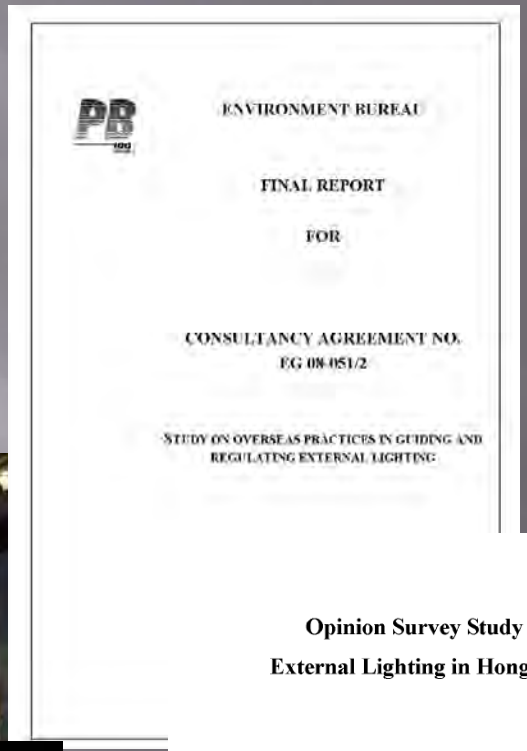
City of Cambridge
Lighting Ordinance Kick-Off Meeting

Light Trespass

Sky Glow

Photograph courtesy of Carl Gardner M.Sc.
Senior consultant, 'Urban Lights' research project,
Bartlett School of Architecture, University College London

Glare



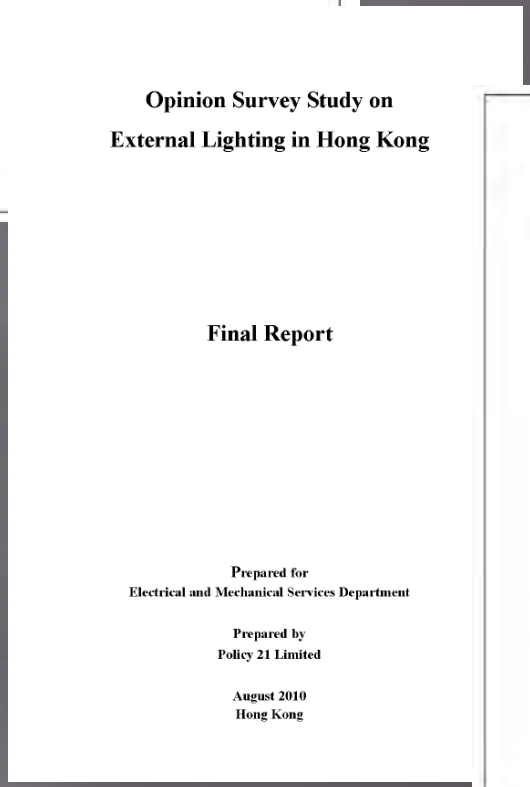
ENVIRONMENT BUREAU

FINAL REPORT

FOR

CONSULTANCY AGREEMENT NO.
EG 08-051/2

STUDY ON OVERSEAS PRACTICES IN GUIDING AND REGULATING EXTERNAL LIGHTING



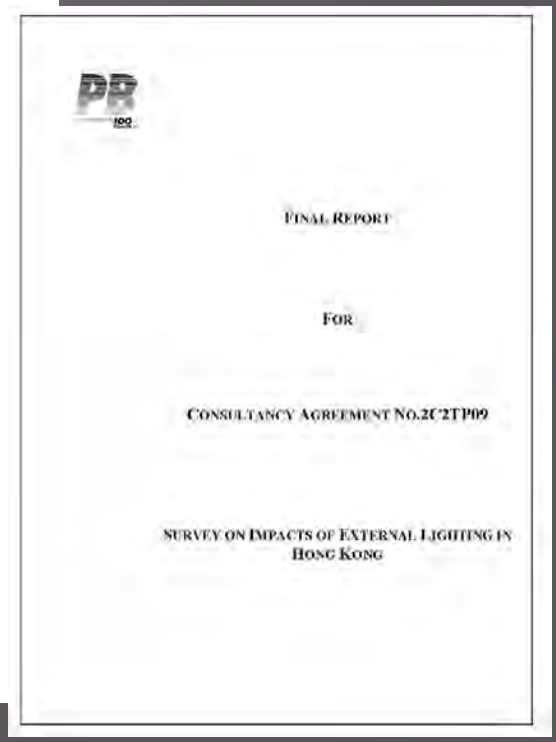
Opinion Survey Study on
External Lighting in Hong Kong

