APPENDIX A: SURVEY OF EXISTING ROAD AND STREET LIGHTING IN PUTRAJAYA

APPENDIX A – SURVEY ON EXISTING ROADS

1 INTRODUCTION

A survey on existing road lighting was carried out on existing roads in Putrajaya. This survey attempts to analyse the quality of road lightings by measuring the lighting levels using an illuminance (lux) meter. Despite the technical impediment of the measurements, the following conclusion can be drawn from the survey:

(a) All Protocol roads within Putrajaya generally comply with and usually exceed the minimum luminance level specified in the BS and CIE standards.

(b) Despite the abundance in lighting, a serious problem in lighting uniformity exists in most Protocol roads. This deficiency (in road lighting uniformity) can perhaps be attributed to the poor photometric characteristics of the luminaire where aesthetic is given primacy over the technical.

(c) This REPORT recommends that a detail and accurate survey using proper luminance meter be conducted by a specialist company for accurate identification and assessment of the (technical aspect) of the (Protocol) road lighting in Putrajaya.

(d) Problems in lighting issues are also identified in this REPORT; problems include sky glow (PM's complex and Grand Mosque) and discomfort glare (Dataran Putra).

Due to the scope and nature of investigation, this REPORT and attendant survey is not meant to be an exhaustive analysis of streets and public lighting in Putrajaya and should only be treated as a 'Preliminary Assessment REPORT'. A separate survey employing specialist company (conclusion (c) above) should be commissioned if such detailed and exhaustive survey is required.

2.0 SCOPE AND METHODOLOGY

2.1 Scope of Survey

The scope of survey conducted in October and November 2001 covers the following inspections at core precinct of Putrajaya:

(a) Measurement of lighting level at Protocol roads within core precinct of Putrajaya, and

(b) Visual inspection to identify problem areas impacting sky glow, light trespass and discomfort glare.

2.2 Illuminance Measurement

Luminance Meter Measurement of lighting level was conducted using a (cosine corrected) illuminance (E – lux) meter. The light sensor was placed on the surface of the road and illuminance (lux) was read off the attached meter. Care was taken to ensure that accuracy of reading is not affected by stray shadows.

Efficacy of Parameters In the specification of road lighting, luminance (L – cd/m^2) is an oft-used parameter, as it describes more accurately the perception of brightness and visualisation for a motorist looking ahead at the azimuth (of the road). Where pedestrian intrusion is a criteria (residential access, pedestrian crossing, park/vehicular access etc) illuminance (E – lux) is specified for pedestrian comfort.
The assessment of road lighting adequacy utilising illuminance measurement is therefore not an accurate indicator.

Cd/m^2 to Lux To provide some assessment of road lighting adequacy, the illuminance data obtained is converted to luminance. Conversion of illuminance to luminance is another approximation based on the following:

(1) $E_{Lambertian} = L \times \pi$

Equation (1) is inferred from the definition of the candela, steradian and the assumption that the surface is Lambertian (a Lambertian surface is an ideal diffusing surface reflecting light equally in all directions). Road surfaces however are not Lambertian and have a specular component depending on the directions of light source and observer. BS 5489 and CIE30.2 describe the following:

2.1 Scope of Survey
(a) Measurement of lighting level in core precinct; and
(b) Visual inspection to identify areas of sky glow, light trespass and discomfort glare.

'…this REPORT and attendant survey should only be treated as a 'Preliminary Assessment REPORT'.
A separate survey employing specialist company should be commissioned …'

(2) E = q x L (CIE 30.2; where q the luminance coefficient is a factor dependent on the vertical angle of throw of the luminaire and 'r' – a 'reduced coefficient' which is a function of the specular property of the road).

(3) E = σ x L (BS 5489; where σ the average luminance coefficient is obtained by consulting tabulation of road types and properties).

BS 5489 avers that 'the great majority of British roads' have an average luminance coefficient of **0.07**. CIE 30.2 list q_o (the average luminance coefficient) as between **0.07 and 0.1**. This REPORT assumes an average luminance coefficient of 0.07.

Margin of Errors The estimation of luminance data in this REPORT should be taken as a guide, as the following will contribute to margin of errors in the assessment:

(a) The error intrinsic in the illuminance meter,

(b) Error arising from field measurements,

(c) The assumption of 0.07 as an average luminance coefficient (theoretically each road type should be considered on its own characteristics), and

(d) Field measurements are not complete (a complete field data would require measurement on a recommended grid between at least two to three columns of luminaire) to determine accurate average and uniformity values.

However despite the margin of errors, estimates of luminance values obtained are reasonably useful to provide a preliminary technical assessment.

2.3 Visual Survey

Visual survey of lighting in core precinct attempts to identify the following luminaire or lighting system:

(a) Contribution to sky glow,

(b) Contribution to light trespass, and

(c) Discomfort glare.

2.4 Sky glow

Sky Glow refers to the wasteful throw of lights into the night sky contributing to light pollution. It is usually a result of:

(a) Misdirected light which throws more light onto the sky than at the intended area.

(b) Wasteful use of wide angle projection in an attempt to 'flood' or 'wash' a façade or monument (instead up to 80% of the light is lost skyward).

(c) Luminaire with a significant portion of lights escaping above the horizontal plane. Luminaire with shields or reflector to limit this upward throw of lights is termed fully or semi 'cut-off' (an exact definition of cut-off differs between BS, CIE and the IESNA and is beyond the scope of this REPORT). Non 'cut-off' luminaire under certain conditions also contributes to discomfort glare.

2.5 Light trespass

Light trespass refers to the intrusion of light into a neighbouring lot. Light trespass is usually a result of:

(a) Misdirected light trespassing onto a neighbouring lot,

(b) Wide angled projected light trespassing onto a neighbouring lot,

(c) Unshielded Luminaire.

***Margin of Errors* Estimation of luminance data in this REPORT should only be taken as a guide:**

) The error intrinsic in the illuminance meter,

) Error arising from field measurements,

) Assumption of 0.07 as an average luminance coefficient, and

) Field measurements are incomplete (a complete field data would require measurement on a recommended grid between at least two to three columns of luminaire) to determine accurate average and uniformity values.
However despite the margin of errors, estimates of luminance values obtained are reasonably useful to provide a preliminary technical assessment.

2.6 Glare

Glare is a complex issue is treated in both CIE 31 and BS 5489:Part 1. Two types of glare are classified:

Disability Glare refers to loss of visibility cause by the disability glare of a source of bright light. An object that is just visible (i.e. at the threshold of visibility) in the absence of glare will merge into the background in the presence of disability glare.

Discomfort Glare refers to the response of the eye to varying and contrasting levels of lights. The contrast of glare source to background lighting, though not causing visibility loss causes a certain amount of discomfort.

The quantification of glare especially disability glare is treated in motorway lighting by the calculation of 'threshold increment' (TI). Formulation of TI is based on the percentage increase in luminance difference required to make an object visible in the presence of disability glare. The appraisal of discomfort glare is subjective and various guidelines are given. Appraisal of discomfort glare include the distinction between 'sparkle' and glare and the effect of 'cut-off' (shielded) lamp source and even mounting height of luminaire on glare restriction formula.

This report will not discourse on the details of glare calculation but will focus on the subject of discomfort glare.

2.7 Out of Scope

This REPORT/SURVEY will not touch on the following subject:

(a) The visual impact of lighting and the coordination of visual lighting impact in the core precincts of Putrajaya,

(b) The impact of colour rendering on architecture and landscape, and

(c) The aesthetic aspect of lighting and light fixture.

3 SURVEY OF LIGHTING LEVELS

3.1 Benchmarks

Before tabulating the data obtain in the survey, recommended values of luminance and uniformity is tabulated in table A3.1 for comparison with measured values. The tabulation in table A3.1 is simplified to consider only the types of roads treated in this SURVEY.

	BS 5489				CIE 115 and 136			
Motorways								
Description	**Class**	**L** cd/m²	**U_o**	**U_L**	**Class**	**L** cd/m²	**U_o**	**U_L**
Main high speed ring and access roads (separate carriageway).	Part 10	2	0.4	0.7	M1	2	0.4	0.7
Secondary high speed access roads (dual carriageway)	Part 2 2/1	1.5	0.4	0.7	M2	1.5	0.4	0.7
Important urban roads precinct distributor.	Part 2 2/2	1.0	0.4	0.5	M3	1.0	0.4	0.5
Local distributor, residential access	Part 2 2/3	0.5	0.4	0.5	M4	0.75	0.4	NR

Table A3.1a – Recommended Lighting Levels

1.2 Out of Scope
This REPORT/SURVEY will not touch on the following subject:

(a) The visual impact of lighting and the coordination of visual lighting impact in the core precincts of Putrajaya,

(b) The impact of colour rendering on architecture and landscape, and

The aesthetic aspect of lighting and light fixture.

***Table A3.1a* Recommended luminance for motorways (in cd/m²) BS 5489 and CIE 115 & 136.**

	BS 5489				**CIE 115 and 136**			
Urban Centres								
Class	**Class**	**L cd/m^2**	**U_o**	**E (lux)**	**Class**	**L cd/m^2**	**U_o**	**E (lux)**
City Centre primarily vehicular		1.5	0.4	NA	Classification M1 to M5			
City centre mixed pedestrian /vehicular		NA	NA	30		NA	NA	25
City Centre wholly pedestrian		NA	NA	25		NA	NA	15
Suburbs primarily vehicular		1.5	0.4	MA	Classification M1 to M5			
Suburbs mixed pedestrian /vehicular		NA	NA	25		NA	NA	20
Suburbs wholly pedestrian		NA	NA	15		NA	NA	10

Table A3.1b – Recommended Lighting Levels

1.2 Tabulation of Data

The section at the back of this REPORT illustrate the locality of measurement and visual presentation of lighting types.

	Protocol Road	**L cd/m^2**	**U_o**	**U_L**	**E lux**	**Comments**
1	Fauna single arm dual carriageway	1.7	0.33	0.5	-	Uniformity problem
	Fauna double arm, 4 lanes separate carriageway	2.4	0.4	0.5	-	Uniformity problem
2	Wau Bulan 6 lanes separate carriageway	2.5	0.4	0.3	-	Uniformity problem
3	Obor 6 lanes separate carriageway	1.1	0.6	0.7	-	Uniformity and uneven light distribution.
4	Persiaran Seri Perdana Flora – 4 lanes, separate carriageway	3 to 6	0.3	0.4	-	Uniformity problem exceeds BS & CIE recommendations
5	Core island ring road –Wau Bulan – 5 lanes single carriageway	3	0.5 – 0.6	0.5 – 0.6		Exceeds BS & CIE recommendations
6	Taman Putra Perdana Mixed pedestrian vehicular (2 lanes)	1	-		14	Comply with recommended values
7	Precinct 9 housing:-					
	(a) Main approach	3	0.45	0.4	45	Exceed BS & CIE recommendations
	(b) Secondary	2	0.75	0.6	40	

Table A3.2 – Tabulation of Lighting Assessment

***Table A3.1b* Recommended illuminance for pedestrian traffic (in lux) BS 5489 and CIE 115 & 136.**

***Table A3.2* Tabulation of Lighting Levels of core precinct from preliminary lighting survey.**

3.3 **Detail Visual Assessment**

Sky glow is a problem at core precinct area especially at:

(a) Grand mosque,

(b) Prime Minister's complex and

Sky glow in these areas are principally due to the usage of wide angle flood light in 'washing' architectural features (especially domes).

Discomfort glare are identified in the following areas:

I. Dataran Purajaya; where the street lights mounted on decorative columns are tilted upwards allowing lights to be directed above the horizontal plane,

II. Certain street lights (Obor and Flora) where the decorative luminaire has poor photometric characteristics, and

III. Wide spread use of globe lights (parks and Wisma Putra).

Light Trespass is not (yet) significant as the level of development Putrajaya has not reached a built-up and density sufficient to warrant such concern.

4 CONCLUSION

From the survey the following conclusion can be drawn.

(a) Most roads and street lights are provided with lighting levels which exceed the BS and CIE recommendation.

(b) In some cases (suburban and core island), lighting levels are high (compared to recommended levels).

(c) Despite the abundance of lighting levels, light distribution and uniformity (especially at main Protocol roads) are poor. The degradation in light distribution and uniformity and inconsistency is due to the poor photometric characteristics of the luminaire where aesthetic is given primacy over the technical.

(d) In view of the above, it is recommended that a detail survey of lighting level and performance be commissioned to be executed by a specialist company with the proper luminance meter.

(e) Some problem area in discomfort glare (Dataran Putrajaya, decorative highway luminaire) and sky glow (flood lighting of PM's complex and grand mosque) is also identified.

(f) This REPORT is a preliminary assessment and is not meant to be an exhaustive or detail technical treatment of the subject.

… from the survey the following conclusion can be drawn:

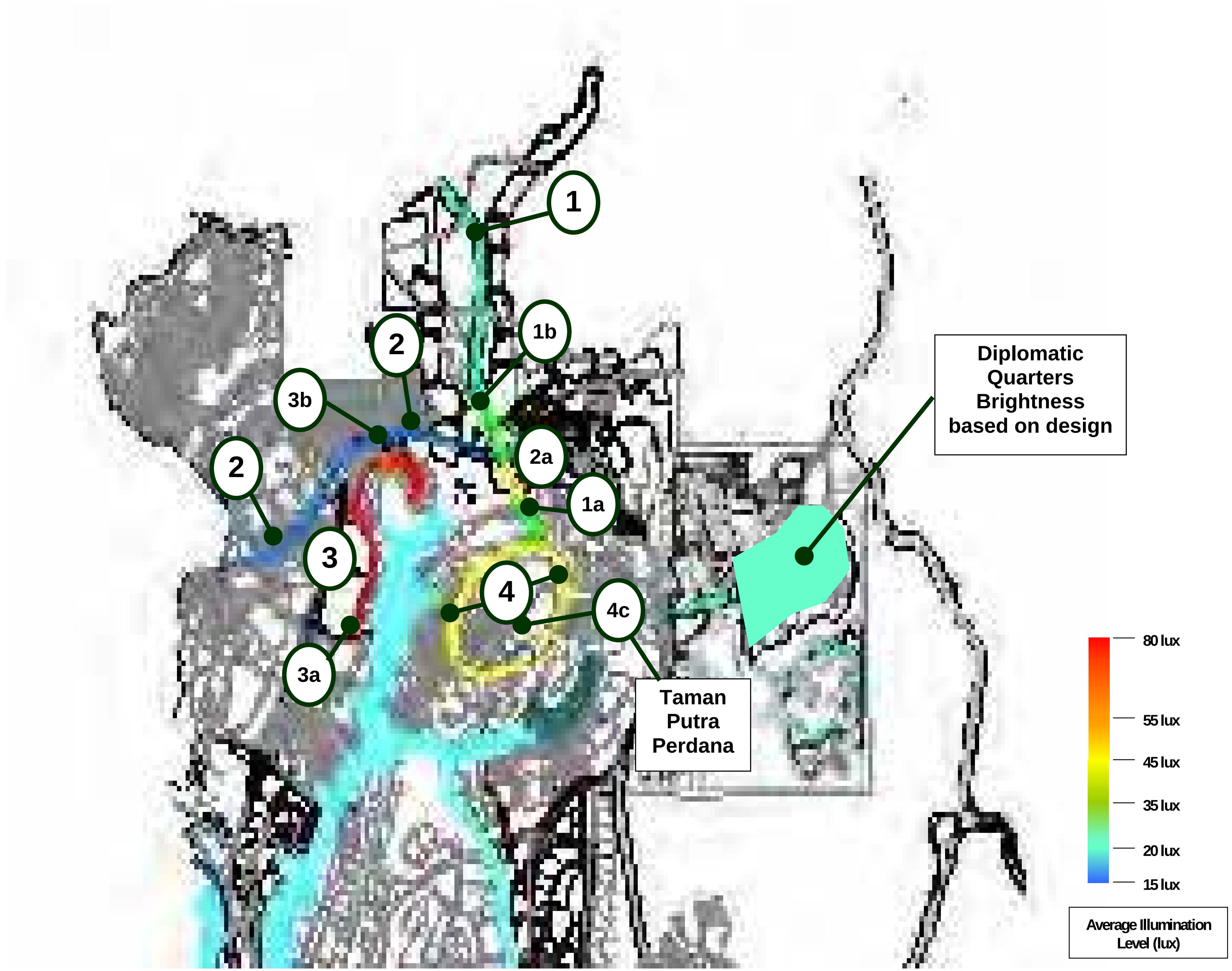
(a) Lighting levels at most roads exceed the BS & CIE recommendation.

(b) In some cases (suburban and core island), levels are relatively high (compared to recommended values).

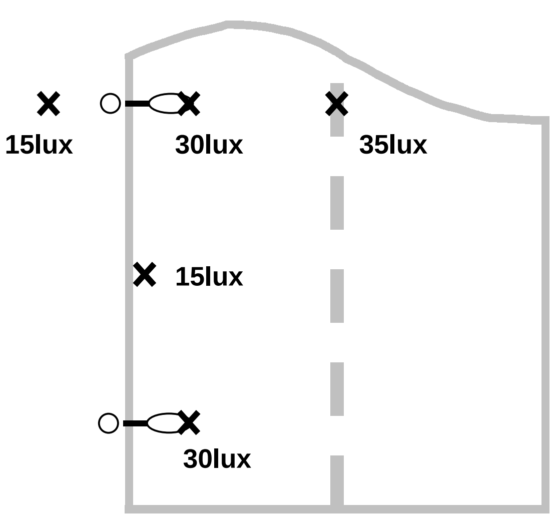
(c) Despite the abundance of lighting, light. The degradation in light distribution, uniformity and consistency is due to the poor photometric characteristics of the luminaire where aesthetic is given primacy over the technical.

(d) It is recommended that a detail survey of lighting level and performance be executed by a specialist company with the proper luminance meter.

SECTION 2 – SURVEY OF EXISTING ROADS

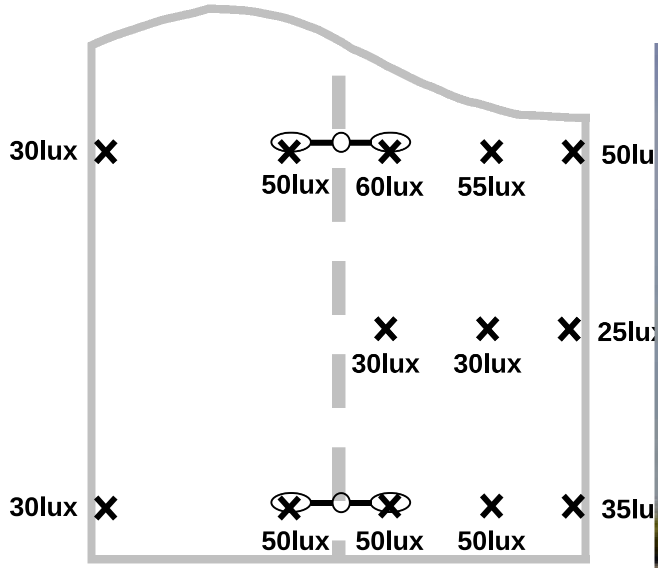


Mapping of illuminance level



Road width – 2 lanes
Lamp height – 12m;
type - 250W SON

<u>Protocol No. 1 – Fauna</u>



Road width – 4 lanes
Lamp height – 12m;
type - 250W SON

<u>Persiaran Persekutuan - Fauna</u>

Location 1 - - Type Fauna

Estimate of overall Uniformity;	$U_o \simeq 0.33$
Estimate of longitudinal Uniformity;	$U_L \simeq 0.5$
Estimate of Average Luminance;	$L_{av} \simeq 1.7$ cd/m²

The uniformity figures falls below the recommended values of
$U_o \simeq 0.4$
$U_L \simeq 0.5$

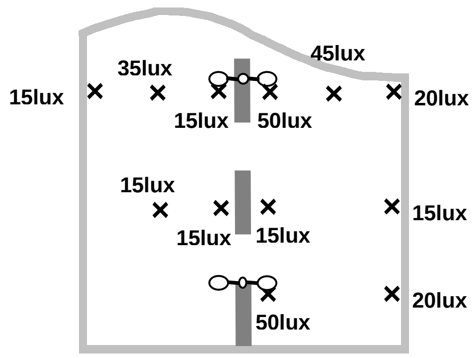
Location 1b - - Type Fauna

Estimate of overall Uniformity;	$U_o \simeq 0.4$
Estimate of longitudinal Uniformity;	$U_L \simeq 0.5$
Estimate of Average Luminance;	$L_{av} \simeq 2.4$ cd/m²

<u>Note:</u>
Glare thresh-hold of fittings seems high.

***<u>Type Fauna</u>* – estimate of luminance uniformity values falls below recommended values.**

Average luminance falls from 1.7cd/m² to 2.4cd/m² (CIE recommendations 2 cd/m²)



No of Lanes: 6
Lamp: 250W SON
Pole Height: 12m

Protocol No. 1 – Wau Bulan

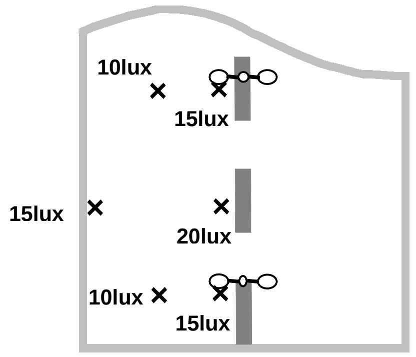
Location 1a - - Type Wau Bulan

Estimate of overall Uniformity; $U_o \simeq 0.4$
Estimate of longitudinal Uniformity; $U_L \simeq 0.3$
Estimate of Average Luminance; $L_{av} \simeq 2.5$ cd/m²

Note:
Non-uniformity along longitudinal (parallel to road) axis is very obvious.

Type Wau Bulan ***– estimate of longitudinal uniformity values is below recommended values.***

Luminance averages 2.5cd/m² (CIE recommendations 2 cd/m²)



No of Lanes: 6
Lamp: 400W SON
Pole Height: 12m

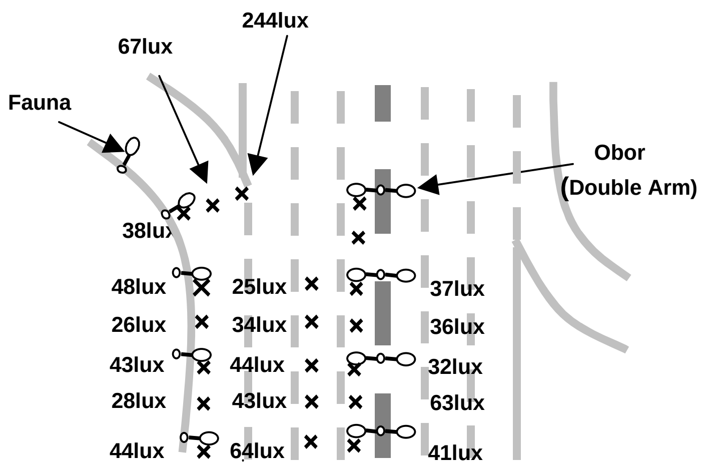
Persiaran Utara - Obor

Location 2 - - Type Obor

Estimates of

overall Uniformity; $U_o \simeq 0.6$
longitudinal Uniformity; $U_L \simeq 0.75$
Average Luminance; $L_{av} \simeq 1.1$ cd/m²

Note:
Despite the estimated values shown, uniformity of lighting level seems to be pronounced from visual inspection.



No of Lanes:
Lamp:
Pole Height:

Protocol No. 2 Obor-Double Arm

Location 2a - Type Obor

Estimates of

overall Uniformity; $U_o \simeq 0.65$
longitudinal Uniformity; $U_L \simeq 0.5$
Average Luminance; $L_{av} \simeq 2.5$ cd/m²

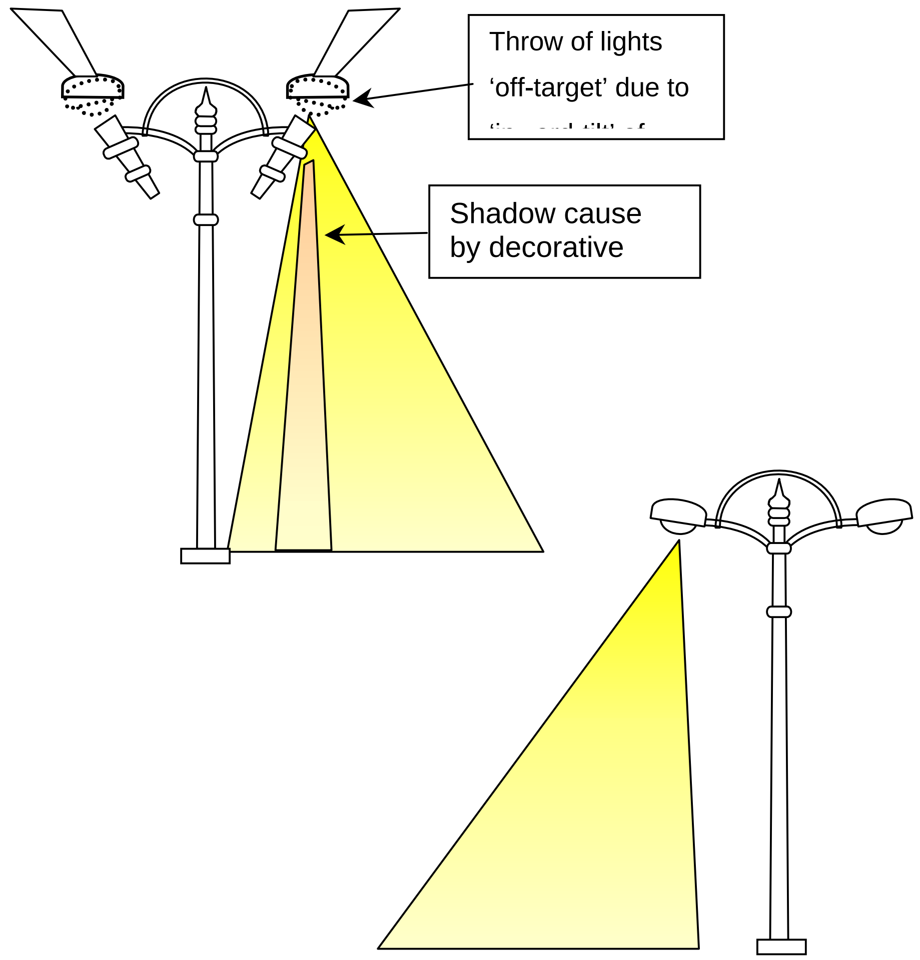


Figure AS2-1 – Poor Photometric Characteristics of Luminaire Type Obor

Luminaire type Obor has poor photometric characteristics due to the following:-

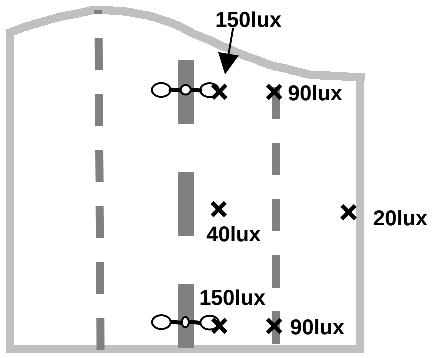
(a) The street luminaire is tilted 'inwards' instead of 'outwards' which is the usual manufacturer recommendation. Due to this the throw of lights onto the road is not distributed evenly onto the road.

