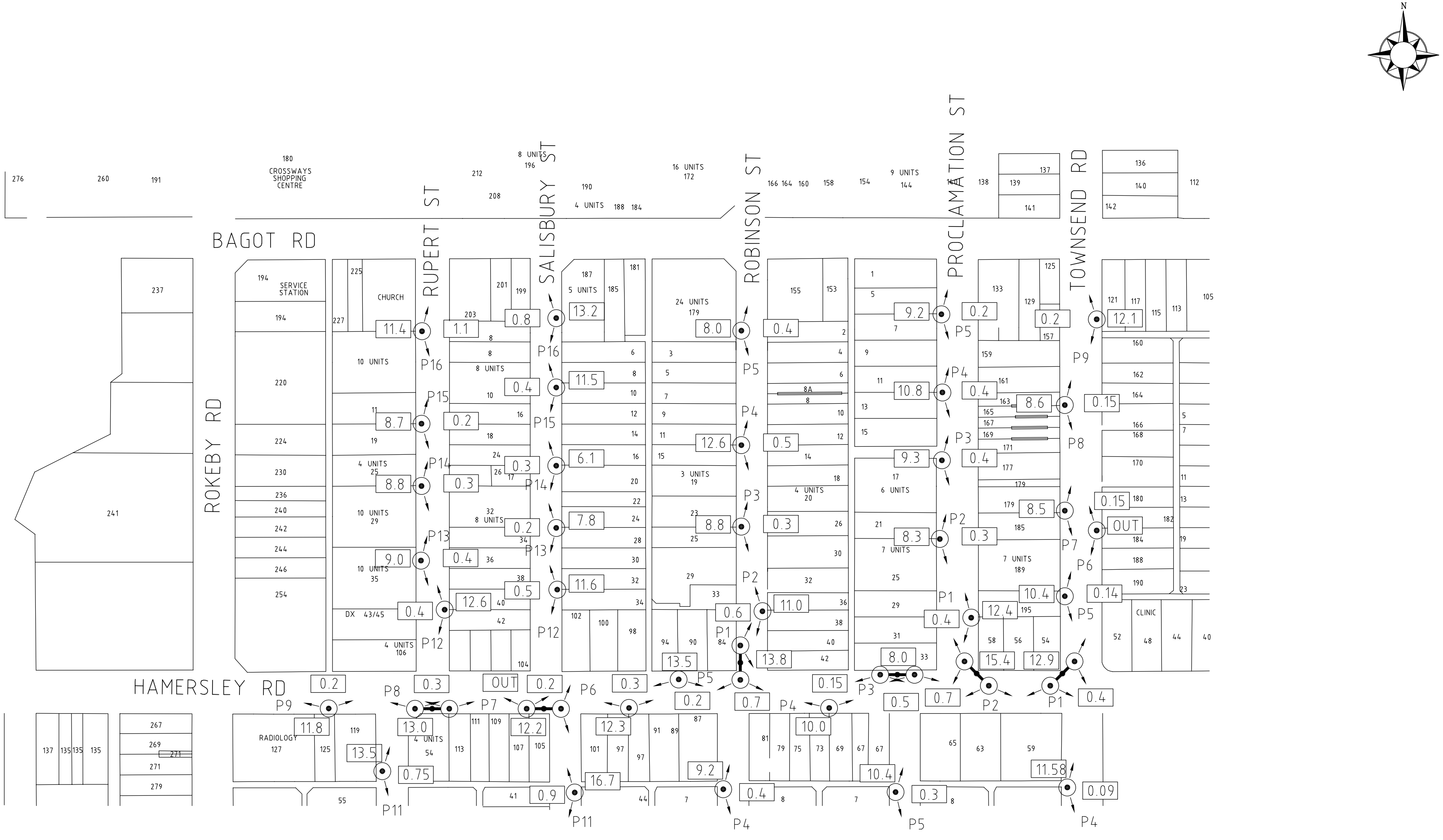

LEGEND

22.0 ILLUMINANCE LEVEL IN LUX

OUT INDICATES STREETLIGHT OUT OF ORDER

SINGLE STREETLIGHT

DOUBLE STREETLIGHT

NOTES

FOR EACH STREETLIGHT, TWO ILLUMINANCE READINGS ARE SHOWN, ONE DIRECTLY UNDER THE STREETLIGHT, THE OTHER AT THE ROAD RESERVE BOUNDARY PERPENDICULAR TO THE STREETLIGHT.

Western Australian Local Government Association

Field Trials 1

Subiaco - Area 2

Sage Consulting Engineers Pty. Ltd.

DRAWN: A.G.R. DATE: 10/2/2005 SCALE: 1:2000 @ A3

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LEGEND

22.0	ILLUMINANCE LEVEL IN LUX
OUT	INDICATES STREETLIGHT OUT OF ORDER
●─○	STREETLIGHT

NOTES

FOR EACH STREETLIGHT, TWO ILLUMINANCE READINGS ARE SHOWN, ONE DIRECTLY UNDER THE STREETLIGHT, THE OTHER AT THE ROAD RESERVE BOUNDARY PERPENDICULAR TO THE STREETLIGHT.

Western Australian Local Government Association

Field Trials 1

Subiaco - Area 3

Sage Consulting Engineers Pty. Ltd.

DRAWN: A.G.R. DATE: 10/2/2005 SCALE: 1:2000 @ A3

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APPENDIX J

SUMMARY OF RECOMMENDATIONS

SUMMARY OF RECOMMENDATIONS

ITEM RECOMMENDATION

1. **Standards**
WALGA encourage local government to adopt AS/NZS 1158 as a policy for technical design of streetlight networks. AS/NZS is appropriate, and should not be considered as excessive. There is a risk to local government if they do not comply with a national standard.

2. **Efficient lamp technologies**
WALGA encourage Western Power and Local Government to use the more efficient lamp technologies in new and replacement street lights.

3. **Underground Power Program**
The Office of Energy encourages energy efficient street lighting for UPP projects, and specifies appropriate AS/NZS 1158 Categories.

4. **Synergy/Western Power Invoicing**
Synergy provide a price breakdown listing maintenance, replacement, energy, and administrative costs to individual Local Government clients.

5. **Mercury**
On overhead power systems, the 80 W mercury vapour street light at 80 m spacing does not comply with AS/NZS 1158. Mercury vapour lamps have half the efficiency of modern lamps. Consequently the use of mercury vapour lamps should be phased out by responsible authorities.

6. **Western Power**
WALGA request Synergy and Western Power to include fluorescent lamps such as compact fluorescent and T5 fluorescent lamps in their available stock.

7. **Energy Efficient Street Lighting Technologies**
For minor road lighting two technologies are available to Local Government:
    - 42 W compact fluorescent
    - 2 X 24 W T5 fluorescent

    Both lamps are mature, not emerging technologies. The compact fluorescent lamp has been available since 1982 and the 42 W version since the early 1990's. T5 fluorescent lamps have been available since the mid 1990's. Both lamp technologies are available in Australian made street lights.
These technologies are equivalent in light output to the common 80 W mercury vapour lamp and offer a halving of energy consumption and greenhouse gas emissions.