Final Report

Prepared for
Electrical and Mechanical Services Department

Prepared by
Policy 21 Limited

August 2010
Hong Kong



FINAL REPORT

FOR

CONSULTANCY AGREEMENT NO.2C2TP09

SURVEY ON IMPACTS OF EXTERNAL LIGHTING IN HONG KONG

Government of Hong Kong Obtrusive Lighting Study

http://www.enb.gov.hk/en/resources_publications/consultancy_studies/

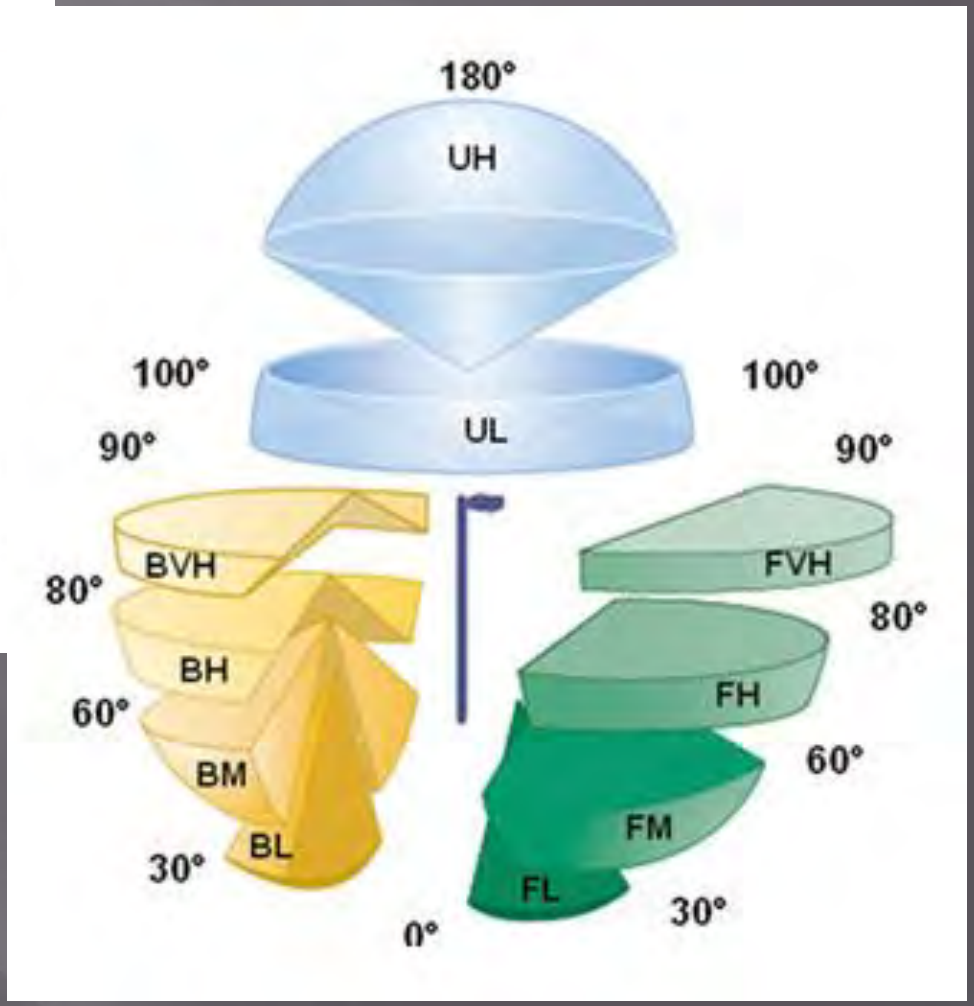
IESNA TM-15-07
(revised)

Luminaire Classification System *for* Outdoor Luminaires

IES The LIGHTING AUTHORITY®

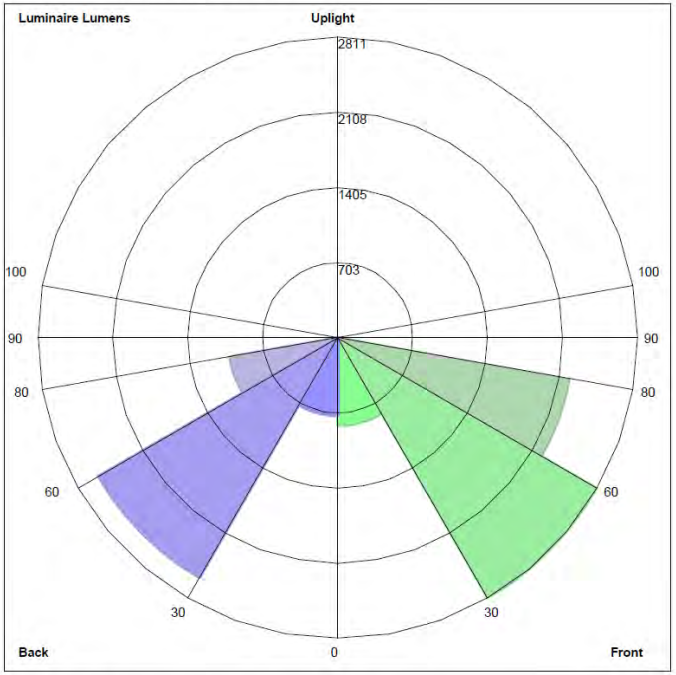
Publication of this Technical Memorandum has been approved by the IESNA.
Suggestions for revisions should be directed to the IESNA.