(b) The decorative fixture gets into the way of the lights causing shadow and degrading light spread.
The figure on the right shows the correct (and usual designed) configuration of light throw and lamp installation.

Type Obor ***–uniformity values measure reasonable but has problem over longer stretch of the road.***

Average luminance falls from 1.1cd/m² to 2.5cd/m² (CIE recommendations 2 cd/m²)

Poor photometric characteristics of luminaire type Obor due to:
(a) 'inward' tilt of lamp (instead of 'outward' tilt);
(b) decorative fixture interfering with light spread causing shadows …



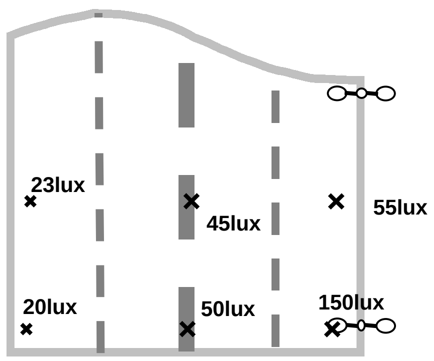
No of Lanes: 4
Lamp: 250W SON
Pole Height: 9m

Persiaran Seri Perdana - Flora

Location 3 - - Type Flora

Estimates of

overall Uniformity; $U_o \simeq 0.2$
longitudinal Uniformity; $U_L \simeq 0.3$
Average Luminance; $L_{av} \simeq 6$ cd/m²
Note: Non-uniformity very high probably due to unsatisfactory photometric characteristics.



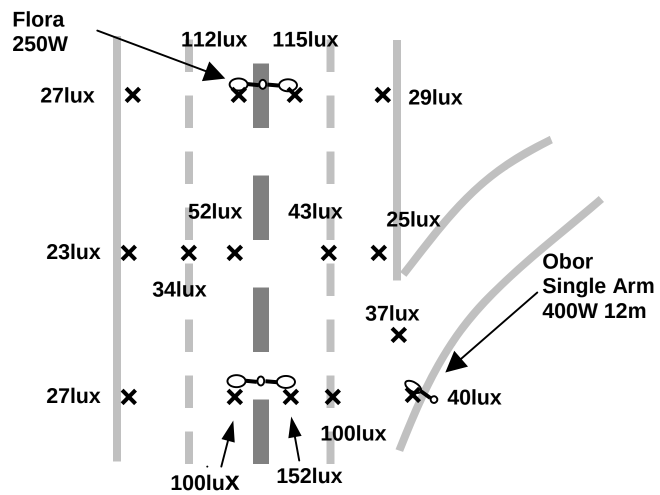
No of Lanes: 4
Lamp: 250W SON
Pole Height: 9m

Persiaran Seri Perdana - Flora

Location 3a - - Flora

Estimates of

overall Uniformity; $U_o \simeq 0.34$
longitudinal Uniformity; $U_L \simeq 0.36$
Average Luminance; $L_{av} \simeq 4$ cd/m²
Note: Non-uniformity very high probably due to unsatisfactory photometric characteristics.



No of Lanes:
Lamp:
Pole Height:

Persiaran Seri Perdana

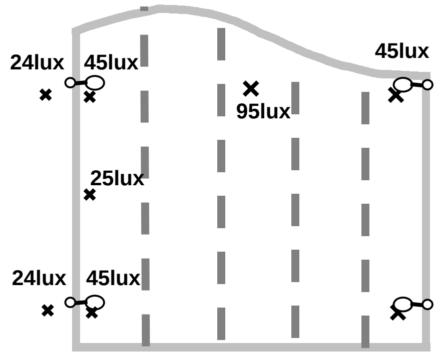
Location 3b – Type Flora

Estimates of

overall Uniformity; $U_o \simeq 0.45$
longitudinal Uniformity; $U_o \simeq 0.4$
Average Luminance; $L_{av} \simeq 3.5$ cd/m²
Note:

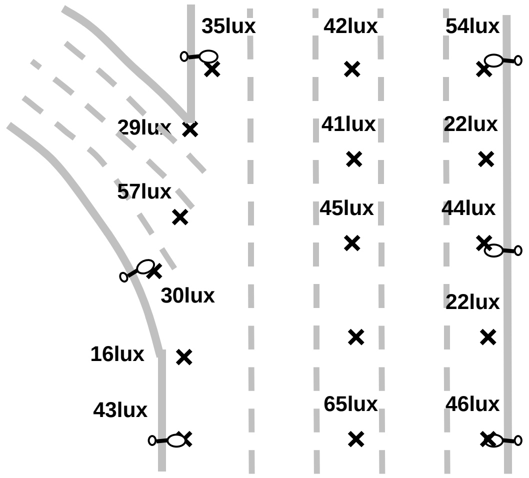
***Type Flora* (Persiaran Seri Perdana) – luminance uniformity values falls below recommended values.**

Average luminance falls from 4cd/m² to 6cd/m² is very high (CIE recommendations 2 cd/m²)



No of Lanes: 5
Lamp: 250W SON
Pole Height: 12m

Persiaran Perdana – Wau Bulan



No of Lanes: 5 lanes
Lamp: 250W SON
Pole Height: 12m

Persiaran Perdana

Locations 4a & 4b – Wau Bulan

***Taman Putra Perdana* – Where pedestrian traffic predominate illuminance values are more important.**

Average illuminance generally exceed 40 lux (about 3 cd/m²) which is slightly high (CIE recommendations for mixed pedestrian/vehicular roads at city centre is 25lux).

Location 4a - - Wau Bulan

(Photos in previous page)

Estimates of

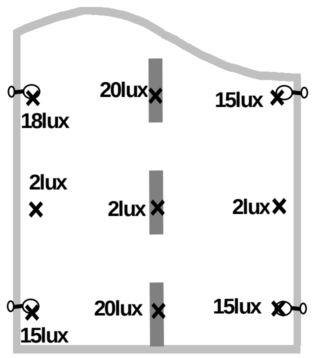
overall Uniformity; $U_o \simeq 0.62$
longitudinal Uniformity; $U_L \simeq 0.6$
Average Luminance; $L_{av} \simeq 3.2$ cd/m²

Location 4b

(Photos in previous page)

Estimates of

overall Uniformity; $U_o \simeq 0.55$
longitudinal Uniformity; $U_L \simeq 0.5$
Average Luminance; $L_{av} \simeq 3.1$ cd/m²



No of Lanes: 2 (mixed)
Lamp: 70W SON
Pole Height: 6m

Taman Putra Perdana

Location 4c - - Taman Putra Perdana

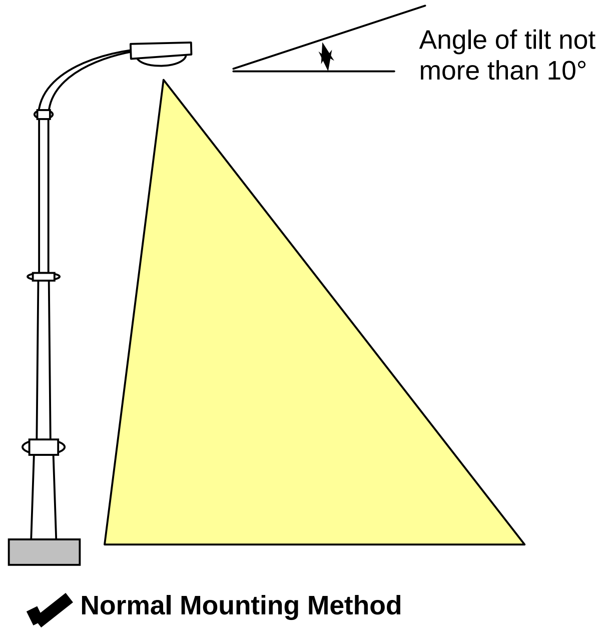
(Photo on the right.)

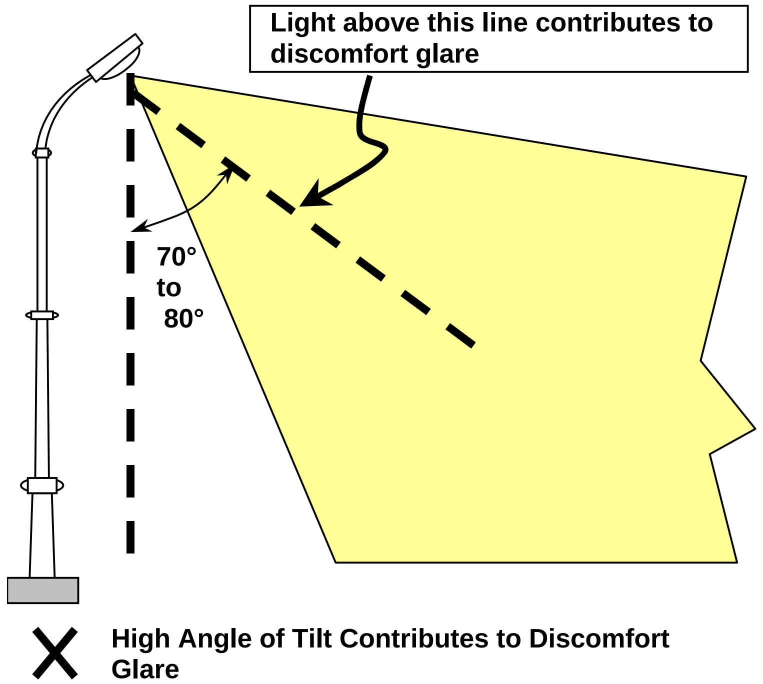
Estimate of
overall Uniformity; $U_o \simeq 0.14$
longitudinal Uniformity; $U_L \simeq 0.1$
Average Luminance; $L_{av} \simeq 1.0$ cd/m²

Note:

Mixed pedestrian/vehicle roads. Recommended uniformity (U_o) more than 0.4. However illuminance is more important and recommended minimum level (for mixed pedestrian/vehicular, city centre) is 25lux. The unsatisfactory uniformity is probably due to the photometric characteristics of the lamps.

Locations 4c – Taman Putra Perdana



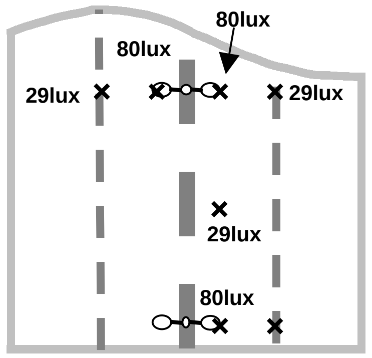


Dataran Putrajaya

No meaningful measurement of lighting level can be made without proper luminance meter.

Note:
The luminaire (which is a normal street light) is up-tilted contributing to significant glare (see figure below)

***Dataran Putrajaya* Upward tilt of luminaire in square contributes to discomfort glare and detract from the night scene.**



No of Lanes: 4
Lamp: 250W SON
Pole Height: 12m

Precinct 9 – Main Approach Road

Precinct 9 - -Housing Area

Estimates of

overall Uniformity; $U_o \simeq 0.45$
longitudinal Uniformity; $U_L \simeq 0.4$
Average Luminance; $l_{av} \simeq 3.1$ cd/m²

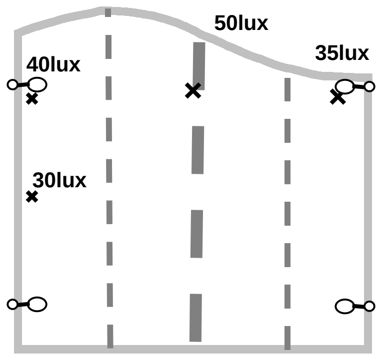
Note: CIE classification for residential access roads M5/C5 recommends:-
$l_{av} \simeq 0.5$ cd/m² $E_{av} \simeq 7.5$ lux
U_o
$\simeq$

Location 9 - -Housing Area

Estimates of

overall Uniformity; $U_o \simeq 0.75$

Wisma Putra
Predominance of Globe Light



No of Lanes: 4
Lamp: 250W SON
Pole Height: 12m

Precinct 9 Housing – Secondary Road

Location 9 - -Housing Area

Estimates of

overall Uniformity; $U_o \simeq 0.75$
longitudinal Uniformity; $U_L \simeq 0.6$
Average Luminance; $L_{av} \simeq 2.0$ cd/m²

Note: CIE classification for residential access roads M4/C4 recommends:-
$l_{av} \simeq 0.75$ cd/m² $E_{av} \simeq 10$ lux
$U_o \simeq 0.4$

Botanical Garden
Predominance of Lantern Tops

Residential ***The estimated average luminance/ illuminance exceed 3cd/m² / 40 lux (about 3 cd/m²).***
The recommended value under CIE Standard is around 0.75cd/m² / 20lux (lux value is more appropriate for mixed pedestrian/vehicular traffic.

Predominance of globe light at Wisma Putra (contributes towards light pollution).

(END OF SURVEY REPORT)

APPENDIX B: LIGHTING PERSONNEL

APPENDIX B: LIGHTING PERSONNEL

1. The functions and duties of the lighting specialist(s)

It is proposed that two persons be recruited:

- City Lighting Manager
- Assistant City Lighting Manager

City Lighting Manager

This senior post will include the following duties:

- Advise on the modification, amendment or extension of the planning approval structure, and its associated legislation, to embrace any form of external lighting as a part of the Planning Approval Application.

- Establish and maintain a comprehensive system to ensure that the detailed design for all external lighting is submitted, reviewed and approved as a part of the overall planning approval process.

- Advise on the establishment of an advisory or mandatory structure that requires all external lighting that is subject of to a Planning Approval Application to be maintained and operated at agreed times.

- Advise and educate PJC personnel in the Development Control Unit, the Urban Design Unit, the Infrastructure & Utilities Unit, the Parks Unit, the Environmental Unit and, within the Urban Development Department, the Development Co-ordination Division, the Building Control Division and the Infrastructure Control Division. Lighting issues prevail in all these units and divisions and it is the responsibility of the City Lighting Manager to ensure that all personnel who have contact with external lighting and related issues are made, and kept aware, of the Lighting Masterplan objectives and value.

- Review and comment on all external lighting design proposals submitted to PJC to ensure compliance with the objectives of the Lighting Masterplan and any other applicable lighting directives or standards. These will include the external lighting of buildings, bridges, structures, landscapes, waterscapes, roads, streets, pedestrian precincts, advertising, security requirements and the permanently installed lighting of any other external element.

- Establish and maintain a system that reviews completed external lighting installations to ensure that these are in compliance with the designs submitted for, and approved through, the Planning Approval Application.

- Establish and maintain a system that encourages and, where possible, ensures the effective and comprehensive maintenance of all installed external lighting in the ownership of public authorities or the private sector.

- Prepare and submit regular reports on the progress towards, or deviation from, the attainment of the Lighting Masterplan objectives.

- Ensure that external lighting is placed and maintained on all relevant planning and development agendas. This to include road and street lighting, advertising lighting and temporary festive lighting.

- Advise and educate external designers, architects, engineers and contractors on the objectives of the Lighting Masterplan to assist such persons to achieve designs that are in compliance with its aims and directives. This will include responsibility for ensuring the appropriate distribution of the Good Lighting Practice guide document.

- Pro-actively encourage high quality external lighting to buildings and structures where this is appropriate and supportive of the aims of the Lighting Masterplan.

- Initiate and participate in appropriate public relations exercises to promote the values of quality external lighting.

- Maintain awareness and knowledge of international developments in lighting design trends, techniques and technology.

- Prepare, or direct preparation by external consultants, lighting design for property owned by PJC.

Assistant City Lighting Manager

This junior post will include the following duties:

- Assist the City Lighting Manager is in his or her full range of duties but with particular emphasis on the following:

- Maintain routine examination of all installed external lighting throughout Putrajaya to ensure comprehensive and effective maintenance and operation at agreed times.

- Liase with private property owners to ensure effective maintenance and operation of external lighting of properties not owned by PJC.

- Instruct and oversee the timely maintenance of external lighting to property owned and/or operated by PJC.

- Examine newly installed external lighting to ensure compliance with the submitted Planning Approval Application.
- Assist in advising and guiding lighting planning and design to conform to the aims of the Lighting Masterplan.

2. The experience and qualifications of the selected personnel.

It is acknowledged that PJC will possibly be establishing a unique precedent in engaging professional lighting personnel to ensure the successful implementation of the Lighting Masterplan. Selected personnel will, ideally, require to be experienced in and appreciative of the:

- Art of lighting design in the architectural and urban environment.

- Science of illuminating engineering in general and road/street lighting in particular.

- Role of lighting in urban society and the night time economy.

- Relationship of artificial light to the natural environment.

- Latest developments in lighting technology.

- Various methods by which lighting design and installation is achieved.

Additionally, the City Lighting Manager will require excellent interpersonal and communication skills. He or she will possess a high level of enthusiasm for the subject of lighting and will appreciate the unique opportunity to influence and shape the perception and image of a new city at night.

The question of lighting qualification and education is complex and perhaps particularly so in Malaysia.

Overview on lighting education and qualification

Lighting does not yet conform to recognised and certifiable standards. Many successful designers have achieved their status through the ‘experience track’ method. This is because lighting design is a young developing profession that is still establishing educational and qualification criteria on a national and international basis. Many designers enter architectural and urban lighting design from architectural, interior design, industrial design, stage lighting design, electrical engineering and pure illuminating engineering. The routes by which people arrive in architectural lighting are various. They include background experience in the lighting manufacturing industry, lighting sales organisations, the consulting engineering community and the arts. A number of lighting training courses exist internationally but it is understood that no specific lighting training is currently available in Malaysia.

Internationally available lighting education comprises courses at technical college, under-graduate and postgraduate levels aimed at providing specific training in lighting and related issues. The long established postgraduate courses are those provided at:

- The University of Sydney
- The Bartlett School of the Built Environment, University College London
- The Lighting Research Centre, Rensselaer Polytechnic Institute, New York State
- The Parsons School of Design, New York.

These courses produce graduates who are considered to be the most highly trained in the art and science of lighting. It is known that a number of Malaysian nationals have completed the postgraduate course at the Bartlett, London. Research is required to determine if other Malaysian or, possibly, Asian nationals have completed courses at the other establishments.

At undergraduate level lighting is frequently included as a subject within a wider curriculum such as architecture or electrical engineering. It is unusual for graduates to specialise in lighting unless they have attended an architectural or building sciences course that includes a strong lighting element. At technical college level or other tertiary education establishments, lighting courses are available in most western countries.

In addition to formal courses, the major lighting and lamp manufacturing organisations such as GE, Philips and iGuzzini teach aspects of lighting coupled to familiarisation with their products.

The PJC requirement – City Lighting Manager

It should be noted that even those who have completed a postgraduate degree in lighting still require their education to be tempered by experience. It is proposed that PJC requires a City Lighting Manager who has ideally completed a postgraduate course in lighting but who also has at least 5 years experience in lighting design and planning. Such experience will ideally have been obtained as an independent lighting design professional working either in a specialist lighting design practice or within an architectural or consulting engineering firm. An acceptable but lesser alternative would be experience obtained in one of the major lighting manufacturing companies that include external lighting within their operation. Exceptionally, a candidate may present who does not have a formal qualification but can demonstrate lengthy (at least 10 years) and in-depth experience in lighting design and planning – such a person should merit equal consideration. An additional consideration is that the successful applicant is likely to have senior grade membership of one or more of the following:

- Illuminating Engineering Society of Australia & New Zealand (IESANZ)
- Illuminating Engineering Society of North America (IESNA)
- International Association of Lighting Designers (IALD)
- Society of Light & Lighting – UK
- European Lighting Designers Association (ELDA)

It is anticipated that a combination of national and international advertising for the post of City Lighting Manager would draw much attention and yield a worthwhile degree of choice. International journals in which to advertise include:

- Lighting (Australia)
- Lighting Equipment News (UK)
- The Lighting Journal (UK)
- Light & Lighting (UK)
- Light (UK)
- Professional Lighting Design (Germany)
- Lighting Design & Application (USA)
- Architectural Lighting (USA)

The PJC requirement – Assistant City Lighting Manager

This post will ideally attract persons with similar levels of qualification as the candidate for City Lighting Manager but is unlikely to attract the same degree of experience.

The level of experience to successfully fulfil the Assistant City Lighting Manager role will have been gained within the lighting manufacturing industry as an in-house designer/specifier or in a junior position within a specialist lighting design group. Alternatively, a young electrical engineer with a keen interest and considerable experience in lighting would be suitable.

3. The department or unit of PJC within which the lighting personnel should be located.

It is proposed that lighting be identified within PJC as an issue that relates particularly to the Town Planning Division, to some degree to the Environmental Division and to a minor degree to divisions within the Urban Development Department. This is because lighting should be considered as a visual and amenity issue. Since much of the work to be done by the City Lighting Manager and his or her Assistant relates to the planning approval system, its enforcement and reviewing the resulting visual outcome, it is proposed that a lighting sub-division be created within the Town Planning Division. It is not currently known how the various divisions and units within PJC communicate. However, it will be important to ensure that effective communication is established and maintained between the lighting sub-division and those :

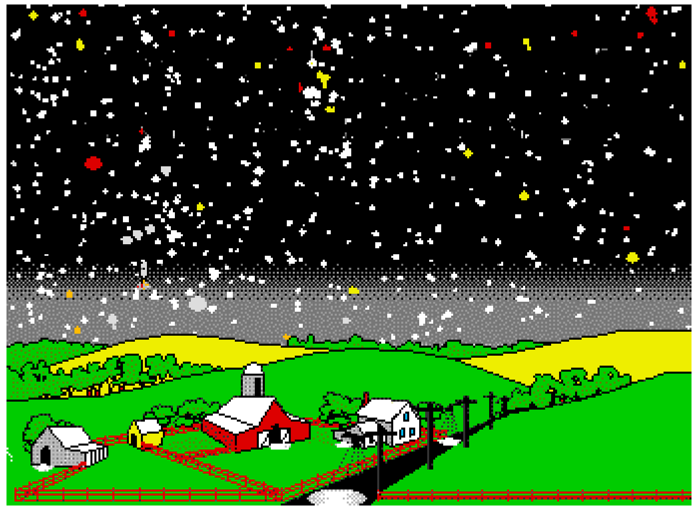
- Responsible for calling for and reviewing information upon which to base a Planning Application Approval.
- Engaged in drawing up strategies, planning and development policies.
- Responsible for co-ordinating infrastructure and utilities. Responsible for enforcing planning law. Managing the development of parklands and water areas
- Engaged in co-ordinating standard regulations, guidelines, plans and research into environmental aspects.
- Responsible for road and street lighting maintenance.
- Who are responsible for enforcing laws relating to infrastructure works such as road lighting and related issues.

From the foregoing it will be appreciated that lighting personnel will require to be involved in a wide range of issues. This reflects the ubiquity of the subject.

APPENDIX C: NIGHT SKY POLLUTION

APPENDIX C – SKY GLOW AND THE NIGHT TIME SKY

INTRODUCTION



In the international arena there is a growing realisation that outdoor lighting which is not well-designed (and especially over-designed) and properly installed is harmful to the night time environment. The nighttime skies of cities are increasing being suffused with a glow, which degrade the clarity of the stars. Due to this, observatories have to be sited increasing further from cities and even towns. In is therefore not surprising that astronomical societies are in the forefront for a growing campaign against night sky pollution. In the U.K. this is represented by the B.A.A. (British Astronomical Association) Campaign for Dark Skies and internationally 'The International Dark Sky Association' (IDA) is in the forefront against night sky pollution.

This section identifies the problem associated with sky pollution and suggests some good practice methods to mitigate against night sky polluion.

1.0 ISSUES IN OUTDOOR LIGHTING

1.1 The Positive Influence of Outdoor Lighting

The introduction of outdoor lighting has contributed immensely to the greater productivity, quality of life and general benefits to humankind. Outdoor lighting is generally associated with roadway lightings. Since the 20th Century, outdoor lighting has increasingly being introduced for purposes other than functional (roadways) and safety. Initial usage of outdoor lightings has progressed from recreational lightings to present day lightings for advertising purposes.

It has been recognised that poorly-designed lighting and especially over-designed lighting scheme is contributing to a growing problem in night time **light pollution**.

1.2 Light Pollution Issues

General Light pollution refers to the general wastage of poorly designed lighting scheme or light fixture. The type of light pollution generally recognised by most standards (U.S.A. Pattern Codes, CIE Publication 1 etc.) are listed in this sub-section.

Sky Glow refers to the wasteful throw of lights into the night sky contributing to light pollution. It is usually a result of:

(a) Misdirected light which throws more light onto the sky than at the intended area.
(b) Wasteful use of wide angle projection in an attempt to 'flood' or 'wash' a façade or monument (instead up to 80% of the light is lost skyward).
(c) Luminaire with a significant portion of lights escaping above the horizontal plane. Luminaire with shields or reflector to limit this upward throw of lights is termed fully or semi 'cut-off'. Non 'cut-off' luminaire under certain conditions also contributes to discomfort glare.

