FINAL REPORT

FOR

CONSULTANCY AGREEMENT No.2C2TP09

SURVEY ON IMPACTS OF EXTERNAL LIGHTING IN HONG KONG

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Abbreviations

AO/PA	–	Administration offices (industrial) or public activity (leisure) area （行政办公（工业）区/公共活动区）
AS	–	Australian Standards
AS/NZS	–	Australian/New Zealand Standards
BS	–	British Standards
BS EN	–	British Standards version of European Standards
CC	–	Commercial Centre (商业中心区)
C&CRB	–	Commercial & commercial/residential boundary
CIBSE	–	Chartered Institution of Building Services Engineering
CIE	–	Commission Internationale de l'Eclariage (International Commission on Illumination)
DB	–	Local (Municipal or Provincial) Standard of People's Republic of China 地方标准（中华人民共和国）
IDA	–	International Dark-sky Association
IESNA	–	Illuminating Engineering Society of North America
ILE	–	The Institution of Lighting Engineers (UK). Currently named as The Institution of Lighting Professionals (ILP).
ISO	–	International Organization for Standardization
JGJ	–	Trade Standard (Construction Industry) of People's Republic of China 中华人民共和国行业标准（建筑工业）
MOE-LPCG	–	Ministry of the Environment Light Pollution Control Guideline (Japan)
MLO	–	Model Lighting Ordinance
RDS	–	Residential -dark surrounds
RE	–	Residential Estate （居住小区）
RLS	–	Residential - light surrounds
RPFI	–	Residential premises facing inside of estate（面向小区内侧的住户）
RPFO	–	Residential premises facing outside of estate （面向小区外侧的住户）
RPFS	–	Residential premises adjacent to street （居住区临街侧）
RPNFS	–	Residential premises not adjacent to street （居住区非临街侧）
SLL	–	Society of Light and Lighting-a Society within the CIBSE

Key Symbols

Symbol		Description
E_{eye}	–	Illuminance on a plane perpendicular to the line of sight to the luminaire (due to a single luminaire or a group of luminaires on the same pole)
E_v	–	Vertical illuminance (due to all light sources) on a relevant surface (such as window or facade) of residential premises for controlling illumination on surrounding properties (light trespass).
h	–	Luminaire height
I_d	–	Luminous intensity emitted by a luminaire towards the line of sight (apply to a single luminaire)
m	–	Magnitude, used to measure brightness of celestial body
$L \cdot A^{0.5}$	–	Luminaire's greatest (average) luminance (in cd/m^2) in the direction between 85° and 90° from the downward vertical multiplying the square root of the light emitting surface area of the luminaire (in m^2) in the direction 90° from the downward vertical.
L_b	–	Building facade luminance for controlling effects of over lit building facades. It is taken as the product of the design average illuminance and reflectance factor divided by π.
L_s	–	Sign luminance for controlling effects of over lit signs. It is taken as the product of the design average illuminance and reflectance factor divided by π, or for self-luminous signs, its average luminance.
L_v	–	Veiling luminance. It is the luminance of scattered light in the background which reduces the luminance contrast between the object and the background.
LPD	–	Lighting power density in W/m^2
TI	–	Threshold increment, the measure of disability glare expressed as the percentage increase in contrast required between an object and its background for it to be seen equally well with a source of glare present.
ULR	–	Upward light ratio

Executive Summary

Background

1. The Government has announced in the 2008/09 Policy Agenda that it plans to study the issue of energy wastage of external lighting and assess the feasibility of regulating external lighting. As such, a consultancy study has been commissioned by the Government to survey the impacts of external lighting in representative districts/ areas in Hong Kong. Parsons Brinckerhoff (Asia) Ltd (PB) was commissioned by the Government in 2009 to undertake the *Survey on Impacts of External Lighting in Hong Kong* (the Study). This report summarises the key findings and recommendations of the Study.

Objectives of the study

2. The objectives of the study were to:

   (i) Identify and survey problems associated with external lighting in Hong Kong; and
   (ii) Recommend the approach and measures to address the problems associated with external lighting in the surveyed districts/areas.

Scope of the study

3. To achieve the above objectives, the study consists of the following tasks:

   (i) Application of relevant overseas experience in identifying and measuring problems associated with external lighting;
   (ii) Investigation of the local environment with respect to external lighting;
   (iii) Survey on the external lighting conditions in Hong Kong;
   (iv) Estimation of the energy consumption of external lighting in the surveyed districts/areas; and
   (v) Assessment of the extent of light nuisance problems in the surveyed districts/areas.

4. The effects of external lighting on human health and effects of obtrusive light on residents, road users and astronomical observations; and an account of the methods and parameters used by overseas authorities and institutions for measuring and assessing the impacts of external lighting on nuisance and energy efficiency are reviewed.

5. The characteristics of external lighting in urban and new town areas and rural areas in Hong Kong; and the parameters shortlisted for assessment of the impacts of external lighting and the associated reference limiting values are summarized. Six representative districts/areas were selected from a preliminary investigation in 23 districts / areas, using visual observation and photographic techniques, for the detailed survey on external lighting conditions.

6. The detailed surveys of the external lighting conditions in the selected six representative districts / areas include the following:-

   (i) Measurements of parameters for the assessment of light nuisance and sky glow caused by external lighting and energy consumption of external lighting in the six selected districts/areas.

   (ii) The energy consumption of external lighting are estimated as well as approaches and measures for the improvement of energy wastage are also proposed.

   (iii) The potential extent of light nuisance problems caused by external lighting are assessed and suggested approaches and measures to deal with these potential light nuisance are proposed.

Review of parameters

7. In the review of relevant overseas experience in assessing the impacts of external lighting, a number of parameters were found to be used by various overseas institutions for measuring and assessing the impact of outdoor lighting concerning light nuisance and sky glow. These are vertical illuminance at windows/facades, luminous intensity, facade and sign luminance, threshold increment, limiting visual magnitude, night sky brightness and Bortledark sky scale.

8. Parameters were also found to be used by various overseas institutions for assessing the light emission properties of luminaires for controlling the impacts of outdoor lighting with respect to light nuisance and sky glow. These in general include luminous, intensity, maximum lumens and upward light ratio.

9. Parameters used for assessing the energy efficiency of outdoor lighting installations include lamp efficacy, control gear loss, luminaire efficiency, light output ratio and lighting power density.

Criteria of Selection

10. The selection criteria for representative districts /areas include

   (i) Preliminary site investigation by visual observation and photographic techniques to record the types, lighting conditions/characteristics, perceived intensity of the external lightings (including facade or window illuminance) to the affected residents.

   (ii) Previous light nuisance records and complaints addressing in mass media as reference;

   (iii) Characteristics of external lighting such as dimensions, types, density, height, angle, distance (from residents) and perceived intensity of external lighting, and the perceived intensity to the affected residents.

11. The following six representative districts / areas were selected out of the preliminarily shortlisted 23 districts/areas for the detailed survey of external lighting characteristics and potential problems caused by external lighting:

   (i) Shun Lee Estate (a public housing estate) (Kwun Tong), urban residential

   (ii) Des Voeux Road Central /Chater Road (Central), urban commercial

   (iii) Paterson Street / Great George Street (Causeway Bay), urban residential-cum-commercial

(iv) Nathan Road /Sai Yeung Choi Street (Mongkok), urban residential-cum-commercial
(v) Yan King Road/Kai King Road(PoLam, Tseung Kwan O),new town
(vi) Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (Sai Kung),rural

Approach for Site Measurements

12. With the support of the sub-consultant, The Hong Kong Polytechnic University (HKPU), we conducted and analyzed site detail measurement for the external lighting in the selected 6 survey districts/areas to assess the extent of light nuisance and energy consumption issue due to impacts of external lighting.

13. The measurement of vertical illuminance on facade/windows was carried out by high dynamic range (HDR) imaging method using a digital camera. This method was used because of the relatively fast measurement of a large number of residential units without entering the residential units. Sign luminance and facade luminance were also taken by the HDR imaging method. Due to the difficulty of accessing residential units, glare caused by bright luminaires was estimated at several typical locations by using photometric data of similar types of luminaires. The energy consumption of external lighting luminaires and signs was surveyed by estimating the wattages of lamps and the hours of operation. The lighting power density (LPD) of signs were also surveyed and estimated for comparison among the survey districts / areas.

Results of the study

14. Based on the survey measurement findings, the current situations of sign luminance (cd/m^2) were insignificant with reference to International Commission on Illumination (CIE)'s standard in the 6 surveyed districts/areas. The energy wastage of external lighting is insignificant due to the luminance factor of individual signs. By detail survey result, it was found that many light fittings at Paterson Street / Great George Street in Causeway Bay and at Des Voeux Road Central/Chater Road (Central) were still switched on after business hour and when not in use. But the situations with long operation hour of external lighting at night were uncommon in other surveyed areas. Types of most light fittings were low efficacy tungsten halogen and electromagnetic ballasted fluorescent tube for externally and internally illuminated signs respectively. These two factors are the main sources of energy wastage.

15. According to the estimate of LPD in surveyed districts/areas, LPD in W/m^2 for most internally and externally illuminated signs appeared on high side as compared to the limiting values recommended by California Building Energy Efficiency Standard (CBEES). However, the CBEES may not be directly applied to Hong Kong in view of the more densely populated urban area, higher building densities, higher ambient light level and different business and social background. A comparison study of the energy consumption of external lighting was conducted in the 6 selected districts / areas together with an analysis of the energy saving potential of several different energy saving measures.

16. Possible energy saving measures (such as turning off unnecessary external lighting at night, using high efficiency luminaires and high efficacy lamp) to reduce energy consumption of external lighting are suggested for each of the six surveyed districts/ areas.

17. Results of the survey show that the situation related to light trespass impacts as identified in the study as a whole are considered not that significant except at Nathan Road and Sai Yeung Choi Street in Mongkok especially in the post-curfew[1] hours. The major light nuisance problem is light trespass assessed by vertical illuminance on windows due to the following situations.

    (i) External lightings were still switched on even after business hours.
    (ii) Some floodlights used for signs were at upward position and inappropriately aim lighting fixtures or symmetrical lightings were used to create spill light.
    (iii) Locations of signs were very close to residential units.
    (iv) Spill light were created by non cut-off lights for pole mounted security/ footpath lighting.

18. The light nuisance problem, glare at residential units and over-bright sign at the surveyed areas are also summarized as the following table. The most significant of light trespass problem is Sai Yeung Choi Street in Mongkok where the density of signs is very high and residential units are in close proximity to the signs. The following various measures are suggested to improve the current existing situations related to the light nuisance in the 6 surveyed districts/areas due to existing external lighting:-

    (i) To educate or encourage residents and office / shop operators to switch off lights that are not used and to adopt a curfew time for turning off or dimming down the lights at night when not in use and after business hours.
    (ii) Aim (or use asymmetrical luminaire) or shield lighting fixtures to target areas and downwards as far as practicable to reduce spill light.
    (iii) Control the sizes / locations of advertising signs with reference to Buildings Department's Guide on Erection & Maintenance of Advertising Signs.
    (iv) Use cut-off lights for security lighting/footpath lighting.

[1] Curfew as used in some international standards (e.g. CIE) is the time after which stricter requirements for the control of obtrusive light The period of darkness is subdivided into *the 'evening' (pre-curfew time) when higher light levels are acceptable and the 'night ' (post-curfew time) when only essential lighting should be operated for purposes such as maintenance of amenity and environmental integrity and for safety, security and overnight commercial activities in some cases.*

Item	Location of Surveyed area	Areas environmental zone	Light trespass at pre-curfew time	Light trespass at post-curfew time	Glare at residential units	Over-bright sign
1	Shun Lee Estate (Kwun Tong)	Urban Residential Area	Insignificant(1)	Quite significant	No	No
2	Des Voeux Road Central/ Chater Road (Central)	Commercial Area	Insignificant	Not that significant	No	No
3	Paterson Street/ Great George Street (Causeway Bay)	Commercial -cum- residential Area	Not that significant	Insignificant	No	No
4	Nathan Road (Mongkok)	Commercial -cum- residential Area	Not that significant	Significant	Yes	No
	Sai Yeung Choi Street South (Mongkok)		Very significant	Significant	Yes	Yes (4 nos. spotted)
5	Yan King Road/ Kai King Road (Po Lam, Tseung Kwan O)	New Town Area	Insignificant	Insignificant	No	No
6	Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (SaiKung)	Rural Area	Insignificant	Quite significant	No	No

Remark
1) Benchmark to classify light trespass impacts forsake of comparison among the surveyed area are listed as follows -

Light Trespass Impact	Major Criteria % of residents having light trespassover CIE standards at pre-curfew or at post-curfew)
Insignificant	Below 20%
Notthat significant	20% to below 40%
Quite Significant	40% to below 60%
Significant	60% to below 80%
Very Significant	80% &above

Conclusion & Recommendation

19. The Study concluded that energy wastage and light nuisance were considered not that significant except for some isolated spots, such as Sai Yeung Choi Street in Mongkok. A voluntary approach with reference guidelines may be more appropriate to deal with the current situation and the proposed guidelines should focus on both light nuisance and energy conservation aspects.

20. Based on overseas experience and the survey results in the six representative districts / areas in Hong Kong, it is suggested to encourage owners of the lighting to adopt a curfew system in various lighting environmental zoning similar to those given in overseas guidelines to deal with the problems of external lighting. The lighting environmental zoning concept, however, should be carefully applied taking into account the local context. It is also suggested that the following list of parameters could be suitable for use in measuring and assessing light nuisance causedby external lighting of external lighting in Hong Kong. Based onthe survey

results, limiting values of these parameters are suggested for reference when considering to assess quantitatively the impacts of external. lighting in Hong Kong.

(i) Vertical illuminance at windows of residential premises
(ii) Luminous intensity of luminaires in direction of residential premises
(iii) Building facade luminance
(iv) Sign luminance

21. As a first stage to deal with the problems due to external. lighting in the surveyed districts/areas, a set of good practices guidelines with a view to limiting the impacts of external lighting on the general public could be developed to encourage voluntary compliance with the guidelines through publicity and education. Some kind of voluntary charter could be promoted in the community to encourage developers, property management companies, shops to implement the guidelines.

22. If the relevant parameter (s) of a lighting installation subject to complaint is found not complying with the guidelines and the owner(s) of the lighting device can be identified, recommendations can be given to the owner(s) to improve the lighting installation.

23. To deal with the problematic spots identified from the 6 surveyed areas, a voluntary approach with reference guidelines may be more appropriate. And the stakeholders are encouraged to switch off unnecessary lightings at night for minimizing the light nuisance and preventing energy wastage of outdoor lighting through education and publicity campaigns.

24. A review should be conducted after a few years of implementation of the voluntary external lighting guidelines. The review may include the experience of implementation of the voluntary outdoor lighting guidelines and the effectiveness of the guidelines in reducing the adverse impacts of outdoor lighting installations. Overseas experience concerning outdoor lighting control should also be reviewed as appropriate to keep our reference materials up-to-date.

1 INTRODUCTION

1.1 Background

1.1.1 Parsons Brinckerhoff (Asia) Ltd was commissioned by the Government in 2009 to undertake the Consultancy Services for Survey on Impacts of External Lighting in Hong Kong.

1.1.2 The Government has announced in the 2008/09 Policy Agenda that it plans to study the issue of energy wastage of external lighting and assess the feasibility of regulating external lighting. As such, a consultancy study has been commissioned by the Government to survey the impacts of external lighting in representative districts/areas in Hong Kong.

1.2 Objectives of Study

1.2.1 The main objectives of the study are to:

(i) identify and survey problems associated with external lighting in Hong Kong; and

(ii) recommend the approach and measures to address the problems associated with external lighting in the surveyed districts/areas.

1.2.2 The study consists of the followings defined to achieve the above two objectives, which include the followings:

(i) to apply overseas standards in identifying and measuring problems associated with external lighting.
(ii) to investigate the local environment with respect to external lighting.
(iii) to survey the external lighting conditions in Hong Kong.
(iv) to estimate the energy consumption of external lighting in the surveyed districts/areas.
(v) to assess the extent of light nuisance problems in the surveyed districts/areas

1.3 Scope of Study

1.3.1 Information collation from overseas practice and experience

The study includes an extensive literature research and review the information from international publications and organizations (such as CIE, IESNA,IDA, ILE, Standardization Administration of China (SAC), Japan Ministry of the Environment) on methods and parameters used for measuring and assessing the impact of external lighting with particular emphasis on those that may be applicable to Hong Kong. Parameters and limiting values used for assessing both energy efficiency of external lighting and the effects on residents were explored with the purpose of establishing the most suitable methods for Hong Kong and to be used in this study.

1.3.2 Selection of survey districts/areas

Six representative districts/areas will be selected for detailed survey of external lighting problems. The six representative districts/areas will cover the following district types/categories:

(a) 1 urban residential district,

(b) 1 urban commercial district,

(c) 2 urban residential-cum-commercial district,

(d) 1 new town district, and

(e) 1 rural area or country park.

1.3.3 The study covers the review of overseas standards in dealing with and regulating the impacts of external lighting in the following 6 representative surveyed districts/areas:

(a) Shun Lee Estate (a public housing estate) (Kwun Tong), urban residential

(b) Des Voeux Road Central/ ChaterRoad(Central), urban commercial

(c) Paterson Street / Great George Street (Causeway Bay), urban residential-cum-commercial

(d) Nathan Road /Sai Yeung Choi Street (Mongkok), urban residential-cum-commercial

(e) Yan King Road/ Kai King Road (Po Lam, Tseung Kwan O), new town

(f) Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (Sai Kung), rural

1.3.4 The above-mentioned 6 surveyed districts/areas are selected from the preliminarily shortlisted 23 districts / areas by means of visual observation in site investigation and photographic techniques on external lighting conditions. The criteria of selection also include previous light nuisance records and complaints addressing in mass media and in comparison with the external light installation related to light nuisance such as dimensions, types, density, height, angle, distance (from residents) and perceived intensity of external lighting (facade or window illuminance) to the affected residents.

1.3.5 In the study, external lighting includes, but not limited to, signs (advertising or non-advertising,standalone or onbuilding facades, self-luminous or illuminated), lighting for building facades and features, lighting outside buildings, shops, restaurants, other public entertainment venues, lighting for sports fields and permanent external video structures. Lighting emitted from building through facades to the outside environment will also be included.

1.3.6 External lighting in this study excludes road lighting, lighting at public transport interchange or terminus, airport and container port, air and marine traffic lighting, lighting of construction sites, and lighting of which the operation is of transient nature.

1.3.7 Recommendations for action

By taking into account results of the survey, local and overseas practice, cost effective mitigation measures are recommended. The measures include engineering technical mitigation measures and management controls.

1.4 Methodology

This study adopts a desktop research and site surveys and measurement. Surveys are conducted to measure and assess the external lighting conditions and one of the representative areas in urban / residential-cum-commercial category, Nathan Road/ Sai Yeung Choi Street (Mongkok) has been firstly picked out to work out a practical methodology / approach and model workflow for the site surveys. The methodology then generally applies to all other selected urban and new town districts / areas.

1.5 Structure of Reporting

In addition to this Introduction Chapter which gives the background, objective and methodology of the study, the report consists of the following chapters:-

Chapter 2: **Review of overseas experience in identifying and measuring problems associated with external lighting**

gives a brief discussion on relevant parameters, standards and thresholds for measuring and assessing the impacts of external lighting in Hong Kong.

Chapter 3: **Investigation of the local environment with respect to external lighting**

summarizes the characteristics of urban and new town areas and rural areas in Hong Kong with respect to external lighting. Then, the review of the impacts of external lighting in different districts/ areas will be discussed. Finally, a summary of the parameters for assessment of impacts of external lighting and the associated acceptable thresholds will be given.

Chapter 4: **Survey of the external lighting conditions in Hong Kong**

describes the methodology to adopt parameters to be measured in conducting site impact assessment and summarizes survey findings on the external lighting situation of 6 selected districts/areas.

Chapter5: **Estimation of energy consumption of external lightings in surveyed districts/areas**

summarizes energy consumption and potential energy saving of the external lighting in 6 selected districts/areas. The approach and measures to deal with energy wastage of external lighting in the surveyed districts/areas based on the survey findings are included.

Chapter6: **Assessment of the extent of light nuisance problems in surveyed districts/areas**

summarizes the intensity and distribution of light nuisance problems due to the external lighting in 6 selected districts/areas. The approach and measures to deal with light nuisance based on the survey findings are included.

Chapter 7: **Conclusion and recommendation**

gives proposed way forward to cope with the problematic spots indentified from surveyed areas, the recommended practice for measuring and assessing the impacts of external lighting m surveyed areas of Hong Kong and recommendation of implementation.

2 REVIEW OF OVERSEAS EXPERIENCE IN IDENTIFYING AND MEASURIG PROBLEMS ASSOCIATED WITH EXTERNAL LIGHTING

2.1 Obtrusive Light Effects of External Lighting

2.1.1 The term obtrusive light is used by CIE and many other authorities and national and professional organizations to mean the following:

Spill light which because of quantitative, directional or spectral attributes in a given context, gives rise to annoyance, discomfort, distraction or a reduction in the ability tosee essential information.

2.1.2 It must be noted that the IESNA uses this definition for the term 'light trespass' to include the effects described in 2.1.4.1 and 2.1.4.2 below but excluding the sky glow effect described in 2.1.4.3.

2.1.3 It is now generally agreed that effects on human societies due to obtrusive light from external lighting installations include effects on residents, road users and astronomical observers. The effects are illustrated in Figure 2.1.

Figure 2.1 - Illustration of obtrusive light causing light trespass, glare and sky glow.

2.1.4 The following list of effects is grouped with reference to the Hong Kong context.

2.1.4.1 Effects on residents

(i) *Light trespass:*
This includes the effects due to spill light entering a residential premises, e.g. house, apartment unit, hotel, hostel, hospital ward, etc, during the hours of darkness. The spill light may cause annoyance, stress, discomfort and reduced sleep quality, etc. The commonly used term to describe this obtrusive light effect is 'Light trespass' although sometimes this term may have wider meanings including the effects of glare from bright light sources and signs.

(ii) *Glare from bright luminaires:*
Glare is caused by the direct view of bright luminaires from normal viewing directions causing annoyance, distraction or discomfort. CIE and many other authorities assess this effect separately from the general effects of light trespass although glare may also be caused by spill light entering the resident's premises.

(iii) *Glare from over-lit building facades and over-bright signs and billboards:*
Other than causing light trespass,over-lit building facades and over-bright signs and billboards close *to* residential wilts can also cause glare to residents.