Prepared by The Luminaire Classification Task Group of IESNA



IES ROAD REPORT
PHOTOMETRIC FILENAME : BLD-SEC-T3-__-102-LED-B.IES

LUMINAIRE CLASSIFICATION SYSTEM (LCS) GRAPH

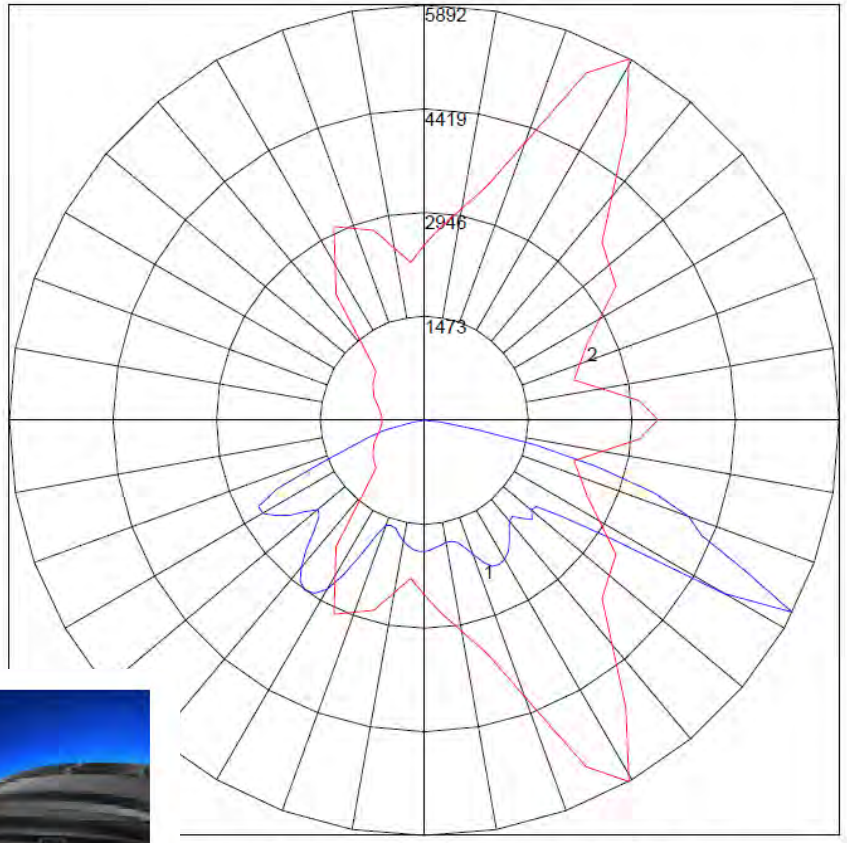


Luminaire Lumens:
Front: Low=823.4, Medium=2810.7, High=2209.1, Very High=35.9
Back: Low=727.7, Medium=2592.8, High=1030.7, Very High=22.5
Uplight: Low=0.0, High=0.0

BUG Rating : B3-U0-G3

IES ROAD REPORT
PHOTOMETRIC FILENAME : BLD-SEC-T3-__-102-LED-B.IES

POLAR GRAPH



= 5892 Located At Horizontal Angle = 60.5, Vertical Angle = 62.5
Through Horizontal Angles (60.5 - 240.5) (Through Max. Cd.)
e Through Vertical Angle (62.5) (Through Max. Cd.)