Light Trespass refers to the intrusion of light into a neighbouring lot. Light trespass cause a loss of privacy (such as street lights intruding into the bedroom and is usually a result of:

i. Misdirected light trespassing onto a neighbouring lot,
ii. Wide angled projected light trespassing onto a neighbouring lot,
iii. Unshielded Luminaire.

The nighttime skies of cities are increasing being suffused with a glow, which degrade the clarity of the skies and stars

Poorly designed lighting and especially over designed lighting scheme contribute to a growing problem in light pollution.

1.2 Light Pollution Issues

(a) Poor lighting Scheme – due to poor design or over design or design in the wrong context.
(b) Sky Glow - wasteful throw of lights into the night sky;
(c) Light Trespass – intrusion of light into neighbouring lot; and
(d) Glare – comprising 'Disability Glare ' (loss in visibility) and discomfort glare (distraction from the surrounding scene).

Glare is a complex issue which is treated in both CIE 31 and BS 5489:Part 1. Two types of glare are classified:

- Disability Glare refers to loss of visibility cause by the disability glare of a source of bright light. An object that is just visible (i.e. at the threshold of visibility) in the absence of glare will merge into the background in the presence of disability glare.
- Discomfort Glare refers to the response of the eye to varying and contrasting levels of lights. The contrast of glare source to background lighting, though not causing visibility loss causes a certain amount of discomfort.

The quantification of glare especially disability glare is treated in motorway lighting by the calculation of 'threshold increment' (TI). Formulation of TI is based on the percentage increase in luminance difference required to make an object visible in the presence of disability glare. The appraisal of discomfort glare is subjective and various guidelines are given. Appraisal of discomfort glare include the distinction between 'sparkle' and glare and the effect of 'cut-off' (shielded) lamp source and even mounting height of luminaire on glare restriction formula. Discomfort glare is usually considered in most publication on minimising Night time light pollution.

1.3 Ecological Concerns

Issues related to light pollution include the following:

Energy Waste Over-design and/or poor outdoor lighting wastes energy due to poor light distribution or over lighting without enhancing security, safety or aesthetic consideration.

Ecological considerations become an issue in ecological enclave (e.g. Wetlands). The wrong usage or even usage itself of lightings should be carefully considered, as artificial lighting will have adverse impact on the bio-ecology of such enclaves. It has also being found that monochromatic lights (i.e. lights with predominantly a single colour such as low pressure sodium) has a higher impact on insect and avian ecology.

2.0 STANDARDS FOR MINIMISING LIGHT POLLUTION

2.2 Publications

In addressing the concerns of light pollution various publication by the B.A.A. (British Astronomical Association) 'Campaign for Night Sky' and the 'International Dark Sky Association' (IDA) has been issued. The IDA's 'U.S.A. Pattern Code' in particular is a generic code which can be modified to the needs of a particular community and is popularly adapted by many cities and municipal authorities in the U.S.A. Some 'good practices' and standard procedures for minimising light pollution included in the following sub-sections are gleaned from the publication listed.

2.3 Lighting Zones

General In lighting codes, it is recognised that different zoned development has differing developed and natural conditions, with differing levels and sensitivities to appropriate outdoor light usage. Because of this, five Lighting Zones are usually defined based on the Environmental Zones defined by the *Commission Internationale de l'Éclairage (CIE)*, and also used by the IESNA:

Zone E1A Dark-Sky Preserves. These are areas close to major active astronomical research facilities, and within and near dark-sky preserves or parks that have identified the preservation of the darkest nighttime environment as a priority. In Putrajaya the inner sanctum of the Wetland enclave would qualify for this classification.

Zone E1 Intrinsic Dark Landscapes Examples are national parks, areas of outstanding natural beauty, areas surrounding major astronomical observatories. In Putrajaya buffer areas

1.3 Ecological concerns

(a) Energy Waste – over design of lights; and

(b) Ecological considerations – principally in ecological enclave (e.g. Wetlands).

2.3 Lighting Zones

Codes recognised that different zoned development require differing levels and sensitivities to outdoor light usage…

(a) Zone E1A – Dark Sky Preserve (Astronomy enclave, Wetlands);

(b) Zone E1 -Intrinsic Dark Landscapes (Buffer around E1A, parks);

(c) Zone E2 – Areas of low ambient brightness (rural residential/ city parks);

(d) Zone E3 – Areas of medium ambient brightness (urban residential); and

(e) Zone E4 – Areas of high ambient brightness (urban areas, commercial, city centres).

surrounding the Wetland enclaves and certain parks may qualify for this classification.

Zone E2 Areas of low ambient brightness. These are suburban and rural residential areas and may include some city parks or car park and pedestrian areas of city parks. Some 'low-rise' residential areas or 'private' residential areas may fall under this classification.

Zone E3 Areas of medium ambient brightness. These will generally be urban residential areas. Most residential district of Putrajaya will fall under this classifcation.

Zone E4 Areas of high ambient brightness. Normally these are urban areas that have both residential and commercial use and experience high levels of nighttime activity. This include the core business district and

1.2 Lamp Type and Shielding Standards

Shielding of lamps is a common practice to minimise light pollution. Shielding refers to the spillage of lights above the horizontal axis of the light fixture. A detail discussions of shielding (or its technical equivalent 'cut-off' or 'semi-cut-off' is in section 2.5 below): Table C2.4 is extracted from the 'U.S.A. Pattern Code ('IDA') in the regulation of shielding and light pollution. The benchmark described in the said standard, if adopted as a mandatory standard may however be difficult to enforce in some instance (e.g. requirement for shielding of lamp at residential homes – last row of table). The benchmarks should therefore be consulted by lighting designer as an indication of 'good-lighting practice'.

The legends used in the table are as follows:

A = all types of fixtures allowed; shielding not required but highly recommended, except that any spot or flood-light must be aimed no higher than 45 degrees above straight down

F = only fully shielded fixtures allowed

X = not allowed

Class and Lamp Type	Lighting Zones				
	E4	**E3**	**E2**	**E1**	**E1A**
<u>Class 1 Lighting (Colour Rendition)</u>					
Output ≥ 2,000 lumens	F	F	F	F	F
Output < 2,000 lumens	A	A	A	F	F
<u>Class 2 Lighting (General Illumination)</u>					
Output ≥ 2,000 lumens	F	F	F	F	F
Output < 2,000 lumens	A	A	A	F	F
<u>Class 3 Lighting (Decorative)</u>					
Output ≥ 2,000 lumens	F	F	X	X	X
Output < 2,000 lumens	A	A	F	F	F
<u>Residential Lighting (All Classes)</u>					
Output ≥ 2,000 lumens	F	F	F	F	F
Output < 2,000 lumens	A	A	A	A	F

Table C2.4 – Lamp Type and Shielding Standards

Notes to the above are as follows:

1) Output refers to the initial designed output of the luminaire.
2) In all cases flood or spot lamps must be aimed no higher than 45 degrees above straight down (half-way between straight down and straight to the side) when the source is visible from any off-site residential property or public roadway.
3) Exceptions to shielding may be allowed in case of seasonal (festive occasions) decorations using typical unshielded low-wattage incandescent lamps.
4) In some cases a 'curfew' on lighting especially Class 3 may be imposed. Curfew hours for lighting may depends on the lighting zone (E1 areas will

C3

Table C2.4 – Lamp Shielding Standards
Shielding standards of lumiaire for different zones.

<u>Note</u> (1) For Class 3 lighting (lights for decorative purposes) lamp types of more than 2,000 lumens is not recommended in lighting zones EA1, E1 and E2.

(2) Generally lamps with output of more than 2,000 lumens require some form of shielding.

have longer curfew hours compared to E4 zones) and are typically from 2.00pm to 8.00am and/or even 12.00pm midnight to 7.00am.

2.5 Shielding and Cut-Off

In defining lamp shielding, the technical terms used are ‘cut-off’ and ‘semi-cut-off’. The definition of cut-off under CIE publication 12 is shown in table C2.5.

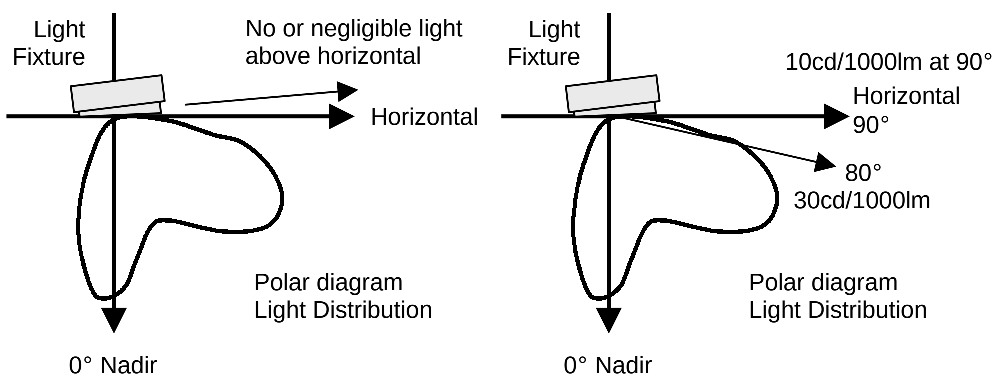
Type of Luminaire	Direction of Max Intensity	Maximum Permissible Value at Intensity emitted At	
		90°	80°
a. Full Cut-Off	0 –68°	*10cd/1000lm	30cd/1000lm
b. Semi Cut-Off	0 –75°	*500cd/1000lm	100cd/lm
c. No Cut-Off	-	1000cd	-
Note * - Up to a maximum value of 1000cd whatever is the luminous flux.			

Table C2.5 - Definition of Cut-Off (CIE 12:1995)

Due to the technical nature of the above, most lighting codes adopt a simplified definition of shielding. For the layman and the non-technical personal:-

A fully shielded fixtures is defined as light fixture with no (or negligible) light output at and above the horizontal axes of the lowest light emitting part of the fixture.

Figures C2.5.1 illustrates the principal of shielding and cut-off.



Simple Definition of Fully-Shielded **CIE-12 Definition of ‘Cut-Off’**

Figure C2.5 – Definitions of Shielding and ‘Cut-Off’

2.6 Limitations of Lumens Per Acre (Lumens Cap)

Over lighting is a common problem where the over-zealous application of lights contributes to energy wastage and a pervasive over-powering of the night time scene. To regulate over lighting and promote efficient lighting design, some measures adopted by outdoor lighting ordinances include:

- Broad limitation on Lumens per Acre (or ‘lumens cap’) generally based on 80,000 lumens per net acre with full cut-off (fco) lighting. Parcels of less than one acre are allowed fco lumens proportionate to the one acre limitations.
- A more sophisticated lumens cap based on lighting zones is proposed under the IDA’s pattern code (table C2.6)

LUMEN CAPS (Initial Lamp Lumens Per Net Acre)	**Lighting Zones**				
	E4	**E3**	**E2**	**E1**	**E1A**
Commercial and Industrial zoning (1)					
Total (fully shielded + unshielded)	20,000	100,000	50,000	25,000	12,500
Unshielded only	10,000	10,000	4,000	2,000	1,000
Residential zoning (2)					
Total (fully shielded + unshielded)	20,000	10,000	10,000	1,0000	5,000
Unshielded only	5,000	5,000	1,000	1,000	0

Table C2.6 Lumens Cap Based on Zoning (extracted from ‘IDA’s U.S Pattern Code’)

C4

Simple definition of ‘Fully-Shielded’: or negligible light throw at or above the horizontal axis of the lowest light emitting part of the luminaire.

2.6 Limitation of Lumens Per Acre (Lumens Cap)

A declared limitation on lumens per acre (lumens cap) places a broad guide or benchmark on lighting design forcing efficient design.

A broad base ‘lumens cap’ may generally be quoted at 80,000 lumens per acre (with fully shielded luminaire).

Table C2.6 is a more sophisticated categorising of lumens cap based on lighting zones based on the IDA’s US ‘Pattern Code’.

Some notes to lumens cap are as follows:

- Seasonal variations (festive occasions etc) to the above are permitted.
- The values in table C2.6 are upper limits and not design goals; design goals should be the lowest levels that meet the requirements of the task.
- Calculation of 'lumens cap' exclude signage lights, internally lit signs, internal building lights, neon lights, temporary lights, festive occasion lights and lights which provide 'sparkle'.
- Footnote (1) refers to all land-use zoning classifications for multiple families, commercial and industrial uses.
- Footnote (2) refers to all residential land-use zoning classifications, including all densities and types of housing such as single-family detached and duplexes.

2.7 Pole Heights

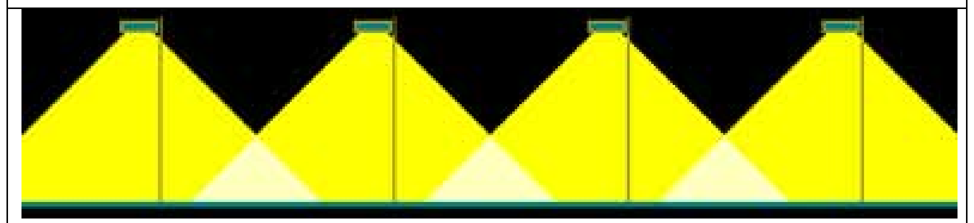
<u>Should Pole Heights be limited</u> Concerns have sometimes being raised with regards to pole height, and call for the inclusion of pole height restrictions be included in a lighting code. However, recent industry findings conclude that restriction on pole heights may not be as intended and restriction of pole heights should not be included in any lighting codes.

<u>Pole Heights in Design</u> In the design of streets and roadway lightings, pole height considerations impact lighting design as follows:

- Uniformity of Lighting. Taller poles will have greater uniformity problems which can be off-set by choosing the luminaire with the correct light distribution,
- Cost, Shorter poles requires more poles increasing cost, and
- Visual impact. Tall poles may not be visually desirable in areas of low rise and generally street lights bears some visual coordination with the surrounding buildings.

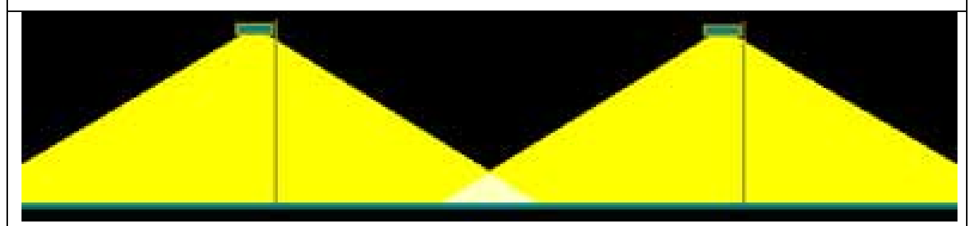
Figure C2.7 is a series of diagram explaining pole height issues:

In attempting to limit the daytime visual impact of tall light poles against landscape views, shorter poles may help but lighting uniformity goals may offset the gains from shorter poles by causing an increase in the number of poles. More poles will result in higher capital and operating cost.



Pole height restrictions may cause more poles to maintain uniformity

If attempting to limit the night time visual impact of lights, in particular the spread of light from high luminaires into surrounding areas (light trespass), pole restrictions may be much less than hoped. Since most area lighting has certain target uniformity levels, shorter poles will mean that more must be used, which may increase the visual impact at night as well as in the daytime. While these poles will be shorter the trade-off of more poles may compromise the original intent to reduce visual clutter.



Pole height restrictions may cause more glare with higher angle candlepower distributions. Some designer in an attempt to avoid increasing the number of

C5

2.7 Issues Concerning Pole Height

A lower visual impact due to shorter poles be off-set by the increase in number of poles causing higher capital and operating cost.

Restricting pole heights to control light spread and ultimately light trespass may be less than hoped for. The trade-off in shorter poles and lower visual impact may cause an increase in the number of poles and increase visual clutter

Pole height restriction may cause more glare. In attempting to avoid increasing the number of poles by using luminaire with wide angle luminance spread, achieving uniformity goals will be at the expense of increase glare.

poles by using luminaries with wide angle luminance, may achieve luminance and uniformity goals at the expense of increased glare.

Figure C2.6 – Consequence of Pole Height Restrictions

In general, it is not recommended that a lighting code limit pole heights. With good designs using fully shielded luminaires, poles with standard heights (up to about 11 meters or 35 feet) are in most situations minimally obtrusive.

2.8 Obtrusive Light Limitations

A proposal to limit luminance level and intensity may be based on table C2.7 below:

Environmental Zones	Sky Glow UWLR [Max.%]	Source Instensity I [kcd]		Building Luminance*** L [cd/m2]
		Before curfew**	After curfew	Average Before curfew
E1	0	0	0	0
E2	5	50	0.5	5
E3	15	100	1.0	10
E4	25	100	2.5	25

Table C2.8 - Obtrusive Light Limitations for Exterior Lighting Installations

Guidance to table C2.7 is as follows:

- **I** = Light intensity in kcd or kilo-candelas
- L = Luminance in Candelas per square metre
- **** Source Intensity** - applies to each source in the potentially obtrusive direction, *outside* of the area lit. The figures given are for general guidance only and for some medium to large sports lighting applications with limited mounting heights, may be difficult to achieve. However, if the recommendations are followed then it should be possible to lower these figures to under 10 kcd (kilocandela).
- ***** Building Luminance** - This should be limited to avoid overlighting, and relate to the general district brightness.
- **UWLR** – Upward Waste Light Ratio (maximum allowable percentage of luminaire flux escaping directly sky wards.

3 PRACTICAL ISSUES IN MINIMISING LIGHT POLLUTION

3.2 Four Characteristics to Good Lighting Practice

C6

Good lighting design aims for an efficient design with minimal impact on the environment. The four characteristics of a good design can be summarised below:

Adequacy of Lights The level of lighting provided is adequate for the intended context and usage and is never over or under provided. Luminance tables provided in codes and standards are guides towards this aim but in 'contextual' lighting luminance guide may not be sufficient and experience may be necessary.

Efficient Positioning and Installation of Light Fixtures aims to maximise the usage in the intended property and minimise the impact onto adjacent properties. Positioning and correct 'aiming' of light fixtures are also important to maintain the intended contextual design element.

Colour Rendering and Energy Efficient Lamps High efficiency lamps are preferred for its lower environmental impact and operating cost. Balanced against this however is the need to maintain the 'quality' of lights. Quality of lights represented by colour rendering is an important element in the design of contextual lighting scheme.

Proper shielding of Lights to reduce glare, light trespass and sky glow are important in maintaining a safe and visually pleasant lit environment.

Table C2.8 proposes benchmarking values mps source intensity (kilocandela) and average building luminance value; e.g. for zone E4 – maximum lamp source kilo-cd Average building luminance less than 25cd/m²; average luminance value (calculated over the total building surface) should not be confused with spot values which is usually much higher.

3.2 Four Characteristics of Good Lighting Practice

(a) Adequacy of Lights (right amount and in the right context)

(b) Efficient Positioning and Installation of Fixtures;

(c) Colour Rendering and Energy Efficient Lamps; and

(d) Proper Shielding of Lights

3.3 Outdoor Advertising Signs

General In the modern environment, outdoor advertising signs are becoming an important and ubiquitous feature of the urban and suburban landscape (and increasing even in the rural landscape). Unfortunately the trend in lighting for advertising signs have been one of increasing visual (and lighting) impact which are frequently obtrusive. Some guides to the regulation of outdoor advertising signs are listed in this sub-section.

Internally Illuminated Sign are signs with light fixture mounted within the signage structure or enclosure. Guidelines for internally illuminated signs are as follows:

(a) Advertising signs must be either constructed with an opaque background and translucent text and symbols, or with coloured background and generally lighter text and symbols.

Signs with white background or other bright background produce the greatest amount of light and such internally lit signs are by nature unshielded light source.

Colour background with lighter text and symbols often convey information more effectively and attractively at a reduced light output compared to signs with bright or white background.

Figure C3.3- Examples of Effective Signage Lights

Externally Illuminated Signs have fixtures mounted externally to the signage structure or enclosure.

I. External light fixtures in this instances is classified as Class 1 lighting in table C2.4 (i.e. all luminaire more than 2,000 lumens are to be fully shielded).

II. Light fixtures should preferably be mounted to shine down. However in case where this is not possible, then careful choice of luminaire with asymmetrical luminance distribution, proper positioning and targeting of luminaire should be implemented to minimise glare and sky glow.

Other Consideration which may be included in regulating advertising signs may be as follows:

- Lamps used for internal illumination shall not be counted towards lumen caps calculation.
- A curfew may be imposed on the lighting of advertising signs.

The following sub-sections illustrates some example of good lighting practice.

C7

Outdoor Advertising Signs; Some Guides

(a) Internally-Lit Signs:

Either constructed with an opaque background and translucent text and symbols, or with coloured background and generally lighter text and symbols.

Signs with white background or other bright background produce the greatest amount of light and are by nature unshielded light source.

Colour background with lighter text and symbols often convey information more effectively and attractively at a reduced light output compared to signs with bright or white background.

(b) Externally Lit Signs:
Luminaire to be fully shielded; and
Light fixture preferably mounted to shine downwards

3.4 Examples of Good Light Practice

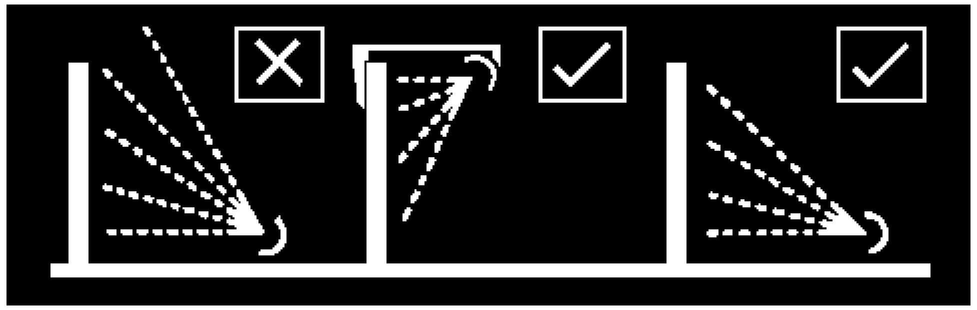


Figure C3.4.1 Use specifically designed lighting equipment that once installed minimises the spread of light near to, or above the horizontal.

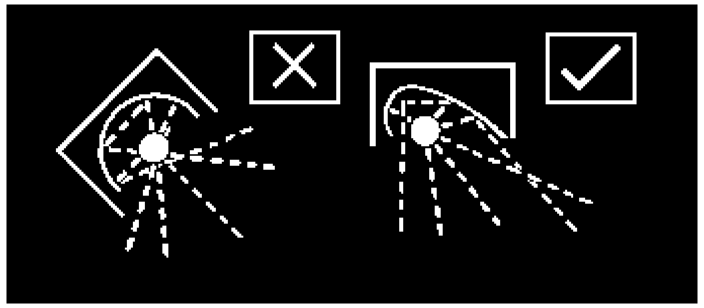


Figure C3.4.2 Wherever flood lights with asymmetric beams that permit the front glazing to be kept at or near parallel to the surface being lit should be used. For proper targeting of objects or slim monument, narrow beam lights (as opposed to generic flood lights) should be used.

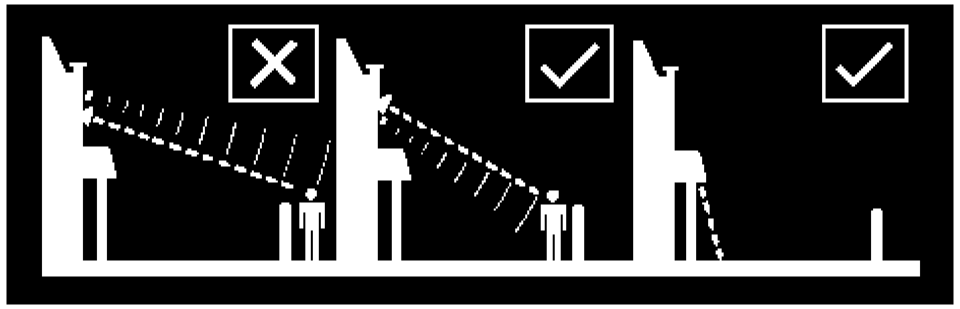


Figure C3.4.3 For road lighting, light near to or above the horizon should be minimised

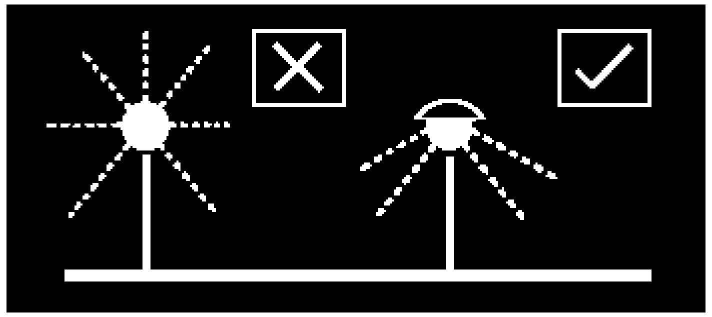
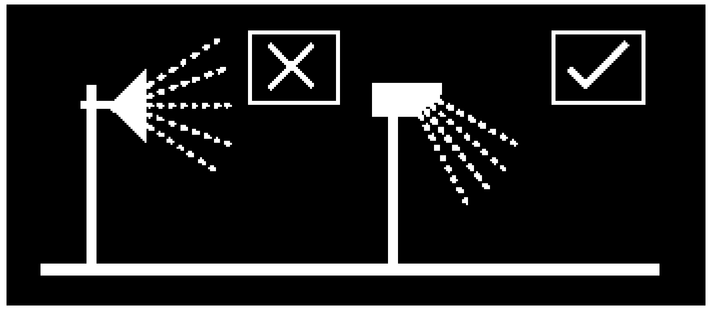


Figure C3.4.4 Proper shielding of luminaire minimise wastage and sky glow.