2.1.4.2 Effect on road users

(i) *Glare:*
Effects on road users (e.g. motorists, cyclists, pedestrians) normally involve a reduction of visibility of objects caused by disability glare from bright light sources. The apparent contrast of objects against their backgrounds will be lowered, rendering them less visible or even invisible, especially if the environment is intrinsically dark. The magnitude of the effect will depend on the level of lighting to which the user is adapted.

2.1.4.3 Effect on astronomical observers

(i) *Sky glow:*

Sky glow is the brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered from the constituents of the atmosphere (gas molecules, aerosols and particulate matter), in the direction of observation. Sky glow actually occurs naturally due to radiation from celestial sources and luminescent processes in the Earth's upper atmosphere. Light from outdoor lighting installations, including light emitting directly upwards and light reflected from the ground, contribute to sky glow significantly if not controlled adequately. The effect of sky glow caused by outdoor lighting is often called 'light pollution' although the term can have a wider meaning to include all adverse effects of light at night.

2.1.4.4 Impacts of external lighting on energy consumption

1. External lighting installations consume energy. Hence, excessive and inappropriate use of external lighting produces an impact on energy consumption. The energy consumed in producing the obtrusive light can be considered to be wasted since the obtrusive light is unwanted. But the energy wastage is difficult to be quantified. Energy efficient outdoor lighting can reduce CO_2 emission and thus contributes to the reduction of the greenhouse effect.

2. Energy consumption of external lighting installations depends on the type of lamps and control gear used, the efficiency (or light output ratio) of the luminaires, the time of operation as well as the level of illumination.

2.2 Methods and Parameters used for Measuring and Assessing the Impact of External Lighting

2.2.1 Introduction

CIE and some overseas authorities and organizations have recommended methods for the measurement and quantitative assessment of the effects due to obtrusive light from external lighting described in section 2.1 above. The methods include environmental zoning, establishment of curfew hour and specifying limits of relevant light technical parameters. The methods recommended by the following organizations/authorities will be reviewed and summarized:

(i) International Commission on Illumination (CIE) Illuminating

(ii) Engineering Society of North America (IESNA)

(iii) International Dark-sky Association (IDA)

(iv) The Institution of Lighting Engineers (UK) (ILE)

(v) Standardization Administration of China (SAC)

(vi) Japan Ministry of the Environment

2.2.2 Lighting Environmental Zoning

Existence of commercial and recreational activities at night and the levels at which these activities are conducted at night are very different in different areas. In order to get a balance between people who desire to enjoy nighttime activities and people who wants a dark night environment, CIE and many overseas authorities and organizations have recommended lighting environmental zoning systems for specifying limits of the lighting parameters used to assess the environmental impact of external lighting.

2.2.2.1 CIE Zoning System

CIE (CIE-126: 1997 & CIE-150:2003) recommends the use of four environmental zones to classify the surrounding environment according to the prevailing brightness of the environment. A description of these four zones is given in Table 2.1.

Table2.1-Classificationof environmental zones for external lighting

Zone	Surrounding	Lighting Environment	Examples
El	Natural	Intrinsically dark	National parks or protected sites
E2	Rural	Low district brightness	Industrial or residential rural areas
E3	Suburban	Medium district brightness	Industrial or residential suburbs
E4	Urban	High district brightness	Town centres and commercial areas

2.2.3 Curfew

2.2.3.1 In order to get a balance between people who desire to enjoy nighttime activities during early part of the night and people who want to rest in a dark environment at the later part of the night, limits for restricting obtrusive light do not need to be equally stringent at all times. Therefore, the concept of 'curfew' has been introduced and adopted in major recommendations for control of obtrusive light. Curfew is the time after which stricter requirements for the control of obtrusive light apply. The period of darkness is subdivided into the 'evening' (pre-curfew time) when higher light levels are acceptable and the 'night' (post-curfew time) when only essential lighting should be operated for purposes such as maintenance of amenity and environmental integrity and for safety and security.

2.2.3.2 Curfew is used by CIE in recommendations on obtrusive light limits and the authorities and organizations adopting the CIE recommendations. IESNA, Australian Standard, ILE of UK, Beijing and Shanghai Municipal Standards and the China Construction Industry Standard all use curfew for specifying obtrusive light limits.

2.2.3.3 CIE rec ommends the curfew hour to be taken as 23:00 hours unless otherwise specified by the controlling authority. Post-curfew hours should be taken as being between 23:00 and 06:00 hours, unless otherwise specified by the controlling authority.

2.2.4 Parameters and limiting values used for assessing the effects on residents

2.2.4.1 Light trespass

The light trespass effects depend, in general, on the amount of light entering an otherwise dark residential interior. The following parameters are recommended by various authorities and organizations. These parameters, the relevant standards/ guidelines, the application conditions and the recommended limits for various environmental zones are given in Table 2.2.

(i) Vertical illuminance *(E_v)* on relevant surfaces, e.g. windows, of residential premises from all lighting installations. This is used by:

- CIE(CIE150:2003)
- ILE(GN01:2005)
- Australian Standard (AS4282-1997)
- Shanghai Municipal Standard (DB31/T 316-2004)
- Beijing Municipal Standard (DB 11/T 388-2006)
- China Construction Industry Standard (JGJ/T 163-2008)
- Japan Ministry of the Environment Light Pollution Control Guidelines (MOE-LPCG)

The CIE limits were the results of many years work by a CIE Technical Committee TC5.12 on obtrusive light. The ILE and China standards adopt the CIE recommendation for this assessment. The Australian Standard, published earlier than the CIE obtrusive light guidelines, uses the same parameter but with recommendations of slightly different limits. Figure 2.2 shows diagrammatically the meaning of E_v. Table 2.2 gives the recommended limits of E_v for control of light trespass.

Figure 2.2 Illuminance E_v and luminous intensity I_d

Table 2.2 -Light technical parameters and limits for the assessment of light trespass

Light Technical Parameter	Standards/ Codes	Application Conditions	Environmental Zones and Recommended Limits			
Vertical illuminance (E_v) [1]	CIE 150:2003 ILE GN01:2005 China JGJ/T 163-2008 Japan MOE-LPCG	Pre-curfew	E1 2 lx	E2 5 lx	E3 10 lx	E4 25 lx
		Post-curfew	0 lx [2]	1 lx	2 lx	5 lx
	Australian standard AS4282- 1997			RDS [3]	RLS [3]	C&CRB [3]
		Pre-curfew		10 lx	10 lx	25 lx
		Post-curfew		1lx	2 lx	4 lx
	Shanghai DB31/ TI16-2004				RPFI [4]	RPFO [4]
		Evening			25 lx	50 lx
		After 23:00			4 lx	25 lx
	Beijing DB11/1388-2006				RPNAS [3]	RPAS [3]
		Before 23:00			10 lx	25 lx
		After 23:00			2 lx	5 lx
TIIuminance on a plane perpendicular to the line of sight to the luminaires (E_{eye}) [6]	IESNA RP-33-99 & TM-11-00		E1	E2	E3	E4
		Pre-curfew	l lx	3 lx	8 lx	15 lx
		Post-curfew	0 lx [7]	l lx	3 lx	6 lx

Notes:

1) Limits apply to nearby dwellings, or potential dwellings, more specifically to their relevant surfaces or parts of surfaces, especially where windows are. The values are the summation of all lighting installations.
2) If the luminaire is for-public (road) lighting then this value may be upto 1 lx.
3) RDS =Residential -dark surrounds, RLS =Residential -light surrounds, C&CRB = Commercial & commercial/residential boundary.
4) RPF1 = Residential premises facing inside of estate (面向小区内侧的住户); RPFO = Residential premises facing outside of estate (面向小区外侧的住户).
5) RPNFS = Residential premises not adjacent to street (居住区非临街侧); RPFS =Residential premises adjacent to street (居住区临街侧)
6) Limits apply to individual luminaire ortogroup of luminaires on a pole.
7) Where safety and security are issues, nighttime lighting is needed. Such lighting should meet IESNA recommendations for the particular property being lighted. Lighting should be designed, however, to minimize light trespass.
8) The lux *(lx)* is the SIbaseunit ofilluminance; that is, "density" of light incidenton a surface.

(ii) Illuminance on a plane perpendicular to the line of sight to the luminaire *(E_{eye}),* individually assessed for a single luminaire or a group of luminaires on a pole. This is used by:

- IESNA
  IESNA uses only one parameter to measure and assess the effects of light trespass which include nuisance due to light entering a premises, glare due to directly viewed luminaires, building facades and signs.

2.2.4.2 Glare from bright light sources,building facades and signs

The effect due to bright light sources is sometimes included in light trespass, e.g. by IESNA, and assessed by the same parameter as given for IESNA in Table 2.3. However, the bright light sources contribute to the vertical illuminance on windows as well as producing glare when the light sources are directly viewed. Hence, it is more appropriate to assess the effect of glare separately.

CIE and several other authorities and organizations recommend the use of luminous intensity or luminance of surfaces for the assessment of the effect of glare on residents. Besides, CIE classifies the effects due to brightly lit building facades and over bright signs in a category 'effects on sightseers'. In Hong Kong, brightly lit facades and over bright signs have more impact on residents therefore, their assessment parameters are included in this section.

The following parameters are recommended by various authorities and organizations.

(i) Luminous intensity emitted by luminaires *(I_d)* in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained, i.e. not where momentary or short-term viewing isinvolved. This is used by:
- CIE (CIE 150:2003)
- ILE (GN01:2005)
- Australian Standard (AS4282-1997)
- Shanghai Municipal Standard (DB31/T316-2004)
- Beijing Municipal Standard (DB 11/T388-2006)
- ChinaConstruction Industry Standard (JGJ/T 163-2008)
- Japan Ministry of the Environment Light Pollution Control Guidelines (MOE-LPCG)

(ii) Building facade luminance *(L_b)* which is taken as the product of the design average illuminance and reflectance factor divided by π. This is used by:
- CIE (CIE 150:2003)
- ILE (GN01:2005)
- Australian Standard (AS4282-1997)
- Shanghai Municipal Standard (DB31/T316-2004)
- China Construction Industry Standard (JGJ/T 163-2008)
- Japan Ministry of the Environment Light Pollution Control Guidelines (MOE-LPCG)

(iii) Sign luminance *(Ls)* which is taken, for illuminated signs, as the product of the design average illuminance and reflectance factor divided by π, or for self-luminous signs, its average luminance. This is used by:
- CIE (CIE 150:2003)
- ILE (GN01:2005)
- Australian Standard (AS4282-1997)
- Shanghai Municipal Standard (DB31/T316-2004)
- China Construction Industry Standard (JG/T 163-2008)
- Japan Ministry of the Environment Light Pollution Control Guidelines (MOE-LPCG)

(iv) Illuminance on a plane perpendicular to the line of sight to the luminaire *(E_{eye})*, individually assessed for a single luminaire or a group of luminaires on a pole. This is used by:

- IESNA

As already noted above, IE SNA uses only one parameter to measure and assess the effects of light trespass which include nuisance due to light entering a premises, glare due to directly viewed luminaires, building facades and signs.

Table 2.3- Light technical parameters and limits for the assessment of the effect of glare on residents due to bright luminaires, building facades and signs

Light Technical Parameter	Standards/ Codes	Application Conditions	Environmental Zones and Recommended Limits			
Luminous intensity emitted by luminaires *(I_d)* in designated directions[1)]	CIE 150:2003 ILE GN01:2005 China JGJ/T 163-2008[2)] Japan MOE-LPCG		E1	E2	E3	E4
		Pre-curfew	2500 cd	7500 cd	10000 cd	25000 cd
		Post-curfew	0 cd[3)]	500 cd	1000 cd	2500 cd
	Australian Standard AS4282-1997			RDS[4)]	RLS[4)]	C&CRB[4)]
		Pre-curfew			See Table 2.3(a)	
		Post-curfew		500 cd	1000 cd	2500 cd
	Shanghai DB31/T316-2004[2)]				RPFI[5)]	RPFO[5)]
		Evening			7500 cd	7500 cd
		After 23:00			1000 cd	2500 cd
	Beijing DB11/T388-2006				RPNAS[6)]	RPAS[6)]
		Before 23:00			2500 cd	7500 cd
		After 23:00			1000 cd	2500 cd
Building facade luminance *(Lb)*	CIE 150:2003 ILE GN01:2005 Japan MOE-LPCG		E1	E2	E3	E4
		All times	0 cd/m^2	5 cd/m^2	10 cd/m^2	25 cd/m^2
	China JGJ/T163-2008[7)]	Large city	--	5 cd/m^2	10 cd/m^2	25 cd/m^2
		Medium city	--	4 cd/m^2	8 cd/m^2	20 cd/m^2
		Small city	--	3 cd/m^2	6cd/m^2,	15 cd/m^2
Sign luminance *(Ls)*	CIE 150:2003 ILE GN01:2005		E1	E2	E3	E4
		Pre-curfew	50 cd/m^2	400 cd/m^2	800 cd/m^2	1000 cd/m^2
		Post-curfew	0 cd/m^2			
	China JGJ/T163-2008 Japan MOE-LPCG	Limits do not apply to signs for traffic control. The use of signs in corporating lighting which is **cyclic or flashing** in nature is deprecated in zooes E1 and E2. In any zones such signs should not be positioned close to windows of habitable rooms.				
	Shanghai DB31/T316-2004			RE[8)]	AO/PA[8)]	CC[8)]
		S≤5 (m^2)		100cd/m^2	400 cd/m^2	1000 cd/m^2
		0.5<S≤2(m^2)		80 cd/m^2	320 cd/m^2	800 cd/m^2
		2<S≤10 (m^2)		60 cd/m^2	240 cd/m^2	600 cd/m^2
		S>10 (m"')		40 cd/m^2	160 cd/m^2	400 cd/m^2
	China JGJJ/T 163-2008[9)]		E1	E2	E3	E4
		S≤5 (m^2)	50 cd/m^2	400 cd/m^2	800 cd/m^2	1000 cd/m^2
		0.5<S≤2(m^2)	40 cd/m^2	300 cd/m^2	600 cd/m^2	800 cd/m^2
		2<S≤10 (m^2)	30cd/m^2	250 cd/m^2	450 cd/m^2	600 cd/m^2
		S>10 (m^2)	---	150 cd/m^2	300 cd/m^2	400 cd/m^2
Illuminance on a plane perpendicular to the line of sight *(E_{eye})*[10)]	IESNA RP-33-99 & TM-11-00		E1	E2	E3	E4
		Pre-curfew	1lx	3lx	8lx	15 lx
		Post-curfew	0 lx[11)]	1 lx	3 lx	6 lx

Notes:

1) Limits apple to each luminaire in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained, i.e. not where momentary or short-term v viewing is involved.
2) If the directly seen luminaires are flashing, the luminous intensity should be half of the given limits.
3) If the luminaire is for public (road) lighting then this value may be up to 500 cd.
4) RDS =Residential-dark surrounds; RLS=Residential-light surrounds; C&CRB =Commercial &commercial/ residential boundary.
5) RPFT = Residential premises facing inside of estate(面向小区内侧的住户);RPFO = Residential premises facing outside of estate (面向小区外侧的住户)
6) RPNFS = Residential premises not adjacent to street (居住区非临街侧); RPFS =Residential premises adjacent to street (居住区临街侧)
7) Large city = non-agricultural population > 500000; Medium = population 200000-500000; Small = population < 200000.
8) RE = Residential estate (居住小区);AO/PA =Administration offices (industrial) or public activity area (行政办公（工业）区/公共活动区); CC = Commercial centre(商业中心区)
9) Apart from adopting the CIE limits, China JGJ/T163-2008 recommends stricter limits for signs larger than 0.5 m^2.
10) IESNA treats glare from luminaires as part of the effects of light trespass which is assessed by one single parameter.
11) Limits apply to individual luminaire or to group of luminaires on a pole.
12) The candela *(cd)* is the SI base unit of luminous intensity; that is, power emitted by a light source in a particular direction.

Table 2.3(a)-Maximum luminous intensity per luminaire for pre-curfew operating times specified in Australian Standard AS4282-1997

Area description		Maximum luminous intensity from each luminaire [1]	
Size of area	Controlling dimension	Level 1control [2]	Level 2 control [3]
Large	> 75 m	7,500 cd	100,000 cd
Medium	≥25m≤75 m	7,500 cd	50,000 cd
Small	<25 m	2,500 cd	25,000cd

Notes to Table 2.3(a)

1) Limits apply to each luminaire (irrespective of the number on a head frame) in the principle plane, for all angles at and above the control direction (10° below horizontal for controlling dimension < 25m; 7° below horizontal for controlling dimension ≥25 m),when aimed in accordance with theinstallation design.
2) Environmentally sensitive areas, i.e. where the existing environment is of high quality, where abutting properties are close to the installation, where they are residential in nature, where the existing ambient light levels are low and where the community requires the best available environmental safeguards to be applied.
3) Level 2 control will permit the use of a wide range of currently used lighting techniques but will limit intensities in the control direction to what might reasonably be expected by careful attention to design and the selection and aiming of luminaires.

2.2.5 Parameters and Limiting Values used for Assessing the Effects on Road Users

2.2.5.1 Disability glare on all road users (drivers, cyclists, pedestrians)

Road users (also called transport system users in CIE 150:2003 and in Australian Standard AS4282-1997) include drivers of all kinds of vehicles, cyclists and pedestrians. Effects on road users normally involve a reduction in the ability to see caused by disability glare from bright light sources. The apparent contrast of objects against their backgrounds will be lowered, rendering them less visible or even invisible, especially if the environment is dark. The magnitude of the effect will depend on the level of lighting to which the user is adapted. The parameter recommended for the assessment of the glare effect on road users due to external lighting which is not road lighting is the threshold increment *(TI),* which is the same parameter used to specify the limitation of glare in road lighting by CIE and many other authorities including Highways Department, of the HKSAR Government.

Table2.4-Light technical parameter and limits for the assessment of disability glare on road users

Light Technical Parameter	Standards/ Codes	Application Conditions	Recommended Limits[1]			
Threshold increment *(TI)*	CIE 150:2003 ILE GN01:2005 China JGJ/T 163-2008 [3] Japan MOE-LPCG	Limits apply at all times	Road classification[2]			
			No road lighting	M5 ME5	M4/M3 ME4/ME3	M2/M1 ME2/ME1
			15% based on adaptation luminance of 0.1 cd/m^2	15% based on adaptation luminance of 1 cd/m^2	15% based on adaptation luminance of 2 cd/m^2	15% based on adaptation luminance of 5 cd/m^2
	Australian Standard AS4282-1997	Limits apply at all times	Environmental zone			
				RDS[4]	RLS[4]	C&CRB[4]
				20% based on adaptation luminance of 0.1 cd/m^2	20% based on adaptation luminance of 1 cd/m^2	20% based on adaptation luminance of 10 cd/m^2

Notes:
1) Limits apply where users of transport systems are subject to a reduction in the ability to see essential information Values given are for relevant positions and for viewing directions in the path of travel.
2) Road Classifications as given in CIE 115-1995 (M1-M5) or in BS EN 13201-2:2003(ME1-ME5)(see Table 2.4(a))
3) JGJ/T 163-2008 uses a statement in the code requiring a *TI* limit of 15% without specifying the adaptation luminance and then refers to the CIE road classification in the explanation attached at the end of the code.
4) RDS = Residential - dark surrounds; RLS = Residential-light surrounds; C&CRB=Commercial&commercial/ residential boundary.

Table 2.4(a) -Road lighting classes and minimum maintained average road surface luminance(CIE 115:1995;BSEN 13210-2:2003; HKSAR HyD Public Lighting Design Manual)

Road lighting class			Minimum maintained road surface luminance (cd/m^2)
CIE	BSEN	HKSAR HyD	
Ml	MEl	Ll	2.0
M2	ME2	L2	1.5
M3	ME3	L3	1.0
M4	ME4	L4	0.75
M5	ME5	L5	0.5

2.2.5.2 Discomfort glare on pedestrians

CIE-136:2000 introduces a new approach to discomfort glare assessment for low mounted luminaires, up to approximately 7m, where the risk exists when pedestrians are looking straight into the luminaires. This approach is based on a parameter defined as the product of L and $A^{0.5}$, where L is the luminair's greatest (average) luminance (in cd/m^2) in the direction between 85° and 90° from the downward vertical and A is the light emitting surface area of the luminaire (in m^2) in the direction 90° from the downward vertical. (See Figure 2.3). CIE-136:2000 mentions that little practical experience with this new approach to assess glare has so far been obtained, therefore relatively high limiting values of glare are recommended. This approach is adopted by the Shanghai Municipal Standard DB31/T316-2004 and the China JGJ Standard JGJ/T 163-2008 using the same limiting values.

Figure 2.3 Definition of L and A for glare evaluation using $L \cdot A^{0.5}$

Table2.5-Light technical parameter andlimits for the assessment of discomfort glare on road users (mainly pedestrians and cyclists).

Light Technical Parameter	Standards/ Codes	Application Conditions	Luminaire Height h (m) and Recommended Limits		
			$h \leq 4.5$	$4.5 < h \leq 6$	$h > 6$
$L \cdot A^{05}$	CIE 136:2000 China JGJ/T 163-2008 Shanghai DB31/ T316-2004	Limits apply at all times	4000 cd/m	5500 cd/m	7000 cd/m

Note. L is the luminaire's greatest (average) luminance (in cd/m^2) in the direction between 85° and 90° from the downward vertical and A is the light emitting surface area of the luminaire (in/m^2) in the direction 90° from the downward vertical.

2.2.6 Parameters and Limiting Values used for Assessing the Effects on Astronomical Observation

2.2.6.1 The magnitude scale and the limiting visual magnitude

There are differences in the way photometry is applied in illuminating engineering and astronomy. Terms used by illuminating engineers, for example intensity and flux, have different meanings in astronomy.

For the nomogram below, the night sky brightness in mag/arcsec^2 can be easily converted from one scale to the other. The horizontal red line shows the natural sky brightness level for an unpolluted and clear starry sky. At this natural level the Milky Way can be seen in all its beauty and around 6,000 stars with the naked eye at the hemisphere of an observer.

The comparison between the scales can be made by drawing a horizontal line and reading the various values at this horizontal line. The more light polluted the sky is, the higher the horizontal line will be drawn.

The second scale is given in the proposed astronomical scale of magnitude per arc second (mag/arcsec^2) in the visual range (V-band). This gives the brightness of the sky of one square arc second. The natural level is around 21.6 mag/arcsec^2. The fourth scale is the often used Bortle scale from 1 to 9 with scale 1 for an excellent dark sky up to scale 9 for the sky above an inner city. The most right scale gives the approximate number of stars that can be seen by an observer at the observer's hemisphere. However, the scales in the figure are approximate and more refined and exact values should be evaluated by the formulas from related literature.