CHARACTERISTICS

IES Classification	Type III
Longitudinal Classification	Short
Lumens Per Lamp	10252 (1 lamp)
Total Lamp Lumens	10252
Luminaire Lumens	10253
Downward Total Efficiency	100 %
Total Luminaire Efficiency	100 %
Luminaire Efficacy Rating (LER)	70
Total Luminaire Watts	146
Ballast Factor	1.00
Upward Waste Light Ratio	0.00
Maximum Candela	5892
Maximum Candela Angle	60.5H 62.5V
Maximum Candela (<90 Degrees Vertical)	5892
Maximum Candela Angle (<90 Degrees Vertical)	60.5H 62.5V
Maximum Candela At 90 Degrees Vertical	0 (0.0% Lamp Lumens)
Maximum Candela from 80 to <90 Degrees Vertical	900 (8.8% Lamp Lumens)
Cutoff Classification (deprecated)	Full Cutoff

Shanghai Urban Environmental Lighting Regulations

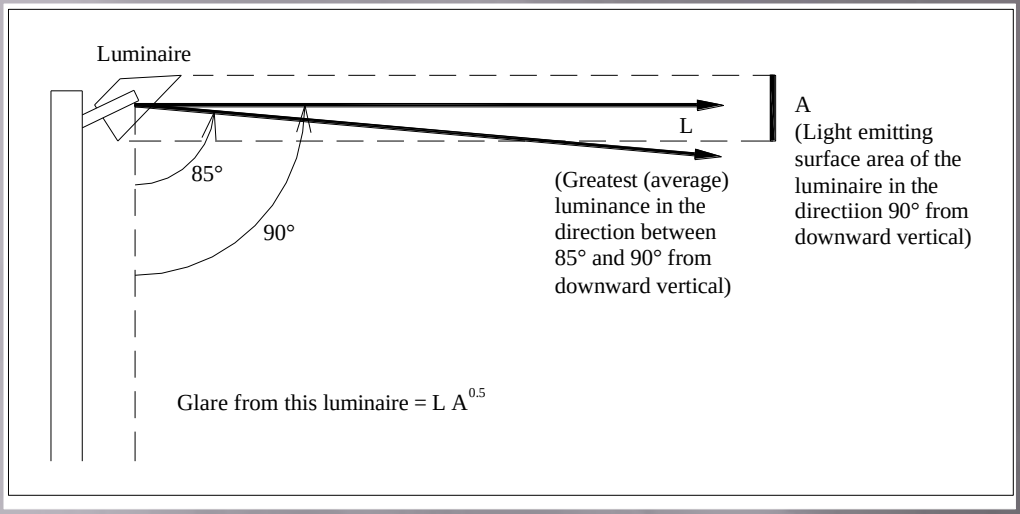


Table 3.1.1 Light technical parameter and limits for the assessment of glare on road users produced by urban lighting luminaires.

Installation Height (m)	Limiting values of $LA^{0.5}$
$h \leq 4.5$	$LA^{0.5} \leq 4000$
$4.5 < h \leq 6$	$LA^{0.5} \leq 5500$
$h > 6$	$LA^{0.5} \leq 7000$

Note: L is the luminaire's greatest (average) luminance (in cd/m²) in the direction between 85° 90° from the downward vertical and A is the light emitting surface area of the luminaire (in m² the direction 90° from the downward vertical.

Table 3.1.2 Control of obtrusive light on residents

	Premises Facing the Inside of Residential Estate		Premises Facing the Outside of Residential Estate	
	Evening	After 23:00	Evening	After 23:00
Vertical Illuminance on House Window (lx)	25	4	50	25
Luminous Intensity of Luminaire Directly Observable (cd)	7500	1000	7500	2500

Note: If the luminaire directly observable is blinking, the limiting intensity should be reduced b half.

Table 3.1.4 Recommendation of **façade luminance** for building floodlighting design

Background Luminance (cd/m²)	Class I Building Luminance (cd/m²)	Class II Building Luminance (cd/m²)
Dark (0.2)	20~32	12~20
Medium (2)	45~70	25~45
Bright (12)	80~130	50~80

Table 3.1.3 Maximum allowable luminance for advertising signs, billboard and lantern boxes (excluding neon signs). [EMSD: Is there any control over the neon signs?]

Sign lit area (m²)	Maximum Allowable Luminance (cd/m²)
≤ 0.5	1000
≤ 2	800
≤ 10	600
> 10	400

Japan Ministry of Environmental Light Pollution Control Guidelines

Table 3.2.1 **Limitation of obtrusive light** on residential units

Light technical parameter	Application or calculation conditions	Lighting Environmental Zones			
		I (E1)	II (E2)	III (E3)	IV (E4)
Illuminance in vertical plane (E_v)	Pre-curfew	2 lx	5 lx	10 lx	25 lx
	Post-curfew	0 lx	1 lx	2 lx	5 lx
Luminous intensity emitted by luminaires (I_d)	Pre-curfew	2500 cd	7500 cd	10000 cd	25000 cd
	Post-curfew	0 cd	500 cd	1000 cd	2500 cd
Building façade luminance (L_b)	All times	0 cd/m^2	5 cd/m^2	10 cd/m^2	25 cd/m^2
Sign luminance (L_s)	Pre-curfew	50 cd/m^2	400 cd/m^2	800 cd/m^2	1000 cd/m^2
	Post-curfew	0 cd/m^2			