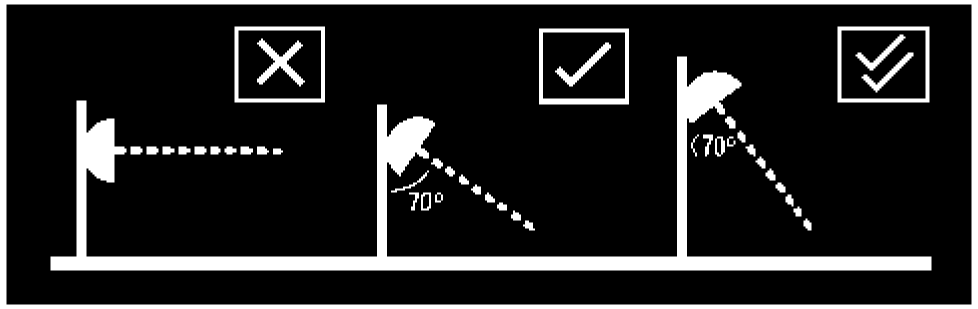


Figure C3.4.5 To keep glare to a minimum, ensure that the main beam angle of all lights directed towards any potential observer is kept below 70 degrees. It should be noted that the higher the mounting height, the

C8

Examples of good lighting practice

lower can be the main beam angle. In places with low ambient light, glare can be very obtrusive and extra care should be taken in positioning and aiming.

Examples of good lighting practice.

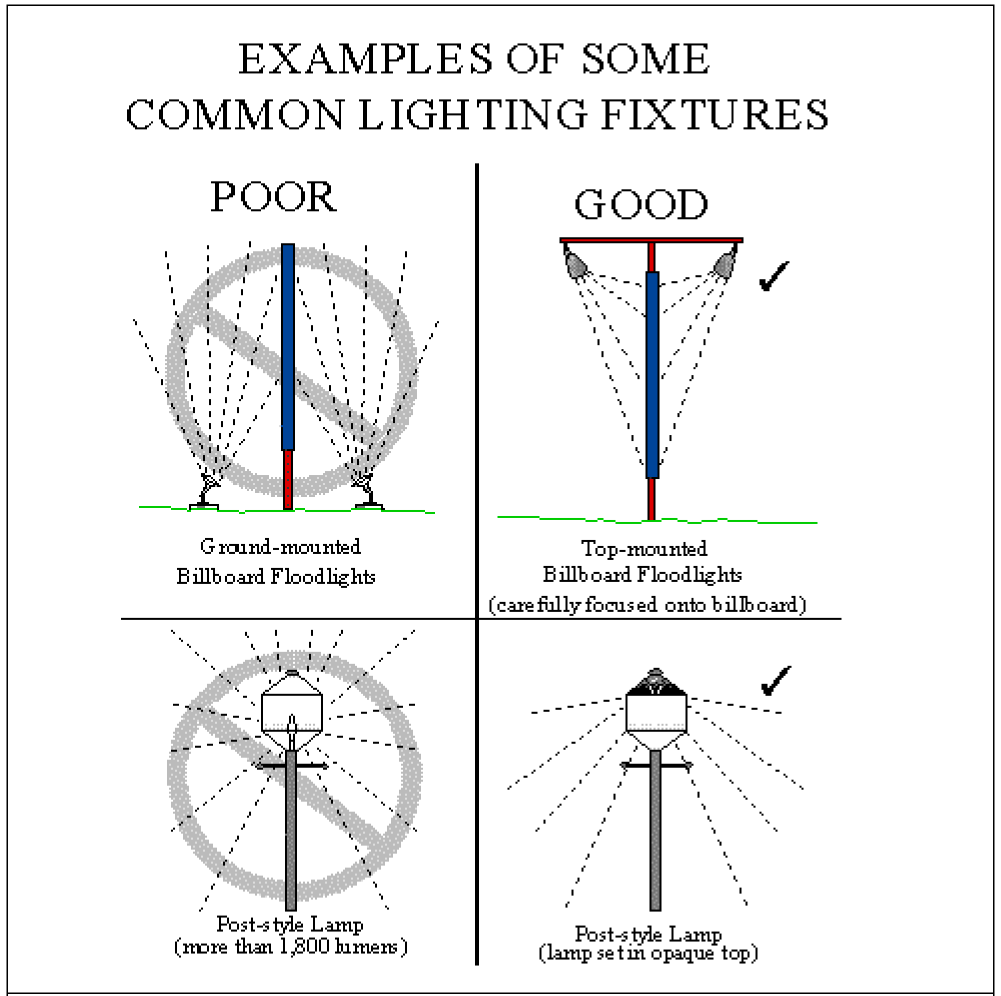


Figure C3.4.6 – Good Lighting Fixture (Outdoor)

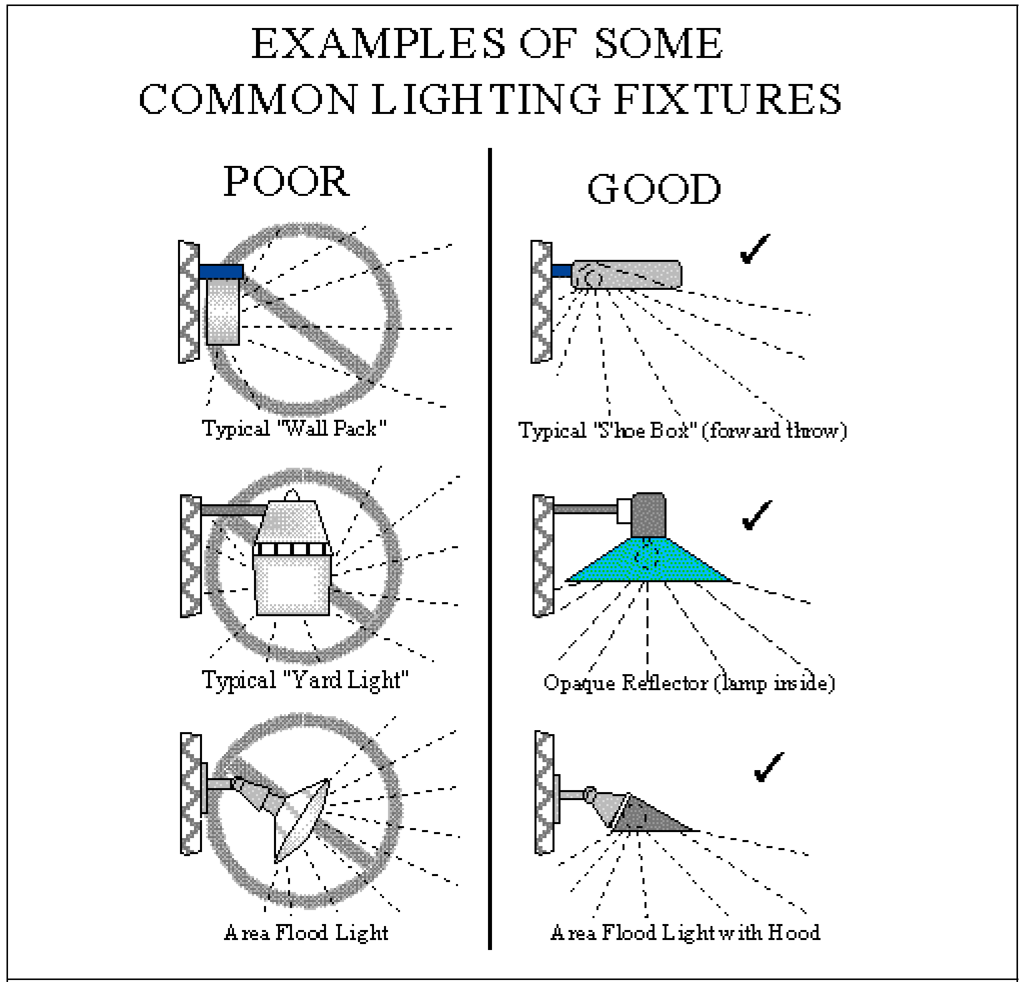


Figure C3.4.7 – Good Lighting Fixture (Wall Mount)

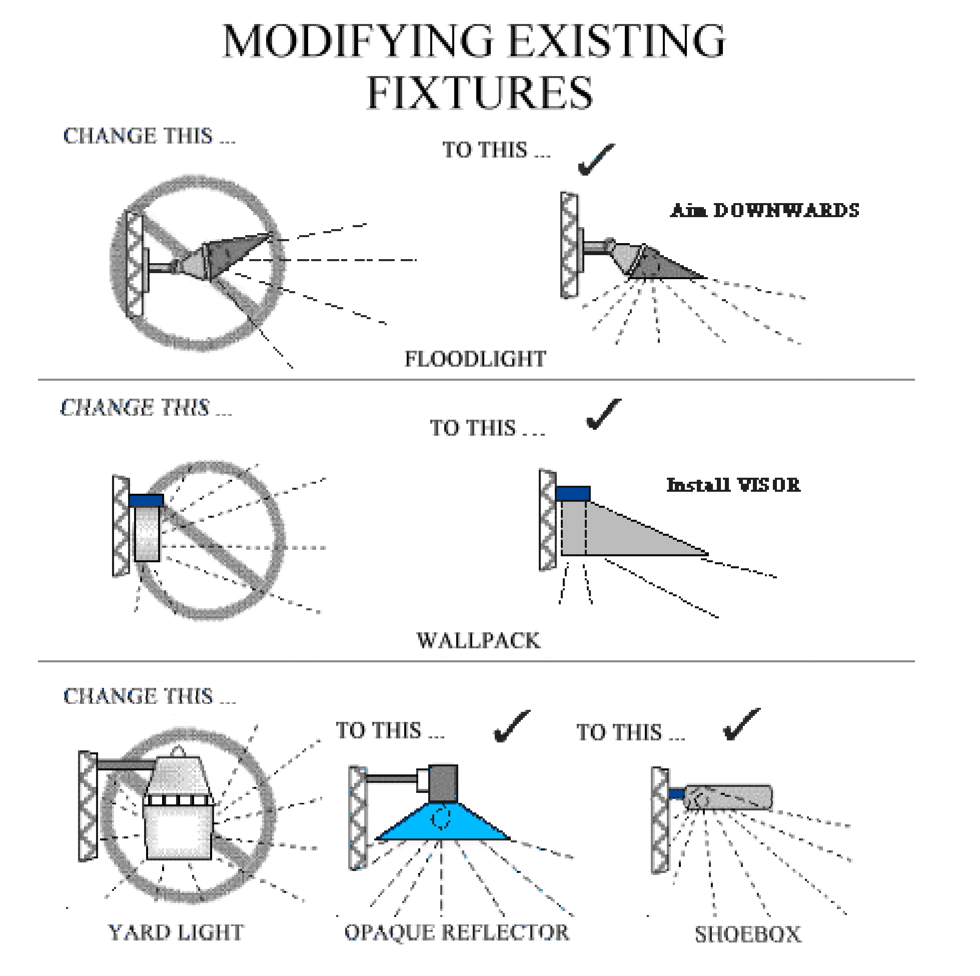


Figure C3.4.8 – Good Lighting Fixture (Modifications)

Modifying existing light fixture – figure C3.4.8

2 REFERENCE

References

(a) '*Outdoor Lighting Code Handbook'* Version 1.12, by the 'International Dark Sky Association' October 2001, http://www.darksky.org

(b) '*Guidance Notes for the Reduction of Light Pollution"* by the B.A.A. Campaign for dark skies http://www.dark-skies.freeserve.co.uk

(c) '*Good Neighbour Outdoor Lighting*' compiled by the 'New England Light Pollution Advisory Group' (NELPAG) and the International Dark-Sky Association, May 1995

(d) '*White Paper on Outdoor Lighting Code Issues*' by 'National Electrical Manufacturer's Association' (NEMA, U.S.A.) Luminaire Section, Aug 1, 2000

(e) 'Framework for Outdoor Lighting Improvement Ordinances' by The Indiana Council on Outdoor Lighting Education, ICOLE http://home.att.net/~icole

(f) '*Supplementary Planning Guidance; External Artificial Lighting*' by the Huntingdonshire District Council, U.K.

(g) 'CIE Publications:1. 'Guide lines for minimizing Urban Sky Glow near Astronomical Observatories'.

(END OF APPENDIX C)

APPENDIX D: POLICY #1 COLOUR & THE HUMAN EYE

APPENDIX D: POLICY #1 COLOUR & THE HUMAN EYE

1. Colour Characteristics

In an environment such as a 'garden city', predominated by green landscaping and natural surroundings, the spectral characteristics of metal halide light sources are particularly suitable. This is because, unlike the high-pressure sodium source, the energy output has peaks in the 400 to 500 nanometre range (the blue green end of the visible spectrum) and a reasonable degree of continuum across the entire 400 to 700 nanometre visible light range. Typically, a high-pressure sodium source peaks in the 550 to 600-nanometre range (the yellow/orange/red range). Correspondingly, the colour and vibrancy of green and blue objects and surfaces appear suppressed under high-pressure sodium light whilst appearing bright and natural under metal halide lighting.

This increased colour quality is further assisted in the case of metal halide sources because these have a higher colour-rendering index (Ra) than high-pressure sodium.

Colour rendering index is defined as:

- A measure of the correspondence between the colour of an object (its "self luminous colour") and its appearance under a reference light source. To determine the Ra values, eight test colours defined in accordance with DIN 6169 are illuminated with the reference light source of the same colour temperature as the source under test and the test light source. The smaller the discrepancy between the two sources, the better the colour rendering property of the lamp being tested.
- A light source with a Ra value of 100 displays all colours exactly as they appear under the reference light source. The lower the Ra value, the worse the colours are rendered.' (courtesy of OSRAM)

Typical **high-pressure sodium** lamps have a colour-rendering index of **Ra 20 – 39**
Typical **metal halide** lamps have a colour-rendering index of **Ra 80 – 90**

2. The Human Eye

The reason that high-pressure sodium is highly favoured is because the human eye response is at its most efficient when operating under light in the 560 nanometre (yellow) region. However, this only holds true when light levels are in the higher range with luminance (in broad terms: "brightness") values above 3.0 candela/m².

At this higher light level, the retina of the eye is operating through its cone receptors. Cone vision is referred to as *photopic vision* and is activated under normal levels of daylight and higher levels of artificial light. At the opposite end of the range of human vision, the eye operates through its rod receptors; these come into operation under very low levels of light such as starlight, measured in the region of 0.001 candela/m²; such vision is referred to as *scotopic vision.* Under these conditions the eye's overall sensitivity changes substantially with response to the yellow/red spectral range dropping in favour of the blue end of the spectrum in the region of 500 nanometres. Cone receptors operate optimally in the yellow light region whilst rod receptors operate optimally in the blue light region. In the light level range that lies between the levels that enable *photopic and scotopic visio*n, the eye operates through both its cones and its rod receptors. This range of vision is referred to as *mesopic vision* and is applicable under levels experienced at twilight and under most *road and street lighting conditions* e.g. 0.3 – 2.00 candela/m².

The cone receptors (operating optimally under yellow light) are concentrated in the foveal area of the retina that enables the narrow central part, (approximately 2 º) of the field to be viewed. The rod receptors (blue light optimised) are located to enable wide, peripheral, vision. This means that broad peripheral (or 'off-axis') vision in roads and streets, illuminated to conventional standards, by high-pressure sodium light sources is less efficient than under those conditions where roads and streets are illuminated by metal halide light sources. The research that lead to this realisation has resulted in the concept of the ' Effective Lamp Lumen Rating. This challenges the precept, established in 1924, that the lumen output of a lamp should be measured under photopic vision conditions. Alternatively, in recognising that the eye's spectral response varies under differing light levels (a recognition based on 100 + year old work by Purkinje) it becomes justifiable to consider the use of Lumen Effectiveness Multipliers. These essentially enable roadway lighting to be designed and calculated on a basis that takes account of the function of the eye when operating under realistic mesopic light conditions provided by sources other than high pressure sodium, in particular, metal halide.

Current research indicates that metal halide lighting could be as much as 80% more effective than high pressure sodium when evaluated under specific conditions relating to reaction times and brightness matching. In practical terms, tests indicate that an average roadway lighting level of 1.0 candela/m² provided by a metal halide light source would require to be equated with 3.9 candela/m² derived from a high-pressure sodium source in order to achieve the same reaction time from a vehicle driver.

Conclusion

Considerable research work has been carried out and continues in this field – see references. However, there is no doubt that the use of metal halide light sources is now wholly justified. Large-scale road lighting applications of this source can be designed to reduced light levels, based on conventional photopic vision calculations and compared to historic light values calculated on the use of high-pressure sodium sources. In the case of the Central Boulevard it is proposed that the use of metal halide lighting be justified on the basis that:

a) There is a requirement, at night, to distinguish this key boulevard from its surrounding streets and approach roads as well from the buildings that bound it.
b) The colour characteristics of metal halide are such that they complement and enhance soft landscape elements.
(c) If economics are to be a consideration for this, the most prestigious axis of Putrajaya, the lighting levels can be reduced (as can electrical loads) in comparison to those that would be expected under high-pressure sodium.

It is proposed that the Central Boulevard lighting be designed to achieve a level of approximately 3.0 candela/m² when used for parades and special occasions, reducing to 2.0 candela/m² under normal conditions. The presently designed luminance value is not currently known.

References

The foregoing is drawn from material published and presented in the following:

1. Dr Ian Lewin. Lamp Spectral Effects at Roadway Lighting Levels. *The Lighting Journal (UK)* March/April 1999.

2. Dr Ian Lewin. Visibility Factors in Outdoor Lighting Design. *The Lighting Journal (UK)* November/December 1999 & January/ February 2000.

3. Lewis, Alan L. ' Visual Performance as a Function of Spectral Power Distribution of Light Sources at Illuminances Use for General Outdoor Lighting'. Submitted for publication in the *Journal of the Illuminating Engineering Society (USA).*

4. Lewis, Alan L. 'Equating Light Sources for Visual Performances at Low Illuminances'. *Journal of the Illuminating Engineering Society (USA).* Vol.27 no.1, Winter 1998 IESNA New York

5. *American National Standard Practice for Roadway Lighting, RP-8* (Proposed). Submitted by the IESNA Roadway Lighting Committee to the IESNA Technical Review Board, September 1998.

In addition to the above, attention is drawn to the following:

- The Long and Lighted Road: Lighting and Driving. *Lighting Futures (USA).* Vol.5 No.1
- The Lighting Research Center (www.lrc.rpi.edu/Futures/LF-Auto/main5.htm)
- Night Vision. LRC Research. (www.lrc.rpi.edu\Projects\night.html)
- Applying Research on Night Vision. LRC Research.

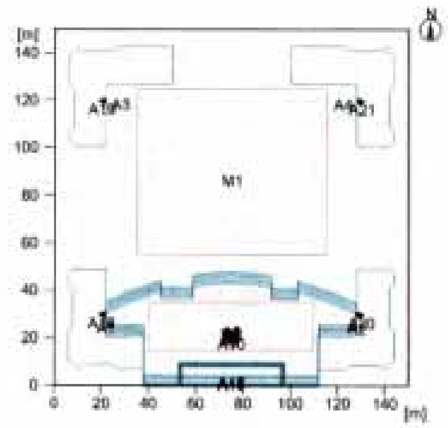
  (www.lrc.rpi.edu\Projects\nvp.html)

APPENDIX E: DATARAN PUTRAJAYA

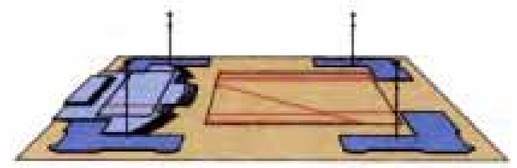
APPENDIX E – DATARAN PUTRAJAYA

1. Project description

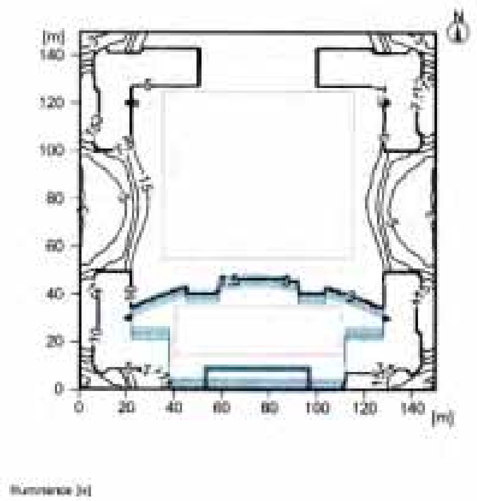
1.1 Overview



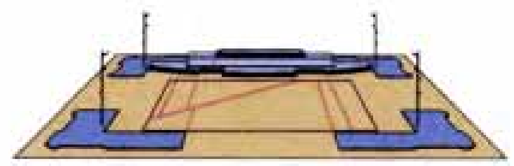
Floor plan



Internal room, sightline 1

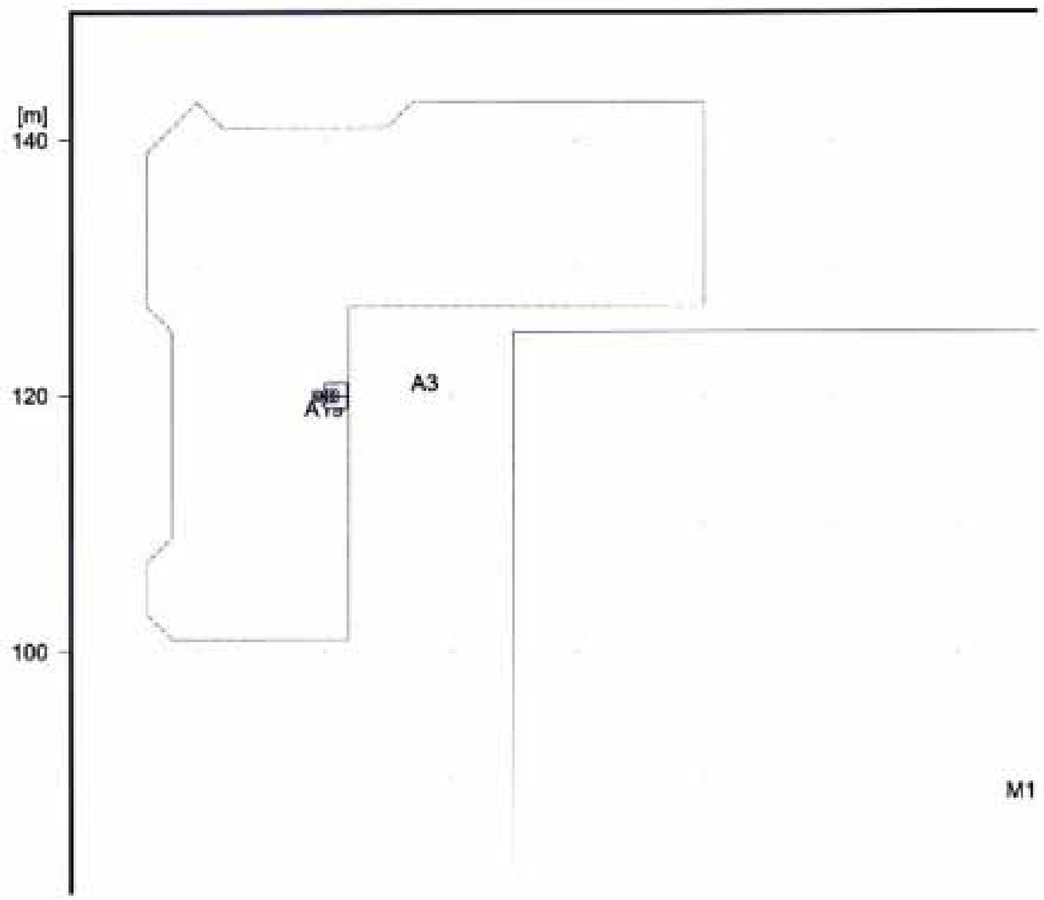


Calculation results



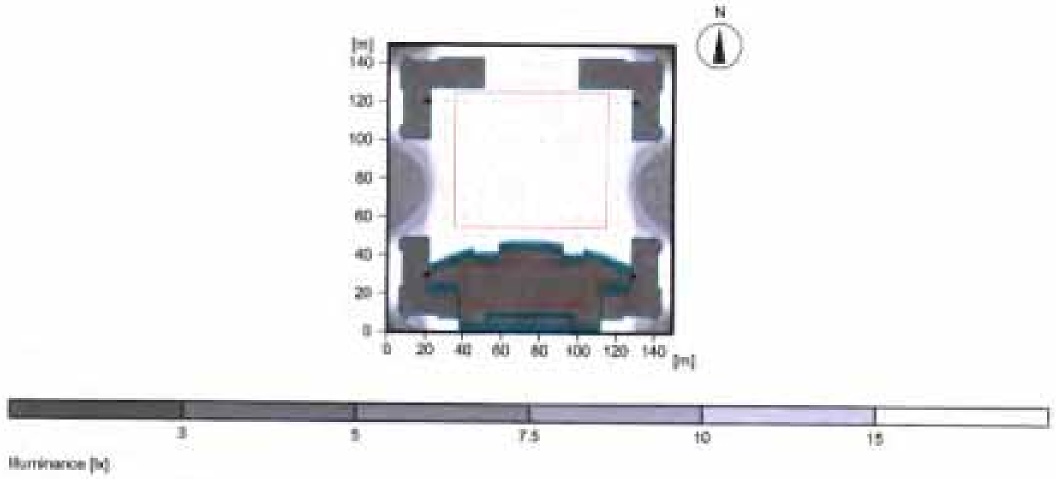
Internal room, sightline 2

1.2 Floor plan



2. Summary

2.1 Result overview



Specifications:

Maintenance factor:	: 0.80
Number of calculation points in x/y direct.	: 151 / 151
Calculation algorithm used	: Direct part
Height reference plane	: 0.20 m

Result reference plane:

Average illuminance	Eav	: 13 lx
Minimum illuminance	Emin	: 0 lx
Maximum illuminance	Emax	: 39 lx
Uniformity g1	Emin/Em	: ---
Uniformity g2	Emin/Emax	: ---