Figure 2.4 Sky Brightness Nomogram
(Source: http://www.darkskiesawareness. org/nomogram.php)

2.2.6.2 Upward light ratio (ULR)

CIE 126:1997 and CIE 150:2003 recommend the use of the upward light ratio (ULR), previously called upward light output ratio installed ($ULOR_{inst}$) in CIE 126:1997, as a parameter for defining the limits for control of sky glow effect. The upward light ratio (ULR) is defined as the proportion of the flux of a luminaire and/or installation that is emitted, at and above the horizontal when the luminaire(s) is mounted in its installed position.

The use of ULR for limiting the effect of sky glow is adopted by various other authorities such as the ILE of UK. IESNA TM-10-00 refers to CIE-126:1997 for measuring and evaluating sky glow and therefore can be considered as also adopting the recommendations of CIE.

Therefore, the following authorities and organizations adopt the use of ULR with limiting values given in Table 2.6:

- CIE (CIE 150:2003 and CIE 126:1997)
- ILE (GN01:2005)
- IESNA (TM-10-00)
- China Construction Industry Standard (JGJ/T 163-2008)
- Japan Ministry of the Environment Light Pollution Control Guidelines (MOE-LPCG)

Table 2.6 -Light technical parameter and limits for control of sky glow effect.

Light Technical Parameter	Standards/ Codes	Application Conditions	Environmental Zones and Recommended Limits (Maximum)			
Upward light ratio (ULR)	CIE 126:1997 CIE 150:2003 IESNA TM-10-00 China JGJ/T388-2008	Limits apply at all times	E1	E2	E3	E4
			0 %	5%	15%	25%
	ILE GN01:2005		0 %	2.5%	5%	15%
	Japan MOE-LPCG	Limits apply at all times	LE-I	LE-11	LE-III	LE-IV
			0 %	5%	15%	20%

Note: The above limitsholds for each individual luminaire.

2.2.7 Parameters and Limiting Values used for Assessing Energy Efficiency of External Lighting

2.2.7.1 Efficiency of lamps, control gear and luminaires

There are many codes on lighting energy efficiency specifying limits of the following parameters:

(i) minimum lamp efficacy
(ii) maximum control gear loss
(iii) minimum power factor
(iv) minimum luminaire efficiency or light output ratio

Most codes are for buildings and mainly for building interior lighting. These codes may also be made reference to for lamps and luminaires used for external lighting.

Beijing DB 11/T388-2006 recommends the use of energy efficient light sources and luminaires meeting the relevant China National GB Standards.

China JGJ/T 163-2008 has a statement requiring that the minimum luminaire efficiency (i.e. light output ratio) for floodlights should be 65%, but this is not restrictive.

California 2008 Building Energy Efficiency Standards (CBEES 2008) (effective from 1 January 2010, replacing the 2005 Standards) require that lamps greater than 100W used in permanent outdoor lighting must have a lamp efficacy of at least 60 lm/W if not controlled by motion sensor. Moreover, this California Energy Code also requires outdoor lighting tousehigh efficacy luminaires.

2.2.7.2 Lighting power density (LPD)

The lighting power density (LPD) in W/m^2 is a commonly used parameter for measuring energy efficiency for lighting of an area. LPD can also be used for assessing energy efficiency of external lighting but the area can be a horizontal area (such as sports fields and car parks) or a vertical area (such as building facade and signs).

China JGJ/T 163-2008 gives non-restrictive recommendations for limiting the LPD of building facade lighting. The recommended LPD limits are shown in Table 2.7.

Table 2.7 -Recommended LPD values for building facade lighting in JGJ/T 163-2008.

Facade reflectance	Size of city [2]	Environmentalzones[1]					
		E2		E3		E4	
		Illumin-ance(lx)	LPD (W/m^2)	Illumin-ance(lx)	LPD (W/m^2)	Illumin-ance(lx)	LPD (W/m^2)
0.6-0.8	Large	30	1.3	50	2.2	150	6.7
	Medium	20	0.9	30	1.3	100	4.5
	Small	15	0.7	20	0.9	75	3.3
0.3-0.6	Large	50	2.2	75	3.3	200	8.9
	Medium	30	1.3	50	2.2	150	6.7
	Small	20	0.9	30	1.3	100	4.5
0.2-0.3	Large	75	3.3	150	6.7	300	13.3
	Medium	50	2.2	100	4.5	250	11.2
	Small	30	1.3	75	3.3	200	8.9

Notes.
1) There should not be any building facade lighting in environmental zone E1.
2) Large city= non-agricultural population >500000; Medium = population 200000-500000; Small = population <200000.

Beijing Municipal Standard 北京市地方标准 DB11/T 388.4-2006 Technical Specification of Urban Nightscape Lighting 《城市夜景照明技术规范》 (Part4: Energy Conservation Requirements) has also given recommendations of limiting values of LPD for building architectural lighting. Table2.8 gives these values.

Table 2.8 -Recommended LPD values for building architectural lighting in DB11/T 388.4-2006

Reflectance (%)	Lowbackground brightness		Medium background brightness		High background brightness	
	lllumin-ance (lx)	LPD (W/m^2)	Illumin-ance (lx)	LPD (W/m^2)	Illumin-ance (lx)	LPD (W/m^2)
70-85	50	3	100	5	150	7
45-70	75	4	150	7	200	9
20-45	150	7	200	9	300	14

Note: The above limits do not apply to areas and/or lime periods with special permit

CBEES 2008 (effective from 1 January 2010, replacing the 2005 Standards) control the power of outdoor lighting by specifying limits, for each of the 4 lighting zones, ofthe following:

(i) general landscape lighting power allowance;
(ii) additional lighting power allowance for specific applications ;
(iii) additional lighting power allowance when light levels are required by local ordinance .

The calculation guideline of lighting power allowance and the respective limits can be referred to the Section 147 of the CBEES 2008 .

The California Standards also has requirements on the maximum allowed lighting power for signsinthe Section 148 of CBEES 2008 as well:

(i) For internally illuminated signs, the maximum allowed lighting power is 12W per square foot of the illuminated sign area and only the area of a single faceis counted for double-faced signs.
(ii) For externally illuminated signs, the maximum allowed lighting power is 2.3W per square foot ofthe illuminatedsign area.

2.3 Luminaire Classification for the Control of Obtrusive Light Effects

There are several luminaire classification systems used in outdoor lighting guidelines, regulations or ordinances for control of obtrusive light effects. The luminaire classifications used for outdoor lighting, but not exclusively for road lighting, are summarized below.

2.3.1 Shielding Classification

The shielding classification classifies luminaires according to the percentage of light projected from the luminaire to directions above the horizontal. The shielding of luminaires is required by some outdoor lighting ordinances or regulations, is commonly used mainly in USA. Table 2.9 is extracted from the information of Outdoor Lighting Code Handbook, Version 1.14 by International Dark-Sky Association to give the descriptions and shielding criteria for the 3 classes fully shielded, partially shielded and unshielded.

Table 2.9 - Shielding classification outdoor luminaires.

Shielding of luminaire	Description	Percentage of light projected above horizontal
Fully shielded	All light emitted by the fixture, either directly from the lamp or a diffusing element, or indirectly by reflection or refraction from any part of the luminaire, is projected below the horizontal.	0%
Partially shielded	More than 0% but less than 10% of the light emitted directly from the lamp or indirectly from any part of the fixture is projected above the horizontal.	>0% and <10%
Unshielded	10% or more of the light emitted directly from the lamp or indirectly from any part of the fixture is projected above the horizontal.	≥10%

2.3.2 Cutoff Classi fication

Cutoff classification classifies luminaire s according to the intensity at (and above) 90° from nadir and at 80° from nadir. This classification system was recommended by IESNA. Table 2.10 gives the description and intensity distribution criteria for the four cutoff classes: full cutoff, cutoff, semi-cutoff and non cutoff.

Table 2.10 - Cutoff classification of outdoor luminaires.

Cutoff classes	Description	Intensity at 90° above nadir (cd/ 1000 lamp lm)	Intensity at 80° above nadir (cd/1000 lamp lm)
Full cutoff	A luminaire light distribution where zero candela intensity occurs at an angle of 90 degrees above nadir, and at all greater angles from nadir. Additionally, the candela per 1000 lamp lumens does not numerically exceed 100 at a vertical angle of 80° from nadir. This applies to all lateral angles around the luminaire.	0 (including all angles ≥90° above nadir)	≤100
Cutoff	A luminaire light distribution where the Candela per 1000 lamp lumens does not numerically exceed 25 at 90° above nadir, and 100 at 80° above nadir. This applies to all lateral angles around the luminaire.	≤25	≤100
Semi-cutoff	A luminaire light distribution where the candela per 1000 lamp lumens does not numerically exceed 50 at 90° above nadir, and 200 at 80° above nadir. This applies to all lateral angles around the luminaire.	≤50	≤200
Non cutoff	A luminaire light distribution where there is no candela limitation in the zone above maximum candela.	No limit	No limit

3 INVESTIGATION OF THE LOCAL ENVIRONMENT WITH RESPECT TO EXTERNAL LIGHTING

3.1 Introduction

3.1.1 This part of the study investigates the local environment with respect to external lighting.

3.1.2 External lighting, exterior lighting and outdoor lighting have the same meaning in this report. These terms are used by various authorities and organizations to mean all lighting outside buildings, including lighting installations on building facades. Lighting for covered outdoor footpaths not enclosed by walls, should also be considered as external lighting.

3.1.3 According to CIE 150:2003, outdoor lighting is provided for a variety of purposes, examples of which are as follows:

(a) For work or recreation- to enable people to see essential detail, in order that they may undertake the work or recreation activities at night for which the area is intended, e.g. freight yards, sporting fields;

(b) For safety or security - to light the area so as to facilitate the safety or security of persons or property, e.g. lighting of roads, pedestrian pathways, and perimeter lighting;

(c) For amenity - to light features of architectural or historical significance, or to light parks or gardens;

(d) For advertising or display - to promote products or services, e.g. lighting of advertising signs, or to give emphasis to commercial premises by means of lighting.

3.2 Types of External Lighting in Hong Kong that may cause Light Pollution

Hong Kong is known as the Pearl of the Orient because of the bright and beautiful lights shining at night. Hong Kong is one of the most densely populated cities in the world. Not only commercial buildings in the business districts are high rise skyscrapers; residential buildings are also high rise and scattered around the business centres and over and around a number of new towns. Many residential premises are mixed with commercial shops in several traditional shopping districts such as Causeway Bay and Mongkok. The following are examples of external lighting that may cause concern on light pollution:

(i) Large advertising signs are put on rooftop of buildings, particularly for buildings along the two sides of the harbour. Some of these signs are changing in colour and/or blinking and/or with moving graphics/letters/characters. The density of these rooftop signs is high and concentrated along Central to Causeway Bay on the Island and Tsim Sha Tsui opposite the harbour.

(ii) Floodlights and/or other types of lighting put on the top of high rise buildings for illuminating the building crown and/or features for emphasizing the building; these emit significant light output towards the sky.

(iii) Building facade lighting by externally mounted floodlights shinning mostly from below and some from above as well.

(iv) Building facade lighting using neon lights and/or LED and/or fiber optics on the surface, some are also blinking and/or changing in colour.

(v) Advertising and company signs (self luminous or illuminated) installed on building facades.

(vi) Advertising and company signs (mostly self luminous) projected outward from building facades.

(vii) Advertising signs (self luminous or illuminated) on road sides along major traffic routes, e.g. near entrance/exit of tunnels.

(viii) Permanent external video structures.

(ix) Floodlights for the illumination of outdoor sports facilities, such as tennis courts, basketball courts, football fields, golf courses, horse racing courses, and swimming pools.

(x) Outdoor area lighting such as lighting for car parks.

3.3 Light Pollution in Hong Kong

3.3.1 Nuisance Complaints caused by External Lighting

As the residents seems to be more aware of light nuisance and light pollution, the number of complaints received by the Environmental Protection Department and other government departments on nuisance caused by lighting is increasing. According to the Friends of the Earth (HK), the number of complaints on light pollution (nuisance) in the past 4 years received by various departments is given in Table 3.1 (www.foe.org.hk, Press Release of 25 May 2009 (Chinese version only)). Table 3.2 (from 香港地球之友《日照 ·夜照》, published in 2009) gives a breakdown of the lighting sources causing the complaints received by EPD in the past 6 years.

Table 3.1 - Number of complaints on nuisance caused by lighting

Year	2005	2006	2007	2008
No.of complaints received by EPD	33	35	40	82
No. of complaints received by other departments *	35	38	47	77
Total no. of complaints	68	73	87	159

*Including Leisure and Cultural Services Department, Housing Department, Highways Department.

Table 3.2 - Number of complaints on different light sources received by EPD

Year	2003	2004	2005	2006	2007	2008
Advertising signs	2	3	15	15	15	24
Floodlights	6	9	15	15	9	27
Others	1	1	3	5	16	29
Video walls	--	--	--	--	--	2
Total	9	13	33	35	40	82

*Including indoor light sources.

3.3.2 Results of a Territory-wide research by HKU on 'Light Pollution' (Sky Glow)

3.3.2.1 From the published Hong Kong Light Pollution Map (http://nightsky.physics.hku.hk),values of night sky brightness in mag/arcsec^2 are given for 191 sites. An analysis of the data given in the map has been carried out with results given in Tables 3.3 & 3.4. Table 3.3 gives the number of sites with night sky brightness of 13-20 mag/arcsec^2 counted from the website map. A summary of the range of night sky brightness in different districts/areas is given in Table 3.4.

3.3.2.2 Tables 3.3 & 3.4 show that very few areas within Hong Kong have dark skiessuitable for astronomical observations which require a sky as dark as 21.6 mag/ arcsec^2 according to suggestion of the International Astronomical Union (IAU). The areas with the darkest night skies in Hong Kong are Eastern Sai Kung and South-western Lantau, where the night sky brightness is 20 mag/arcsec^2 or more, meaning that the limiting magnitude is greater than 5.8, or over 2000 stars are visible to the naked-eye.

3.3.2.3 More than half of the surveyed sites have night sky brightness of 15 mag/arcsec^2 or below, i.e. more than 430 times brighter than the natural sky or having a limiting visual magnitude of approximately 1.5 or only about 15 brightest stars are visible to the naked-eye. There are 14 sites with night sky brightness of 13 mag/arcsec^2 or less, meaning the night sky is over 2,750 times brighter than the natural night sky or the limiting magnitude is near to 0 or almost all the stars are not visible to the naked-eye.

3.3.2.4 The data shows that the urban areas of Hong Kong Island and Kowloon have high night sky brightness as well as many sites in the new towns in the New Territories have also high sky brightness.

Table 3.3 - Number of sites with different night sky brightness (from Hong Kong Light Pollution Map by HKU, http://nightsky .hysics.hku.hk)

Night sky brightness in mag/arcse^2	**Equivalent night sky luminance in mcd/m^2**	**No. of times brighter than natural night sky (21.6 mag/ arcses^2 0.25 mcd/m^2**	**Approx. limiting visual magnitude**	**Approx. number of stars visible to the naked** eye	**Number of sites* identified from the map**
≤13	≥687.7	>2750	<0	0	14
14	273.8	>1090	0.5	≈5	39
15	109.0	>430	1.5	≈15	57
16	43.4	>170	2.5	≈30	46
17	17.3	>69	3.4	≈120	16
18	6.9	>27	4.3	≈250	10
19	2.7	10.9	5.0	≈800	6
≥20	≤1.1	≤4.4	5.8	≥2000	3

*Total number of sites identified from the map =191

Table 3.4 - Range of night sky brightness in different districts/areas

District/Area		Night sky brightness (mag/arcsec^2)
Hong Kong Island	West Mid-level	16
	Wan Chai	13
	North Point / Quarry Bay / Tai Koo Shing	14-16
	Jardine's Lookout	16
	SaiWanHo / Shau Kei Wan / Chai Wan	14-16
	Shek O	19
	Stanley	17
	Aberdeen/Wong Chuk Hang	15-16
Kowloon	Tsim Sha Tsui/ Yau Ma Tei / Mong Kok	13-16
	Shun Shui Po /Lai Chi Kok / Mei Foo	15-17
	Hung Hum/To Kwa Wan	13-16
	ChoiHung/DiamondHill/ Tsz Wan Shan	15-16
	Kwun Tong	15-16
New Territories	Tseung Kwan O	14-16
	Sai Kung	17-20
	Kwai Chung/Tsing Yi	14-15
	Tsuen Wan	13-16
	Sha Tin	14-17
	Ma On Shan	15
	Tai Po	16
	Fan Ling	14-17
	Sheung Shui	14-17
	Yuen Long /Tuen Mun	13-16
	Tin Shui Wai	14-16
	MaiPo	16
	Tung Chung	13-18
	Lantau Island (except Tung Chung)	16-20
	CheungChau	16-18
	Lamma Island	18

3.4 Identification of Selected Districts / Areas for Detailed Site Survey / Investigation

3.4.1 Proposed representative districts / areas for detailed site survey / investigation Taking into account the characteristics of external lighting, types, lighting conditions / characteristics,perceivedintensity ofthe external lightings (including facade or window illuminance) to the affected residents as well as previous light nuisance records and complaints addressing in mass media as reference, the six districts / areas for detailed site survey / investigation have been selected and are listed as follows:-

1. Shun Lee Estate (a public housing estate) (area close to sports ground) (Kwun Tong)
2. Des Voeux Road Central / Queensway (Central)
3. PatersonStreet / GreatGeorgeStreet / Hennessy Road (CausewayBay)
4. Nathan Road / Sai Yeung Choi Street (Mongkok)
5. Yan King Road / Kai King Road (Po Lam,Tseung Kwan O)
6. Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (Sai Kung)

Characteristics of external lighting in these 6 selected districts / areas are summarized in Table 3.5.

Table3.5 - Characteristics of external lighting in the 6 selected districts/areas

Item	Proposed location of representative Districts / Areas	District Type / Category	Region	Nature, Resident Type	Major Light Nuisance Sources (Note 1)
1	Shun Lee Estate (a public housing estate) (near sports ground) (Kwun Tong)	Urban / Residential	KLN	Public rental housing estate	[S], [SL]
2	Des Voeux Road Central / Queensway (Central)*	Urban / Commercial	HK Island	Traditional office area, hotel	[S], [EL], [FL], [VW],[IL]
3	Paterson Street / Great George Street/Hennessy Road (Causeway Bay)*	Urban / Residential-cum-Commercial	HK Island	Shopping area with pedestrian area, private housing, hotel	[S], [EL], [FL], [VW],[IL]
4	NathanRoad/Sai Yeung Choi Street (Mongkok)*	Urban / Residential-cum-Commercial	KLN	Shoppingarea with pedestrian area, private housing, hostel	[S], [EL], [FL], [VW],[IL]
5	Yan King Road / Kai King Road (Po Lam)*	New Town	NT	Public subsidized sale housing estates, private housing estate with shopping plaza	[S], [EL]
6	Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (Sai Kung)	Rural	NT	Villagehouses	[FL]

Note 1 Lighting nuisance esource abbreviations are
[S]: signs(advertisingornon-advertising, standalone or on building facades, self-luminous or illuminated),
[FL): lighting for building facades and features,
[EL]: lighting out side buildings, shops, restaurants, other public entertainment venues,
[SL]: lighting for sport fields,
[VW]·permanent external video structures,
[IL]: lighting emitted from building through facades to the outside environment
*denotes districts *I* areas with light nuisance complaints

3.5 Parameters Considered Suitable for Assessment of the Problems of External Lighting and the Recommended Thresholds for Assessment Purpose in the Survey

3.5.1 Lighting Environmental Zoning

Since different districts/areas have different population densities and different levels of commercial and recreational activities at night, it is recommended that a lighting environmental zoning system similar to the CIE system to be adopted for the survey in the study.

A 4-zone lighting zoning system similar to the CIE lighting environmental zoning system is adopted by a number of countries for mandatory control or voluntary guidelines of outdoor lighting. The countries adopting or recommending the use of zoning system similar to the CIE zoning system include the North America countries (USA,Canada and Mexico), UK, Mainland China and Japan.

A zoning approach based on the CIE environmental zones is initially suggested for lighting assessment purpose in this survey. The suggested preliminary classification is given in Table 3.6 where the planning zones in the Hong Kong Metroplan Residential Zones, New Towns Residential Density Zones and Rural Area Residential Density Zones are referenced to for sake ofillustration.

Table 3.6 -Lighting environmental zones for the lighting survey

Zone	Lighting Environment	Suggested preliminary classification
E1	Intrinsically dark	Country parks and designated areas for astronomical observations
E2	Low district brightness	Rural Residential Density ZonesRR2, RR3, RR4, RR5,Village (with New Territories Exempted Houses); MetroplanResidential Zone 3;and New Towns Residential Density Zones R3 & R4 (Excluding areas already classified as country parks which is suggested to belong to zone E1 by default)
E3	Medium district brightness	Rural Residential Density Zone RR1; Metroplan Residential Zone 2; and New Towns Residential Density Zones R2
E4	High district brightness	Metroplan Residential Zone 1;andNew Towns Residential Density Zones R1

For the survey under the study, the 6 selected districts/areas would be classified according to the zoning in Table 3.6. However, Hong Kong's specific situations such as small geographic size, building mix and building density should be taken into account when considering feasibility of applying lighting environmental zone concepts territory-wide.

3.5.2 Curfew Hour

Curfew hour is recommended in many guidelines and also enforced in some outdoor lighting laws. Curfew hour is proposed for assessment purpose in this survey. Curfew is defined as 11:00 p.m. or mid-night depending on the zoning beyond which more stringent reference threshold limits are recommended for controlling obtrusive light.

3.5.3 Parameters and Limiting Values for Quantitative Assessment of the Effects on Residents

3.5.3.1 Light trespass

Based on international recommendations and existing guidelines used in overseas countries and the mainland which have metropolitan areas with economic activities comparable to Hong Kong, the vertical illuminance on the windows of residential units is a suitable parameter to measure and assess the effect of light trespass on residents. In order to simplify the measurement or calculation, the vertical illuminance at the centre of the window can be used. The illuminance is due to light from all light sources that emit light towards the resident's window.

After compared the technical standards in Table 2.2 in Section 2.2.4.1, the limiting values used in CIE 150:2003 guideline are proposed to be a preliminary benchmarking for assessing the light trespass conditions in Hong Kong. In fact, this CIE standard is comprehensive as it consists of 4 different sets of limiting value to cater all 4 lighting environmental zones. Furthermore, this CIE standard is far more representative, not just because it is equivalent to the ILE GN01:2005 guideline, China JGJ/T 163-2008 standard and Japan MOE-LPCG guideline in the table, but also the limiting values in Australian standard AS4282-1997 and Beijing Municipal Standard DB11/T388-2006 are exactly the same or similar to those values of CIE standard in zone E3 and E4 respectively. The proposed limiting values for assessing light trespass using the vertical illuminance at centre of windows of residential units are given in Table 3.7. However, these proposed limiting values may not be suitable for control of outdoor lighting installations as the effect is summation of the light from all light sources shining at the resident's premises. It is only suitable for assessing the level of light trespass affecting the residents in the site measurements.