Australian Standard AS 4282
Control of the Obtrusive Effects of Outdoor Lighting

Table 3.4.1 Limiting values for controlling obtrusive light on residents in AS 4282:1997

Light technical parameter	Application or calculation conditions	Zones		
		Commercial and commercial/ residential boundary	Residential light surrounds	Residential dark surrounds
Illuminance in vertical plane (E_v)	Pre-curfew:	25 lx	10 lx	10 lx
	Curfewed hours:	4 lx	2 lx	1 lx
Luminous intensity emitted by luminaires (I_d)	Pre-curfew:	Limits as determined Table #(a) on Maximum luminous intensity per luminaire for pre-curfew operating times. Alternatively, curfewed hours limits may be applied, at the discretion of the designer.		
	Curfewed hours:	2500 cd	1000 cd	500 cd

Table 3.4.1(a) **Maximum luminous intensity per luminaire** for pre-curfew operating times

Area description [EMSD: Define the meaning.]		Maximum luminous intensity from each luminaire*	
Size of area??	Controlling dimension	Level 1 control (Note 1)	Level 2 control (Note 2)
Large	> 75 m	7500 cd	100,000 cd
Medium	≥25 m ≤75 m	7500 cd	50,000 cd
Small	<25 m	2500 cd	25,000 cd

Institute of Lighting Engineers (UK)
Guidance Notes for the Reduction of Obtrusive Light GN01

Table 1 – Obtrusive Light Limitations for Exterior Lighting Installations

Environmental Zone	*Sky Glow ULR [Max %] (1)*	*Light Trespass (into Windows) Ev [Lux] (2)*		*Source Intensity I [kcd] (3)*		*Building Luminance Precurfew (4)*
		Pre curfew	*Post curfew*	*Pre curfew*	*Post curfew*	*Average, L [cd/m2]*
E1	*0*	*2*	*1**	*2.5*	*0*	*0*
E2	*2.5*	*5*	*1*	*7.5*	*0.5*	*5*
E3	*5.0*	*10*	*2*	*10*	*1.0*	*10*
E4	*15.0*	*25*	*5*	*25*	*2.5*	*25*

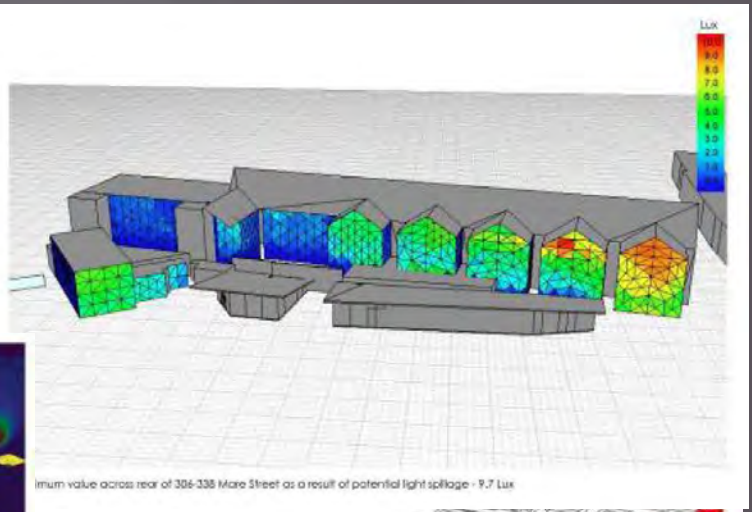
ULR *= Upward Light Ratio of the Installation is the maximum permitted percentage of luminaire flu for the total installation that goes directly into the sky.*

Ev *= Vertical Illuminance in Lux and is measured flat on the glazing at the centre of the window I Light Intensity in Cd*

L *= Luminance in Cd/m2*

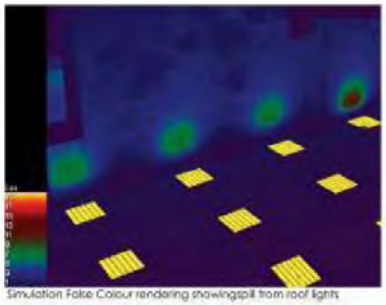
Curfew *= The time after which stricter requirements (for the control of obtrusive light) will apply; ofte a condition of use of lighting applied by the local planning authority. If not otherwise state 23.00hrs is sugge:*