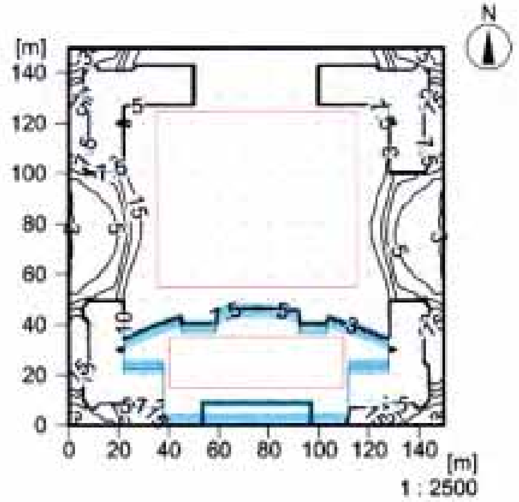
Total luminous flux of all lamps	: 838400 lm
Total power	: 0 W
Total power per area	: 0.00 W/m²/100 lx

Type	No.\Manuf.		
		Siteco Fremd	
1	2	Order no.	: !VOR5x5
		Luminaire name	: Secondary Reflector 2000 x 2000mm
		Equipment	: 1 x 0 W / 150000 lm
3	4	Order no.	: !VOR2x2
		Luminaire name	: Secondary Reflector 800 x 800mm
		Equipment	: 1 x 0 W / 20000 lm
4	2	Order no.	: !VOR5x5
		Luminaire name	: Secondary Reflector 2000 x 2000mm
		Equipment	: 1 x 0 W / 228000 lm

2.1 Result overview

		Siteco Innen1	
2	24	Order no.	: !5NA 726 0-1 VS 11C
		Luminaire name	: Projector
		Equipment	: 1 x HIT-DE 1000W 0 W / 100 lm

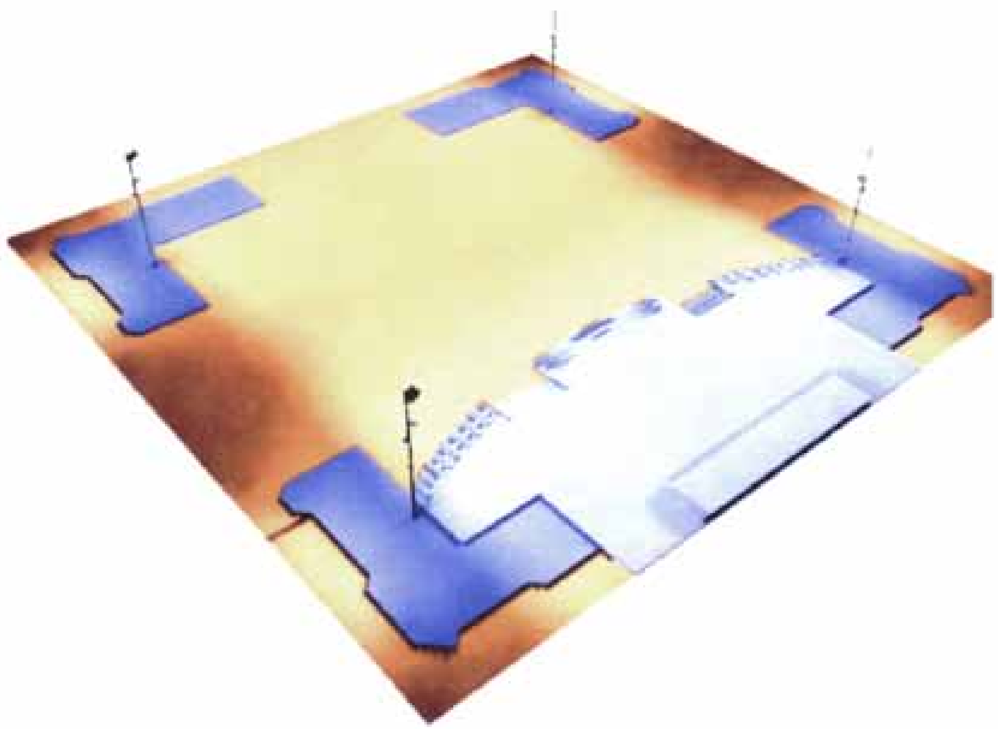
3.2 Isolines representation, Illuminance, Reference plane



Illuminance [lx]

Height of the reference plane		: 0.20 m
Average illuminance	Eav	: 13 lx
Minimum illuminance	Emin	: 0 lx
Maximum illuminance	Emax	: 39 lx
Uniformity g1	Emin/Em	: ---
Uniformity g2	Emin/Emax	: ---

3.3 3D luminance distribution, Variable view



Luminance on the room-surrounding surfaces:

Minimum: 0 cd/m²
Maximum: 8 cd/m²

3.4 3D luminance distribution, View from rear

Luminance on the room-surrounding surfaces:

Minimum:	0 cd/m²
Maximum:	8 cd/m²

APPENDIX F: AUTOMATED MONITORING AND CONTROL ON STREET LIGHTING

APPENDIX F – AUTOMATED MONITORING AND CONTROL ON STREET LIGHTING

1.0 INTRODUCTION

This Section presents a brief overview of automated monitoring system for Street and Public Lighting. The Section lists the issues which need to be addressed in the implementation of a Metropolitan-wide automation system.

Putrajaya's present implementation of an automated 'Street and Public Lighting' monitoring system is touched on and the Section concludes by offering some suggestions and recommendations for policy adoption by Putrajaya.

2.0 AUTOMATED MONITORING AND CONTROL OF STREET AND PUBLIC LIGHTINGS

2.1 Automation Systems – A Brief Historical Perspective

2.1.1 Since the widespread adoption of direct digital control ('DDC') in automation systems in the commercial and industrial environment from the 1970s, automation systems has undergone a steady evolution in cost (decreasing) and capability (increasing). DDC automated system can be differentiated from its earlier technological predecessor which has actuator and sensor systems essentially rooted in mechanical systems (pneumatic and hydraulic).

2.1.2 The industry wide adoption of DDC systems can perhaps be attributed to the followings

(a) Decreasing cost in computer chips (Moore's law).

(b) Successful adoption of industry-wide standards in the computer industry (International Standard Organisation) engenders a Thriving market in computer technology allowing easy market entry to new players and encouraging innovation.

(c) The popularity of the **NET** (internet) which encourages the wide spread development of **computer networking** technology.

2.1.3 DDC automation systems can be classified into the following based on its separate evolution within its industry niche:

(a) Industrial systems generally include 'Programmable Logic Controllers' (PLC) and plant-wide automation. This sector is the largest sector in the DDC automation market. Early and active players in this field include 'Elsag Bailley', 'Foxboro', 'Honeywell', 'Johnson Controls', 'Siemens' etc.

(b) Equipment automation and specific process automation. The HVAC (heating, ventilation and air conditioning) industry was the earliest adherent to the DDC automation movement. Other specific automation sector under this category include the automotive sector ('CAN in Automation'; **CAN** – Controller Area Network). This sector taken as a whole is as large (or perhaps larger) than the industrial plant wide system described in (a) above. Players in this niche include Modicon (a German company), Rockwell International (USA), ASi (Actuator Sensor Interface), Allen Bradley etc.

(c) SCADA (System Control and Automated Data Acquisition) systems originally developed for the electrical power industry saw wide spread adoption from the early 1980s. SCADA technology has since been adopted for other application especially SCADA in monitoring networks (gas piping, utility networks etc). Industry players include 'Foxboro', 'Johnson Controls', 'Siemens', 'Allen Bradley' etc

Widespread adoption of DDC in automation system:
(a) Decreasing cost in chips;
(b) Adoption of industry wide standards;
(c) Growth of the 'NET'.

Classification of DDC-based automation systems:
(a) Industrial systems; 'Programmable Logic Controllers' (PLC), plant-wide automation etc;
(b) Equipment automation; HVAC sector, CAN in car sector;
(c) SCADA; system control and automated data acquisition;
(d) Building automation system

(d) Building Automation Systems / Building Management Systems (BAS or BMS) pertains to the implementation of automation in buildings. This sector started later and was hobbled by cost issues and fragmentary standards in its early days (the 1980s).

(e) BAS/BMS is at present experiencing a resurgence and players in this sector include 'Honeywell', 'Landis & Gyr', and

2.2 Open Standards in Automation

2.2.1 Open standards are industry wide adoption of a common technological platform and implies universal availability, public-domain knowledge-base and vendor neutrality. Open standards are important for further progress of the automation industry:

(a) It allows easier entry for new market players (proprietary standards in contrast restrict new entrant with technological and legal barriers).

(b) Innovation and new products can be developed at lower cost and easier adoption by the market.

(c) Open standards ultimately drive cost downwards and at the same time deliver increasing system capability and innovation for the consumer.

2.2.2 Open Standards are also coloured by the reality of existing installed-base and vendor-driven standards development (which requires funding). Open standards are also viewed by market players as the 'holy grail' of market domination (witness the VHF/Betamax tussle of the video industry during the late 1970s/early 1980s). Since the 1980s, development of industry-wide open standards in automation systems has been fragmentary, sometimes acrimonious and coloured by national pride (principally intra-European and European versus North American).

2.2.3 Movements towards global standards are principally driven by the following bodies:

(a) Standard organisations listed below adopts standards drafted by standard writing organisation (SWO).

(b) European Standard Organisation (CENELEC),

I. International Standard Organisation (ISO),

II. International Electrotechnical Commission (IEC),

(c) American National Standard Organisation (ANSI).

Open Standards' under the above organisations are however compromised by industry clout of market players. Due to this the CENELEC, ISO/IEC and ANSI standards virtually include description of all systems of major industry player. Instead of uniformity, a diversity of standards is officially sanctioned leading to fragmentation of the industry. The 'mother' of all standards for automation is the **ISO/IEC 61158:2001**.

2.2.4 **Convergence Initiatives** are voluntary industry-driven initiatives which perhaps can be more ideally termed as 'global open standard' movement:

(a) **BACnet** (principally centred around North America) for the home and building automation market,

(b) **Fieldbus Foundation** which encompass a multitude of vendors principally centred around North America for the industrial automation sector.

(c) **Konnex** (European) comprising the technologies of EIB ('European Installation Bus'), EHSA ('European Home System Association'), and BatiBus (France).

(d) Vendor Specific Standards driven by the de-facto reality of 'installed base' (this may in fact be the over-riding factor leading to a true global standard; 'Windows' operating system became a world standard principally on the marketing success of Microsoft). Main vendor system include:

(e) In Europe – the Profibus system (Siemens) dominate,

(f) In North America – LonWorks (Echelon Corp) and Fieldbus Foundation dominate.

(g) **Nascent Open standards** (in the sense that they are touted as widely accepted, in reality are not yet 'de-facto' but have the **possibility** of becoming widely accepted in the long term) include:-

I. CEBus, EIA-6000 (USA) incorporates 'plug-and-play' capability into common electrical appliances (systems which have device-intensive standard such as in the fire alarm industry are ideal users),

II. 'X-10' defines standards for power-line carrier,

III. 'Blue-tooth' defines standards for incorporating networking capability into electrical appliances using principally wireless (R.F. in the ISM band) technology.

2.2.5 Open Standards or industry wide standards should be **important consideration** in the implementation of any automation system:

(a) Proprietary systems are frequently touted by vendors as the most optimal system neglecting to mention its drawback:

I. Support, back-up and spares are proprietary i.e. the vendor is locked into a captive market for support, back-ups and spares,

II. The 'Optimal' designation is controversial, as proprietary system does not encourage innovation and multiple party development.

III. Proprietary systems can and will be overwhelm by industry wide standard system leading to its probable future demise. In Malaysia, automation system implemented since the 1980s has already experience the problem of obsolescence due to discontinued product, discontinued support, and discontinued market presence.

(b) Open standards in contrast:

I. Allow a wider option for industry support and spare parts,

II. Scalability (up grades and expansion) issues are easier to address, and implement.

III. Obsolescence is less of a concern.

3.0 AUTOMATION SYSTEM FOR STREET AND PUBLIC LIGHTINGS (SPL)

3.1 System Design

3.1.1 System design for automation of street and public lighting can be depicted (on a generic basis – i.e. non-vendor specific) in the following series of diagrams (tables F3.1.1, F3.1.2, and figure 3.1.1.3). Thefunctions listed in tables 1 and 2 are only indicative and may be implemented in full or partially.

TABLE F3.1.1- ACTIVE CONTROLS

Function	Actuator	Device	Comments
1 Switching of Lamps	Contactor	Lamps	Can be implemented:- (a) Individual contactor with intelligent addressable capability at each individual lamps. (b) Individual contactor without intelligent capability at each individual lamps. (c) Contactor switching per circuit
2 Dimming of Lighting level	Contactor Intrinsic thyristor	Multi-tap wound ballast Electronic ballast	Recommended solution. Not recommended.
3 Switching of circuits	Contactor	Circuits in switch boards.	This would be a redundant function if function 1 above is implemented.
4 Switching of Switch Boards	Contactor	Main Circuit Breaker in Switch Board	Remote active switching of switch board should only be implemented with a set of on-site safety procedure, otherwise this can be a potential for hazard and dangerous accidents.

TABLE F3.1.2- MONITORING FUNCTIONS			
Function	**Sensor**	**Device**	**Comments**
1 Lamp Status	Current and/or Voltage transducers.	Lamps	The current and/or voltage input into lamps can infer lamp performance, operating hours etc. Can be implemented together with the individual intelligent device-level controller described in table 1-1(a) above.
2 Lamp component status	Current and/or voltage or circuit break transducer	Lamp component (ballast)	Depending on the sophistication of the sensor, component sensing can infer component failure or impending failure.
3 Circuit status	Current and/or voltage or circuit break transducer	Lamp circuit	Depending on the sophistication of the sensor, circuit sensing can infer circuit break, operation hours etc.
4 Switch Board status	Current, voltage transducers, auxiliary contact etc.	Main Breaker and Switch Board	Depending on the sophistication of the sensors provided, switch board status and energy consumption can be log for management analysis and 'data mining'.

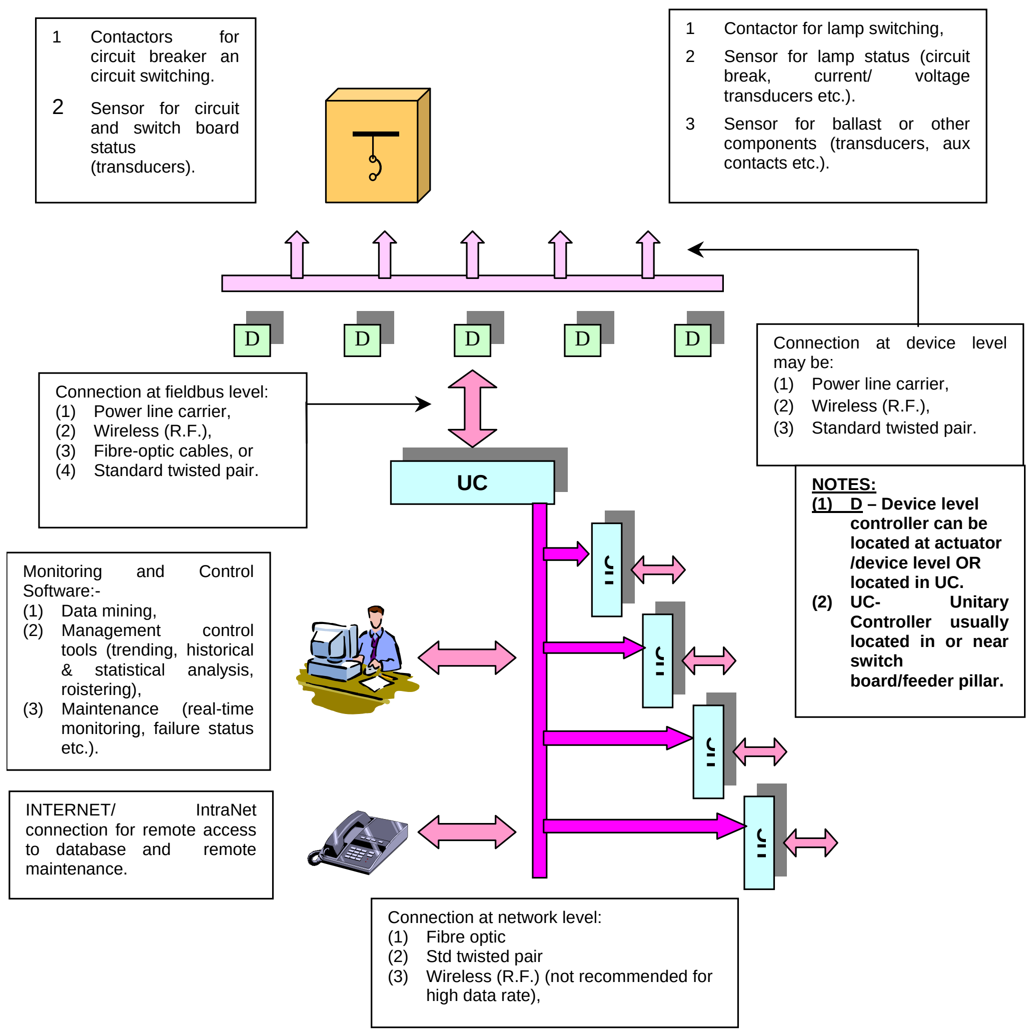


Figure F3.1.3 – Generic Network Architecture of SPL Automation and Monitoring System

***Table F3.1.2* – Possible Monitoring Functions implemented in Street Lighting System Automation System.**

Figure F3.1.3 – Generic Architecture of SPL Automation and Monitoring System.

3.2 Dimming of Street Lights

3.2.1 Due to the proposal to maintain multi level lighting at the Main Boulevard/Protocol roads, the issues of dimming of street lights are discussed in this section. Two main technologies are currently available for dimming of street lamps:-

(a) **Electronic ballast** and solid state thyristor switching to control current levels in lamps. and
(b) Multi-tap wound ballast with step dimming levels (typically only two).

3.2.2 Electronic Ballast has a long history and was first commercially available in the 1970s. Traditionally dimming of lights for filament lamps are easily implemented by voltage /current limiting transformers/resistors (which are technologically simple and cheap to manufacture). However discharge lamps (of which fluorescent and SON/HBI street lamps fall under this category) cannot be dimmed using this technology. Early solid state dimmers were only designed for filament lamps. Solid state dimmers designed for discharge lamps were first commercially available for fluorescent lamps (from the late 1980s). The early dimmers (for fluorescent lamps) suffers from serious setback:

(a) Prone to failure,
(b) Harmonics generation which cause secondary problem to the electrical network,
(c) Unsatisfactory performance (early dimmers for fluorescent lamps can only dim from 50% and its dimming capability diminishes rapidly with age).
(d) Very high capital cost which (despite the denial of vendors) off-set any savings in energy.

The above concerns are still valid to-date. Quality and harmonics problems have been ameliorated to a certain extent by the use of better quality components and design standard **but** at substantial capital cost increase. Implementation of electronic ballast by the electrical engineer should proceed with **caution** (even for fluorescent lamps) and care should be taken to evaluate the quality and reliability of such ballast.

Unfortunately in choosing a quality and reliable dimmable ballast, the energy savings gains may be off-set from the significantly higher cost.

3.2.3 Multi-tap wound ballast with step dimming levels is recommended. However implementation of multi-tap wound ballast should be proceeded with caution with care taken to evaluate the quality and reliability if said ballast.

3.3 Existing Street and Public Lighting (SPL) Automation System in Putrajaya

3.3.1 Two pilot projects on monitoring and control system are currently being implemented in Purajaya. The SPL monitoring aims to provide monitoring of lamp, circuit and (some) component failures, and dimming of lamps to achieve energy savings.

(a) Protocol roads, monitoring right down to individual lamps and circuits.
(b) Both projects used hybrid multi-wound type ballast with capability for step dimming (via multiple taps).

3.3.2 The basic system configuration of the SPL Automation system as shown in figure G3.3.2, is generally made up as follows:

(a) At Device Level; Basic Signalling Module (BSM) located at each street lights. The BSM is a device-level semi-intelligent unit. It will monitor lamp status data and probably has capability to implement active control. Possibility of active control of dimmable ballast is also mentioned. The BSM is connected (at device level network) to the next level of control (fieldbus level) using power line carrier technology (the cost savings in additional cables at device level is however translated to higher device level (BSM) unit cost).
(b) At the Fieldbus Level; data loggers located in feeder pillars arbitrate between device level BSM and higher level networking. Fieldbus data loggers can be stand alone or connected (via twisted pair cables) to other data loggers.

Dimming of Discharge Lamps can be implemented using 2 technologies:
(a) Electronic Ballast;
(b) Multi-tap wound ballast

Implementation of electronic ballast by the electrical engineer should proceed with caution (even for fluorescent lamps) and care should be taken to evaluate the quality and reliability of such ballast

Unfortunately in choosing a quality and reliable dimmable ballast, the energy savings gains may be off-set by significant higher capital cost.

(c) At the Net-Work Level data loggers are connected to central command centres with any of the following or combination depending on site conditions:

I. Wireless using Radio modem (private radio channel),
II. Wireless using GSM modem (via cell-phone service provider),
III. Telephone cable connection (via telecom service provider),
IV. Fibre optic cables, or twisted pair.

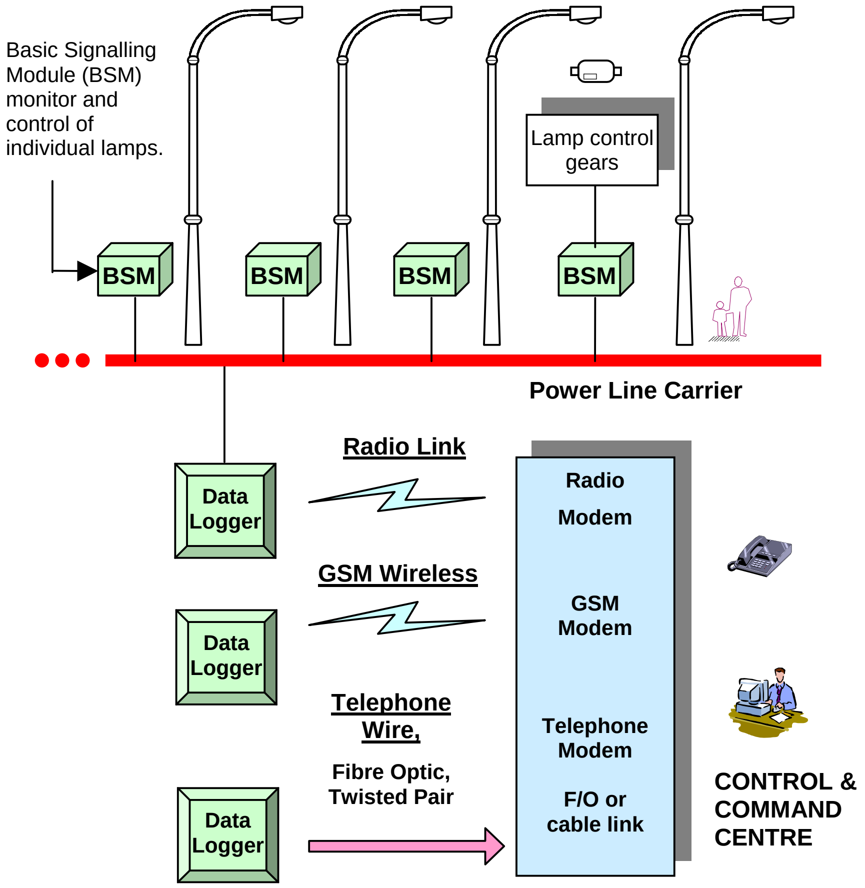


Figure F3.3.2 – Configuration of SPL Automation System (Pilot Scheme)

4.0 ISSUES IN THE IMPLEMENTATION OF A CITY-WIDE SPL AUTOMATION SYSTEM

4.1 General

In the implementation of a SPL automation system (and any automation system), the issues listed in this sub-section must be addressed:

4.2 Readiness of Facilities Managers

Facility managers (in this case Putrajaya) must be ready for the operation and maintenance of automation based management system. Sub-issues include:

(a) Availability of maintenance staff with knowledge and awareness of automation system.
(b) Commitment from management for implementation and **continued operation** of automation system.
(c) Facility managers must have management staff with knowledge and awareness of automation system and in particular data analysis.
(d) Maintenance, management and work procedures will have to be changed to make them compatible with the automation system.

4.3 Commitment of Management

Commitment at management level is also important for the continuous operation and evolution of automation system. Operation of automation systems are frequently not static and by right should evolve from its inception at physical completion. Evolution issues include:

(a) Up-grades of system hardware and software to make it more effective,
(b) Evolution of work procedures in the integration of automation system in the maintenance and management procedure (new procedures may even be evolved as new benefits are discovered).

Issues in implementing a City Lighting Network (CLN):

4.2 Readiness of facilities managers:
(a) Availability of staff with expertise and/or knowledge of automation;
(b) Commitment from management for implementation and continued operation of automation system;
(c) Management staff with knowledge and/or awareness of automation system.
(d) Maintenance, management and work procedures to fit in with and be compatible with automation system.

4.3 Commitments of Management
(a) Upgrades of hardware and software;
(b) Evolution of work procedure and integration of automation system into maintenance and management procedures.

4.4 Adopt Open Standards in Automation System.

4.5 Include Surge Protection.

4.4 Adoption of Open standards

Open Standard or industry wide standard system should be adopted early during implementation stage to minimise the possibility of future system obsolescence, product obsolescence and/or bad technical support.

4.5 Include Surge Protection

The electronics in automation equipment are sensitive and where cables linking systems are exposed to atmospheric originated electromagnetic activities (electric thunderstorm etc) equipment failure due to electric surge and transient are common problems. A complete and integrated surge protection system should be included in the design during inception.