Table 3.7 - Proposed limits for assessing light trespass (extracted from CIE standard)

Light Technical Parameter	**Application Conditions**	**Lighting Environmental Zones and Proposed Limits**			
Vertical illuminance at centre of window (E_v) [1]	Pre-curfew	El	E2	E3	E4
		2 lx	5 lx	10 1x	25 lx
	Post-curfew	0 1x[2]	1 lx	2 lx	5 lx

1) The values are the summation of all lighting installations.
2) If thereis publie (road) lighting then this value may be up to 1 lx.

3.5.3.2 Glare from bright light sources, building facades and signs

Based on the international recommendations and existing guidelines used in overseas countries and the mainland, the following three parameters are suitable for use in assessing glare due to direct view of bright light sources, building facades, signs (including permanent external video structures) in the survey:

(i) Luminous intensity emitted by luminaires (I_d) in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained, i.e. not wheremomentaryorshort-termviewingisinvolved.

(ii) Buildingfacade luminanc (L_b) which can be taken as average luminance or the product of the average illuminance and reflectance factor divided by π

(iii) Sign luminance (L_s) which is taken, for illuminated signs, as the average luminance or the product of the design average illuminance and reflectance factor divided by -n, or for self-luminous signs, its average luminance.

After compared the related technical standards in Table 2.3 of Section 2.2.4.2 concerning the luminous intensity emitted by luminaires *(I_d)* in designated directions, building facade luminance *(L_b)* and sign luminance *(L_s)* the limiting vah1es used in CIE 150:2003 guideline (also equivalent to the ILE GN01:2005 guideline, China standard JGJ/T 163-2008 and Japan MOE-LPCG guideline) is more comprehensive as this is the only set of limiting values that catered all 4 lighting environmental zones. The limiting values used in CIE guideline are therefore proposed for assessing the glare impacts in Hong Kong. Table 3.8 gives the proposed limiting values for these three parameters. In addition to the proposed limits of light trespass in Section 3.5.3.1, all these limits of glare impact are also in line with the CIE 150:2003 guidelines and actually, this standard is widely adopted in many developed / developing countries to assess the impact of outdoor lighting to the environment.

Table 3.8 - Proposed parameters and limits for assessing glare impact on residents from bright luminaires, building facades and signs (including video walls).

Light Technical Parameter	**Application Conditions**	**Lighting Environmental Zones and Proposed Limits**			
		E1	E2	E3	E4
Luminous intensity emitted by luminaires (I_d) in directions towards residents [1]	Pre-curfew	2500 cd	7500 cd	10000 cd	25000 cd
	Post-curfew	0 cd	500 cd	1000 cd	2500 cd
Building facade luminance (L_b)	Pre-curfew	0 cd/m^2	5 cd/m^2	10cd/m^2	25 cd/m^2
	Post-curfew	0cd/m^2	5 cd/m^2	10 cd/m^2	25 cd/m^2
Sign luminance (L_s) [2]	Pre-curfew	50 cd/m^2	400 cd/m^2	800 cd/m^2	1000 cd/m^2
	Post-curfew	0cd/m^2	400 cd/m^2	800cd/m^2	1000 cd/m^2

1) If the directly seen luminaires are flashing, the luminous intensity should be halfof the given limits.
2) Signs include video walls but exclude signs for traffic control. The use of signs incorporating lighting which is cyclic or flashing in nature is deprecated in zones El and E2. In any zones such signs should not be positioned close to windows of habitable rooms.

3.5.4 Parameters and Thresholds for Quantitative Assessment of the Effects on Road Users

3.5.4.1 Disability glare on all road users (drivers, cyclists, pedestrians)

The Highways Department uses also the threshold increment *TI* for the assessment of glare due to road lighting according to lighting classes of roads. In the Public Lighting Design Manual of Highways Department, it is also mentioned that the undesirable effects of light pollution should be minimized making reference to the ILE publication - Guidance Notes for the Reduction of Light Pollution (Obtrusive Light), which recommends the use of CIE guidelines. Hence, it can be considered that the *TI* is a suitable parameter for assessing the effect of glare on road users. Since the Highways Department specifies a *TI* of 20% for road lighting class L5 and 15% for road lighting classes Ll - L4, the same *TI* limits are suggested to be used for assessing glare from non road lighting installations. The recommended limiting valuesaregiven inTable 3.9.

Table 3.9 -Recommended parameters and limitsfor assessing glareimpact on road users due to non road lighting

Light Technical Paramete	**Application Conditions**	**Recommended Limits** [1]			
		Road classification [2]			
		No road lighting	L5	L4/L3	L2/L1
Threshold increment (*TI*)	Limits apply at alltimes	20% based on adaptation luminance of 0.1 cd/m^2	20% based on adaptation luminance of 1cd/m^2	15% based on adaptation luminance of 2cd/m^2	15% based on adaptation luminance of 5 cd/m^2

1) Limits apply where road users are subject to a reduction in the ability to see essential information. Values given are for relevant positions and for viewing directions in the path of travel.
2) Road classifications as given in Public Lighting Design Manual of Highways Department

3.5.4.2 Discomfort glare on pedestrians

Little experience has been collected on the use of the new parameter $L \cdot A^{0\ 5}$ in CIE-136:2000 for assessing discomfort glare effect on road users, mainly pedestrians and cyclist. In the reviewed standards/guidelines, only the China Construction Industry Standard and Shanghai Municipal Standard adopt the CIE recommendation of using this parameter. Major developed countries such as USA, UK, Australia and Japan do not use this parameter. Moreover, discomfort glare on pedestrians is normally transient and is not a serious concern. Therefore, it is recommended not to adopt this parameter in Hong Kong for the assessing of glare.

3.5.5 Parameters and Limiting Values for Quantitative Assessment of the Effects on Astronomical Observation

3.5.5.1 The limiting visual magnitude and the night sky brightness

The limiting visual magnitude and the night sky brightness are both suitable parameters for assessing the sky glow effect. However, there is not much meaning in setting target limiting values for the urban and suburban skies. It may be useful to adopt limiting values for specifying the target achievable limiting magnitude or night sky brightness in mag/arcsec^2 in special conservation zones for astronomical observations. Preliminarily, target minimum values of the limiting magnitude and night sky brightness can be set at +6.0 and 20 mag/arcsec^2, respectively (Table 3.10). According to the recent HKU light pollution survey, these values are achievable in areas such as Eastern Sai Kung and South-western Lantau.

Table 3.10 -Proposed parameters and limits for assessing the performance of special conservation zones for astronomical observations.

Light technical parameter	**Proposed limit**	**Application conditions**	**Applicable zone**
Limiting visual magnitude	≥6.0	Limits apply all times	Special conservation zone for astronomical observations
Night sky brightness in mag/ arcsec^2	≥20 mag/arcsec^2		

3.5.5.2 Upward light ratio (ULR)

The upward light ratio (ULR) can also be considered to be adopted for use. However, a detailed study of the implications must be conducted before adopting this parameter. It is because ULR cannot be measured on site and assessment of ULR can only be made by calculations, aided by computer software if necessary. The calculation of ULR involves the availability of photometric data of the luminaires, and the locations and aiming angles of the luminaires. In addition, as more astronomical observations and activities will be carried out in lighting environmental zone E1 (intrinsically dark) rather than E2, E3 & E4. The ULR applicable to zone E1 is significant and meaningful to Hong Kong situation. At this stage a limit of 0% ULR is proposed only for lighting environmental zone E1 or even only for the special conservation zone for astronomical observations (Table 3.11). Although an ULR of not more than 25% is recommended in lighting environmental zone E4 such as commercial centres according to the CIE recommended limits, most astronomical observations will not be conducted in zone E2, E3 & E4. In addition, many existing floodlights for signs and for building facades in residential and commercial areas in Hong Kong are installed such that the lights are aiming at a direction pointing upwards for specific needs. The ULR limits could not be applicable to other zones in Hong Kong.

Table 3.11 - Recommended parameter and limit for assessing lighting installations for reducing sky glow effect.

Lighttechnical parameter	**Proposed limit**	**Application conditions**	**Applicable lighting environmental zone**
ULR	0%	Limits apply all times	E1

3.5.6 Parameters and Limiting Values for Quantitative Assessment of Energy Efficiency of External Lighting

3.5.6.1 Efficiency of lamps, control gear and luminaires

Hong Kong has already a voluntary Building Energy Code for lighting (Code of Practice for Energy Efficiency of Lighting Installations 2007 Edition) recommending limiting values of lamp efficacy and control gear loss for lighting installations in buildings. In the 2007 Edition of the Lighting Energy Code, it is stated that the requirements for the minimum allowable lamp luminous efficacy and the maximum allowable control gear loss are extended to outdoor lighting. It is recommended the lamp efficacy and control gear loss for outdoor lighting installations should alsocomply with the limits given in this lighting energy code.

3.5.6.2 Lighting power density (LPD)

The lighting power density (LPD) in W/m^2 could also be a suitable parameter for assessing the energy efficiency for lighting of building facades and signs. Noting that the LPD limits in overseas standards may not be directly applicable to Hong Kong's local context for meaningful comparison in view of the more densely populated urban area, higher building densities, and different business and social background, the study instead attempts to compare the LPD of external lighting across the 6 surveyed districts/areas.

With reference to the limiting values adopted by China JGJ/T 163-2008, the Beijing Municipal Standard DB 11/T 388.4 - 2006 and California Building Energy Efficiency Standard, the recommended limiting values for local use are given in Table 3.12. The recommended LPD values for building facade lighting are taken from the recommended limits Beijing Municipal Standard (The limits of Beijing Municipal Standard and China Trade Standard are similar but the former one is comparatively lenient). A single upper limit is recommended for each lighting environmental zone instead of values depending on facade reflectance for simplicity. The LPD values for externally and internally illuminated signs are recommended to be about $26W/m^2$ and $130W/m^2$ respectively based on the California 2008 Building Energy Efficiency Standards but those values do not mention to be applied for which lighting zones. Therefore, the recommended LPD values will only be the reference point for all the zones within this survey study.

Table 3.12 -Proposed limiting values of light power density for assessing energy efficiency of lighting for building facade and signs.

Type of lighting	**lighting Environmental Zones and proposed limiting values of Lighting Power Density (W/m^2)**			
	El	E2	E3	E4
Building facade lighting [1)]	0	7	9	14
Externally illuminated signs [2)] [4)]	26			
Internally illuminated sign [3)4)]	130			

1) Only the illuminated area of the building facade shall be used for calculating the LPD.
2) Only the illuminated area of the sign shall be used for calculating the LPD.
3) Only the luminous area of the sign shall be counted for calculation of LPD; for double-faced signs, only the area of a single face shall be counted
4) The values of LPD are for reference only given the fad that only single values of LPD for externally illuminated signs and internally illuminated signs appeared in California 2008 Building Energy Efficiency Standards.

4 SURVEY OF THE EXTERNAL LIGHTING CONDITIONS IN HONG KONG

4.1 Introduction

This part of the study firstly describes the general methodology to survey the external lighting situation of 6 representative districts/areas. The details of survey on external lighting conditions of the 6 representative districts/areas are included.

4.2 Survey Methodology

Before full survey for the 6 representative districts / areas for the study, a pilot survey was conducted to measure and assess the external lighting conditions at one of the representative areas in urban / residential-cum-commercial category, Nathan Road/Sai Yeung Choi Street (Mongkok) to work out a practical methodology/approach and model workflow for all the surveys. The methodology was then generally applied to all other selected urban and new town districts/areas and variations that existed would be further elaborated in the sub-section, 'Particular Measuring Requirement' of each representative districts/areas.

4.2.1 Pre-requisitions

Referring to the overseas practice, specific terms such as the lighting environmental zoning and curfew would be based on for the quantitative assessment of external lighting conditions. A lighting zoning system similar to the CIE lighting environmental zoning system is preliminarily adopted for those representative districts/areas and the system is given in Table 4.1. We will also compare the external lighting conditions in selected districts with the limits recommended in international reference standards. Details of the recommended limits in international standards are given in Table 4.2.

Table 4.1 -Lighting environmental zones adopted for survey

Zone	Lighting Environment	Examples of areas
El	Intrinsically dark	Country parks and designated areas for astronomical observations
E2	Low district brightness	Rural residential areas
E3	Medium district brightness	Residential areas, new towns
E4	High district brightness	City / town centres, commercial areas and designated commercial cum residential areas

Furthermore, the parameters and limits for measuring and assessing the light trespass, glare and night sky brightness as well as the energy efficiency of external lightings are proposed inthe Section 3.5,and summarized in Table 4.2.

Table 4.2. -Proposed parameters and thresholds for detailed survey in different district types.

District / area type	Preliminary lighting environmental zone classification	Relevant parameters to be measured	Proposed limits for comparison with the measured values		Reference Standard / Code for proposed limits
Urban residential (Kwun Tong)	E3	E_v at selected points on facade/window [1]	Pre-curfew	10 lx	CIE Standard
			Post-curfew	2 lx	
		I_d of bright luminaires in directions towards residents [2]	Pre-curfew	10000 cd	CIE Standard
			Post-curfew	1000 cd	
		L_s sign luminance	Pre-curfew	800 cd/m^2	CIE Standard
			Post-curfew	800 cd/m^2	
		LPD for signs [3]	Externally illuminated	26 W/m^2	California Energy Code
			Internally illuminated	130 W/m^2	
		Night sky brightness	No proposed limit for urban area		N/A
Urban commercial (Central)	E4	E_v at selected points on facade/window [1]	Pre-curfew	25 lx	CIE Standard
			Post-curfew	5 lx	
		I_d of bright luminaires in directions towards residents [2]	Pre-curfew	25000 cd	CIE Standard
			Post-curfew	2500 cd	
		L_b facade luminance	Pre-curfew	25 cd/m^2	CIE Standard
			Post-curfew	25 cd/m^2	
		L_s sign luminance	Pre-curfew	1000 cd/m^2	CIE Standard
			Post-curfew	1000 cd/m^2	
		LPD for building facade lighting [3]	Illuminated facade	14 W/m^2	Beijing Municipal Standard
		LPD for signs [3]	Externally illuminated	26 W/m^2	California Energy Code
			Internally illuminated	130 W/m^2	
		Night sky brightness	No proposed limit for urban area		N/A
Urban residential cum commercial (Causeway & Mongkok)	E4	E_v at selected points on facade/window [1]	Pre-curfew	25 lx	CIE Standard
			Post-curfew	5 lx	
		Id of bright luminaires in directions towards residents [2]	Pre-curfew	25000 cd	CIE Standard
			Post-curfew	2500 cd	
		L_b facade luminance	Pre-curfew	25 cd/m^2	CIE Standard
			Post-curfew	25 cd/m^2	
		L_s sign luminance	Pre-curfew	1000 cd/m^2	CIE Standard
			Post-curfew	1000 cd/m^2	
		LPD for building facade lighting [3]	Illuminated facade	14 W/m^2	Beijing Municipal Standard
		LPD for signs [3]	Externally illuminated	26 W/m^2	California Energy Code
			Internally illuminated	130 W/m^2	
		Night sky brightness	No proposed limit for urban area		N/A

District/ area type	Preliminary lighting environmental zone classification	Relevant parameters to be measured	Proposed limits for comparison with the measured values		Reference Standard / Code for proposed limits
Newtown (Tseung Kwan O)	E3	E_v at selected points on Facade/window[1)]	Pre-curfew	10 lx	CIE Standard
			Post-curfew	2 lx	
		I_d of bright luminaires indirections towards residents [2)]	Pre-curfew	10000 cd	CIE Standard
			Post-curfew	1000 cd	
		L_S sign luminance	Pre-curfew	800 cd/m^2	CIE Standard
			Post-curfew	800 cd/m^2	
		LPD for signs[3)]	Externally illuminated	26 W/m^2	California Energy Code
			Internally illuminated	130 W/m^2	
		Night sky brightness	No proposed limit for urban area		N/A
Rural / country park (Clear Water Bay)	E2	E_v at selected points on facade/window[1)]	Pre-curfew	5 lx	CIE Standard
			Post-curfew	1 lx	
		I_d of bright luminaires indirections towards residents[2)]	Pre-curfew	7500 cd	CIE Standard
			Post-curfew	500cd	
		L_s sign luminance	Pre-curfew	400 cd/m^2	CIE Standard
			Post-curfew	400 cd/m^2	
		LPD forsigns[3)]	Externally illuminated	26 W/m^2	California Energy Code
			Internally illuminated	130 W/m^2	
	E1	Night sky brightness	≥20 mag/arcsec ^{2}		N/A

Notes
1) Calculated from measured luminance L and estimated reflectance p : $E_V=\pi L/p$
2) Calculated from measured luminance L and estimated projected area A_P of luminaire. $I_d=LA_P$
3) Estimated from numberof luminaires and typical wattages.

4.2.2 Information of Survey Area

Before carrying out the on-site measurement of the impact of external lighting, certain information of the representative districts / areas shall first be explored by means of both desktop and site study.

For the site study, photo taking isthe major activity torecord the external lighting condition within the survey area and two sets of photo are to be taken: one set to illustrate the overall perception ofthe external lighting condition of each building block along the survey streets / roads with both unique manual settings and night-view-scene auto setting provided by the digital camera; and the other set to illustrate the existence of external lighting in smaller sections (e.g. floodlights in front of each shop, projected advertising panel of each building block) such that the quantity of luminaires could be estimated by checking these photos. In addition,the flashing/flickering /colour changing effects of external lighting are recorded by video for further investigation. Accessible places (e.g. cafes / salons above ground floor level) that may be available to carry out the proposed measurement at sensitive receiver side shall also be identified during the site study with supplementary photo / video records.

For the desktop study, information such as building name, building nature (i.e. residential / commercial) and number of floor and residential flats and the dimensions of survey area are to be explored so as to work out a baseline template with quantities and dimensions for sampling of proposed measurement and further quantifying the energy consumptions of external lighting in the survey area.

4.2. 3 Proposed Methodology /Approach for Survey

4.2.3.1 Based on the information consolidated in previous sections, the actual measurement / assessment were carried out in the survey area in July & August 2009.

(i) Parameter to be measured for assessing the effect of light trespass

- Vertical illuminance (E_v) from all lighting installations on relevant surfaces, e.g. windows, of residential premises is to be measured by application of the High Dynamic Range (HDR) Photography technology that the luminance level on each building block is captured by the camera that connected to a computer to control the exposure sequences. This raw data of the selected building blocks shall be further processed by the free licensed software and available on internet, 'Photosphere' to evaluate the measured luminance L (in cd/m^2) and the value of wall / facade reflectance ρ wm1ld then be estimated with reference to the building material so as to calculate the vertical illuminance E_v (in lx) by using the formula: $E_v = \pi L/\rho$.

(ii) Parameters to be measured for assessing the effect ofglare

- Luminous intensity emitted by luminaires (I_d) in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained. This parameter was proposed to be assessed at the sensitive receiver side where access could be granted, in which the luminous intensity (in cd) is calculated from measured luminance L (in cd/m^2) and estimated projected area A_p (in m^2) of luminaires by using the formula: $I_d = L\ A_P$ Due to the limitation to conduct intensity measurements on site as stated in Section 4.2.6, the parameters of some typical residents will be estimated by using the photometric polar curve of the similar bright luminaire according to the resident's view angle to the luminaire.

- Sign luminance (L_s) is to be measured by application of the High Dynamic Range Photography technology which luminance level of the selected signage is captured by the camera that connected to a computer to control the exposure sequences. The data capture by the images shall be further processed by the software, 'Photosphere' to evaluate the measuredluminance L_s (in cd/m^2).

(iii) Parameter used for measuring the magnitude of night sky brightness

- The night sky brightness is a suitable parameter for assessing the sky glow effect and the recommended limit value on sky glow effect is only applicable to the rural area at the Clear Water Bay Country Park. However, measurements of sky glow will also be conducted in all other selected districts / areas.
- It may be useful to adopt the night sky brightness in mag/arcsec^2 in special conservation zones for astronomical observations in rural area and the Sky Quality Meter is used for this measurement.

(iv) Parameters to be used for assessing energy efficiency of external lighting

- Lighting power density (LPD) in W/m^2 is used for assessing energy efficiency of signs and facade lightings on vertical area as well as shop front lighting. A luminaire schedule has been consolidated to list out the possible luminaire types, lamp types and nominal lamp / circuit wattages within the survey area such that the lighting power density could be estimated as the quantities of luminaire in each building block has been identified at the information gathering stage.
- Since LPD limits in overseas standards may not be directly applicable to Hong Kong, the LPD of external lighting including shop front lighting will be also estimated and compared across the 6 surveyed districts/areas.

(v) Over-illumination aspects will be assessed by comparing the measurement parameters with the corresponding proposed limit values in Table 4.2.

4.2.4 Approach for Site Measurements in Urban Areas

4.2.4.1 The survey team was formed by the Consultant and the sub-consultancy of lighting specialist, the Hong Kong Polytechnic University. A group briefing would first be conducted to all the team members concerning the scope and division of works based on the information collected in previous site visits and they would also be reminded some basic responsibilities to maintain safety awareness and minimal disturbance to the stakeholders (e.g. road users,residents, management offices, etc.) within the survey area.

4.2.4.1 After having confirmed the readiness of site survey conditions, often in between 19:30 and 20:00, they would be divided into at least 4 teams and each team would be assigned a different task of measurement or photo/video recording for 2 times in total (before and after the preset time (i.e. presumed curfew) of each representative district/area) in the selected urban areas:

1. High Dynamic Range (HDR) Imaging System would be applied that a Sigma 10-20rnrn F4-5.6 EX DC HSM lens equipped on the Digital Single-Lens Reflex (DSLR) Camera, Canon 350D was fixed on the tripod and connected to a notebook computer for controlling the exposure sequence. This photography technique could capture the luminance values (in cd/m^2) for the whole picture taken after further processing by the software 'Photosphere'.

2. Luminance Meter would be used to measure the sign luminance, L_s (in cd/m)^2 and also some sample points for validating the luminance values of the building envelope measured by the application of HDR Imaging System.

3. Photos/videos should be taken along the main survey areas with external lighting for recording the quantity and type of the luminaires/lamps before and after the preset time of each representative district/area.

4. Sky Quality Meter would be used to assess the sky glow of the selected districts/areas but the place of measurement could also be immediately near the survey area at a higher position so that the measured values would not be affected by the nearby lighting.