** = From Public road*



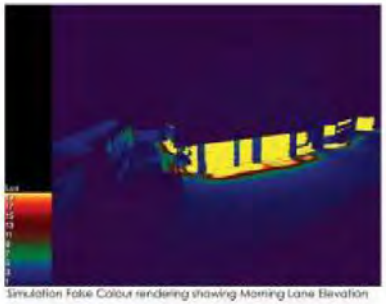
imum value across rear of 306-338 Mare Street as a result of potential light spillage - 9.7 Lux

Simulation rendering showing light spill from roof lights

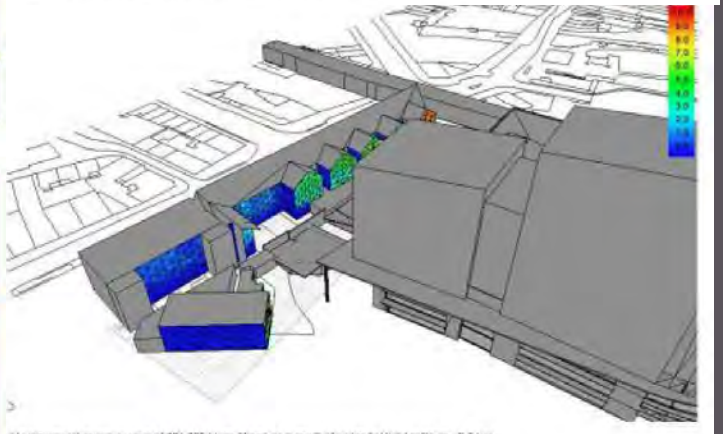


Simulation Fake Colour rendering showingspill from roof lights

Simulation rendering showing Morning Lane Elevation

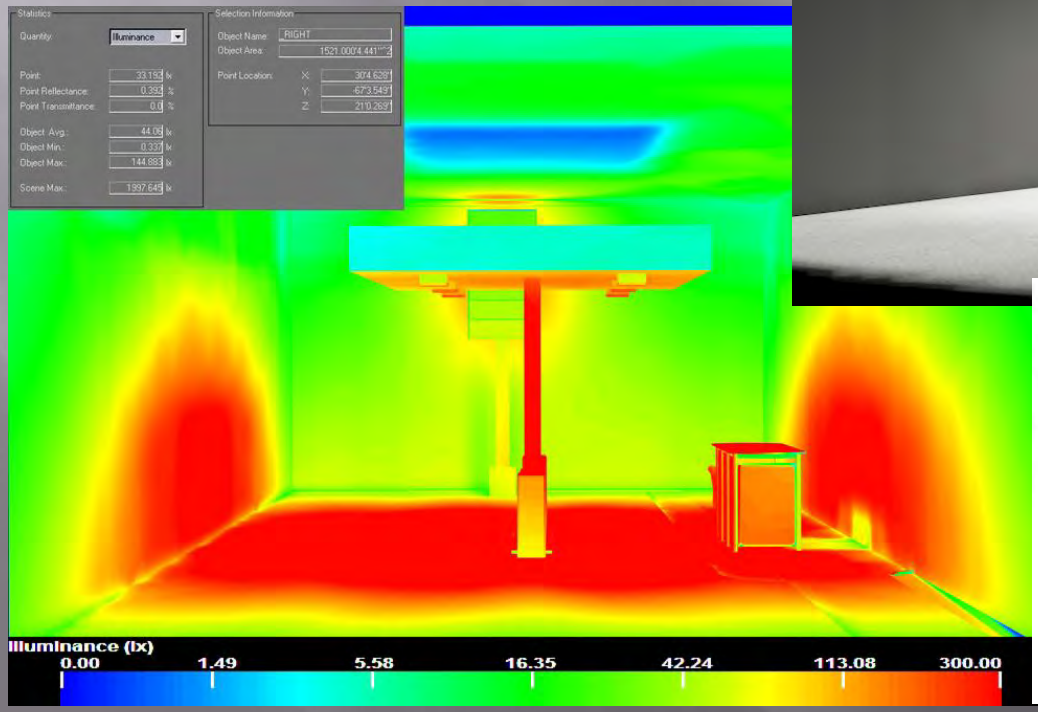


Simulation Fake Colour rendering showing Morning Lane Elevation



Maximum value across rear of 306-338 Mare Street as a result of potential light spillage - 9.7 Lux

Outdoor Site Performance (OSP) Method
Lighting Research Center



Outdoor site-lighting performance: A comprehensive and quantitative framework for assessing light pollution

JA Brons MSc, **JD Bullough** PhD and **MS Rea** PhD
Lighting Research Center, Rensselaer Polytechnic Institute, Troy, NY, USA

Received 8 April 2008; Revised 8 May 2008; Accepted 10 May 2008

Outdoor Site-Lighting Performance (OSP) is a comprehensive method for predicting and measuring three different aspects of light pollution: glow, trespass and glare. OSP is based upon the philosophy that a rational framework is necessary for optimising private and public desires for and against night-time lighting. Results are presented from over one hundred outdoor lighting installations that provide an empirical foundation for acknowledging the benefits of night-time lighting while establishing limits on light pollution. Recommended limits for glow, trespass and glare are offered to stimulate discussion among all stakeholders concerned with night-time lighting.