4.6 Common Failures

The Malaysian automation scene is littered with automation system which suffers from the following common problems:

(a) Automation becoming 'white elephant' due to product obsolescence, poor technical support and discontinued market presence.
(b) Management indifference to automation after practical completion of system. Most facility managers adopt a commitment only during implementation stage but during operation and maintenance, automation issues are side-lined. This creeping side-lining ultimately lead to the 'slow-death' of the automation system.
(c) Poor technical support. A serious shortage at the technician level on automation system is an obstacle to most facility managers which can only be overcome with staff training.
(d) Indifferent and expensive back up and support from the automation vendor after practical completion.

5.0 <u>POLICY RECOMMENDATIONS FOR IMPLEMENTATION OF A CITYWIDE LIGHTING NETWORK (CLN)</u>

5.1 Benefits of SPL Automation

Present Putrajaya policy on implementation of SPL automation system at district levels (but not yet on a CLN level) is laudable and on the right track. Benefits of automation system include:

5.1.1 <u>Data Analysis and Data Mining</u> Proper analysis of data (data mining) provides critical management information for optimal performance; e.g.

(a) The stocking of spares and inventory is optimised by analysing historical data. Trending analysis also provides insight on (year-round) time-related consumption of spares and inventory. Traditional management of stock and inventory suffers from over-stocking and poor inventory keeping.
(b) Trending analysis on failures provides information useful for preventive maintenance. Defective models and spares (which are not obviously defective) can be spotted based on trending analysis.
(c) Analysis of 'abnormal' data points to impending failure or faulty maintenance procedure.
(d) Analysis of energy consumption, consumption of spares and staff deployment provides valuable data on cost appraisal, and budget allocation etc.
(e) Other nuggets of management (or commercial) information are waiting to be discovered from analysis of data ('**data mining**' is a relatively new field in information technology).

5.1.2 <u>Faster Response to Equipment Failure</u> A faster response time to SPL failure and shorter down time of equipment. Effective utilisation of automation system also reduces staff deployment and monitoring of lamp failure.

Common Failures of Automation Systes:

(a) System becoming 'white elephant' due to product obsolescence, poor technical support & discontinue market presence;
(b) Management indifference especially after practical completion leads to creeping side-lining and ultimate demise of the automation system;
(c) Poor in-house technical support; and
(d) Indifferent and/or expensive back-up from vendors after practical completion.

Benefits of a SPL automation include:

(a) <u>Data analysis and data mining</u> – provides critical management information for optimal performance;
(b) <u>Faster response</u> to equipment failure including reduction of staff deployment.

For the effective maintenance of metropolitan-wide street and public lighting system, the highest man-power allocation is frequently spent on monitoring and repair of faulty equipment. Due to the wide geographical dispersion of equipment, common methods of monitoring include:

(a) Full time monitoring crew making regular patrols (this method is cumbersome and not practical where manpower is an issue),

(b) Reliance on the public to report equipment failure. A public hot-line on SPL is commonly adopted as the reporting avenue.

5.2 Policy Recommendation

5.2.1 Further and expanded Implementation of SPL Automation System

(a) Putrajaya should further the implementation of SPL automation system in the city of Putrajaya.

(b) This policy should be expanded to include the bulk of the Central Boulevard and Core Precinct area (which will become the focal point of Putrajaya).

(c) Expanded automation may even include active switching of lightings in certain core and critical areas (this 'sub-policy' should however be adopted after careful consideration of the 'readiness' of Putrajaya to maintain and operate a sophisticated automation system).

5.2.2 Consistent Policy

A consistent policy on automation system should be adopted in the implementation of automation system. Though it is not the scope of this REPORT to propose detail policies, some broad policy statements are suggested as follows:

(a) Open-Standard A strong statement on adoption of open-standard (with reference to the ISO/IEC 61158) should be included.

(b) Registration of Vendors Any vendor proposing automation system for Putrajaya should be properly pre-qualified:

I. Submit conformance certification to any of the systems named in the ISO/IEC 61158,

II. Should provide commitment that their system can interoperate with existing system (without hidden cost to ensure interoperability),

III. Commitment to provide back-up, spares and up grade (a certain amount of consumable spares should always be provided at the local premise of the vendor), and

IV. Should be domiciled in Peninsular Malaysia.

5.2.3 Design Masterplan A broad masterplan on SPL automation may be included in the I.C.T. masterplan (if available). The Masterplan for automation may include the following:

(a) Hierarchy of control:

I. Full monitoring and active control (switching and dimming) of lights in Central Boulevard and precincts considered focal areas,

II. Full monitoring (without active control) of 'non-focal' core precincts (protocol roads), and

III. Group monitoring in outlying district (monitoring at feeder pillars only).

The hierarchy of controls are only suggestions and should be debated with engineering and ICT department (PJc) before adoption.

(b) Design standards include the following:

I. Conformance to open-standard (ISO/IEC 61158 is suggested as a base reference),

II. Inclusion of surge protection equipment as an integral component in the design. Surge protection should be hierarchy based protection class.

III. Compatibility of components (especially dimmable ballast) supplied by other vendors.

(c) Integration with other automation system and I.C.T. networks maintained by PJc. This include the following possibilities:

I. The SPL automation cable at the network level can be integrated with existing city-wide I.C.T. cabling infrastructure.

POLICY RECOMMENDATIONS

5.2.1 Further expansion in implementing automation system;

5.2.2 Adopt consistent policies:
(a) Adopt Open Standards;
(b) Register Vendors in Automation Systems.

5.2.3 Draft a CLN Masterplan, which may be included in the I.C.T. Masterplan (if available), issues include;
(a) Hierarchy of controls;
(b) Design standards (open standards, surge protection etc);
(c) Integration with other automation system and ICT networks.

5.2.4 Commitment of Management:
(a) Inclusion of automation as an agenda in management procedures especially in ISO9000 procedures.
(b) Maintain a strong culture in information technology; and
(c) Maintain and sustain continuing education and training for administrative and maintenance staff in automation and I.C.T.

II. Integration with existing city-wide automation system (if available). Automation systems include city-wide information board messaging, traffic control and monitoring and building automation systems,

III. Integration of SPL automation to the Internet or (city-wide intranet).

IV. Integration above will usually be implemented at the sub-net level.

5.2.4 Commitment of Management

Strong statement of management to automation policies and procedures should be included and sub-policies are as follows:

(a) Inclusion of automation as an agenda in the management procedure (especially the ISO9000 procedure),

(b) Maintain a strong culture in information technology; this can be monitored by efficiency targets or improvements gleaned from analysis of utilisation of automation, and

(c) A continuing and sustain education and training of administrative and maintenance staff in automation (and I.C.T.).

(END OF APPENDIX F)

APPENDIX G: ENGINEERING STANDARDS & SUBMISSION PROCEDURES

APPENDIX G – ENGINEERING STANDARDS

1.0 INTRODUCTION

The section Is a review of existing standards and procedures commonly applicable in Peninsular Malaysia for the design and submission of street lightings. Putrajaya standards and procedures pertaining to street and urban lightings are also listed. Some preliminary recommendation to present approval and procedures are then listed in this section.

2.0 LEGAL FRAMEWORK FOR SUBMISSION

2.1 Statutory Framework

2.1.1 In Malaysia roads and highway falls under the purview of the National Land Code. Two broad areas of existing responsibilities can be delineated:-

(a) Roads under the jurisdiction of local district councils and state authorities,

(b) Tolled expressways and highways under the jurisdiction of the ***Malaysian Highway Authority*** (MHA was set up under an act of parliament, Act 231; 1980 has legal jurisdiction over interurban highways.

2.1.2 In the promotion of standards and guidelines, the authorities responsible are therefore the legal entities listed above. As Putrajaya falls under the definition of a local council, this report will only concentrate on the situation named under (a) above.

2.2 Responsible Approving Authorities

I2.2.1 In the construction of local and district roads (and therefore the implementation of design standards including road lighting standards), two procedures are normally applicable:

(a) Where roads are implemented by the state or federal Government as infrastructure development, such roads are usually constructed by the JKR (***Jabatan Kerja Raya*** also known as the Public Works Department). In such case the JKR is the responsible authority approving standards for road constructions.

(b) Where roads are implemented by private developer under the purview of the '*Roads, Buildings and Drainage Act*', the local district, municipal or city council is the responsible authority approving standards.

2.3 Responsibility for Maintenance

2.3.1 In the maintenance of roads and road fixtures and lightings, the local authorities (which is the local district/town/city councils) are responsible for upkeep of the lighting fixtures. In reality the following cases are applicable:-

(a) All city halls have their own maintenance departments responsible for road lighting.

(b) Most municipal (towns) councils and some district councils have their own maintenance departments responsible for road lighting.

(c) Most district councils and some municipal councils sub-let the maintenance of road lighting to a third party:-

I. usually TNBD Sdn Bhd (a subsidiary company of Tenaga Nasional Berhad responsible for maintenance works),

II. sometimes the district JKR (JKR role in maintaining public street lights has been diminishing for the past ten years and only in remote district is the JKR still playing this traditional role).

2.1 Statutory Framework

In Malaysia, roads and highway falls under the purview of the National Land Code. Two areas of responsibility can be delineated:

(a) Road under the jurisdiction of local district councils and state authorities;

(b) Interurban highways and expressways under the jurisdiction of the Malaysian Highway Authority (MHA).

3.0 DESIGN STANDARDS

3.1 Codes, Standards and Practice

3.1.1 Standards and Codes of Practice commonly quoted by local authorities (and the highway/road engineering design fraternity in Malaysia) in the application and design of road lighting are as follows:-

(a) British Standards (BS) and code of practice (CP) 5489 published in ten parts is by far the more popular standards;

- *I.* BS 5489 Part 1 – *Guide to the general principals,*
- II. BS 5489 Part 2 – Code of practice for lighting for traffic routes,
- III. BS 5489 Part 3 – Code of practice for Lighting of subsidiary roads and associated pedestrian areas,
- *IV.* BS 5489 Part 4 – *Code of practice for single-level road junctions including roundabouts,*
- *V.* BS 5489 Part 5 - *Code of practice for grade-separated junctions,*
- VI. BS 5489 Part 6 – *Code of practice for Lighting for bridges and elevated roads,*
- *VII.* BS 5489 Part 7 – *Code of practice for the lighting of tunnels and underpass,*
- *VIII.* BS 5489 Part 8 – *Code of practice for lighting that may affect aerodromes, railways, harbours and navigable inland waterways,*
- IX. *BS 5489 Part 9 – Code of practice for urban centres and public amenity areas,*
- X. BS 5489 Part 10 - *Code of practice for lighting for motorways*.

(b) Commission Internationale de L'Ȅclairage (CIE or International Commission on Illumination); CIE publications:-

- I. 115-1995, 12.2-1977 *Recommendations for the Lighting of Roads for Motor and Pedestrian Traffic*,
- II. 12.2-1977, *Recommendations for the Lighting of Roads for Motorised Traffic,*
- III. 30.2-1982, *Calculations and Measurement of Illuminance in Road Lighting,*
- IV. 31-1076, *Glare and Uniformity in Road Lighting Installations,*
- V. 47-1979, *Road Lighting for Wet Conditions,*
- VI. 91-1992, *Guide to the Lighting of Urban Areas,*
- VII. *92 – 1992, Guide to the Lighting of Urban Areas*.

3.1.2 Procedures adopted by most local authorities for approval of road and street lightings usually fall under the purview of the '*Roads, Buildings and Drainage Act*'. In most cases, submission procedure for streetlights are included as part of submission procedures for roads and drainage which is a subset of D.O. application (D.O. – Development Order).

3.2 Local Standards in Submission of Street Lighting Installations

3.2.1 Most local authorities **<u>do not</u>** have firm and written guidelines for street lighting approvals beyond a delegation of professional responsibilities to the submitting professional (submitting professional defined under the '*Roads, Buildings and Drainage Act*' in this case refers to the professional engineer). Some municipal councils and city halls have simple written guidelines (***garispanduan***) for compliance by the submitting professional. Municipal councils and city halls publishing written guidelines for street lighting submission include DBKL, Majlis Perbandaran Shah Alam.

3.2.2 Where no written guidelines are published, conditions for approval are usually imposed (on an ad-hoc basis) by the district engineer responsible at the district or municipal level.

3.2.3 Common requirements quoted by most local authorities in approval of streetlights are as follows:-

(a) **<u>Poles</u>** The type of poles are specified (hot dipped galvanised octagonal). with height depending on road type and width. The hinged cover for service compartment is sometimes specified (top hinged etc.).

3.1 Codes and Standards
Standards commonly quoted by local authorities in the application and design of road lighting are as follows:-
(a) British Standards (BS) 5489 published in ten parts is by far the more popular standards;
(b) Commission Internationale de L'Ȅclairage (CIE or International Commission on Illumination); CIE publications

Submission procedures for streetlights are included as part of submission procedures as a subset of D.O. application.

(b) **Lamps** specified are usually SON for highways and motorways and MBF (mercury) lamps in housing estates. Some city halls and municipal authorities limit the brands of street lamps citing maintenance constraint in storage of spares (e.g. DBKL and MPSA). Common brand names quoted include '*Philips*', '*Schreder*', and '*Thorn*'.

(c) **Electrics** Most council (including DBKL) require a minimum cable size of 16mm² copper with no requirement on laying 4 core cables. MPSA however has a requirement insisting that 4-core cables be laid in all cases irrespective of the number of lights or circuits.

(d) **Controls** Most council specify time switch and/or light sensor. DBKL insist only on timer switch (since mid-1980s, DBKL decided that photocells are more troublesome in maintenance compared with timer switch as photocells persistently loses their sensitivity due to dust coating). However some municipal council (e.g. Penang) still insist on photocells only.

(e) **Spares** Some municipal councils and city halls insist that spares be provided by the developer on handing over to the said council. Spares include lamps and lanterns (15% to 25%), components such as ballast, igniters (10% 60 15%), and poles (10%).

(f) **Feeder Pillars** for streetlights are usually left to the discretion of the professional engineer responsible.

4.0 EXISTING PROCEDURES AND STANDARDS IN PUTRA JAYA

4.1 Existing Lighting Design

The lighting designed in Putra Jaya can generally be delineated into the following areas:

(a) Non-core areas of residential and commercial district which generally employs functional street luminaires in general compliance with the specifications listed in 3.2.3. above.

(b) Non-core areas still to be developed or under development, this include the Diplomatic enclave. It is expected that the ambient and signature of the lighting in these areas will be commented by the specialist consultant (LDP).

(c) Lighting in most roads (protocol and non-protocol roads) is generally designed to CIE standards. The average luminance level of **2 cd/m²** is an oft quoted figure. Site measurements of road lighting is reported in appendix A.

(d) SON lamps are generally used in all roads including residential road lighting.

4.2 Putra Jaya Design and Submission Guidelines

4.2.1 Special guidelines for street lighting submission published by the *Jabatan Bangunan*, Putrajaya are listed as follows:-

(a) Street Lighting Poles:-

I. (Service) door to be provided with latch.
II. Able to withstand a wind speed of at least 35m2sec.
III. The use of cut-out fuse and neutral must be changed to terminal block (?) approved by PPj.
IV. The value of fuse must be 6A.

(b) **Luminaire**

I. Must be built and constructed for easy maintenance such as changing of lamp, control gear, reflector and lamp-holder without requirement of special tools.

(c) **Feeder Pillar**

I. methods of lamp control must be provided i.e. photocell, bypass and timer.
II. Miniature Circuit Breaker (MCB) must be at least 6kA (short circuit rating)

(d) **System of Electrical Circuit**

I. Use 4c –PVCSSWAPVC copper cables where the minimum size is 16mm².

II. (The) circuit must be installed in sequence (of) RYB.

III. Cables must be run in duct.

(e) **Earthing System**

I. The feeder pillar must be supplied (with) earth chamber for purpose of testing (?).

II. Earth (impedance) readings of at least 1 ohms (must be obtained).

(f) **Luminance** must comply with the following parameters:-

I. Average luminance (L_{av}) $\geq$ 2 cd/m²

II. Overall Uniformity (U_o) > 0.4

III. Longitudinal Uniformity (U_L) > 0.75

IV. Threshold Increment (T_I) < 10%

(g) Spares

I. Amount of spares to be at least 5% of the total quantity installed.

II. Spares include igniters, capacitors, bulbs, ballast and poles.

4.3 Maintenance

From information provided by Perbandanan Putrajaya (municipal authority) maintenance of street lights in Putrajaya is at present undertaken by a private company (TNBD).

4.4. Automated Controls of Street Lights

4.4.1 Special design features include the following:-

(a) Implementation of hybrid multai-wound type electronic ballast for all street luminaire in protocol roads.

(b) Implementation of a special electronic and computer based 'Street and Public Light' (SPL) monitoring system for protocol roads

4.4.2 A pilot project is currently being implemented at the Central Boulevard. This pilot project include the use of hybrid type (multi-tap wound with electronic control) ballast for dimming of street lamps and the connection of street and public lightings in an automated network. Appendix **F** has a more detail treatment of this subject.

5.0 RECOMMENDATIONS FOR ENGINEERING STANDARDS

5.1 General Approval Requirements

Two aspect are important in the approving procedure for street and public lighting:

(a) Design Approval include the approval of luminance or illuminance levels, maintenance factor etc., and

(b) Components Approval include the physical quality and standards of luminaire and lamps. Components approval however are only applicable where street luminaries falls under the maintenance of Putrajaya (i.e. luminaire on private property and under the maintenance jurisdiction of private owners should not be subject to component approval).

Components Standards

5.2.1 Ballast are components which though unseen contribute to energy wastage. Electronic ballasts are one means of energy savings. However due to reasons (which are discussed elsewhere by the author) electronic ballast despite its more than 15 years technology is still not popularly accepted by the electrical engineering fraternity. A more realistic solution for energy efficiency (and which is adopted by most energy efficiency codes world wide including the Malaysian Energy Codes) is to specify 'low loss' conventional ballast. However as 'low loss' ballast for SON, MBF and HBI lamps are still not popular industry standards, a first step should be made by including loss figures in the proposed Putra Jaya lighting codes. Recommended values are as follows:-

5 RECOMMENDATIONS

5.1 General Approval Requirement

(a) Design approval; and

(b) Components approval.

5.2 Components Standards

(c) ***Ballast*** *– specify standard loss ballast (low loss ballast for discharge lamps is as yet not available). Publication of loss figures at least filters out sub-standard and high loss (inefficient) ballast.*

	Lamp Type	Maximum Allowable Losses
(i)	Sodium 70W	15W
(ii)	Sodium 100W	20W
(iii)	Sodium 150W	22W
(iv)	Sodium 250W	30W
(v)	Sodium 400W	45W
(vi)	Metal Halide 70W	16W
(vii)	Metal Halide 100W	16W
(viii)	Metal Halide 150W	20W
(ix)	Metal Halide 250W	34W
(x)	Metal Halide 400W	40W
(xi)	Metal Halide 1000W	60W
(xii)	Mercury 80W	12W
(xiii)	Mercury 125W	15W
(xiv)	Mercury 250W	18W
(xv)	Mercury 400W	28W

Table G5.2.1 – Recommended Loss Values for Ballast

5.2.2 IP Rating All luminaire should be certified to comply with the appropriate IP ratings (IP rating refers to the degree of water-tightness of a luminaire). Luminaire especially decorative and luminaries usually faces problems of water tightness. This will contribute to maintenance problem and fitting and electrical failure. IP ratings to be specified should be as follows:-

	Installation Conditions	IP Rating
(i)	Exposed to weather but located under roofing, awning or rain shield.	IP53
(ii)	Exposed to general weather.	IP 55
(iii)	Buried in ground	IP 65
(iv)	Underwater light (fountain, swimming pool etc)	IP 66

Table G5.2.2 – Recommended IP Ratings

5.2.3 Certification procedures to ensure that lamps and luminaire supplied are to the rating and quality as claimed should be included. The following certification procedures are recommended:-

(a) Electrical integrity Certification include Jabatan Elektrik,Suruhanjaya Tenaga (formerly known as the 'Jabatan Bekalan Elektrik & Gas') approval (which usually requires SIRIM certification of compliance to the relevant safety standards).

(b) Ballast Loss Values Certification authority include SIRIM and internationally recognised certification authorities (such as KEMA and UL).

(c) IP Rating To confirm compliance to IP rating certification authority includes SIRIM and internationally recognised certification authorities (UL).

Table G5.2.3 is a list of standards applicable for certification for components approval.

5 RECOMMENDATIONS

5.2 Components Standards

*(a) **IP Rating** – All luminaire should be certified to comply with the appropriate IP rating.*

*(b) **Certification** – procedures to ensure lamps and luminaire are to rating and quality claimed.*

	Components	Standards	Comments
1	**Inductive ballast for discharge lamps**:		
	(a) Safety requirements	IEC 61347-2-9	Replace IEC60922
	(b) Performance Requirements	IEC 60923	
	(c) Ballast losses	Table G5.2.1.	
2	**Tubular fluorescent lamps:**		
	(a) Inductive ballast - safety requirements	IEC 61347-2-8 MS 141 Pt 1	replace IEC60920 Prescribed item under the jurisdiction of the *Jabatan Elektrik,* Suruhanjaya Tenaga.
	(b) Inductive ballast - performance Requirements	IEC 60921 MS 141 Pt 2	
	(c) Inductive ballast losses	6W maximum	
	(d) Starters for fluorescent lamps	IEC 60155	
	(e) Electronic ballast - Safety Requirements	IEC 61347-2-3	replace IEC60928
	(f) Electronic ballast - performance Requirements	IEC 60929	
4	**Transformer for neon lamps - General safety requirements**	IEC 61050	
5	**Luminaire (light fittings)**		
	(a) Luminaires - general requirement and tests	IEC 60598-1	
	(b) Particular requirements	IEC 60598-2	
	(i) Fixed general purpose luminaires	IEC 60598-2-1	
	(ii) Recessed luminaires	IEC 60598-2-2	
	(iii) Roads and street lightings	IEC 60598-2-3	
	(iv) Floodlights	IEC 60598-2-5	
	(v) Luminaire with built-in transformers for filament lamps	IEC 60598-2-6	
	(vii) Luminaires for swim-ming pool and similar applications.	IEC 60598-2-18	
	(c) Degree of protection (IP rating) of luminaires	IEC 529 and table G5.2.2.	
	(d) Luminaire photometric data	Verification of photometric data claimed by vendor.	
6	**Lamps**		
	(a) Self-ballasted lamps – safety requirement	IEC 60968	
	(b) High pressure mercury	IEC 60188	
	(c) Low pressure sodium	IEC 60192	
	(d) High pressure sodium	IEC 60662	
	(e) Double-capped fluorescent lamps - performance requirements	IEC 60081	Prescribed item under the jurisdiction of the *Jabatan Elektrik,* Suruhanjaya Tenaga.
	(f) Single-capped fluorescent lamps – safety and performance requirements	IEC 60901	
	(g) Tungsten filament lamps - Performance requirements	IEC 60064	
7	**Feeder Pillars**		
	(a) Manufacturer license	Jabatan Elektrik (S.T.)	Licensing under the Electricity Act
	(b) Assembly standard	IEC 60439-1	Type tests may not be specified
	(c) Degree of protection	IP55 for outdoor feeder pillars IP42 for indoor feeder pillars	

Notes: Test certificates shall be from nationally and internationally recognised testing laboratories.

Table G5.2.3 – Applicable Standards for Components Certification

5 RECOMMENDATIONS

Table G5.2.3 – List of Standards for components certification and approval.

5.3 Standardisation

5.3.1 A more detail standardisation of design for street lighting poles especially in non-core areas where standard galvanised poles will predominate.

5.3.2 Some standardisation generalities to non-standard type lightings poles in core/protocol areas. Issues include:-

(a) Extent, type and construction of banner protrusion along poles for mounting of buntings, flags and banners.

(b) Standardisation of cable entry and service compartment.

5.3.3 Standardisation issues impacting maintenance of street luminaire to be addressed. This include the requirement for specifying or limiting the brands and types of components.

5.4 Design Standards

5.4.1 <u>CIE Standards</u> Given Malaysia's membership in the International Standard Organisation (ISO) and the eventual phasing out of British Standards (BS) in favour of European Standards (EN), it is recommended that all design should be in accordance with CIE Standards; unless and until a Malaysian Standard become current (a technical committee under SIRIM ISC-E is currently attempting to draft a code/standard for Road Lightings – late 2001 to-date).

5.4.2 <u>Luminance / Illuminace Level</u> should generally be in accordance with the recommended values listed in CIE publication 115. Special requirement are however for special Protocol roads and Central Boulevard such as the requirement of lighting controlled to (perhaps) two levels:

(a) 50% for normal usage,

(b) 100% during special occasions.

5.4.3 <u>Energy savings measures</u> using multiple lamps on a pole and multi-circuit switching (though technically inelegant) may be a more practical solution towards the same end. Statement requiring such multiple lamps and, alternate circuiting of luminaire may be included. Dimming if cannot be avoided should be implemented with care taking into considerations:

(a) Multi-wound hybrid-electronic ballasts are preferred over pure electronic ballast (this may however change in the future when cost, reliability and technology improve).

(b) Quality ballast issues are important, as many system fail due to the cheap electronic ballast. Unfortunately in keeping to rigorous standards and maintaining reliable components, the energy savings gains are off-set from the high capital cost.

5.4.4 Night Time Sky Pollution; mitigating factors include:

(a) For monument and façade-feature lighting use narrow beam and proper positioning of lights.

(b) Where unipole or advertising boards are to be lit, 'top down' flooding rather than bottom-up flooding to be used, and careful selection of beam spread and luminaire position to be considered.

(c) Appendic C has a detail treatment on this subject.

5.4.5 <u>Maintenance</u> In the design of street lights the various factors affecting the design goals of average luminance levels and uniformity are listed in table G5.4.5. As can be noted from the table, the cleaning intervals for lamps is a factor set during design calculations. It is therefore imperative that Putrajaya should specify a standard cleaning intervals for designers in their luminance level submission.

5 RECOMMENDATIONS

5.3 Standardisation

Standardisation of poles, and pole details (banner protrusion, cable entry door etc) and perhaps limitation to luminaire type.