4.2.5 Measuring Instruments

(i) Illuminancemeter (KonicaMinoltaT-10/Center337MiniLightmeter)
(ii) Luminance meter (Minolta LS100)
(iii) HighDynamic Range (HDR) Imaging System(Canon 350Dwith Sigma 10-20rnrn F4-5.6 EX DC HSM lens)
(iv) Sky Quality Meter (Unihedron SQM-L)

4.2.6 Limitation for Measurement of Glare on Residents due to Bright Luminaries

4.2.6.1 In all the studied guidelines, the glare on residents is assessed by the intensity of bright luminaires in the direction of view of the residents. CIE150:2003 mentions about measurements both on site and in laboratory. For site measurement, it recommends the measurement of illuminance at the position of concern and then the intensity calculated by $I = E \cdot d^2$, where I is the intensity of the bright luminaire, E the measured illuminance at the position of concern (resident) and d is the distance between the luminaire and the resident. Because the objective is to measure the glare effect due to each single luminaire, the measurement must be carried out either with only the luminaire on or with effective shielding of all light from other light sources.

4.2.6.2 CIE 150:2003 (p. 21) states that *"It is recommended that the luminous intensity data be obtained from tests conducted by a laboratory that is independently accredited as competent to carry out the type of measurements involved."* Then the intensity can be determined by knowing the directions of the view from the residents (windows) to the luminaire concerned with reference to the aiming direction of the l luminaire. The determination involves mainly the calculation of angles and then the required intensity can be obtained from the intensity distribution tested in a laboratory.

4.2.6.3 The best approach for the glare measurement of the target bright light sources should be using the luminance meter from the point of view at the sensitive receiver side. However, access to the residential premises to assess glare is subject to the owner / occupant's permission. Even if the premises are accessible, it is also not practicable to measure the glare caused by the bright luminaire visible to the residents because there are too many light sources in the area making the shielding of light from other sources impracticable, if not totally impossible.

4.2.6.4 For assessing the glare problems in this study, an alternative is to identify the existence of glare problem by visual inspection such as proximity of bright light sources to nearby residential flats as well as the aiming angles. Once the glare problem is observed in the selected districts / areas, related photometric data,

aiming angle and the distance between the bright light source and the most affected residential flats will be collected and recorded, and to determine the intensity of bright luminaires in the direction of view of the residents by using the photometric polarcurve of the similar bright luminaire.

4.2.7 Limitation for Measurement of LPD for Internally & Externally Illuminated Signs

4.2.7.1 As it is not practicable to open up the signs to count the quantities of luminaries installed inside the signs, the following assumptions are made for our estimation of LPD for internally illuminated signs:

(i) Batten fluorescent tubes to be adopted;
(ii) It sbatten areas of T8 FL36W batten is $0.06 \text{xl.} 2 = 0.072 m^2$;
(iii) Electromagnetic ballast efficiency is 0.8 ;
(iv) sign luminaire space factor is 0.4;

Hence, in general, the LPD of internally illuminated signs are estimated to about $250 W/m^2$(i.e. 36/0.8/0.072x0.4). The value of LPD will be varied slightly due to various sizes of signs.

4.2.7.2 As it is difficult and not practicable to determine the exact model of external luminaries installed, the power wattage of the counted quantities are estimated according to the similar type of externally luminaires by visual observation. The values of LPD for externally illuminated signs are estimated by the total estimated power wattage of luminaries dividing by total estimated area of its externally illuminated signs.

4.2.8 Measurement of Vertical Illuminance on Facade/Windows of Residents

The high dynamic range imaging (HDRI) technique was used to measure luminance values for estimation of the vertical illuminance on facade/windows which is the parameter used for assessing the light trespass into residential premises.

4.2.9 Benchmark to Classify the External Lighting Impacts

4.2.9.1 Light trespass affecting the sensitive receivers is considered a suitable indicator to gauge the extent of external lighting impacts in respect of light nuisance in the surveyed districts/areas. The major criterion selected for assessing the external lighting impact to the sensitive receivers in the selected districts/areas is the light trespass measured at pre-curfew and post-curfew when compared with the CIE standards. For comparison, the proposed benchmark to classify the extent of external lighting impact in the surveyed districts/areas as a whole is shown in the below table.

Table 4.3-Benchmark to classify the light trespass impacts

Light Trespass Impact	Major Criteria (% of residents having light trespass over CIE standards at pre-curfew or at post-curfew)
Insignificant	Below 20%
Not that significant	20% to below 40%
Quite Significant	40% to below 60%
Significant	60% to below 80%
Very Significant	80% & above

4.3 Survey on External Lighting Conditions of 6 Representative Districts / Areas in Hong kong

4.3.1 Shun Lee Estate (Kwun Tong) in Urban Residential Area (E3)

4.3.1.1 District I Area Overview

Shun Lee Estate (Kwun Tong) is a typical public /subsidized housing estate in residential district /area and a balanced and self-contained community, in terms of provision of infrastructure and community facilities such as shopping centres, schools,markets,car parks, playgrounds/sports courts and bus terminus /mass transportation. Residents near/facing the playgrounds/sports courts andresidents facing to the signs probably affected by the sign and sport lighting illumination.

The total size of the uncovered horizontal areas being surveyed was about 3,450sqm. The length 383m along Lee On Road was surveyed to carry out the assessment impacts of external lighting on five residential buildings, basketball court and podium shopping centre. The boundary of proposed surveyed district/area is shown on Appendix A

Basketball Court and Podium (shopping centre) were selected for surveying since the residents living near to both areas having the highest probability of suffering the light illumination from the signs and sport lighting because most of the logo signs and external lighting are located in both areas.

There is one residential building with 96 residential flats at the side facing the Basketball Court. Meanwhile, there are 4 residential buildings with about 1,038 residential flats at the side facing the podium shopping centre.

4.3.1.2 Particular Measuring Requirements / Measurement Data

1) Effect of light trespass

The HDR image capture was carried out within two time slots. The first time slot was from 20:00 to 21:30 when most of the outdoor lights were on. The second time slot was from 23:00 to 00:15 when a number of the outdoor lights were turned off. The number of windows with estimated vertical illuminance is 530. The survey results are summarized as follows:-

Description	Period20:00-21:30 Pre-curfew	Period 23:00-00:15 Post-curfew
Total number of windows with vertical illuminance estimated (Shun Lee Estate)	530	
Average vertical illuminance (in lx)	4.01 lx	1.91 lx
Max vertical illuminance (in lx)	25.66 lx	4.71 lx

The following table shows percentage of survey points exceeding CIE limits and limits recommended in the Shanghai standard DB31/T316-2004, at pre-curfew and post- curfew.

	Period 20:00-21:30 Pre-curfew			Period 23:00-00:15 Post-curfew		
	Proposed limit (in lx)	No. of point exceeding limit	Percentage	Proposed limit (in lx)	No. of point exceeding limit	Percentage
Pre-curfew: 10 lx, Post-curfew: 2 lx. (CIE Limit- E3)	10	4	0.8%	2	223	42.1%
Pre-curfew: 25 lx, Post-curfew: 4 lx. (Shanghai Limit-E3)	25	1	0.2%	4	22	4.2%
Pre-curfew: calculated avg 4.01lx,Post-curfew: calculated avg 1.91 lx.	4.01	225	42.5%	1.91	223	42.1%

2) Glare on residents due to bright luminaires

The luminous intensities (I_d) emitted by the closest luminaires in directions where bright surfaces of luminaires affect resident flats at the lower levels (i.e. 1/F to 3/F) of the building are evaluated and the highest value was around 4380.06 cd, which is lower than the limit recommended in the CIE Standard (l0,000cd).

3) Sign luminance

The measurement was taken at about 20: 15 on the survey day. The sign was found to be turned off at about 22:00. The recommended limits apply to all times and there was no distinction of pre-curfew and post-curfew time.

Location	Type of sign	No.of signs surveyed	No. of signs exceeding the limit			
			400 cd/m^2	600 cd/m^2	800[1)] cd/m^2	1000 cd/m^2
Shun Lee Shopping Centre	Internally illuminated	0	0	0	0	0
	Externally illuminated	0	0	0	0	0
	Neon	1	0	0	0	0
	Total	1	0	0	0	0

Note:
1) Recommended limit of sign luminance in zone E3 by CIE150:2003. This is also the proposed limiting luminance for zone E3 in Table3.8 in Section 3.5.3.

4) Building facade luminance

There was no purposely illuminated facade in the survey area.

5) Sign lighting power density

The lighting power densities of signs in the survey area were estimated by total luminaire power dividing by sign area. The recommended limits apply to all times and there was no distinction of pre-curfew and post-curfew time. The following table gives the overall statistics of the lighting power density of signs estimated in the survey area.

Location	Type of sign	No. of signs surveyed	No. of internally illuminated signs exceeding the limit
			130[1] W/m^2
Shun Lee Shopping Centre	Internally illuminated	0	0
	Total	0	0
	Type of sign	No. of signs surveyed	No. of externally illuminated signs exceeding the limit
			26[2] W/m^2
	Externally illuminated	0	0
	Neon	1[3]	1
	Total	1	1

Notes:
1) Recommended limit of internally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This also the proposed limiting LPD for zone E3 in the Table 3.12in Section 3.5.6.
2) Recommended limit of externally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD for zone E3 in the Table 3.12 in Section 3.5.6.
3) Neon power consumption is assumed: 15W/m; sign area: 15m^2; neon tube length: 103m; LPD = 15x103/15=103W/m^2.

6) Sky glow

The sky glow was measured at high positions at Shun Lee Estate Shopping Centre, and they were ranged from 16.85 to 17.08 mag/arcsec^2. The measurement location is representative as it is higher than the surrounding external lightings and provides adequate measuring angle directed to the sky.

4.3.2 Des Voeux Road Central /Chater Road (Central) in Commercial Area (E4)

4.3.2.1 District/ Area Overview

Central is a Commercial district/area and it should be so representative since Central is not only the heart of central business district (CBD) but is also an international financial centre in Hong Kong. Most famous flagship shops of world-known brand names are located in Central, the extent of internal / external facade lightings is extensive for the commercial / office buildings nearby and so do the upward light beams and advertising panels on the roof top of the skyscrapers that inevitably light up the sky at night times.
Chater Road and Des Voeux Road Central were selected for surveying since both are one of the most crowded areas in Central and most of the advertising panels and external lighting are located in both areas.

The total size of the uncovered horizontal areas being surveyed was about 8,590sqm. Typical sections of lengths 161m and 213m along Chater Road and Des Voeux Road respectively were surveyed in the study to carry out the assessment impacts of external lighting on 6 buildings (6 commercial including 1 hotel) and 32 commercial buildings. The boundary of proposed surveyed district/area is shown on Appendix A

4.3.2.2 Particular Measuring Requirements / Measurement Data

1) Effect of light trespass

There is only one building being used for hotel purpose within the survey area. As a hotel, it is mainly used for short-term residential purpose by tourists. Vertical illuminance on facade/windows facing Chater Road and Statue Square were estimated by HDR imaging technique. The images for these two facade were taken at two time periods, once at 20:00-20:50 and the second time at 00:00-00:45.

The number of windows with estimated vertical illuminance is 280. The survey results are summarized as follows:-

Description	Period 20:00-20:50 Pre-curfew	Period 00:00-00:45 Post-curfew
Total number of windows with vertical illuminance estimated (Des Voeux Road Central / Chater Road (Central))	280	
Average vertical illuminance (in lx)	10.89 lx	4.93 lx
Max vertical illuminance (in lx)	27.07lx	16.92 lx

The following table shows percentage of survey points exceeding CIE and Shanghai limit at pre-curfew and post-curfew.

	Period 20:00-20:50 Pre-curfew			Period 00:00-00:45 Post-curfew		
	Proposed limit (in lx)	No. of point exceeding limit	Percentage	Proposed limit (in lx)	No. of point exceeding limit	Percentage
Pre-curfew: 25 lx, Post-curfew: 5 lx. (CIE - imit - E4)	25	5	1.8%	5	93	33.2%
Pre-curfew: 50 lx, Post-curfew: 25 lx. (Shanghai -imit -E4)	50	0	0.0%	25	0	0.0%
Pre-curfew: calculated avg 10.89 lx, Post-curfew: calculated avg 4.93 lx.	10.89	92	32.9%	4.93	93	33.2%

2) Glare on residents due to bright luminaires

By the on site observation, there was no bright luminaire directly viewed by the hotel residents and therefore, no potential glare was identified in Central.

3) Sign luminance

The average luminances of signs in the survey area were obtained by the HDR technique. CIE150:2003 recommends the use of a luminance meter to take at least three readings visibly chosen for the measurement of average luminance. All measurements of sign luminance were taken in the period of 20:00-22:15. The recommended limits apply to all times and there is no distinction of pre-curfew and post-curfew time. All signs larger than 5 m^2 and most signs smaller than 5 m^2 were included in the survey. These included signs installed on building facades and standalone signs such as those at bus/tram stops. The following table gives the overall statistics of the luminance of signs measured in the survey area.

Location	Type of sign	No. of signs surveyed	No. of signs exceeding the limit			
			400 cd/m^2	600 cd/m^2	800 cd/m^2	1000 [1)] cd/m^2
Des Voeux Road Central	Internally illuminated	3	2	1	0	0
	Externally illuminated	8	0	0	0	0
	Neon	2	0	0	0	0
	Total	13	2	1	0	0
Chater Road	Internally illuminated	9	4	1	1	0
	Externally illuminated	5	0	0	0	0
	Neon	2	0	0	0	0
	Total	16	4	1	1	0
Total Central survey area	Internally illuminated	12	6	2	1	0
	Externally illuminated	13	0	0	0	0
	Neon	4	0	0	0	0
	Total	29	6	2	1	0

Note:
I) Recommended limit of sign luminance in zone E4 by CIE150:2003. This is also the proposed limiting luminance for zone E4 in Table 3.8 in Section 3.5.3.

4) Building facade luminance

There were only 2 building facades in the survey area with facade lighting installed. The crown of Building " FCR-B1" is lit to a yellowish appearance but for only a small area with a large setback from the main facades of the building so that people nearby on the street level cannot see the illuminated crown.

Along Des Voeux Road Central, Building "FDV-B1" has floodlights illuminating the lower floors only. The following table gives a summary of the measurement results.

Building facade	Average luminance (cd/m^2) CIE limit 25 cd/m^2 apply to all times
Building "FCR-B1" (facade facing Chater Road)	12.9
Building "FDV-B 1"(facade facing Des Voeux Road Central)	7.9

From the above results, all the purposely illuminated facades have average luminance lower than the limit recommended in CIE and the proposed limits in Table 3.8 in Section 3.5.3.

5) Sign lighting power density

The lighting power densities of signs in the survey area were estimated by total luminaire power dividing by sign area. The recommended limits apply to all times and there is no distinction of pre-curfew and post-curfew time. Based on the assumptions in para. 4.2.7.1, the LPD of internally illuminated signs is estimated to about 250W/m^2. The following table gives the overall statistics of the lighting power density of signs estimated in the survey area.

Type of sign	Location	No. of Signs surveyed	No. of internally illuminated signs exceeding the limit		
			130[1] W/m^2		
Internally illuminated	Des Voeux Road Central	3	3		
	Chater Road	9	9		
	Total	12	12		
Type of sign	Location	No. of Signs surveyed	No. of externally illuminated signs exceeding the limit		
			26[2] W/m2	60 W/m^2	100 W/m^2
Externally illuminated	Des Voeux Road Central	8	7	7	3
	Chater Road	5	5	5	4
	Total	13	12	12	7
Neon	Des Voeux Road Central	2	1	1	1
	Chater Road	2	2	0	0
	Total	4	3	1	1

Notes:

1) Recommended limit of internally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD in the Table 3.12 in Section 3.5.6.
2) Recommended limit of externally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD in the Table3.12 in Section 3.5.6.

6) Luminance and Lighting Power Density of Building Facade Lighting

Building facade	Average luminance (cd/m^2) (CIE and our proposed limit 25 cd/m^2 apply to all times)	LPD for building facade lighting[1)]
Building "FCR-B1" (facade facing Chater Road)	12.9	Facade lighting fixtures cannot be viewed.
Building "FDV-B1"(facade facing Des Voeux Road Central) {only 3 of 7 lamps were lit up at measurement}	7.9	5.55 W/m^2 [2)]

Notes:

1) Except 7 facade lighting fixtures (3 of 7 lamps were lit up at measurement) of Building "FDV-B1", other facade lighting fixtures were recessed and cannot be viewed. We only provided Facade light LPD for the Butlding "FDV-B1".
2) The LPD for the Building "FDV-B1" was estimated as 1296 W/m^2 [=250W x 7 /(7 5m x 18m)] for all 7 lamps lit up and 5.55 W/m^2 [=250W x 3 / (7.5m x 18m)) for only 3 of 7 lamps turning ON in this case. The facade lighting LPD is less than 14 W/m^2 for E4 Zone according to the propsed limits for E4 zone in Table 3.12.

7) sky glow

The sky glow was measured along the open areas near Statue Square and they were ranged from 14.92 to 15.34 mag/$arcsec^2$. The measurement spots were the only locations at ground floor level not sandwiched by near by tall buildings and allowed the measurement taken place effectively.

4.3.3 Paterson Street / Great George Street (Causeway Bay) in Commercial-cum-residential Area (E4)

4.3.3.1 District/ Area Overview

Causeway Bay is a Residential-cum-Commercial district/area and is one of the most crowded areas in Hong Kong. Causeway Bay is characterized by a mixture of old and new multi-story buildings, with shops and restaurants at street level and commercial or residential units above and some of the shops are open until well after midnight.

Great George Street and Paterson Street were selected for surveying since both are one of the most crowded areas in Causeway Bay and the residents living above the shopping units are probably affected by the signs illumination since many advertising panels and external lighting are located there.

The total size of the uncovered horizontal areas being surveying was about 3,230sqm. Typical sections of lengths 92m and 136m along Great George Street and Paterson Street respectively were surveyed in the study to carry out the assessment impacts of external lighting on 8 buildings (4 commercial and 4 residential) along Great George Street and 19 buildings (1 commercial and 18 residential) along Paterson Street. The boundary of proposed surveyed district/area is shown on Appendix A .

4.3.3.2 Particular Measuring Requirements / Measurement Data

1) Effect of light trespass

HDR images were taken at various locations in Paterson Street and Great George Street covering the whole area of study. Residential units in the buildings in the survey location were included in the survey of the effect of light trespass on residents by estimating of vertical illuminance on facade/ windows.

These buildings represent all buildings with residential units in the survey area except a building, which was under renovation with the facade covered by scaffolding, and a hotel which has a large setback for facade facing Great George Street. The HDR image capture was carried out within two time slots. The first time slot was from 20 :00 to 22:00 when most of the outdoor lights were on. The second time slot was from 00:00 to 02:00 when a number of the outdoor lights were turned off.

The number of windows with estimated vertical illuminance is 656. The survey results are summarized as follows:-

Description	Period 20:00-22:00 Pre-curfew	Period 00:00 to 02:00 Post-curfew
Total number of windows with vertical illuminance estimated (Causeway Bay)	656	
Average vertical illuminance (in lx)	17.96 lx	4.17 lx
Max vertical illuminance (in lx)	143.55 lx	129.53 lx

The following table shows percentage of survey points exceeding CIE and Shanghai limit at pre-curfew and post-curfew.

	Period 20:00-22:00 Pre-curfew			Period 00:00-02:00 Post-curfew		
	Proposed limit (in lx)	No. of point exceeding limit	Percentage	Proposed limit (in lx)	No. of point exceeding limit	Percentage
Pre-curfew: 25 lx, Post-curfew: 5 lx. (CIE Limit-E4)	25	148	22.56%	5	129	19.66%
Pre-curfew: 50 lx, Post-curfew: 25 lx. (Shanghai Limit-E4)	50	43	6.55%	25	8	1.22%
Pre-curfew: calculated avg 17.96 lx, Post-curfew: calculated avg 4.17 lx.	17.96	231	35.2%	4.17	190	29.0%

2) Glare on residents due to bright luminaires

By the on site observation, there was no bright luminaire directly viewed by the residents and therefore, no potential glare was identified in Causeway Bay.

3) Sign luminance

The average luminance of signs in the survey area was obtained by the HDR technique. CIE150:2003 recommends the use of a luminance meter to take at least three readings visibly chosen for the measurement of average luminance. All measurements of sign luminance were taken in the period of 20:00-22:15. The recommended limits apply to all times and there is no distinction of pre-curfew and post-curfew time. The following table gives the overall statistics of the luminance of signs measured in the survey area.

Since the facade of two buildings was under renovation at the time of survey, the floodlights and signs located there were temporary installations. Therefore the signs at these two buildings were not included in the survey. Except for those signs at two buildings, all signs larger than 5 m^2 and most signs smaller than 5 m^2 were included in the survey.

Location	Type of sign	No. of signs surveyed	No. of signs exceeding the limit			
			400 cd/m^2	600 cd/m^2	800 cd/m^2	1000[1)] cd/m^2
Paterson Street	Internally illuminated	24	2	0	0	0
	Externally illuminated	21	3	0	0	0
	Neon	5	0	0	0	0
	Total	50	5	0	0	0
Great George Street	Internally illuminated	6	1	0	0	0
	Externally illuminated	7	0	0	0	0
	Neon	1	1	1	0	0
	Total	14	2	1	0	0
Total Causeway Bay survey area	Internally illuminated	30	3	0	0	0
	Externally illuminated	28	3	0	0	0
	Neon	6	1	1	0	0
	Total	64	7	1	0	0

Note:
1) Recommended limit of sign luminance in zone E4 by CIE150:2003. This is also the proposed limiting luminance for zone E4 in Table 3.8. in Section 3.5.3.

4) Building facade luminance

There was no purposely illuminated facade in the survey area.

5) Sign lighting power density

The lighting power densities of signs in the survey area were estimated by total luminaire power dividing by sign area. The recommended limits apply to all times and there is no distinction of pre-curfew and post-curfew time. Based on the assumptions in para. 4.2.7.1, the LPD of internally illuminated signs is estimated to about 250W/m^2. The following table gives the overall statistics of the lighting power density of signs estimated in the survey area.

Type of sign	Location	No. of signs surveyed	No. of internally illuminated signs exceeding the limit		
			130[1] W/m^2		
Internally illuminated	Paterson Street	24	24		
	Great George Street	6	6		
	Total	30	30		
Type of sign	Location	No. of signs surveyed	No. of externally illuminated signs exceeding the limit		
			26[2] W/m^2	60 W/m^2	100 W/m^2
Externally illuminated	Paterson Street	21	21	21	18
	Great George Street	7	7	7	7
	Total	28	28	28	25
Neon	Paterson Street	5	4	3	2
	Great George Street	1	0	0	0
	Total	6	4	3	2

Notes:

1) Recommended limit of internally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD in the Table 3.12 in Section 3.5.6.