TM-11-00

Light Trespass: Research, Results *and* Recommendations

IES
The LIGHTING AUTHORITY®

Publication of

Prepared
IESNA Ro

Table 1. Recommended Light Trespass Limitations

Environmental Zone	Pre-Curfew Limitations*	Post-Curfew Limitations*
E1	1.0 (0.10)	0.0 (0.00)**
E2	3.0 (0.30)	1.0 (0.10)
E3	8.0 (0.80)	3.0 (0.30)
E4	15.0 (1.50)	6.0 (0.60)

* Lux (footcandles) values on a plane perpendicular to the line of sight to the luminaire (s).

**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

LEED – Light Pollution Reduction (1 Point)

Meet uplight and light trespass requirements, using either the backlight-uplight-glare (BUG) method (Option 1) or the calculation method (Option 2). Projects may use different options for uplight and light trespass.

MLO lighting zone	Luminaire uplight rating
LZ0	U0
LZ1	U1
LZ2	U2
LZ3	U3
LZ4	U4

	MLO lighting zone				
Luminaire mounting	LZ0	LZ1	LZ2	LZ3	LZ4
	Allowed backlight ratings				
> 2 mounting heights from lighting boundary	B1	B3	B4	B5	B5
1 to 2 mounting heights from lighting boundary and properly oriented	B1	B2	B3	B4	B4
0.5 to 1 mounting height to lighting boundary and properly oriented	B0	B1	B2	B3	B3
< 0.5 mounting height to lighting boundary and properly oriented	B0	B0	B0	B1	B2
	Allowed glare ratings				
Building-mounted > 2 mounting heights from any lighting boundary	G0	G1	G2	G3	G4
Building-mounted 1–2 mounting heights from any lighting boundary	G0	G0	G1	G1	G2
Building-mounted 0.5 to 1 mounting heights from any lighting boundary	G0	G0	G0	G1	G1
Building-mounted < 0.5 mounting heights from any lighting boundary	G0	G0	G0	G0	G1

IDA – IES Model Lighting Ordinance

Illuminating ENGINEERING SOCIETY

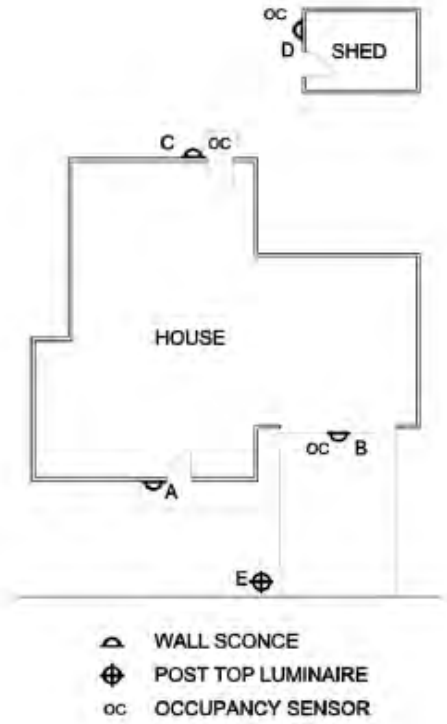
INTERNATIONAL DARK-SKY ASSOCIATION

JOINT IDA - IES

MODEL LIGHTING ORDINANCE (MLO)

with USER'S GUIDE

June 15, 2011



A. General Requirements

For residential properties including multiple residential properties not having common areas, all outdoor luminaires shall be fully shielded and shall not exceed the allowed lumen output in Table G, row 2.