5.4 Design Standards

CIE standards *is recommended over BS as the CIE will be part of the ISO and given Malaysia's membership in the ISO.*

Energy Saving *measures to be included in design standards include use of energy savings lamps.*

Night Time Sky Pollution – *mitigating factor required.*

Maintenance *– design factor affecting maintenance factor listed in table G5.4.5.*

Cleaning intervals (months)	Degree of protection of lamp housing					
	IP 23 minimum			IP 54 minimum		
	Pollution category					
	High	Medium	Low	High	Medium	Low
6	0.61	0.69	0.96	0.91	0.92	0.96
12	0.53	0.62	0.94	0.86	0.88	0.94
18	0.48	0.58	0.92	0.83	0.85	0.92
24	0.45	0.56	0.91	0.81	0.83	0.91
36	0.42	0.53	0.90	0.79	0.82	0.90

(1) High pollution occurs in the middle of large urban areas in heavy industrial areas.

(2) Medium pollution occurs in semi-urban, residential, and light industrial areas.

(3) Low pollution occurs in rural aeas.

Table G5.4.5. Luminaire Depreciation Factors (table 3.2 of CIE 92)

(END OF APPENDIX G)

5 RECOMMENDATIONS

Table G5.4.5 – Luminaire depreciation factor (table 3.2 of CIE Publication 92).

APPENDIX H: FREQUENTLY ASKED QUESTIONS

<u>**APPENDIX H – FREQUENTLY ASKED QUESTION**</u>

1.0 INTRODUCTION

In the course of preparing the "Putrajaya Urban Lighting Masterplan" and its key policies, various questions were raised by developers and consultants. This section is a reply to 'Frequently-Asked-Questions' (FAQ) to the Masterplan and its key policies.

2.0 POWER SUPPLY RELATED ISSUES

2.1 Upgrade to power supply and even substation required if street lights are upgraded from 250W SON (high pressure sodium) to 400W metal halide (MH)

Policy 1 of the Masterplan advocate the distinction of the Central Boulevard from its surrounding areas by the use of high colour rendering lamps (MH) instead of relatively 'monochromatic lamp' (SON). Vigorous objections to this policy include the opinion that usage of 400W MH over 250W SON will increase power requirement to street lightings by 100% thereby necessitating **major** cost increase in power supply cables and even upgrading of power station to cater for this increase.

(a) Upgrading of Substation

In the planning of any development, the calculation of load demand is an essential exercise which determines the number, size and capacity of (electrical power) substation space allocated within the development. Street lightings usually constitute a very small percentage (typically 5% or less) of the total load demand in any development. The reasons for this are:

Road lighting lamps at 250W or 400W are relatively small loads (at the micro level) compared to building services loads such as pumps and air conditioning motors.

I. Due to the relatively low level demand of road lightings ($2cd/m^2$ or about 20lux etc) compared to lightings in internal building (typically 300lux or more), the watts per m^2 for road lightings is very much less compared to internal building lights.

Thus an increase from 250W SON to 400W road should not in typical case require major expansion or upgrade to existing power station unless in **exceptional** case where existing substation is already overloaded (usually in very old city centre substation). It should also be noted that power station capacities are usually sized with spare capacity of about 15% to 30%.

(b) Power supply require upgrading

Street lighting 'feeder pillars' are typically designed at capacities of 60Amps, 100Amps, 120Amps, 150Amps and 200Amps rating. Cable ratings to feeder pillars are sized at standard $70mm^2$ (aluminium) irrespective of the feeder pillar rating. Street lighting circuits are also designed with $16mm^2$ -3 phase cables (present Putrajaya requirement). Due to the 'highly dispersed' nature of street lighting loads (refer also 2.1 (a) ii above), an increase of 400W MH lamps over 250W SON will not (unless in **very exceptional** case) impact on or have any effect on power supply cables to street lightings. Even a doubling of road lighting level (say from $2cd/m^2$ to $3cd/m^2$) which may require additional 400W lamp circuits **will not** (unless in very exceptional ase) require the upgrading of power supply cables. Figure H2.1.1 illustrates this.

2.1 Upgrade to power supply and even substation required if street lights are upgraded from 250W SON (high pressure sodium) to 400W metal halide (MH)

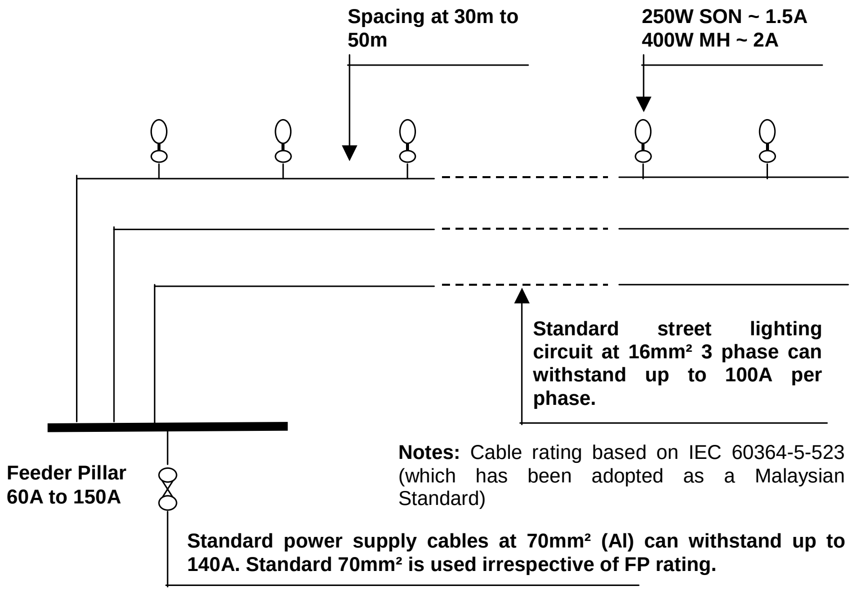
<u>*Upgrading of substation*</u>

Street lightings usually constitute a very small percentage (typically 5% or less) of the total load demand in any development.

Thus an increase from 250W SON to 400W road should not in typical case requires major expansion or upgrade to existing power station. It should also be noted that power station capacities are usually sized with spare capacity of about 15% to 30%.

<u>*Power supply require upgrading*</u>

Due to the 'highly dispersed' nature of street lighting loads, an increase of 400W MH lamps over 250W SON will not impact on or have any effect on power supply cables to street lightings.



The number of lamps per circuit and even per feeder pillar is usually restricted by the highly dispersed nature of street lights. Thus most street lighting feeder pillars and street lighting circuits are usually 'under-loaded' and lamps can be safely upgraded from 250W to 400W without major upgrade to cables.

Figure H2.1.1 – Typical Circuiting For Street Lights

3.0 METAL HALIDE VERSUS HIGH PRESSURE SODIUM

Objections raised include safety of metal halide, unsuitability of metal halide and the high cost of metal halide. An opinion has even been voiced that metal-halide is dangerous ('will-explode'), is not well suited for street lights and present a 'sterile' white ambience. Champs Elysées, Paris has been quoted as opting for SON rather than white metal halide.
In the advocacy of metal halide and 'white SON' for the Central Boulevard, the principle of a high colour rendering (CR) lamp is the basic thrust of the policy. High pressure sodium (SON) has a typical colour rendering index (CRI) of 20-39 while metal halide has a CRI of 80 – 90. White SON has typical colour rendering of around 80.

3.1 Unsuitability of 'white' metal halide

CIE 12 and BS 5489 made no reference to lamp source or colour rendering beyond a recommendation of average luminance, uniformity and glare thresh-hold levels. It is therefore **not correct** to assert that metal-halide is unsuitable and unsafe in the design of street light. However latest research and recommendation recognise the efficacy of high CRI lamp source particularly in scotopic (night time) vision. As is well known (refer 'Glossary of Technical Terms' – subsection 4), visual acuity during daytime (photopic) peaks at around 555nm (yellowish-green). However visual acuity at night (scotopic) shifts the peak sensitivity of human perception to around 480nm (bluish-green). Thus monochromatic SON will suffer a lower efficiency in perception at night. Table H3.1 compares the 'brightness' efficacy of various lamps based on 'Mesopic' (gloomy evening) conditions.

Table H3.1

Lumens Effectiveness Multipliers (High Pressure Sodium = 1,00)
From Brightness Matching Mesopic Functions

Luminance (cd/m²)	0.01	.01	0.1	1	3	10
Metal Halide	2.25	2.11	1.82	1.35	1.13	1.00
High Pressure Sodium	1.00	1.00	1.00	1.00	1.00	1.00
Clear Mercury	1.48	1.43	1.38	1.22	1.09	1.00
Low Pressure Sodium	0.47	0.51	0.61	0.82	0.95	1.00

From Adrian, Werner "The Influence of Spectral Power Distribution for Equal Visual Performance in Roadway Lighting Levels." Proceedings of the 4th International Lighting Research Symposium, Orlando, 1998. Lighting Research Office of the Electrical Producers Institute, Pleasant Hill, California

The Champs Elysées, Paris (a central boulevard in the heart of Paris) has been quoted as opting for sodium lamps. However it should be noted that the Champs Elysée in their latest street lights up-grade selected 'white' sodium with a CRI of 80 for pavement lightings ('Screder Group News Report No 21'). The use of high CRI light source (such as metal-halide) is gaining international recognition as a concept for inner city lighting. In Petaling Jaya the streets at the overhead bridge ('Matshusita junction', Petaling Jaya) uses metal-halide without apparent diminishing of lighting performance.

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CIE 12 and BS 5489 made no reference to lamp source or colour rendering beyond a recommendation of average luminance, uniformity and glare thresh-hold levels. It is therefore not correct to assert that metal-halide is unsuitable and unsafe in the design of streetlight.
Latest research and recommendation recognise the efficacy of high CRI lamp source particularly in scotopic (night time) vision.

In Petaling Jaya the streets at the overhead bridge ('Matshusita junction', Petaling Jaya) uses metal-halide without apparent diminishing of lighting performance.

3.2 Higher glare due to metal halide

It has also been claimed that metal-halide or high colour rendering lamp source will present glare control problems in street light. This is again a **not correct** as glare control is suitably covered in CIE12 and BS5489 by the 'Threshold Increment' (TI) index. The T.I. index is a function of lamp design, lamp spacing, pole height etc and do not depend on lamp source or CRI of lamp. The subject of glare is a highly technical subject and previous recommendations based on 'glare control marls' has been found to be unsuitable. CIE 31 has a detail treatment on this subject.

3.3 High Cost of Metal Halide

It has also been asserted that metal halide will cost exceptionally higher than SON with figures of 150% been quoted. From a survey of market in December 2001 it was found that the cost comparison between metal halide and SON lamps are not exceptionally higher (see table H3.3). The cost comparison assumes the complete fittings to be changed. However depending on the selection of luminaire housing, change-over to metal halide may involve only a change of lamp and lamp control (not the housing). In this case, cost incurred for changing over to metal halide will be lower. From the quotations we note that the cost of metal-halide lamps with luminaire **is not significantly** higher as claimed.

A summary of average cost from the three suppliers are as follows:

Fittings	**Unit Cost in Ringgit**	
	Metal Halide	**SON**
(a) 400W with gears	RM280	285
(b) 250W with gears	RM250	230
(c) 150W with gears	-	185
(d) 400W with housing	RM1,800	RM1,700
(e) 250W with housing	RM1,700	RM1,600

Table H3.3 – Comparison of cost

3.4 Safety Issues

Metal halide belongs to the category of lamps known as **gas discharge** lamps. In gas-discharge lamp, an electric current is discharged into a gas-filled glass or translucent container. The ionisation of the gas molecules or atoms results in the generation of light. The colour of light emitted depends both on the mixture of gases and the material coating inside the gas tube. In fluorescent lamps, ionisation of the gas produces invisible light in the ultraviolet range. The 'excitation' of the phosphor coating on the inside of the tube converts the UV light into visible light.

In low pressure sodium or mercury lamp, the active ingredient is sodium or mercury vapour mixed with an inert gas (often neon or argon). The vapour pressure is usually very low (at a millionth of one atmosphere). In high pressure lamps or high intensity discharge (HID) lamps, the energy of the electron discharge into the gas is at relatively higher energy level. Metal halide is similar to mercury vapour except that it has small amount of additive comprising various metallic halides.

High pressure sodium (HPS) operates at relatively lower pressure (about ¼ atmosphere) whilst metal halide (MH) operate at higher pressures of 2 to 4 times atmosphere. MH lamps pressurised at above atmospheric pressure leads to the perception that it is explosive. However as in most 'engineered' system for consumer usage, MH lamps are designed for safe operation within statistical limits of hazard. An example would be the NGV canister used in cars powered by natural gas and which is pressured at about 1000psi. Despite concerns raised by layman of 'potential bombs' on the highway, thousands of cars fitted with NGV canisters are currently cruising the highway without higher statistical hazard and neither has there been reported instances of NGV canisters exploding even in an accident involving natural gas powered vehicle. It should however also be noted that high pressure sodium (if not handled properly) is just as dangerous (hot sodium is a highly reactive chemical and metallic sodium reacts with water to produce hydrogen gas which is highly explosive). Both HPS and MH lamps are designed with an inner arc tube (hard quartz for MH and

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Glare control is suitably covered in CIE12 and BS5489 by the 'Threshold Increment' (TI) index. The T.I. index is a function of lamp design, lamp spacing, pole height etc and do not depend on lamp source or CRI of lamp. The subject of glare is a highly technical subject and previous recommendations based on 'glare control marls' has been found to be unsuitable. CIE 31 has a detail treatment on this subject.

3.3 High Cost of Metal Halode
From a survey of market in December 2001 it was found that the cost comparison between metal halide and SON lamps are **not exceptionally higher**. The cost comparison assumes the complete fittings to be changed. However depending on the selection of luminaire housing, change-over to metal halide may involve only a change of lamp and lamp control (not the housing). In this case, cost incurred for changing over to metal halide will be lower.

3.4 Safety Issues
MH lamps pressurised at above atmospheric pressure leads to the perception that it is explosive. However as in most 'engineered' system for consumer usage, MH lamps are designed for safe operation within statistical limits of hazard.

translucent ceramic for HPS) sealed within an outer glass envelope. MH lamps are widely used in installation requiring high CRI such as sports stadium, auditorium and even factories without any perceptible increase in hazard.

The only real issue pertains to the hazard from the disposal of lamps and leaching of toxic chemicals into the environment. Mercury which is added into most gas discharge lamp (including sodium lamps) improve the efficiency of lamps (lower arc temperature etc). Mercury however has a high toxic potential to the environment. This issue is addressed by the industry with the following approach:

(a) Proper disposal of lamps Proper disposal of lamps include a central disposal agency. In some countries proper disposal is enforced by legislation (come states in the U.S.A.). In Malaysia there is at yet no legislative support for the proper disposal of lamps.

(b) Low mercury lamp Industry experts are working towards lamps with less mercury additive.

3.5 Comparative cost of maintenance for MH and HPS

Table H3.5.1 is a comparison listing the differences in the lamp types for the most common sizes.

Table H3.5.1 - A Summary of Lamp Type

Factor	**Incand-escent**	**Fluorescent**	**MH**	**HPS**	**LPS**
Wattage	25-150	18-95	50-400	50-400	18-180
Output (lumens)	210-2700	1000-7500	1900-30000	3600-4600	1800-33000
Efficiency (lumens/watt)	8-18	55-79	38-75	72-115	100-183
Lumen Main-tenance	90 (85)	85 (80)	75 (65)	90 (70)	100 (100)
Lamp Life (hours)	750-2000	10000 - 20000	10000 - 20000	18000 - 24000	16000
CRI	90-95	30 - 90	80-90	20-39	

Notes: **Wattage** and **output** refers to the common available lamp rating for outdoor lightings.
Efficiency refers to luminous efficiency taken at 50% mean lifetime and do not include ballast loss.
Lumen Maintenance refers to percent of initial lamp putput at 50% of mean lifetime at at end of lifetime (parenthesis).
Lamp life refers to the approximate mean lifetime of lamp.

From the perspective of maintenance, we can conclude from the table above as follows:

(a) MH is less efficient than HPS The efficiency of a lamp translate from the lamp flux output (lumens) to the power input (watts). MH lamps are about 50% less efficient than LPS lamps. Thus to maintain a certain lighting level using (say) 250W HPS, 400W will be required if MH lamps are used. A lower lamp efficiency translate to higher electricity cost.

This view should however be tempered by the perspective of brightness efficacy based on CRI (refer section 3.1 and table H3.1 preceding; remember that the 'lumens' is defined to be weighted at 555nm).

3.4 Safety Issues

Safety issue pertains to the hazard from the disposal of lamps and leaching of toxic chemicals into the environment (especially Mercury which is added into discharge lamps to improve the efficiency of lamps. This following are approach adopted by industry:

(a) Proper disposal of lamps Proper disposal of lamps include a central disposal agency. In Malaysia there is at yet no legislative support for the proper disposal of lamps.

(b) Low mercury lamp Industry experts are working towards lamps with lower mercury content.

3.6 Comparative cost of maintenance for MH and HPS

(a) MH is less efficient than HPS
A lower lamp efficiency tramslate to higher electricity cost.

(b) Lument maintenance and Lamp Life
MH has a lower lumen maintenance and life (about 30% lower). A lower lamp life will require a shorter 're-lamping' period.

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MH has a lower lumen maintenance and life (about 30% lower). A lower lamp life will require a shorter 're-lamping' period.

A quick calculation of maintenance cost for energy consumption and relamping yields the result in table H3.5.2.

Table H3.5.2
Maintenance Cost – Annual Energy & Relamping Cost (5000 lamps)

	250W HPS	400W MH	
i. Annual electricity cost 400 hours per month Tariff G	RM 120,000.00	RM 192,000.00	
ii. Annual Re Lamping 80% for HPS 110% for MH Inclusive of ballast	RM 1,000,000.00	RM 1,650,000.00	
Total Cost	RM 1,120,000.00	RM 1,842,000.00	
	100%	164%	

(END OF FAQ)

3.6 Comparative cost of maintenance for MH and HPS

A quick calculation of maintenance cost (energy and relamping) confirms that annual maintenance cost for MH is about 60% higher than HPS (Malaysian context only) (Table H3.5.2).

APPENDIX I: GLOSSARY OF TEHNICAL TERMS

APPENDIX I – GLOSSORY OF TECHNICAL TERMS

This section is a glossary of basic terms and concepts in the physics of lighting including measurement concepts in lighting. The subjective response of the human eye to colours and brightness are some issues impacting design and choice of lights.

1.0 THE PHYSICAL NATURE OF LIGHT

1.1 **Electromagnetic Radiation** Light is a form of radiation similar to radio waves and X-rays known collectively as **electromagnetic radiation**. Electromagnetic radiation is also a form of energy which is all around us

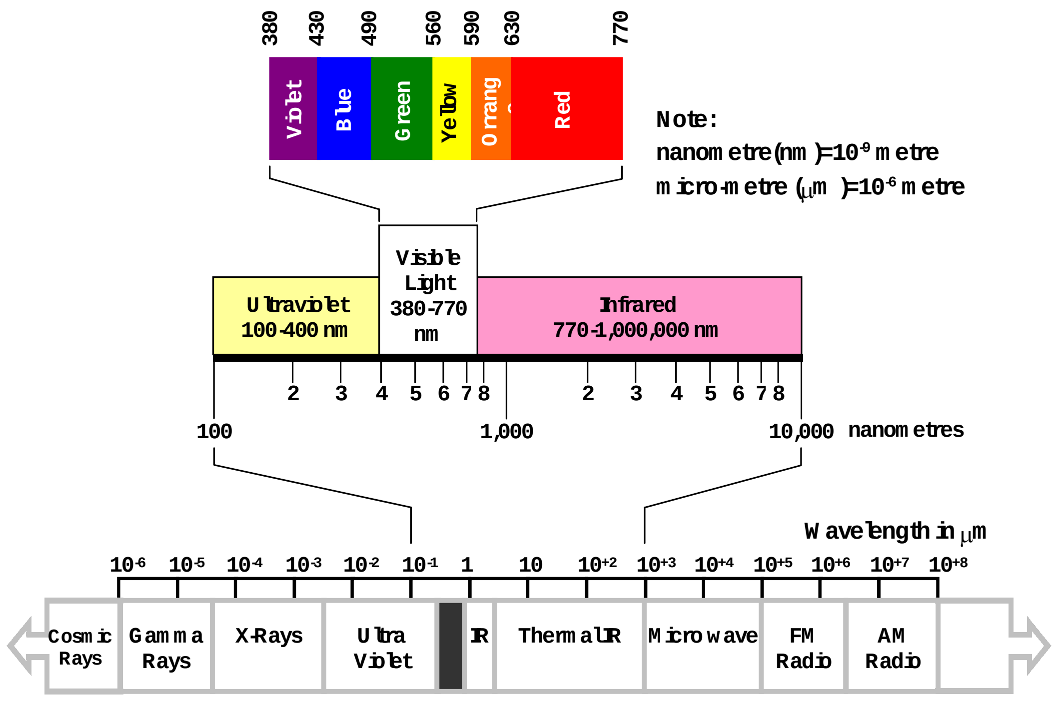
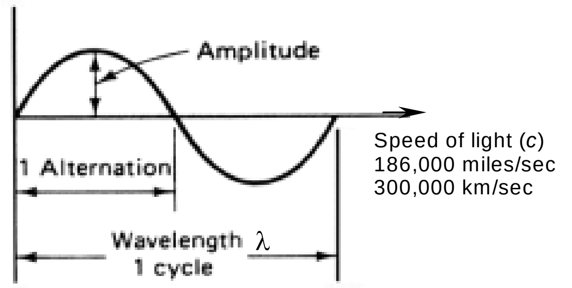


Figure I1.1 – The Electromagnetic & Visible Light Spectrum

and travels at the speed of light (186,000 miles/seconds or 300,000 km/seconds). The electromagnetic spectrum encompasses a diversity of energy from radio waves at one end to X-ray at the other end with the visible light spectrum falling somewhere in the middle (**figure I1.1**).

Wavelength, Frequency and Energy of Light The energy of electromagnetic radiation is directly related to its frequency. **Figure I1.2** shows the relationship between wavelength and frequency of a wave propagation. Ultraviolet light at the lower wavelength band (or higher frequency) has higher energy level compared to infrared at the higher wavelength band. For this reason ultraviolet rays are more harmful due to its higher energy level and higher penetration power on living tissue cells



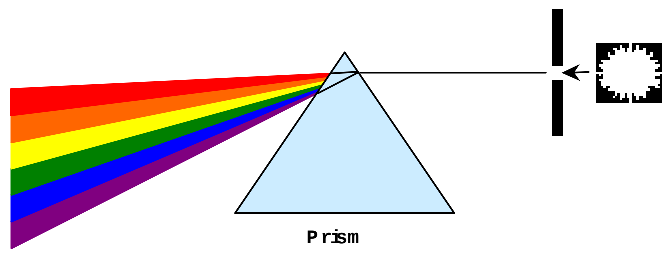
Electromagnetic wave travels at the speed of light (*c*), Frequency is the number of cycles per sec (*f*). Thus the relation ship between *c*, *f* and λ is as follows:

$$\lambda = c / f$$

Figure I1.2 – Wavelength and Frequency

2.0 SPECTRAL ENERGY OF LIGHTS

2.1 **Colours** As can be seen in figure 1, the visible light spectrum spans a range of wavelength, which the eyes perceive as colours. Typical 'white light' source (such as sun-light) has a mixture of all lights within the six colours bandwidth (**figure I2.1** shows a narrow beam of white light being split into the colour spectrum).



Light at different wavelength (or energy) when refracted in glass travels at (slightly) different speed. Due to this a beam of white light refracted in a glass prism is split up into its component colours.

Figure I2.1 – The colour of white light

1.1 Electromagnetic Radiation

*Electromagnetic radiation is a form of energy which is all around us and travels at the speed of light (186,000 miles/seconds or 300,000 km/seconds). The electromagnetic spectrum encompasses a diversity of energy from radio waves at one end to X-ray at the other end with the visible light spectrum falling somewhere in the middle (**figure I1.1**).*

1.2 Wavelength, Frequency and Energy of Light

Frequency (f) is the number of cycles per sec. Wavelength (λ) is the distance travelled in one cycle.

$$\lambda = c / f;$$

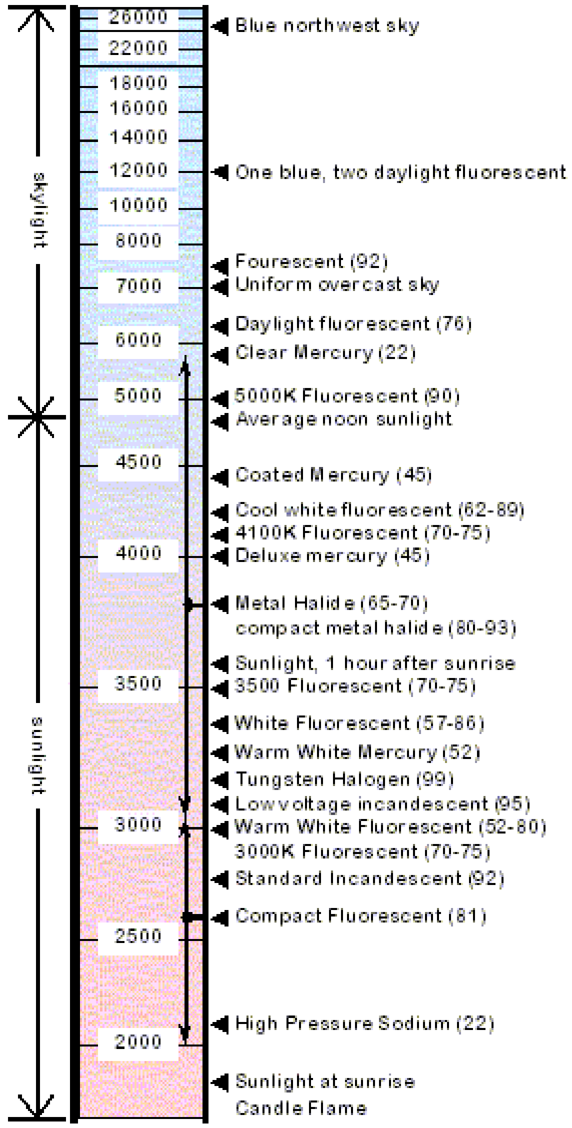
c = speed of light (300,000km/sec)

2.1 Colours

The visible light spectrum spans a range of wavelength which the eyes perceive as colours. Typical 'white light' source (e.g. sun-light) has a mixture of all lights within the six colour band. Figure I2.1 shows a beam of white light being split into the colour spectrum.