2) Recommended limit of externally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD in the Table 3.12 in Section 3.5.6.

6) Sky glow

The sky glow was measured at the roof of a building in the district and they were ranged from 15.59 to 16.80 mag/arcsec^2. The measurement location was near the surveyed area and could be accessed to the roof floor to take the data with minimum influence by nearby external lighting.

4.3.4 Nathan Road / Sai Yeung Choi Street South (Mongkok) in Commercial-cum-residential Area (E4)

4.3.4.1 District /Area Overview

Mong Kok is a Residential-cum-Commercial district/area and is one of the most crowded areas in Hong Kong. Mong Kok is characterized by a mixture of old and new multi-story buildings, with shops and restaurants at street level and commercial or residential units above.

Nathan Road and Sai Yeung Choi Street South were selected for surveying since both are one of the most crowded areas in Mong Kok and the residents living above the shopping units having an extremely large probability of suffering the light illumination from the signs and sport lighting because most of the advertising panels and external lighting are located in both areas.

The total size of the uncovered horizontal areas being surveyed was about 4,820sqm. Typical sections of lengths 140m and 137m along Nathan Road and Sa Yeung Choi Street South respectively were surveyed in the study to carry out the assessment impacts of external lighting on 17 buildings (10 commercial and 7 residential) facing to Nathan Road and 25 buildings (5 commercial and 20 residential) facing to Sai Yeung Choi Street South. The boundary of proposed surveyed district/area is shown on Appendix A.

4.3.4.2 Particular Measuring Requirements / Measurement Data

1) Effect of light trespass

HDR images were taken at various locations in Nathan Road and Sai Yeung Choi Street South covering the whole area of study. The effect of light trespass on residents were also estimated based on the vertical illuminance on facade/windows.

These buildings represent all buildings with residential units in the survey area except one building at Nathan Road which was covered by a large advertising sign. The HDR image capture was carried out within two time slots. The first time slot was from 20:00 to 22:00 when most of the outdoor lights were on. The second time slot was from 00:00 to 02:00 when a number of the outdoor lights were turned off.

The number of windows with estimated vertical illuminance is 678. The survey results are summarized as follows:-

Description	Period 20:00-22:00 Pre-curfew	Period 00:00 to 02:00 Post-curfew
Total number of windows with vertical illuminance estimated (Mongkok)	678	
Average vertical illuminance(in lx)	63.05 lx	12.27 lx
Max vertical illuminance (in lx)	1,272.35 lx	183.78 lx

The following table shows percentage of survey points exceeding CIE and Shanghai limit at pre-curfew and post-curfew.

	Period 20:00-22:00 Pre-curfew			Period 00:00-02:00 Post-curfew		
	Proposed limit (in lx)	No. of point exceeding limit	Percentage	Proposed limit (in lx)	No.of point exceeding limit	Percentage
Pre-curfew: 25 lx, Post-curfew: *5* lx. (CIELimit-FA)	25	494	72.86%	*5*	498	73.45%
Pre-curfew: 50 lx, Post-curfew: 25 lx. (Shanghai Limit -E4)	50	310	45.72%	25	60	8.85%
Pre-curfew:calculated avg 63.05 lx, Post-curfew: calculated avg 12.27 1x.	63.05	237	34.96%	12.27	202	29.8%

2) Glare on residents due to bright luminaires

All the residential premises in the survey area were not accessible without authorization by the residents. Therefore, this parameter was estimated instead of measured.

For assessing the glare problems in Mongkok, the existence of glare problem was identified by visual inspection such as proximity of bright light sources to nearby residential flats as well as the aiming angles. According to site observations, the potential glare problems were found at four locations at Sai Yeung Choi Street South.

The luminous intensities (I_d) emitted by the high bay flood lights mounted outside one of commercial centres in directions to the affected residents at three residential buildings nearby were evaluated in range between 4,168 cd and 37,596cd and the highest value was around 37,596cd that exceeded the recommended limits of CIE Standard (25,000cd).

3) Sign luminance

The average luminance of signs in the survey area was obtained by the HDR technique with consistency check by a spot luminance meter. CIE150:2003 recommends the use of a luminance meter to take at least three readings visibly chosen for the measurement of average luminance. All measurements of sign luminance were taken in the period of 20:00-22:00. The recommended limits apply to all times and there is no distinction of pre-curfew and post-curfew time. All signs larger than 5 m^2 and most signs smaller than 5m^2 were included in the survey. The following table gives the overall statistics of the luminance of signs measured in the survey area.

Location	Type of Sign	No. of signs surveyed	No. of signs exceeding the limit			
			400 cd/m^2	600 cd/m^2	800 cd/m^2	1000[1] cd/m^2
Nathan road	Internally illuminated	25	0	0	0	0
	Externally illuminated	23	2	1	1	0
	Neon	17	0	0	0	0
	Total	65	2	1	1	0
Sai Yeung Choi Street	Internally illuminated	41	9	5	2	1
	Externally illuminated	52	7	5	5	3
	Neon	8	1	1	0	0
	Total	101	17	11	7	4
Total Mongkok survey area	Internally illuminated	66	9	5	2	1
	Externally illuminated	75	9	6	6	3
	Neon	25	1	1	0	0
	Total	166	19	12	8	4

Note:
1) Recommended limit of sign luminance in zone E4 by CIE150:2003. This is also the proposed limiting luminance for zone E4 in Table 3.8in Section 3.5.3.

4) Building facade luminance

There was no purposely illuminated facade in the survey area.

5) Sign lighting power density

The lighting power densities of signs in the survey area were estimated by total luminaire power dividing by sign area. The recommended limits apply to all times and there is no distinction of pre-curfew and post-curfew time. Based on the assumptions in para. 4.2.7.1, the LPD of internally illuminated signs is estimated to about *250W/m²*. The following table gives the overall statistics of the lighting power density of signs estimated in the survey area.

Type of sign	Location	No. of signs surveyed	No. of internally illuminated signs exceeding the limit		
			130[1] W/m²		
Internally illuminated[3]	Nathan road	25	25		
	Sai Yeung Choi Street	41	41		
	Total	66	66		
Type of sign	Location	No. of signs surveyed	No. of externally illuminated signs exceeding the limit		
			26[2] W/m²	60 W/m²	100 W/m²
Externally illuminated	Nathan road	23	22	20	16
	Sai Yeung Choi Street	52	52	48	40
	Total	75	74	68	56
Neon	Nathan road	17	17	9	1
	Sai Yeung Choi Street	8	8	8	7
	Total	25	25	17	8

Notes:
1) Recommended limit of internally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD in the Table 3.12 in Section 3.5.6.
2) Recommended limit of externally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD in the Table 3.12 in Section 3.5.6.

6) Sky glow

The sky glow was measured at the roof of a building and they were ranged from 16.10 to 16.41 mag/arcsec². The measurement location was near the surveyed area and could be accessed to the roof floor to take the data with minimum influence by nearby external lighting.

4.3.5 Yan King Road /Kai King Road (Po Lam, Tseung Kwan O) in New Town Area (E3)

4.3.5.1 District / Area Overview

Yan King Road / Kai King Road (Po Lam) is a New Town district/area and including public / subsidized housing estates and private housing estate with shopping plaza. The provision of community facilities and mass transportation are well developed next to the Po Lam.

The total size of the uncovered horizontal areas being surveyed was about 1,550sqm. Typical sections of lengths 193m and 55m along Yan King Road and Kai King Road respectively were surveyed in the study to carry out the assessment impacts of external lighting on 12 residential buildings facing to Yan King Road and 2 residential buildings facing to Kai King Road. The boundary of proposed surveyed district/area is shown on Appendix A.

4.3.5.2 Particular Measuring Requirements / Measurement Data

1) Effect of light trespass

Site assessment were taken at various strategic locations in Yan King Road/ Kai King Road. The effect of light trespass to nearby buildings were then estimated based on the vertical illuminance on facade/windows.

The number of windows with estimated vertical illuminance is 647. The survey results aresummarized as follows:-

Description	Period 20:00-21:30 Pre-curfew	Period 22:45-00:00 Post-curfew
Total number of windows with vertical illuminance estimated (Po Lam,Tseung Kwan O)	647	
Average vertical illuminance (in lx)	2.19 lx	1.53 lx
Max vertical illuminance (in lx)	9.87 lx	7.85 lx

The following table shows percentage of survey points exceeding CIE and Shanghai limit at pre-curfew and post-curfew.

	Period 20:00-21:30 Pre-curfew			Period 22:45-00:00 Post-curfew		
	Proposed limit (in lx)	No. of point exceeding limit	Percentage	Proposed limit (in lx)	No. of point exceeding limit	Percentage
Pre-curfew: 10 lx, Post-curfew: 2 lx. (CIE Limit - E3)	10	0	0.00%	2	125	19.32%
Pre-curfew:25 lx, Post-curfew: 4 lx. (Shanghai Limit - E3)	25	0	0.00%	4	22	3.40%
Pre-curfew: calculated avg. 2.19 lx, Post-curfew: calculated avg. 1.53 lx.	2.19	212	32.77%	1.53	227	35.09%

2) Glare on residents due to bright luminaires

By the on-site observation, there was no bright luminaire directly viewed by the residents and therefore, no potential glare was identified at Yan King Road/Kai King Road (Po Lam).

3) Sign luminance

The average luminance of signs in the survey area was obtained by the HDR technique. CIE150:2003 recommends the use of a luminance meter to take at least three readings visibly chosen for the measurement of average luminance. All measurements of sign luminance were taken in the period of 20:00-22:00. The recommended limits apply to all times and there is no distinction of pre-curfew and post-curfew time.

In the survey area, significant signs which may affect residents of two residential buildings are those on the facade below the podium level of a private shopping centre. These signs are similar except some difference in the graphics shown. The centre white portion of the signs is brightest and hence, for each sign, measurement of average luminance is taken separately for the centre part and the outer perimeter which is purple. These were the only signs found with an area larger than 5 m^2.

The following table gives the overall statistics of the luminance of signs measured in the survey area.

Location	Type of sign	No. of signs surveyed	No. of signs exceeding the limit			
			400 cd/m^2	600 cd/m^2	800[1)] cd/m^2	1000 cd/m^2
Private shopping centre	Internally illuminated	7	0	0	0	0
	Externally illuminated	0	0	0	0	0
	Neon	0	0	0	0	0
	Total	7	0	0	0	0

Note:
1) Recommended limit of sign luminance in zone E3 by CIE150 2003. This is also the proposed limiting luminance for zone E3 in Table3.8 in Section 3.5.3,.

4) Building facade luminance

There was no illuminated facade in the survey area.

5) Sign lighting power density

The lighting power densities of signs in the survey area were estimated by total luminaire power dividing by sign area. The recommended limits apply to all times and there is no distinction of pre-curfew and post-curfew time. Based on the assumptions in para. 4.2.7.1, the LPD of internally illuminated signs is estimated to about 250W/m^2. The following table gives the overall statistics of the lighting power density of signs estimated in the survey area.

Location	Type of sign	No. of Signs surveyed	No. of internally illuminated signs exceeding the limit		
			130[1] W/m^2		
Private shopping centre	Internally illuminated[3]	7	7		
	Total	7	7		
			No. of externally illuminated signs exceeding the limit		
			26[2] W/m^2	50 W/m^2	100 W/m^2
	Externally illuminated	0	0	0	0
	Neon	0	0	0	0
	Total	0	0	0	0

Notes.

1) Recommended limit of internally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD in the Table 3.12 in Section 3.5.6.
2) Recommended limit of externally illuminated sign LPD by the California 2008 Building Energy Efficiency Standards. This is also the proposed limiting LPD in the Table 3.12 in Section 3.5.6.

6) Sky glow

The sky glow was measured at the roof of a representative building in the district and the measured values were ranged from 17.28 to 17.54 mag/ arcsec^2 . The measurement location was near the surveyed area and the roof floor could be easily accessed for measurement with minimum influence by nearby external lighting.

4.3.6 Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (Sai Kung) in Rural Area (E2)

4.3.6.1 District/Area Overview

Clear Water Bay Country Park with two villages Tai Hang Hau and Tai Wan Tau are including in the survey area of rural district / area. The major external lightings are security and street lightings only in this area and will not cause the sky glow problem. This area is selected for this study and aimed to measure sky glow and investigate what level of the sky glow are affected by the sky glow of the adjacent / nearby districts/ areas such as Tseung Kwan O through the light scattering by the suspended fine solid particles in the atmosphere. The site measurement data were taken in July, 2009. The boundary of proposed surveyed district/areais shown on Appendix A

4.3.6.2 Particular Measuring Requirements / Measurement Data

1) Effect of light trespass

Digital images of 2 scenes, one at each of the two villages Tai Hang Hau and Tai Wan Tau, of residential building facades were taken. These images were used for the assessment of light trespass using the parameter, vertical illuminance on facade/ windows.

Since there is no commercial lighting in the area and the street lights and security lighting are all turned on throughout the whole night, the values are used to assess the effect of light trespass using recommended limits for both pre-curfew time and post-curfew time.

The number of windows with estimated vertical illuminance is 42. The survey results are summarized as follows:-

Description	Period 20:15-21:30 Pre-curfew	Period 00:00 to 02:00 Post-curfew
Total number of windows with vertical illuminance estimated (Sai Kung)	42	
Average vertical illuminance (in lx)	1.64 lx	16.4 lx
Max vertical illuminance (in lx)	7.55 lx	7.55lx

The following table shows percentage of survey points exceeding CIE limit at pre-curfew and post-curfew.

	Period 20:15-21:30 Pre-curfew			Period 00:00-02:00 Post-curfew		
	Proposed limit (in lx)	No. of point exceeding limit	Percentage	Proposed limit (in lx)	No. of point exceeding limit	Percentage
Pre-curfew:5 lx, Post-curfew:1lx. (CIE Limit- E2)	5	4	9.52%	1	17	40.48%
Pre-curfew: calculated avg 1.64 lx, Post-curfew: calculated avg 1.64 lx.	1.64	13	30.95%	1.64	13	30.95%

2) Glare on residents due to bright luminaires

By the on site observation, there was no bright luminaire directly viewed by the residents and therefore, no potential glare was identified in the survey area.

3) Sign luminance

There was no sign found in the survey area.

4) Building facade luminance

There was no purposely illuminated facade in the survey area.

5) Sky glow

The sky glow was measured at mainly four areas in Clear Water Bay and they were ranged from 17.23 to 18.74 mag/arcsec^2.

5 ESTIMATION OF ENERGY CONSUMPTION OF EXTERNAL LIGHTINGS IN SURVEYED DISTRICTS/AREAS

5.1 Introduction

5.1.1 In this Chapter, one of the main objectives is to estimate the energy consumption of external lighting at the surveyed districts/areas based on the survey findings in Chapter 4.

5.1.2 The overall energy consumption could be estimated and possible energy saving measures on external lighting in the 6 surveyed districts / areas will be provided with reference to internationally accepted good practices and standards.

5.1.3 The estimated energy consumptions for all the surveyed districts / areas are summarized and illustrated in the formats of table and chart for review before recommending approach to deal with energy wastage of external lighting in the surveyed districts/areas in Hong Kong.

5.2 Findings of Survey Results

5.2.1 Based on the survey findings, the current situations of sign luminance (cd/m^2) were insignificant with reference to CIE's standard in the 6 surveyed districts/areas. The energy wastage of external lighting is insignificant due to the luminance factor of individual signs.

5.2.2 Two (2) main types of energy wastage are:-

a) Unnecessary operation hour of external lighting ;

b) Light fittings with low energy efficiency.

5.2.3 Some less energy-efficient lamp types could still be found and some illuminated signs were still switched on overnight. The detail was shown in Table 5.1. The range of lighting circuit wattage related to less energy efficiency lighting in kW is from 20kW to 164kW. However, the magnitudes of such figures appear insignificant while comparing with the overall electricity consumption of the buildings.

5.2.4 From the estimate of lighting power density (LPD) in surveyed districts/areas, LPD in W/m^2 for most internally and externally illuminated signs appeared on high side as compared to the limiting values recommended by California Building Energy Efficiency Standard (CBEES). However, the CBEES may not be directly applicable to Hong Kong in view of the more densely populated urban area, higher building densities, higher ambient light level and different business and social environment. A comparison study of the energy consumption of external lighting was conducted in the 6 selected districts / areas together with an analysis of the possible energy saving of several different energy saving measures.

5.2.5 From technical perspective, proportional reduction of the existing illumination level is not practicable to be implemented as redesign and replacement for most of the existing lighting installation will be required, which bring huge inconvenience to the public in addition to cost issues. Instead, possible energy saving measures (such as turning off non-essential lighting at recommended post-curfew time, using higher efficiency luminaires and high efficacy lamp) to deal with energy wastage of external lighting are suggested for each of the six surveyed districts / areas.

Table 5.1- Comparison of excessin operation hour after pre-set time and estimated low lighting fitting efficacy to be used in 6 surveyed districts / areas

Item	Location of surveyed area	Total Lighting circuit wattage (kW)	Related to operation hour		Related to low efficacy lighting fitting[1)]			
			Lighting circuit wattage at midnight (kW)	% of excess in operation hour[2)] after pre-set time (in term of kWh)	Lighting circuit wattage (kW)	Daily energy consumption		
						Sub-total for TH /IL & ITEB (kWh)	Total for lighting installation (kWh)	% of estimated lighting used (in term of kWh)
1	Shun Lee Estate (Kwun Tong)	56.2	0.3	6%	20	83	238	35%
2	Des Voeux Road Central/Chater Road (Central)	466	376	52%	158	1,247	3,856	32%
3	Paterson Street / Great George Street (Causeway Bay)	423	159	25%	123	672	2,834	24%
4	Nathan Road (Mongkok)	619	139	17%	164	1,278	6,670	19%
	Sai Yeung Clwi Street South (Mongkok)	492	135		66			
5	Yan King Road / Kai King Road (Po Lam, Tseung Kwan O)	241	10.2	7%	120	493	1,039	47%
6	Clear Water Bay Country Park (Sai Kung)	19.8	1.98	35%	19.8	46	46	100%

Remarks:

1 For this study, low energy efficiency lightings denote tungsten halogen (TH)/ Incandescent Lamp (IL) and fluorescent tube with electromagnetic ballast (FTEB)

2. Excess in operation hour after pre-set time denotes unnecessary light fitting to be turned on for 8 hours (22:00 to 06 00) for Sai Kung; for 7 hours (23:00 to 06:00) in Shun Lee, Central and Tseung Kwan 0, for 6 hours (00:00to 6 00) in Causeway &Mong Kok respectively.

5.3 General Energy Saving Measures

Two (2) different measures for energy saving are generally introduced and the concerns when these measures come to implementation are briefly described. The relationship between the following measures may be interrelated such that the estimated energy savings should not be additive.

5.3.1 Measures ES1 -Reduction in Operation Hour of External Lighting at Night

5.3.1.1 Curfew as used in some international standards (e.g. CIE) is the time after which stricter requirements for the control of obtrusive light. The period of darkness is subdivided into the 'evening' (pre-curfew time) when higher light levels are acceptable and the 'night' (post-curfew time) when only essential lighting should be operated for purposes such as maintenance of amenity and environmental integrity and for safety, security and overnight commercial activities in some cases.

5.3.1.2 Turning off or dimming down the lighting when they are not needed could save energy. To facilitate estimation of the energy saving potential by reducing operation hour of external lighting, the concept of curfew as stipulated in CIE Standard may be applied such that after certain specified time at night the external lighting will be assumed to be switched off. In case of all other outdoor lighting to be turned off during the post-curfew period, the immediate advantages are to reduce the energy consumption as well as the potential light trespass, glare and sky glow. However, before adopting a curfew time, discussions and studies amongst the interested parties are required to reach mutual agreement. The lighting control could first be set as the voluntary guideline, for example, automatic controls through the photocell, programmable time clock or yearly astronomical controls to turn lighting off during daylight hours. Other controls may be required to tum off some or all lighting in specific areas during curfew when lighting is not appropriate. Wide range of relevant controls is readily available in the market, which meet almost all the anticipated performance requirements. Apart from those automatic, programmable, and remote-controlled lighting controls, dimming and multi-lamp switching options for bi-level illumination levels are also becoming more feasible, especially for fluorescent sources.

5.3.1.3 Cost Analysis (Measures ES1)
Timer switch is generally applied to switch off the external lighting automatically or otherwise, these lightings could be manually turned off after business hour of the shops in most cases. Therefore, no additional cost is assumed

5.3.2 Measures ES2 -Luminaire Replacement with Electronic Ballast for T8 Fluorescent Tube and High Efficacy Lighting Sources

5.3.2.1 Using full-output electronic ballast rather than conventional electromagnetic ballast can reduce the power (ballast) loss and improve efficacy of tube lights at higher frequencies, resulting in additional savings if the ballast is optimized to provide the same light output as with the conventional choke.

5.3.2.2 Use of higher efficacy lighting sources (e.g. metal halide, high pressure sodium lamp, triphosphor fluorescent lamp) for replacement of the less energy efficient lamp types can reduce energy consumption. For this study, tungsten halogen, halophosphate fluorescent lamps and incandescent reflector lamp are classified as the less energy efficient lamps. Larger savings can be achieved if the lighting scheme is redesigned during major refurbishment project.

5.3.2.3 However, high initial lighting equipment cost, need to re-design the lighting layout, corresponding labor cost for the new installations are big disadvantage of this measure. Development of products with new optical systems on the market in future will likely increase luminaries placement flexibility.

Typical Cost Analy sis for Retrofit (Measures ES2)

i) Using high efficacy 36W T8 Fluorescent tube with electronic ballast at 6 hours daily operation

Total lighting load (Halophosphate at 79 lm/W, Electromagnetic ballast at 0.8 efficiency)= 36/0.8 =45W
Total lighting load (Triphosphor at 90 lm/W, Electronic ballast at 0.92 efficiency) = 36/0.92 x (79/90) =34.35W
Load reduction= 45-34.35 = 10.65W
Operation time: 6hours per day &365 days per year
Total energy saving= (0.65 x 6 x 365) = 23.33kWh
Assume the Electricity rate to be $1/kWh
Total cost saving per year= 23.33 x 1= $23.33

Replacement cost per unit including Triphosphor T8 36W lamp,electronic ballast and labour cost is estimated to be $220.
Replacement cost of 36W lamp only per unit is estimated to be $25.

From technical data, the lamp life is 15,000 hours, for the lamp operating in 6 hours per day, the lamp can last for about 7 years.

Without replacement of lamp, the estimated payback period is approx. 10 years (i.e. 220/23.33 = 9.4 years).
With replacement of lamp, the estimated payback period is approx. 11 years (i.e. 245/23.33 =10.5 years).