Exceptions

1. **One partly shielded or unshielded luminaire at the main entry, not exceeding the allowed lumen output in Table G row 1.**
2. **Any other partly shielded or unshielded luminaires not exceeding the allowed lumen output in Table G row 3.**
3. **Low voltage landscape lighting aimed away from adjacent properties and not exceeding the allowed lumen output in Table G row 4.**
4. **Shielded directional flood lighting aimed so that direct glare is not visible from adjacent properties and not exceeding the allowed lumen output in Table G row 5.**
5. **Open flame gas lamps.**
6. **Lighting installed with a vacancy sensor, where the sensor extinguishes the lights no more than 15 minutes after the area is vacated.**
7. **Lighting exempt per Section III (B.).**

B. Requirements for Residential Landscape Lighting

1. **Shall comply with Table G.**
2. **Shall not be aimed onto adjacent properties.**

Property Type: Residential
Lighting Zone 1

Luminaire Type	Location	Luminaire Description	Fully Shielded	Lamp Type	Initial Luminiare Lumens*	Maximum Allowed Initial Luminaire Lumens (Table G)	Controls	Compliant
A	Front Entry	Decorative wall sconce	No	9W CFL	420	420	None	Yes
B	Garage Door	Fully shielded wall pack	Yes	23W CFL	1050	1260	Occupancy Sensor	Yes
C	Back Entry	Decorative wall sconce	No	7W CFL	280	315	Occupancy Sensor	Yes
D	Shed Entry	Fully shielded wall pack	Yes	40W INC	343	1260	Occupancy Sensor	Yes
E	Driveway	Fully shielded post top	Yes	13W CFL	1260	1260	None	Yes

*Initial Luminaire Lumens are calculated by multiplying the total initial lamp lumens by the luminaire efficiency.
If the luminaire efficiency is not known, assume an efficiency of 70% and multiply the lamp lumen value by 0.7.

Residential

IDA – IES Model Lighting Ordinance

A. Prescriptive Method

An outdoor lighting installation complies with this section if it meets the requirements of subsections 1 and 2, below.

1. Total Site Lumen Limit

The total installed initial luminaire lumens of all outdoor lighting shall not exceed the total site lumen limit. The total site lumen limit shall be determined using either the Parking Space Method (Table A) or the Hardscape Area Method (Table B). Only one method shall be used per permit application, and for sites with existing lighting, existing lighting shall be included in the calculation of total installed lumens.

The total installed initial luminaire lumens is calculated as the sum of the initial luminaire lumens for all luminaires.

B. Performance Method

1. Total Site Lumen Limit

The total installed initial luminaire lumens of all lighting systems on the site shall not exceed the allowed total initial site lumens. The allowed total initial site lumens shall be determined using Tables D and E. For sites with existing lighting, existing lighting shall be included in the calculation of total installed lumens.

The total installed initial luminaire lumens of all is calculated as the sum of the initial luminaire lumens for all luminaires.

Commercial

Table A - Allowed Total Initial Luminaire Lumens per Site for Non-residential Outdoor Lighting, Per Parking Space Method

May only be applied to properties up to 10 parking spaces (including handicapped accessible spaces).

LZ-0	LZ-1	LZ-2	LZ-3	LZ-4
350 lms/space	490 lms/space	630 lms/space	840 lms/space	1,050 lms/space

Table B - Allowed Total Initial Lumens per Site for Non-residential Outdoor Lighting, Hardscape Area Method

May be used for any project. When lighting intersections of site drives and public streets or road, a total of 600 square feet for each intersection may be added to the actual site hardscape area to provide for intersection lighting.

LZ-0	LZ-1	LZ-2	LZ-3	LZ-4
Base Allowance				
0.5 lumens per SF of Hardscape	1.25 lumens per SF of Hardscape	2.5 lumens per SF of Hardscape	5.0 lumens per SF of Hardscape	7.5 lumens per SF of Hardscape

Table D Performance Method Allowed Total Initial Site Lumens

May be used on any project.

Lighting Zone	LZ 0	LZ 1	LZ 2	LZ 3	LZ 4
Allowed Lumens Per SF	0.5	1.25	2.5	5.0	7.5
Allowed Base Lumens Per Site	0	3,500	7,000	14,000	21,000

Table E Performance Method Additional Initial Luminaire Lumen Allowances. All of the following are "use it or lose it" allowances.

All area and distance measurements in plan view unless otherwise noted.

Lighting Application	LZ 0	LZ 1	LZ 2	LZ 3	LZ 4
Additional Lumens Allowances for All Buildings except service stations and outdoor sales facilities. A MAXIMUM OF THREE (3) ALLOWANCES ARE PERMITTED. THESE ALLOWANCES ARE "USE IT OR LOSE IT".					
Building Entrances or Exits. This allowance is per door. In order to use this allowance, luminaires must be within 20 feet of the door.	400	1,000	2,000	4,000	6,000
Building Facades. This allowance is lumens per unit area of building façade that are illuminated. To use this allowance, luminaires must be aimed at the façade and capable of illuminating it without obstruction.	0	0	8/SF	16/SF	24/SF

Approach

- What's bad or good?
- How can it be defined?
- Prescriptive or performance?
- How will it be enforced?