2.2 **<u>Colour Temperature</u>** The variation in the amount of colours within a light mixture affects the appearance of the light in terms of its relative 'warmness' or 'coolness'. To describe this variation in relative 'warmness' and 'coolness' or the colour of light sources, the term '**colour temperature**' is used.

Colour temperature or Correlated Colour Temperature (CCT) due to its theoretical basis in the study of 'black body' radiation should apply only to sources with a **continuous spectrum** (such as incandescent lamps and natural light). However for light sources with non-continuous spectral distribution (such as fluorescent lamps and discharge lamps where the spectrum consist of peaks of energy), CCT is used mainly on an empirical sense (i.e. in a very 'near approximate' sense) to describe the degree of 'whiteness' of the said light source. **Figures I2.2** shows the colour temperature chart of various light sources.



The Colour Temperature of light is correlated to the temperature of a laboratory 'black body' and its corresponding colour as it is heated through the various stages of incandescent from red to blue white. The Correlated Colour Temperature (CCT) is in Kelvin . The colour rendering index (CRI) for each source is shown in brackets

<u>Figure I2.2</u> - The correlated colour temperature of various light sources (in Kelvin

2.3 **<u>Colour Rendering</u>** A more common method of characterising light sources by its colour is the **Colour Rendering Index (CRI)**. The **CRI** compares the spectral energy content of a light source to that of a standard reference source with full-spectrum. The CRI value is a numerical value and is 100 for full-spectrum natural white light. Incandescent lights are considered nearly white and has CRI close to 100. Most lights have CRI typically in the range 20 to 80.

The CRI model is not a perfect model and should only be used to compare light source with the same colour temperature. For example (about) 6000K daylight fluorescent and clear mercury has CRI of 76 and 22 respectively. The daylight fluorescent will therefore render colours better than clear mercury. The difference between a 3400K tungsten halogen with CRI 99 and an ordinary 2800K incandescent with CRI 92 can usually also be differentiated by most observers. Despite the small difference in CRI values, the tungsten halogen will render colours more vividly compared to the ordinary incandescent.

Colour rendering is a very important concept in the selection of lights for visual impact especially in the case of (building) façade and monument lighting.

3.0 <u>THE POWER AND INTENSITY OF LIGHT</u>

3.1 **<u>Optical watt</u>** The fundamental unit of optical power is defined as the watt (W) which is equivalent to a rate of energy of 1 Joules (**J**) per second.

1 watt (optical power) = 1 Joule per second

3.2 **<u>Luminous Flux, Lumen (lm)</u>** The photometric equivalent of the optical power for visible light is the **lumens (lm)**, which has to take into account the sensitivity of the human eyes by weighting it towards yellowish-green light (at 555nm). The average human eyes have the greatest response at 555nm. The lumens is also referred to as the **luminous flux**.

1 watt at 555nm = 683.0 lumens

2.2 Correlated Colour Temperature (CCT)

The variation in the amount of colours within a light mixture affects the appearance of the light in terms of its relative 'warmness' or 'coolness' and this variation in relative 'warmness' and 'coolness' is term '**colour temperature**'. Theoretically CCT is defined as light colour correlated (or compared) to the temperature of a laboratory 'black body' as it is heated through the various stages of incandescent from red to blue white. The Correlated Colour Temperature (CCT) is in Kelvin.

2.3 Colour Rendering Index (CRI)

The **CRI** compares the spectral energy content of a light source to that of a standard reference source with full-spectrum. The CRI value is a numerical value and is 100 for full-spectrum natural white light. Incandescent lights are considered nearly white and has CRI close to 100.

3.1 Optical Watt

The fundamental unit of optical power is defined as the watt (W)[

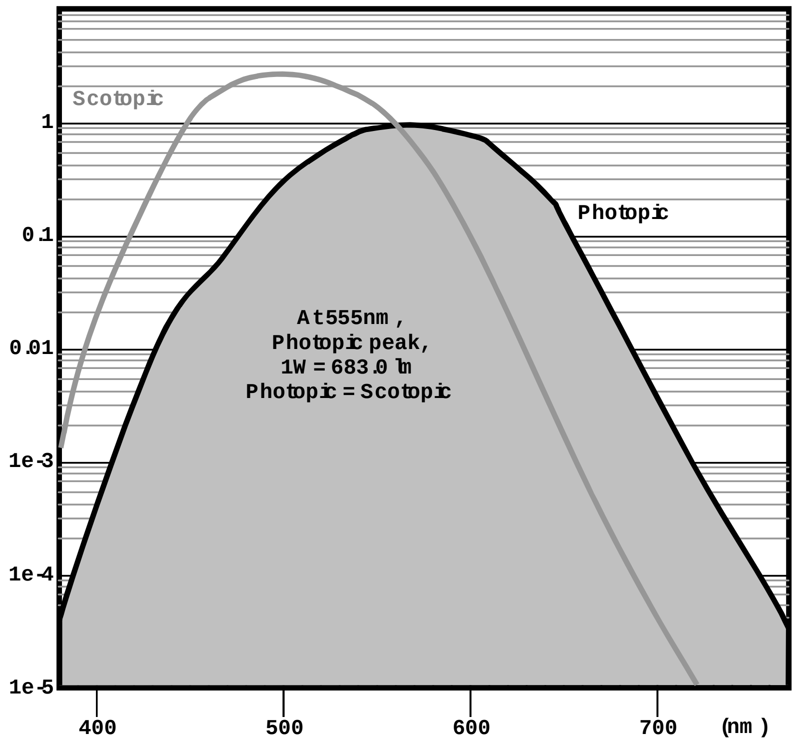
1 watt optical = 1 Joule per second

3.2 Luminous Flux, Lumen (lm)

1 watt at 555nm = 683 luments

The watt take into account the optical sensitivity of the human eye by weighting ut towards yellowish-green light at 555nm.

The CIE (*Commission Internationale De L'Éclairage* or International Commission on Illumination) has defined the responsiveness of the human eye in terms of **Photopic** (daytime) and **Scotopic** (night time) vision. **Figure I3.2** shows the CIE photopic and scotopic response curve.



The vertical scale measures the relative sensitivity with maximum response at 555nm (relative sensitivity 1) for photopic response. Note that scotopic sensitivity is enhanced.

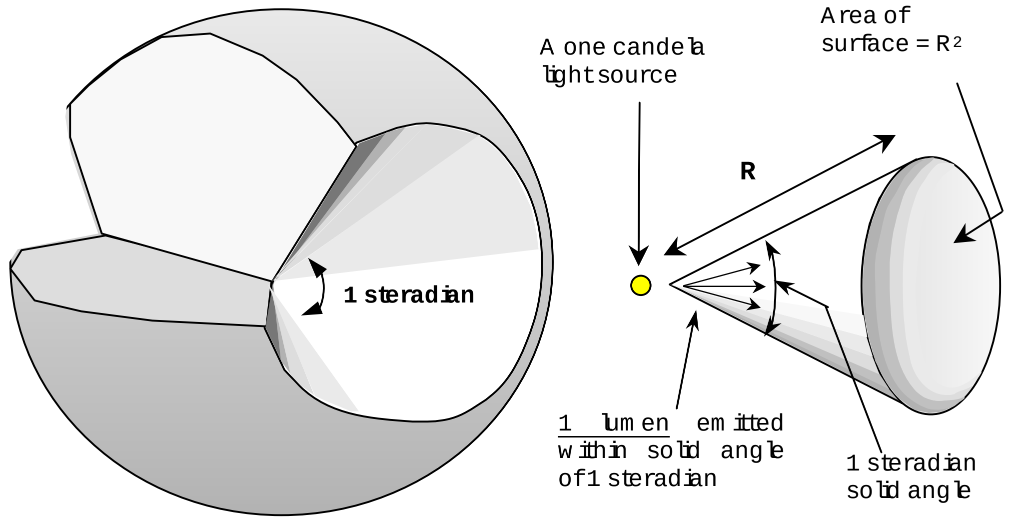
Figure I3.2 – CIE Photopic and Scotopic Sensitivity curves

3.3 **Luminous Intensity (I)** As light is dispersed from a point source quantification of light power has to take into account the geometry of space. The standard geometrical projection for luminous flux is a cone with a solid angle of one steradian (see **figure I3.3**). The basic unit of irradiance or luminous intensity is the **candela** (**cd**).

1 candela is a light source which emits

1 lumen per steradian, isotropically in all directions.

Due to the definition of a steradian, one candela (or 1 lm per steradian) will project a luminous flux of 1 lumens per sq. ft. at one foot from the point source or 1 lumens per sq. metre at one metre from the point source (see **figure I3.3**).



A one steradian solid angle is when the area of the surface cut by the solid angle is equal to the square of the radius. A solid sphere has a total solid angle of 4π steradian.

The **Candela** is a light source which emits (isotropically or equally in all directions) an intensity of **1 lumen within a 1 steradian** solid angle. A one candela source will project 1 lumen/ft² for a 1 feet radius and 1 lumen/m² for a 1 metre radius.

Figure I3.3 – Geometries, Steradian and the Candela

3.4 **Luminance (L)** is the luminous intensity per unit area projected in a given direction. The unit of luminance is the candela per sq. metre (cd/m²) which is also called the **nit**. The footlambert (fL) is also in common use. Luminance is a common quoted parameter in the specification of lighting performance and it is commonly represented by the designation '**L**'.

1 cd/m² = 1 nit

1 fL=3.426cd/m²

3.5 **Illuminance (E)** is the luminous flux incident on a surface per unit area or the photometric flux density. It is expressed in lumens per unit area. The units of illuminance which is also commonly represented by the designation '**E**' is as follows:

1 lux (lx) = 1 lumen /m²

1 foot-candle (fc) = 1 lumen /ft²

***Photopic* – daytime visual response (peaks at 555nm);**
***Scotopic* – night time visual response (sensitivity peaks shifts from photopic). Scotopic response is also enhanced compared to photopic.**

3.3 Luminous Intensity (I)

*The basic unit of irradiance or luminous intensity is the **candela** (**cd**).*
*A **1 candela** light source emits **1 lumen per steradian** isotropically in all directions.*

*One **Steradian** solid angle is when the area of the surface cut by the solid angle is equal to the square of the radius (a solid sphere has 4π Steradian).*

3.4 Luminance (L)
L is the luminous intensity per unit area projected in a given direction (in candela per sq. metre – cd/m² or footLambert)

1 cd/m² = 1 nit

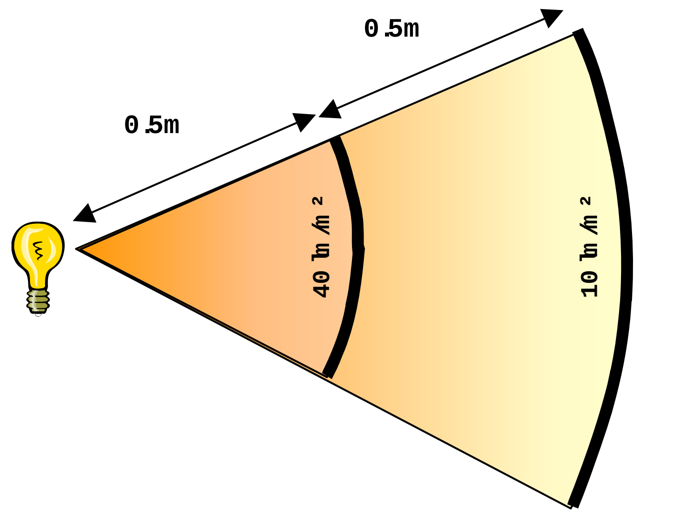
1 footLambert (fL) = 3.426 cd/m²

3.5 Illuminance (E)
E is the luminous flux incident on a surface per unit area or the photometric flux density (in lumens per unit area):

1 lux (lx) =1 lumen / m²

1 footcandle (fc) = 1 lumen / ft²

3.6 **Inverse Square Law** Lighting intensity as for all electromagnetic radiation follows the inverse square law. Lighting intensity per unit area falls inversely with the square of the distance (**figure I3.6**).



The inverse square law states that the intensity per unit area of light is inversely proportional to the square of the distance.

$E \propto 1/d^2$ OR $E_1 \times d_1^2 = E_2 \times d_2^2$

Figure I3.6 – The Inverse Square Law

4.0 PHOTOMETRY

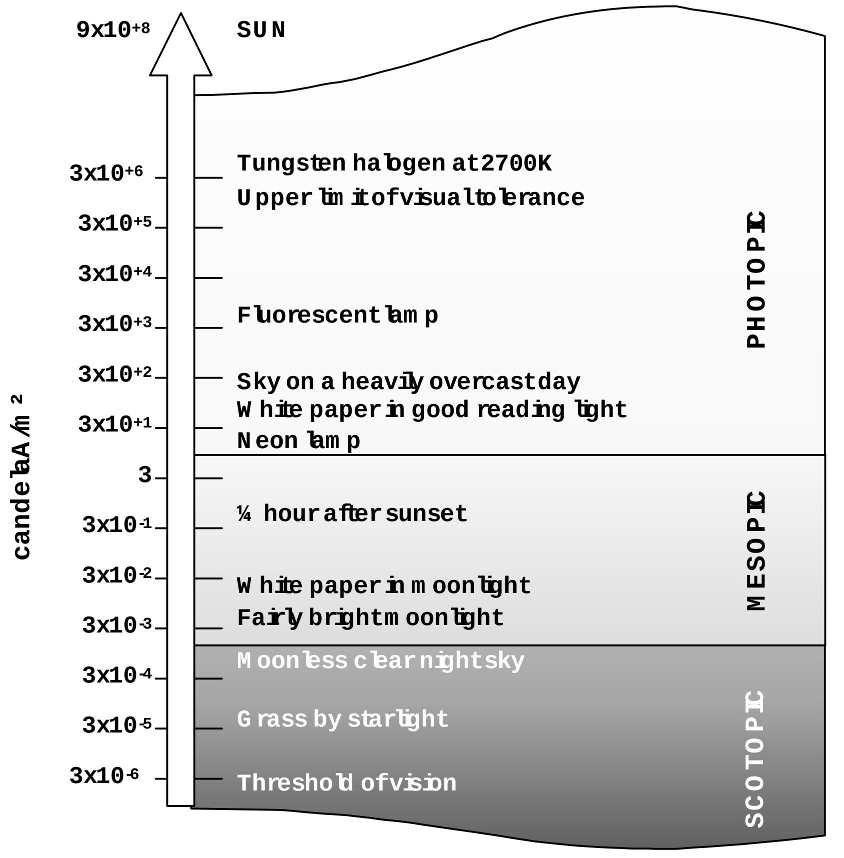
4.1 **Brightness and the Luminance/Illuminance Confusion** Both luminance (*L*) and illuminance (*E*) are quantities measuring the density of light energy falling on a surface.

Luminance (*L* in cd/m²) measures the intensity per unit area **projected** in a given direction. Luminance is therefore sensitive to the direction of projection (or perception) and perhaps can be perceived as a '**perception**' measurement. Some experts also aver that luminance is a quantity which is most akin with '**brightness**'. It should however be cautioned that luminance is a measurable quantity whilst '**brightness**' is a subjective value and both terms are **not** interchangeable. **Figure I4.1** charts human perception over a range of luminance value.

Brightness is a subjective value which can be perceived differently by different people and under different circumstances. The response of the human eye to the magnitude of lights is complex, non-linear and depends on the sensitivity of the retina (age), the colour of the light, the uniform background lighting level (photopic/mesopic/scotopic conditions) and the presence of glare.

Illuminance (*E* in footcandle or lux) measures the luminous flux **incident** on a surface.

In codes and standards, luminance (*L – cd/m²*) is more commonly specified for roads and highway lightings while illuminance (*E* – fc/lux) is preferred for interior lightings.



Luminance levels perceived by the human eye. The sensitivity of the human eyes respond logarithmically to the luminance level. The range of human perception ranges over a luminance level of 12 orders magnitude.

Figure I4.1 – Luminance Chart

3.6 The Inverse Square Law
Lighting intensity per unit area falls inversely with the square of the distance.

4.1 Brightness and the Luminance/ Illuminance Confusion
Both luminance (L) and illuminance (E) measure the density of light energy falling on a surface.
*Luminance (L in cd/m²) measures the intensity per unit area **projected** in a given direction. L is therefore sensitive to direction of perception.*
*Illuminance (E in footcandle or lux) measures the luminous flux **incident** on a surface.*
Brightness is a subjective value. Luminance is sometimes quoted as most akin to 'brightness'.

In codes and standards, luminance (L – cd/m²) is more commonly specified for motorways whilst illuminance (E – fc or lux) is preferred for interior lightings and/or pedestrian traffic.

4.2 **Photometry** The difference between luminance (*L*) and Illuminance (*E*) is best illustrated by the different methods employed by both types of photometers.

Luminance photometer mimics the human eyes. The luminance photometer is aimed at a lighted surface or light source and brought to focus. The luminous flux captured through the aperture and focusing lens of the photometer falls onto a photo-detector permitting a measurement of luminance.

In contrast, the illuminance photometer is placed directly under a light source or onto the surface to be measure. The illuminance measured is irrespective of the direction of the light source. **Figure I4.2** illustrate the fundamental difference between the luminance and the illuminance photometers.

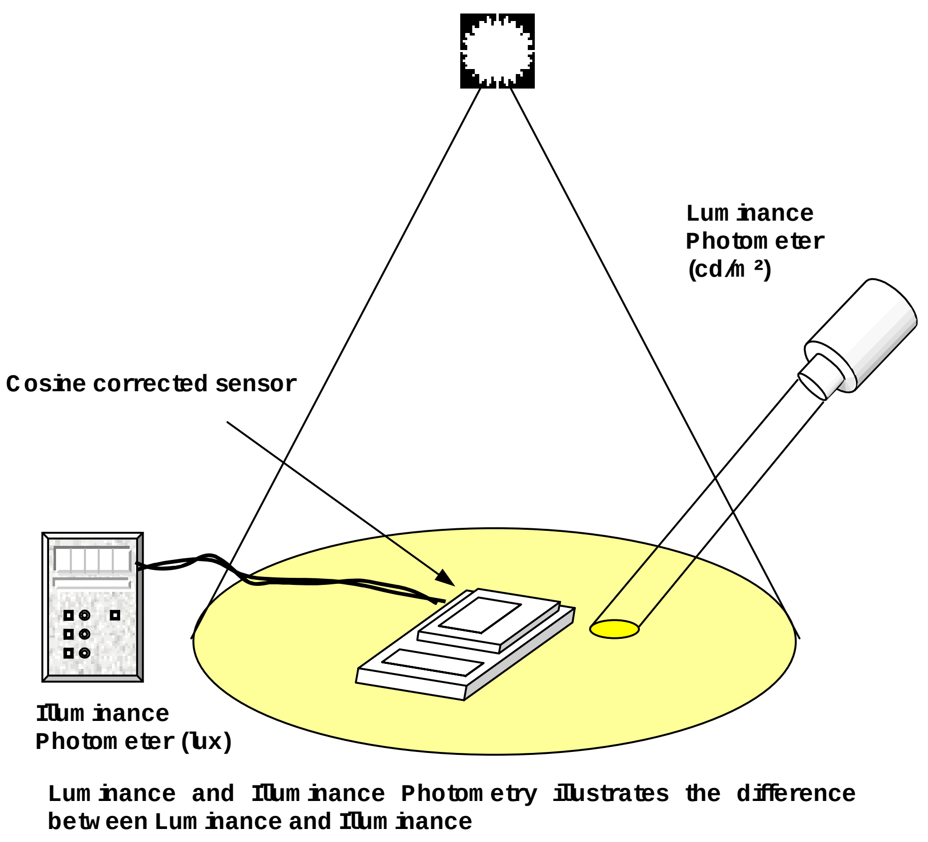


Figure I4.2 – Photometers

5.0 REFLECTION ON A SURFACE

5.1 **Specular, Diffuse and Spread Reflection** Light reflected off a mirror obeys the law of reflection. In such case, the reflection is said to be specular. Hard shiny surfaces are primary specular. Diffuse reflection occurs when the light is scattered in all directions when reflected. Fine granulated surfaces (such as powders) present a uniformly bright (instead of shiny) surface in all directions. Reflections which are a combination of both specular and diffuse is termed spread reflection. Spread reflection usually has a dominant directional component which is partially diffused by surface irregularities. **Figure I5.1** illustrates the difference between specular, diffuse and spread reflection.

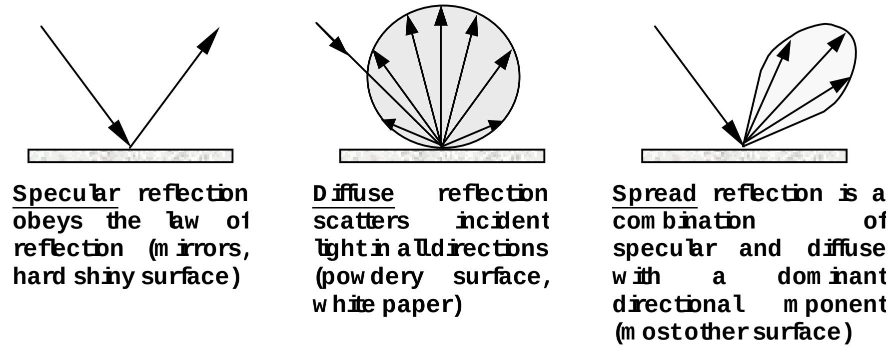


Figure I5.1 – Specular, Diffuse and Spread Reflection

5.2 **Lambert's Cosine Law and the Lambertian Surface** Lambert's Cosine law states that the irradiance or luminous intensity falling on a surface varies as the cosine of the incident angle (see **figure I5.3**).

5.3 **Lambertian Surfaces** are perfectly diffusing surfaces which obeys Lambert's Cosine Law. Light falling onto a Lambertian surface provides a uniform diffusion of luminance when viewed from all directions. Prefect Lambertian surface is a theoretical ideal but most every day objects with a matte surface (such as paper, towel, carpets etc) approximate Lambertian surface closely. In calculation of interior lighting, all surface are assumed to be Lambertian to simplify calculations. For outdoor

I5

4.2 Photometry

Luminance photometer mimics the human eyes. The luminance photometer is aimed …ghted surface or light source and brought to focus. The luminous flux captured through the aperture and focusing lens of the photometer falls onto a photo-detector permitting a measurement of luminance.

The illuminance photometer is placed directly under a light source or onto the surface to be measure. The illuminance measured is irrespective of the direction of the light source.

5.1 Specular, Diffuse and Spread Reflection

***Specular reflection** – obeys the law of reflection (highly reflective surface such as mirrors and hard shiny surfaces);*

***Diffuse reflection** – scatters incident light in all directions (powdery surface, white paper);*

***Spread reflection** – is a combination of specular and diffuse reflection with a dominant directional component (most surfaces).*

5.2 Lambert's Cosine Law

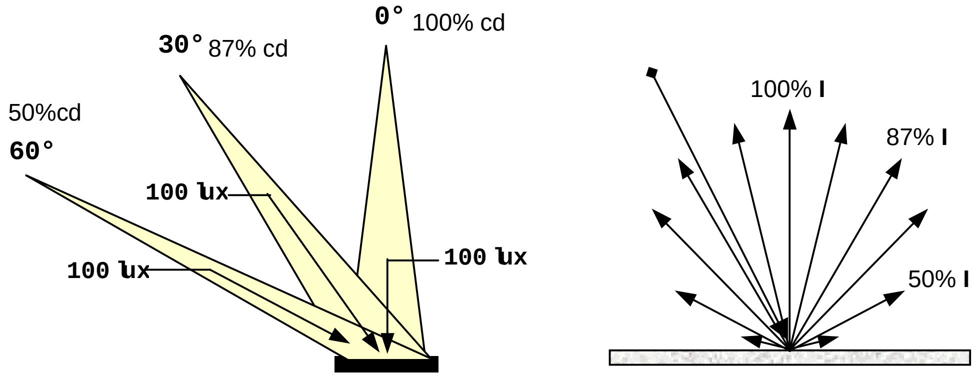
Irradiance or luminous intensity falling on a surface varies with the cosine of the incident angle.

5.3 Lambertian Surface

A perfectly diffusing surface which obeys Lambert's Cosine Law. A Lambertian surface provides a uniform diffusion of luminance viewed from all directions.

façade and monument lighting however this may be an over-simplification. **Figure I5.3** illustrates the property of a Lambertian surface.

References



Lambert's Cosine Law states that the luminous intensity of a light incident on a surface is proportional to the cosine of the incident angle.

$I \; \alpha \; \cos(\gamma)$ OR $I_{\gamma} = I\cos(\gamma)$

Lambertian Surface is a perfectly diffusing surface which obeys Lambert's Consine Law. As the luminous intensity falls in proportion to the cosine of its incident angle, the area spread by the incident beam increases. Thus luminance viewed at any angle for a Lambertian surface is equal.

Figure 15.3 – Lambert's Cosine Law and Lambertian Surface

6.0 REFERENCE

(a) '*Lectures on Physics*' by Richard P. Feynman, Addison-Wesley 1995

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(c) '*Light Measurement Handbook*', Alex Ryer http://www.intl-light.com

(d) '*Introduction to Light and Colour, Part I and II*', Sam Mills, AIA, IES, Oct 1987 and Nov 1987 of Architectural Lighting Magazine

(e) '*Brightness, Luminance, and Confusion*' 1993 by Charles P. Halsted