Hence, payback period longer than the lamp life is economically not attractive for retrofitting the existing lighting. In other words, it saves energy but not save money.

ii) Using high efficiency 400W Flood light (Replacement from tungsten halogen type to metal halide type) at 6 hours daily operation

Similarly,
Load reduction=400-400/0.93x(16/75) ≏308.24W
Total energy saving=308.24 x 6 x 365=675.05kWh
Total cost saving per year=$675.05

Cost per luminaire (400W metal halide flood light) =$3,000
Total replacement cost(labour cost included)=$4,000
Payback= 4000/675.05 = 6 years

From technical data, the lamp life is 24,000 hours, for the lamp operating in 6 hours per day, the lamp can last for about 11 years.

From the above, the payback period for using high efficacy fluorescent tube with electronic ballast is around 5 years longer than using high efficiency flood light. However , whether it is advisable to carry out such conversion depends on quantity of light fittings, existing lamp types, ballast types, operation hours, etc. Therefore, the cost benefit analysis should be further evaluated in each survey district /area based on the figures in the above calculations in case retrofit of existing lighting is to be considered.

5.4 Comparison of Energy Consumptions in 6 Surveyed Districts/Areas

5.4.1 In this section, the estimated daily and annual energy consumptions of lighting installations for each surveyed districts/areas are summarized and illustrated into table and chart formats for review. These 6 surveyed districts/areas, ranging from a quiet and dark rural country park to the loud commercial-cum-residential areas, should be classified into different representative categories when we are studying the relationships between business activities and the external lightings in terms of operation hours, luminaire types and energy consumptions. At the end, the estimated energy consumption for all the surveyed districts/areas will be consolidated into table and bar chart format for easy comparison amongst them in kilowatt-hour per square meter (kWh/m^2).

5.4.2 The overall energy consumption and LPD of internal and external illmininated signs of the 6 surveyed districts / areas are summarized in Table 5.2 and Figure 5.1 with annual energy consumption per unit area for comparison The “surveyed area (unit: m^2)”is estimated based on both the lit areas (vertical & horizontal sign areas) and the uncovered horizontal surveyed site area which is estimated for the road areas where most of the external lighting installations in the respective surveyed district/ area are located and other areas with buildings are in general excluded .

5.4.3 The descending order for these six selected districts / areas (in terms of annual kWh/ m^2) is as follows:

i. Nathan Road/ Sai Yeung Choi Street South (Mongkok) -238.1 kWh/m^2
ii. Great George Street /Paterson Street (Causeway Bay)- 233.6 kWh/m^2
iii. Yan King Road/Kai King Road(Tseung Kwan O)-158.8kWh/m^2
iv. Chater Road /Des Voeux Road Central (Central)-135.2kWh/m^2
v. Shun Lee Estate (Kwun Tong)- 24.3 kWh/m^2
vi. Tai Hang Hau and Tai Wan Tau Villages (Clear Water Bay) -0.6 kWh/m^2

5.4.4 Noting that the LPD limits in overseas standards may not be directly applicable to Hong Kong's local context for meaningful comparison, the study instead attempts to compare the LPD of external lighting across the 6 surveyed districts/areas. For shop front lighting installation, LPD_1 denote that the estimated electrical power consumed by shop front lighting installations per unit shop front area of an illuminated space while LPD_2 denote that the estimated electrical power consumed by shop front lighting installations per unit shop front and floor area of an illuminated space. "Shop front area (unit: m^2)"is estimated based on the shop front vertical entrance area and "Shop front and floor area (unit: m^2)" is estimated based on both the shop front vertical entrance area and covered horizontal area outside the entrance. The respective LPD_1 & LPD_2 for these six selected districts / aresa (in terms of W/m^2) are summarized in Table 5.3 and their descending order are as follows:-

1. Nathan Road / Sai Yeung Choi Street South (Mongkok) -153W/m^2 & 78W/m^2
2. Chater Road/DesVoeuxRoadCentral(Central)-105W/m^2 &53W/m^2
3. Great George Street /Paterson Street (Causeway Bay) -95W/m^2 & 49W/m^2
4. Shun Lee Estate (KwunTong)-94W/m^2 &56W/m^2
5. Yan King Road /Kai King Road (Tseung Kwan O)-30W/m^2 &20W/m^2

5.4.5 For LPD for shop front lighting, the highest value of LPD_1 and LPD_2 are estimated to 153W/m^2 and 78W/m^2 respectively in Mongkok. And the range LPD_1 and LPD_2 for six surveyed areas are from 30W/m^2 to 153W/m^2 and from 20W/ $m^2$to 78W/m^2 respectively.

5.4.6 For the annual energy consumption per unit area, the highest value before preset time (i.e. pre-curfew) is 198kWh/m^2 in Mongkok and the highest value after preset time (i.e. post-curfew) is 7lkWh/m^2 in Central. Infact, the category of the highest two values in selected districts / areas (i.e. Mongkok (238kWh/m^2) and Causeway (233kWh/m^2)) are the same as residential-cum-commercial with both the preset time at 00:00 presumed. At the same time, the energy consumption in Central after preset time is higher than that in Mongkok but the former district has one more operation hour after preset time (at 23:00). Predictably, these three districts mentioned in this paragraph dominate the energy consumption of external lighting and suggests that it is much in proportion with the commercial activities. After studying different energy saving measures in Section5.3,the percentages of energy saving for the same measure certainly vary among the selected districts / areas because of the difference in quantity and type of external lighting.

Table 5.2 - Comparison of Estimated Energy Consumption in 6 Surveyed Districts/ Areas

Item	Category	Surveyed Districts	Surveyed Location	Preset Time	Estimated surveyed Area[1] (m^2)	Quantity of Lamp Counted	LPD limits on Internal illuminated sign (W/m^2)	LPD limits on External illuminated sign (W/m^2)	Total Lighting Circuit Wattage (kW)	Daily Energy Consumption (kWh) Before Preset	Annual Energy Consumption per Unit Area (kWh/m^2) Before Preset	Daily Energy Consumption (kWh) After Preset	Annual Energy Consumption per Unit Area (kWh/m^2), After Preset	Total Daily Energy Consumption (kWh) 19:00to 06 :00	Total Annual Energy Consumption (kWh) / (kWh/m^2) 19:00 to 06:00
1	Urban/ Residential	Shun Lee Estate	Podium Shopping Centre & Basketball Court	23:00	3,490	383	Nil	103	56.2	225	23	13	14	238	86,943 / 24.3
2	Urban/ Commercial	Central	Chater Road & Des V oeux Road Central	23:00	10,288	858	192 to 306	20 to 350	466.0	1,864	64	1,992	71	3,856	1,407,385 / 135.2
3	Urban/ Residential-cum-Commercial	Causeway Bay	Great George Street & Paterson Street	0:00	4,347	587	216 to 288	36to 1062	423.4	2,117	173	717	60	2,834	1,034,510 / 233.6
4		Mongkok	Nathan Road & Sai Yeung Choi Street South	0:00	10,013	2,228	192 to 288	35to 1660	1,1120	5,560	198	1,110	40	6,670	2,434,550 / 238.1
5	Urban/New Town	Tseung Kwan O	Yan King Road &Kai King Road	23:00	2,335	252	216 to 288	Nil	242.0	968	148	72	11	1,040	379,600 / 158.8
6	Rural	Clear Water Bay Country Park	Tai Hang Hau, Tai Wan Tau, Lung Ha Wan, Country Park (TaiHang Tun)	22:00	29,490	396	Nil	Nil	19.8	30	04	16	0.2	46	16,622 / 0.6

Notes
1 The "surveyed area" is summation of the lit areas (vertical & horizontal sign areas) and the uncovered horizontal surveyed s1te area wh1ch is the estimated for the road areas where most of the external lighting installations in the respective surveyed district/ area are located and other areas with buildings are in general excluded.
2 Estimated LPD on internally illuminated signs are varied due to various size of signs.

Figure5.1-Bar Chart for Comparison of Estimated Energy Consumption in 6 Surveyed Districts/Areas

Note: The scenarios and figures inthisbar chart are directly referred to Table 5.2

Table 5.3- Comparison of Estimated LPD for shop front lighting installations in 6 Surveyed Districts/ Areas

Item	Category	Surveyed Districts	Surveyed Location	Estimated lighting power for shop front area (kW)	Estimated surveyed shop front area (m^2)	LPD_1 for shop front lighting (W/m^2)	Estimated lighting power for shop front and floor area (kW)	Estimated surveyed shop front and floor area (m^2)	LPD_2 for shop front lighting (W/m^2)
1	Urban / Residential	Shun Lee Estate	Podium Shopping Centre & Basketball Court	49	525	94	49	876	56
2	Urban / Commercial	Central	Chater Road & Des Voeux Road Central	290	1,449	105	290	5,482	53
3	Urban/ Residential- - cum- Commercial	Causeway Bay	Great George Street & Paterson Street	137	1,449	95	137	2,805	49
4		Mongkok	Nathan Road & Sai Yeung Choi Street South	312	2,039	153	312	4,004	78
5	Urban /New Town	Tseung Kwan O	Yan King Road & Kai King Road	19	634	30	19	950	20
6	Rural	Clear Water Bay Country Park	Tai Hang Hau, Tai Wan Tau, Lung Ha Wan, Country Park (Tai Hang Tun)	-	-	NA	-	-	NA

Note
1. The "Shop front area (unit: m^2)" is estimated based on the shop front vertical entrance area and "Shop front and floor area (unit: m^2) " is estimated based on both the shop front vertical entrance area and covered horizontal area outside the entrance (e g. the width of pavement)

5.5 Proposed Measures to Cope with Energy Wastage in the Surveyed Areas

5.5.1 To identify whether there is any energy wastage in the surveyed districts / areas, two major criteria are applied:

i) Is the unnecessary lighting turned off appropriately?

ii) Is the lamp type used of proper (in terms of design, operation & maintenance) and energy-efficient?

5.5.2 For the first criterion, we tried to assume those unnecessary lighting to be switched off after recommended curfew hour and estimate how much energy could be saved in this regard (Measure ES1). The results of each surveyed districts / areas are summarized in the table below. However, the figures in the table are the estimated maximum values while the actual energy savings are dependent on the different scenarios on the level of implementation. In site visual observation, approx. half external lightings in various survey areas to be operated after pre-set time would be further switched off in about 3 hours later by rough estimation. Discount factor 0.75 is applied for estimation of energy consumption (kWh) after pre-set time.

5.5.3 For the second criterion,we tried to assume the less energy-efficient lamp type to be replaced by more energy-efficient lamp type / control gear (Measure ES2). By rough estimation and assumption regarding nos. of less energy efficient lights, discount factor 0.5 is applied for estimated number of fluorescent tube with electromagnetic ballast.

5.5.4 The following Tables 5.4 to 5.7 show potential energy saving (kWh) per annual in different scenarios of implementation for the measures. It is noted that the magnitude of energy saving from replacing the less energy efficient lighting (i.e. measure ES2) is not that much and for the commercial and commercial-cum-residential areas, the proportion of energy saving from reducing unnecessary operation hours of external lighting (i.e. measure ES1) is relatively more significant.

Table 5.4 - Estimated Potential Energy Saving (kWh) per annual in Scenario 1 The most favourable (100% Implementation for the Measures)[1)]

Measures		Shun Lee	Central	Causeway Bay	Mongkok	Tseung Kwan O	Clear WaterBay	Total for 6 surveyed areas
ES1	(kWh)	766	720,601	230,087	343,830	18,922	12,461	1,326,667
	(%)	1%	51%	22%	14%	5%	75%	25%
ES2	(kWh)	30,587	214,602	103,432	135,415	26,380	2,752	513,167
	(%)	35%	15%	10%	6%	7%	17%	10%
ES1 & ES2	(kWh)	30,769	782,286	288,158	413,363	44,640	13,155	1,572,370
	(%)	35%	56%	28%	17%	12%	79%	29%

Table 5.5 - Estimated Potential Energy Saving (kWh) per annual in Scenario 2 More favourable (80% Implementation for the Measures)[2)]

Measures		Shun Lee	Central	Causeway Bay	Mongkok	Tseung Kwan O	Clear Water Bay	Total for 6 surveyed areas
ES1	(kWh)	613	576,481	184,070	275,064	15,137	9,969	1,061,333
	(%)	1%	41%	18%	11%	4%	60%	20%
ES2	(kWh)	24,470	171,681	82,746	108,332	21,104	2,202	410,534
	(%)	28%	12%	8%	4%	5%	13%	8%
ES1 & ES2	(kWh)	24,615	625,829	230,527	330,690	35,712	10,524	1,257,896
	(%)	28%	44%	22%	14%	9%	63%	23%

Table 5.6 - Estimated Potential Energy Saving (kWh) per annual in Scenario 3 Average (50% Implementation for the Measures)

Measures		Shun Lee	Central	Causeway Bay	Mongkok	Tseung Kwan O	Clear Water Bay	Total for 6 surveyed areas
ES1	(kWh)	383	360,301	115,043	171,915	9,461	6,231	663,333
	(%)	0.4%	26%	11%	7%	2%	37%	12%
ES2	(kWh)	15,294	107,301	51,716	67,708	13,190	1,376	256,584
	(%)	18%	8%	5%	3%	3%	8%	5%
ES1 & ES2	(kWh)	15,385	391,143	144,079	206,681	22,320	6,577	786,185
	(%)	18%	28%	14%	8%	6%	40%	15%

Table 5.7 - Estimated Potential Energy Saving (kWh) per annual in Scenario4 Less favourable (20% Implementation for the Measures)

Measures		Shun Lee	Central	Causeway Bay	Mongkok	Tseung Kwan O	Clear Water Bay	Total for 6 surveyed areas
ES1	(kWh)	153	144,120	46,017	68,766	3,784	2,492	265,333
	(%)	0.2%	10%	4%	3%	1%	15%	5%
ES2	(kWh)	6,117	42,920	20,686	27,083	5,276	550	102,633
	(%)	7%	3%	2%	1%	1%	3%	2%
ES1& ES2	(kWh)	6,154	156,457	57,632	82,673	8,928	2,631	314,474
	(%)	7%	11%	6%	3%	2%	16%	6%

Remarks:

1) 100% implementation means all existing external lightings at night will beswitched off for Measure ES1 and all estimated quantity of existing fluorescent tubes with electromagneticballast will be replaced by electronic ballast for Measure ES2.

2) 80'/o implementation means 80% of existing external lightings at night will be switched off for measure ES1 and 80% of estimated quantity of existing fluorescent tubes with electromagnetic ballast will be replaced by electronic ballast for Measure ES2.

5.5.5 According to the survey results, two main types of energy wastage problems related to the existing installation were spotted as follows:-

(i) Unnecessary operationhour ofexternal lighting sat night.
(ii) Low efficacy light fitting produces an impact on energy consumption.

5.5.6 To deal with potential energy wastage of the existing external lightings in survey areas, turning off unnecessary external lighting at night (measure ESl) could be the most direct measure to save energy. Respective owners are encouraged to turn off the unnecessary lighting at night to reduce the energy wastage in commercial-related districts /areas (Central, Causeway Bay, Mongkok)where the estimated potential saving will be from 26% to 7% (scenario 3) (assuming the average scenario of 50% implementation for the measures) as shown on Table 5.6. However, the absolute saving in term of kWh will be comparably small when comparing with the total electricity consumption of the typical buildings as a whole.

5.5.7 And then, the proposed measure ES2 could be introduced to encourage owners of the lighting to replace the existing low efficacy lightings by using high efficacy lamp sources such as metal halide, higher luminous efficacy fluorescent with electronic ballast. However, replacement cost for existing lighting is a major concern as long payback period makes the measure not economically attractive.

6 ASSESSMENT OF THE EXTENT OF LIGHT NUISANCE PROBLEMS IN SURVEYED DISTRICTS/AREAS

6.1 Introduction

6.1.1 In this Chapter, based on the survey findings, the extent (e.g. no. of hour), intensity and distribution of light nuisance problems due to external lighting in the surveyed districts/areas are assessed.

6.1.2 Approaches and measures will be recommended to deal with the light nuisance problems, if any, of external lighting in the surveyed districts/areas based on the survey findings.

6.2 Findings of Survey Result

6.2.1 General

The situation related to light trespass impacts as identified in the study as a whole are considered not that significant except at Nathan Road and Sai Yeung Choi Street in Mongkok. The 6 surveyed districts/areas range from a low brightness rural country park with residential villages to very high brightness commercial-cum-residential area. These 6 surveyed areas have environmental zone classified as low brightness zone E2 to high brightness E4 according to the CIE environmental zoning.

6.2.2 Shun Lee Estate (Urban Residential Area)

The surveyed area of Shun Lee Estate is an urban residential area with a shopping centre and a basketball court. It was found that light trespass of some spotsin the survey is quite significant but light nuisance situation was not that significant overall. The potential nuisance situation is from the security lighting affecting lower floors and the interior lighting or residential units affecting those in close proximity due to the high density of flats in the estate. It is a reason to explain the relatively higher % of light trespass at post-curfew time.

6.2.3 Central (Commercial Area)

The surveyed area of Central which is a commercial district is also bright. However, the density of floodlights and signs is not as high as those in Mongkok. Moreover, since this is not a residential area, light nuisance effect on residents is not an issue.

6.2.4 Causeway Bay & Mongkok (Commercial-cum-residential Area)

The results found that the commercial-cum-residential area of Mongkok has the potentially the highest light nuisance situation because many residential premises are in close proximity to the high brightness commercial area with high density of floodlights, internally illuminated signs and neon signs. The surveyed area in Causeway Bay is also bright but it was found that the light nuisance situation is not as significant as Sai Yeung Choi Street South in Mongkok because the density of floodlights and signs is not as high as those in Mongkok.

6.2.5 Tseung Kwan O(New Town)

The surveyed area of Yan King Road/Kai King Road, Tseung Kwan O is a new town with high density of residential units and shopping arcade. Being a new town developed in recent years,the layout of residential and commercial area has been better planned. There is adequate separation between the residential units and the commercial shopping arcade. The potential light nuisance problems, if any, were due mainly to the street lighting and security lighting affecting lower floors of the residential units near to street level. Security lighting of a car park may also cause nuisance problem to residents in close proximity in the same estate. The high density of residential units may also produce potential nuisance problem due to interior lighting of nearby residential units. It is a reason to explain the relatively higher % of light trespass at post-curfew time.

6.2.6 Clear Water Bay Country Park (Rural Area)

The surveyed area of the rural Clear Water Bay Country Park with nearby villages Tai Hang Hau and Tai Wan Tau has little light nuisance problem. As the density of residents in the villages is still not very low,and that the area is nearby the new town of Tseung Kwan 0 which is only 2-3 km away, there is some sky glow problem. The part of the rural Clear Water Bay Country Park under the survey is not suitable for astronomical observation.

6.2.7 Summary of light nuisance situations on the 6 Surveyed Districts/Areas

The following Table 6.1 summarizes the current situation of light nuisance problems in terms of light trespass at pre-curfew and post curfew time, glare at residential unitsand over-bright sign from the 6 surveyed areas:-

Table 6.1–Summary of current situation of light nuisance problems

Item	Location of Surveyed area	Areas environmental zone	Light trespass at pre-curfew time	Light trespass at post-curfewtime	Glare at residential units	Over-bright sign
1	Shun Lee Estate (KwunTong)	Urban Residential Area (E3)	Insignificant	Quite significant	No	No
2	Des Voeux Road Central/Chater Road (Central)	Commercial Area (E4)	Insignificant	Not that significant	No	No
3	Paterson Street// Great George Street (Canseway Bay)	Commercial -cum- residential Area (E4)	Not that significant	Insignificant	No	No
4	Nathan Road (Mongkok)	Commercial -cum- residential Area (E4)	Not that significant	Significant	Yes	No
	Sai Yeung Choi Street South (Mongkok)		Very significant	Significant	Yes	Yes (4 nos. spotted)
5	YanKing Road/ Kai KingRoad (Po Lam, Tseung Kwan O)	New Town Area (E3)	Insignificant	Insignificant	No	No
6	Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (Sai Kung)	Rural Area (E2)	Insignificant	Quite significant	No	No

6.3 General Control Measures

Three (3) type of control measures to deal with light nuisance are generally introduced and the concerns when these measures come to implementation are briefly described.

6.3.1 Type 1 -Reduction in operation hour of external lighting at night

6.3.1.1 Measure M1 is to educate or encourage the owners, shop operators and residents to switch off lights when not in use or dim down the lighting when full illumination not necessary in accordance with the concept of curfew time (say 23:00 or 24:00) recommended by CIE standard. This is a simple measure and relatively easy to implementation.

Pros:

- Reduce light trespass problem in the post-curfew hours and to certain extent realising energy saving opportunities.
- Reduce nuisance to residents who desire a darker environment for better sleep quality during the time when most people would sleep (and residents who want better sleep quality may benefit).
- Reduce sky glow in the countryside at night (and residents with interest to view celestial bodies may benefit)

Cons:

- With a voluntary approach, effectiveness of the proposed measure depends very much on the cooperation of the stakeholders. With a mandatory approach, it may arouse concerns of various stakeholders and requires manpower for implementation of the measure, e.g. in checking whether non-exempted lights are switched off after the curfew hour.
- Essential lights such as those for safety, security or business may need to be kept on even after the curfew time.

6.3.2 Type2-Positioning and type of lighting

The following measures are to educate or encourage the owners of existing lighting to modify the existing lightings as possible measures but are difficult to implement as redesign and replacement for the existing lighting installations may be required in the surveyed district / area which may not be practicable. However, such measures could be considered for application in new lighting installations as a measure to prevent light nuisance arising from the new lighting.

6.3.2.1 Measure M2 is to aim (or use asymmetrical luminaire) or shield lighting fixtures to target areas and downwards as far as practicable to reduce spill light.

Pros:

- Reduce sky glow (and residents with interest to view celestial bodies may benefit).
- Reduce nuisance to residents especially those at levels higher than the floodlights / facade lights (and neighbouring residents may benefit).
- Reduce nuisance to the residents facing sport ground light.

Cons:

- May cause difficulty in lighting design / installation. Modifications to existing lighting may not be practicable.

- The quantity and hence cost of down lighting used for facade / signs may be more to achieve more even illuminance level on external ilhnninated signs.

6.3.2.2 Measure M3 is to control the sizes and location of advertising signs with reference to Buildings Department's Guide on Erection & Maintenance of Advertising Signs so that the clearance to the building could be appropriately maintained.

Pros:

- Reduce nuisance to residents facing the advertising signs (and neighbouring residents may benefit).

Cons:

- Requires careful definition of the sizes / locations, which may cause dispute.
- Requires cost for rearrangement of advertising sign configmation.
- Nuisance may still exist even the BD's guide is followed.

6.3.2.3 Measure M4 is to use lights with suitable cut-off facilities for security lighting/footpath lighting.

Pros:

- The security lights / footpath lights will not cause nuisance to residents at higher levels (and residents may benefit from this measure). And it is about minimum nuisance to residents could be maintained.
- Reduce sky glow (and residents who want to view celestial bodies may benefit).

Cons:

- Requires cost for replacement of security lights / footpath lights. Overall effectiveness of the cut-off lights depends on design and actual installation.
- The actual number of lighting may be increased, in which may use more energy and need more capital cost.

6.3.3 Type 3-Conducting an impact assessment before installation work in new lighting or existing lighting with major renovation as preventative measure

6.3.3.1 Owners of new or existing (with major renovation) external lighting installations are encouraged to conduct an impact assessment before the major renovation work and operation of the lighting.

Pros:

- Reduce the potential of nuisance caused by external lighting (and neighbouring residents may benefit).
- Reduce sky glow (and residents who want to view celestial bodies may benefit).

Cons:

- Increase cost of the external lighting installation due to impact assessment and need for better lighting design using higher quality lighting installations.
- It is not possible to distinguish "new" and "existing" external lighting.

6.4 Proposed Measures to Cope with Light Nuisance Problems in the Surveyed Areas

6.4.1 The situation related to light trespass impacts as identified in the study as a whole are considered not that significant except at Nathan Road and Sai Yeung Choi Street in Mongkok. The major light nuisance problem is light trespass assessed by vertical illuminance on windows due to the following situations.

(a) Extemal lightings were still switched on even after business hours.
(b) Some floodlights used for signs were at upward position and inappropriately aim lighting fixtures or symmetrical lightings were used to create spill light.
(c) Locations of signs were very close to residential units.
(d) Spill light were created by non cut-off lights for pole mounted security/ footpath lighting.

6.4.2 The following various measures to deal with the above-mentioned situations related to the lighting trespass in the 6 surveyed districts/areas for improvement due to existing external lighting:-

Ml. To educate or encourage the owners, shop operators and residents to switch off lights when not in use or dim down the lighting when full illumination not necessary to adopt the concept of curfew time (say 23:00) recommended by CIE standard.

M2. To educate or encourage the owners of existing lighting to aim (or use asymmetrical luminaire) or shield lighting fixtures to target areas and downwards as far as practicable to reduce spill light.

M3. To remind the owners of existing lighting to follow the sizes / locations of advertising signs with reference to Buildings Department's Guide on Erection & Maintenance of Advertising Signs. (For example, signs could be not project beyond the centre line of a street; signs could be not less than clearance of3.5m and a minimum distance of lm from the curb if projecting over a pavement; and signs could be not less than clearance of 5.8m if projecting over a street.)

M4. To educate or encourage the owners of existing lighting to use lights with suitable cut-off facilities for security lighting/footpath lighting.

6.4.3 In fact, during major refurbishment project, choosing luminaires of higher light output ratio and using the cut-off and shielded luminaries can also limit the disability and discomfort glare, reduce light trespass and sky glow since good luminaries preventing the emission of light at and above the horizontal level can reduce visual intrusion and direct upward light to a minimum.

7 CONCLUSION AND RECOMMENDATION

7.1 Introduction

7.1.1 As mentioned in Chapter 5 & 6, the energy wastage and light nuisance were considered not that significant except for some isolated spots, such as Sai Yeung Choi Street in Mongkok. A voluntary approach with reference guidelines may be more appropriate to deal with the current situation and the proposed guidelines should focus on both light nuisance and energy conservation aspects.

7.2 Proposed Way Forward to Cope with the Problematic Spots identified from Surveyed Areas

7.2.1 At present, there is no regulatory control in regulating the external lighting impacts in Hong Kong. It was also found that energy saving from replacing the existing lighting with more energy efficient lighting is not that much and the light nuisance situation was not that significant except in some individual spots of the survey areas. A voluntary approach with reference guideline may be more appropriate to deal with the situation in the 6 surveyed districts/areas.

7.2.2 Voluntary reference guidelines could be considered to include the following various measures and practices for minimizing light nuisance and preventing energy wastage of outdoor lighting in the 6 surveyed districts/areas due to existing external lighting :-

1. To educate or encourage residents and office / shop operators to switch off lights that are not used and to adopt a curfew time for turning off or dimming down the lights at night when not in use and after business hours.
2. To encourage owners of existing lightings to use the higher efficacy luminaires to replace the existing one.
3. Aim (or use asymmetrical luminaire) or shield lighting fixtures to target areas and downwards as far as practicable to reduce spill light.
4. Control the sizes / locations of advertising signs with reference to Buildings Department's Guideon Erection & Maintenance of Advertising Signs.
5. Use lights with suitable cut-off facilities for security lighting/footpath lighting.

7.2.3 In addition to the above-mentioned measures to existing external lightings, it is recommended that an impact assessment may be conducted for new or existing (with major renovation) external lighting installations before the installation/renovation work and operation of the lighting as preventive measures tominimize the possible light nuisance with appropriate light level and separation from residents. The effectiveness of the measure depends on the co-operation attitude of residents and shop operators in the current situation under voluntary approach.

7.2.4 The stakeholders are encouraged to follow the proposed guidelines through education and publicity, or persuasion when the recommendations in the guidelines are not followed. Education and publicity campaigns are effective measures as some past examples show that reputable companies/ organizations would respond to complaints against light nuisance or energy wastage of their outdoor lighting installations and carried out various mitigation measures. Financial incentive scheme may be one of possible measures to encourage the stakeholders to carry out some improvement works of external lightings related to the light trespass situation.

7.2.5 The key disadvantage of this voluntary approach is that the government has no authority to control the situation on use of external lighting in private premises. For prudent private property owners and building managers, however, bad publicity due to any adverse effect of artificial light, including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste in their buildings could reduce the building's market value, more so if there are litigations against the lighting nuisance. They may also try to avoid adverse impression from the public which may become the potential initiative for the promotion of guideline.

7.3 Recommended Practice (reference guideline) for Measuring and Assessing the Impacts of External Lighting in Hong Kong

7.3.1 Introduction

7.3.1.1 The voluntary guidelines could contain for reference a recommended zoning system for the control of outdoor lighting; a set of recommended curfew hours for each lighting zone and a set of limiting values for control of light trespass & glare for each lighting zone.

7.3.1.2 Details of the recommended lighting zone system, curfew hours and parameters and values to limit the effect of light nuisance are given in the following sections and Tables 7.1 to 7.5. Apart from the 6 surveyed districts/areas, it is possible for the proposed measures to be adopted in other similar districts/areas of Hong Kong.

7.3.2 Lighting Environmental Zoning

7.3.2.1 Since different districts/areas have different population densities and different levels of commercial and recreational activities which require different lighting conditions at night, a lighting environmental zoning concept, if adopted, should be carefully applied taking into account the local context as Hong Kong is a high densely populated city with mixed land use and different social activities at night. The benefits and limitations of an environmental zoning system for external lighting, however, should be taken into account when considering for application in Hong Kong. Using a lighting zoning system can provide benefit to the majority of the general public in different sectors. Firstly, the zoning system allows sufficient brightness in areas with commercial and recreational activities at night for those who desire to enjoy night shopping and recreational activities. Secondly, it provides a darker environment for the residents in residential areas to enjoy good quality leisure time and rest at home during nighttime. Thirdly, zoning can also give opportunities to protect intrinsically dark areas for astronomical observers to conduct astronomical observations with little interference from the urban lighting. However, the limitations and practicability of zoning system for Hong Kong's context include for example, difficulty to classify zones with medium district and high district brightness which will be not just a technical issue.

7.3.2.2 To provide the maximum benefits to different sectors of the general public, a 4-zone lighting zoning system similar to the CIE lighting environmental zoning system could be considered, with adaptations, for adoption in Hong Kong.

7.3.2.3 The suggested preliminary lighting zone classification is given in Table 7.1 for illustration which gives only a guideline to start with the classification of lighting environmental zones in Hong Kong using the Residential Density Zoning for Metroplan Area, New Towns and Rural Areas.

Table 7.1 - Recommendation of lighting environmental zones

Zone	Lighting Environment	Provision of areas of different ambient brightness for different nighttime activities	Remarks
E1	Intrinsically dark	For astronomical observation.	e.g. Country parks and designated areas for astronomical observations
E2	Low district brightness	For people who want to have a rural living condition including having a low night time ambient brightness.	e.g. Rural Residential Density Zones RR2, RR3, RR4, RR5, Village (with New Territories Exempted Houses); Metropl.an Residential Zone 3; and New Towns Residential Density Zones R3 & R4 (Excluding areas already classified as country parks which is suggested to belong to zone El by default)
E3	Medium district brightness	For residential areas where people would enjoy the convenience of commercial activities nearby (e.g. the convenience of buying everyday needed items without traveling long distance). Even for a little commercial activity at night, such as a convenience store, the area will need to be brighter than a solely residential area, i.e. the area would have medium ambient brightness.	Rural Residential Density Zone RR1 ; Metroplan Residential Zone 2; and New Towns Residential Density Zones R2
E4	High district brightness	For areas with high level of commercial and recreational activities at night. These areas are with high nighttime brightness for residents and visitors to enjoy nighttime shopping and recreation.	Metropl.an Residential Zone 1; and New Towns Residential Density Zones R1

7.3.2.4 However, practical issues relating to implementing the zoning concept in Hong Kong should be taken into consideration. Building mix and building density make it difficult to classify zones. Zoning classification is not just a technical issue. It is also a social issue and will arouse disputes among stakeholders with differing interests or concerns. Possibility could be considered to classify only the geographic areas broadly into the low brightness and high brightness zone.

7.3.3 Establishment of Curfew Hour

7.3.3.1 With establishment of curfew hours, suitable commercial and/or recreational activities can still operate during the early part of the night and residents can enjoy a darker environment for good quality sleep during the later part of the night. Unnecessary waste of energy can be avoided by requiring some non-essential lights to be turned off after the curfew hour. A preliminary recommendation of curfew hours for the 4 suggested lighting environmental zones is given in Table 7.2.

Table 7.2 -Recommended curfew hours for the 4 suggested lighting zones

Lighting Environmental Zone	E1	E2	E3	E4
Curfew hour[1)]	21:00	22:00	23:00[2)]	24:00[2)]

Notes:
1) The curfew hour is the time when all non-essential lights should be switched off All non-essential lights should be kept off after the ourfew hour until dawn of the next day.
2) Exemption shall be given to functioo.al lighting installations which require all night operation. such as signs of 24 hour stores. Such lights should not cause nuisance to nearby residents.

7.3.3.2 However, it may be difficult to define non-essential lights as lightings are often used for business needs and security and safety reasons. It may also be difficult to have a widely acceptable definition of non-essential lights.

7.3.4 Light Trespass, Glare from Bright Light Sources, Building Facades and Signs

7.3.4.1 CIE Standard with the stringent limiting values is mostly adopted in some pioneer countries for light nuisance prevention. The CIE Standard listed in Table 7.3 can be used as a reference for Hong Kong light nuisance assessment.

Table 7.3-Parameters and limits for assessing light trespass extracted from CIE standard.

Light Technical Parameter	Application Conditions	Lighting Environmental Zones and Recommended Limits			
Verical illuminance at centre of window (E_v)[1)]		E1	E2	E3	E4
	Pre-curfew	2 lx (CIE)	5 lx (CIE)	10 lx (CIE)	25 lx[4)] (CIE)
	Post-curfew	0 lx (CIE)	1 lx[4)] (CIE)	2 lx[4)] (CIE)	5 lx[4)] (CIE)
Luminous intensity emitted by luminaires (I_d) in directions towards residents[2)]	Pre-curfew	2500 cd (CIE)	7500 cd (CIE)	10000 cd (CIE)	25000 cd (CIE)
	Post-curfew	0 cd (CIE)	500 cd (CIE)	1000 cd (CIE)	2500 cd (CIE)
Building facade luminance (L_b)	Pre-curfew	0 cd/m^2 (CIE)	5 cd/m^2 (CIE)	10 cd/m^2 (CIE)	25 cd/m^2 (CIE)
	Post-curfew	0 cd/m^2 (CIE)	5 cd/m2 (CIE)	10cd/m2 (CIE)	25 cd/m^2 (CIE)
Sign luminance (L_s)[3)]	Pre-curfew	50 cd/m^2 (CIE)	400 cd/m^2 (CIE)	800 cd/m^2, (CIE)	1000 cd/m^2, (CIE)
	Post-curfew	0 cd/m^2 (CIE)	400 cd/m^2 (CIE)	800 cd/m^2 (CIE)	1000 cd/m^2 (CIE)

Note:
1) The values are the summation of all lighting installations.
2) If the directly seen luminaires are flashing, the luminous intensity should be half of the given limits.
3) Signs include video walls but exclude signs for traffic control. The use of signs incorporating lighting which is cyclic or flashing in nature is deprecated in zones E1 and E2. In any zones such signs should not be positioned close to windows of habitable rooms.
4) In a few survey areas, the measured results are far from the limiting values of CIE standards.

7.3.4.2 Comparing the survey results of *vertical illuminance at centre of window* (E_v) in the surveyed districts / areas with Table 7.3, the existing value of the survey results are generally not exceeding the limits of CIE standard except that the light trespass at pre-curfew time of a certain proportion of residents in E4 zones and the light trespass at post-curfew time in E2, E3 & E4 zones (such as Central, Causway Bay, Nathan Road and Sai Yeung Choi Street South) are higher than the limits of CIE standard. For *Luminous intensity* emitted by luminaires (I_d) in directions towards residents, Building facade luminance and Sign luminance for all zones and light trespass at pre-curfew time for El, E2 & E3 zones and at post-curfew time for E1 zone,the limits of CIE standard are not exceeded.

7.3.4.3 For the light trespass at pre-curfew time and post-curfew time of E4 zone, parameters and limits for assessing light trespass with reference to the survey results in Central, Causeway Bay (CB), Nathan Road (NR) and Sai Yeung Choi Street South (SYCS) comparing with various standards or 20% demarcation line of resident benefit are listed in Table 7.4 for the proposed limits selection to encourage the 6 surveyed districts/areas for improvement.

Table 7.4 -Limits for assessing light trespass with reference to the survey results In Central，Causeway，Nathan Road and Sai Yeung Choi Street South.

Light Technical Parameter	Application Conditions	Lighting Environmental Zones and Recommended Limits							
Vertical illuminance at centre of window (E_v)[1)]		E1	E2	E3	E4				
	Pre-curfew				reference	Central	CB	NR	SYCS
		2lx (CIE)	5lx (CIE)	10 lx (CIE)	25 lx (CIE)	25 lx (CIE)	27lx (200%)	32lx (200%)	113lx (20%)
	Post-curfew	0 lx (CIE)	1lx (CIE)	2 lx (CIE)	5 lx (CIE)	7 lx[1)] (20%)	5lx (200%)	15lx (200%)	15 lx (20%)

Note:
1. (20%) denotes 20% demarcation line of resident benefitmeansthat no more than 20% of the residential units surveyed hav ing vertical illuminance on window of greater than the representative recommended values at pre-curfew and post-curfew times. For example in Central, if the recommended limits of vertical illuminance on window is 7 1x at post-curfew, about 20% of the existing residential units will be greater than that value.

7.3.4.4 As a starting point of Hong Kong light nuisance prevention with the ease of implementation and encouragement of further improvement, the suggested reference limiting values shall be not too far from the values of existing surveyed situation We suggested the limiting values of the light trespass at pre-curfew time of E4 zone and at post-curfew time of E4 zones be established in comparing with various standards or 20% demarcation lines of resident benefit in Table 7.4 to come up with pragmatic reference values. The suggested limiting values in Table 7.5 may serve as a reference when limiting values for light trespass are considered for inclusion into the voluntary guidelines. A review can be carried out some years later after launch of the guidelines to formulate future policy dependent on the actual experience.

Table 7.5 -Summary of proposed parameters and limits for assessing light trespass

Light Technical Parameter	Application Conditions	Lighting Environmental Zones and Recommended Limits			
Vertical illuminance at centre of window (E_v) [1]		El	E2	E3	E4
	Pre-curfew	2 lx (CIE)	5 lx (CIE)	10 lx (CIE)	50 lx [4] (Shanghai)
	Post-curfew	0 lx (CIE)	1 lx [4] (CIE)	2lx [4] (CIE)	25lx [4] (Shanghai)
Luminous intensity emitted by luminaires (I_d) in directions towards residents [2]	Pre-curfew	2500 cd (CIE)	7500 cd (CIE)	10000 cd (CIE)	25000 cd (CIE)
	Post-curfew	0 cd (CIE)	500 cd (CIE)	1000 cd (CIE)	2500 cd (CIE)
Building facade luminance (L_b)	Pre-curfew	0 cd/m^2 (CIE)	5 cd/m^2 (CIE)	10 cd/m^2 (CIE)	25 cd/m^2 (CIE)
	Post-curfew	0cd/m^2 (CIE)	5 cd/m^2 (CIE)	10 cd/m^2 (CIE)	25cd/m^2 (CIE)
Sign luminance (L_s) [3]	Pre-curfew	50 cd/m^2 (CIE)	400 cd/m^2 (CIE)	800 cd/m^2 (CIE)	1000 cd/m^2 (CIE)
	Post-curfew	0 cd/m^2 (CIE)	400 cd/m^2 (CIE)	800 cd/m^2 (CIE)	1000cd/m^2 (CIE)

Notes:
1) Thevalues are the summation of all lighting installations.
2) If the directly seen luminaires areflashing, the luminous intensity should be half of the given limits.
3) Signs include video walls but exclude signs for traffic control. The use of signs incorporating lighting which is cyclic or flashing in nature is deprecated in zones El and E2. In any zones such signs should not be positioned close to windows of habitable rooms.
4) In some of the survey areas, the measured values of a certain proportion of residents exceed the limiting values of CIE standards. And *(Shanghai)* denotes"Shanghai Municaipal Standard DB31/T316-2004"

7.4 Recommendation

7.4.1 As a first stage to deal with the problems due to external lighting in the surveyed districts/areas, a set of guidelines with a view to limiting the impacts of external lighting on the general public (the guidelines) could be developed to encourage voluntary compliance with guidelines through publicity and education. Some kind of voluntary charter could be promoted in the community to encourage developers,property management companies,shops to implement the guideline.

7.4.2 If the relevant parameter(s) of a lighting installation subject to complaint is found not complying with the guidelines and the owner(s) of the lighting device can be identified, recommendations can be given to the owner(s) to improve the lighting installation.

7.4.3 To deal with the problematic spots identified from the 6 surveyed areas, a voluntary approach with reference guideline may be more appropriate. And the stakeholders are encouraged to switch off unnecessary lightings at night for minimizing the light nuisance and preventing energy wastage of outdoor lighting through education and publicity campaigns.

7.4.4 A review should be conducted after a few years of implementation of the voluntary external lighting guideline. The review may include the experience of implementation of the voluntary outdoor lighting guidelines and the effectiveness of the guidelines in reducing the adverse impacts of outdoor lighting installations. Overseas experience concerning outdoor lighting control should also be reviewed again to keep our reference materials up-to-date.

Appendix A-
General information of Site Survey Areas

A.l Shun Lee Estate (Kwun Tong)

The boundary of proposed surveyed district/area is shown on the following site plan.

1. Urban / Residential Category- Shun Lee Estate (a public housing estate) (Kwun Tong)

Legend:

(boundary of survey area)

Overall Summary

The total estimated size of the uncovered horizontal surveyed site areas being surveyed: *3,450m²*

The total estimated areas for internal and external signs in the survey area: *40m²*

Total of buildings: *5 nos.*

A.2 Des Voeux Road Central / Chater Road (Central)

The boundary of proposed surveyed district/area is shown on the following site plan.

2. Urban / Commercial Category - Des Voeux Road Central / Chater Road (Central)

Legend:

(boundary of survey area)

Overall Summary:

The total estimated size of the uncovered horizontal surveyed site areas being surveyed: *8.590m²*
The total estimated areas for internal and external signs in the survey area: *1,698m²*

Street name: *Des Voeux Road Central*
Street length to be surveyed: *213m*
Total of buildings: *32 nos.*

Street name: *Chater Road*
Street length to be surveyed: *161m*
Total of buildings: *6 nos.*

A.3 Paterson StreetI Great George Street(Causeway Bay)

The boundary of proposed surveyed district/area is shown on the following site plan.

3. Urban / Residential-cum-Commercial Category- Paterson Street / Great George Street / (Causeway Bay)

Legend:

(boundary of survey area)

Overall Summary

The total estimated size of the uncovered horizontal surveyed site areas being surveyed: *3,230m²*
The total estimated areas for internal and external signs in the survey area:
1,117m²
Street name: *Paterson Street*
Street length to be surveyed: *136m*
Total of buildings: *19 nos.*

Street name: *Great George Street*
Street length to be surveyed: *92m*
Totalofbuildings: *8 nos*

A.4 Natban Road I SaiYeung Choi Street South (Mongkok)

The boundary of proposed surveyed district/area is shown on the following site plan.

2. Urban / Residential-cum-Commercial Category -Nathan Road / Sai Yeung Choi Street South (Mongkok)

Legend:

(boundary of survey area)

Overall Summary

The total estimated size of the uncovered horizontal surveyed site areas being surveyed: *4.820 m^2*
The total estimated areas for internal and external signs in the survey area: *5.198m^2*

Street name: *Nathan Road*
Street length tobe surveyed: *140m*
Total of buildings: *17 nos.*

Street name: *Sai Yeung Choi Street*
Street length to be surveyed: *136m*
Total of buildings: *25 nos.*

A.5 YanKing Road/ Kai KingRoad (Po Lam, Tseung Kwan O)

The boundary of proposed surveyed district/area is shown on the following site plan.

5. New Town Category-Yan King Road / Kai King Road (PoLam)
Legend:

(boundary of survey area)

Overall Summary

The total estimated size of the uncovered horizontal surveyed site areas being surveyed: *1,550m^2*
The total estimated areasfor internal and external signs in the smvey area: *785m^2*

Street name: *Yan King Road*
Street length to be surveyed: *193m*
Total of buildings: *12 nos.*

Street name: *Kai King Road Street*
Street length to be surveyed: *155m*
Total of buildings: *2 nos.*

A.6 Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (Sai Kung)

The boundary of proposed surveyed district/area is shown on the following site plan.

6. Rural Category - Clear Water Bay Country Park with nearby villages, Tai Hang Hau and Tai Wan Tau (Sai Kun)

Legend:

(boundary of survey area)

Overall Summary

District Name	StreetNumber	Purpose	Vertical Area (m^2)
Tai Wan Tau	N/A	Residential	N/A
Tai Hang Hau	N/A	Residential	N/A