The background of the slide is a dark, starry night sky. In the foreground, the dark silhouette of a tree with many bare branches is visible, creating a complex pattern against the starry background. The text is overlaid on this scene.

Scotobiology Compliant Luminaire

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Market for Low LP Luminaires

Cities

Highest population and ALAN Density

Human health priority

Opportunity for mass-marketed luminaires

However 24/7 lifestyles



Market for Low LP Luminaires

Small Towns

Small tax base

Re-lamping may not be practical

New technology for new developments

Environmental impact visible to citizens

Market for Low LP Luminaires

Rural Property Lighting

Vanity, security, visibility

Low value market – economical luminaires

Low ambient levels – uniformity required

Wildlife sensitivity – illumination levels,
colour, timing

New marketing campaign to promote new paradigm



Scotobiology

(Study of the biological need for periods of darkness)

Tenants of Light Pollution Abatement

1. Reduce light trespass,
2. Reduce illumination levels,
3. Reduce the blue content in ALAN, and
4. Reduce the duration of ALAN.

Optics

(There's no such thing as "simple optics")

Shielded and Full (or Sharp) Cut-off fixtures

Uniformity

Baffle view of LEDs



Complex and competing requirements

Shielded Fixtures

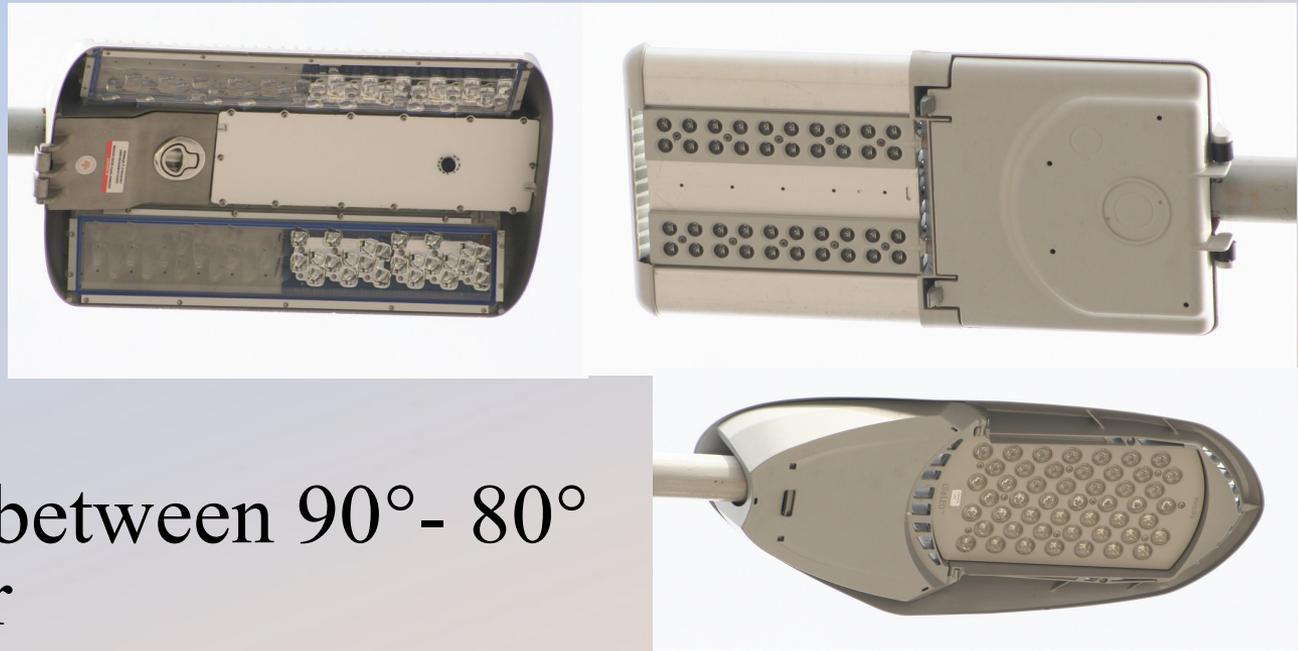
Minimize extent of illumination
(FCO/SCO optics)

- Limits environmental impact
- Reduces glare and light trespass
 - Less glare = visibility with less light
 - Reduces electricity usage ✓
 - Allows smaller luminaires ✓
 - Reduces cost of hardware ✓

(May use natural features, buildings as shields)



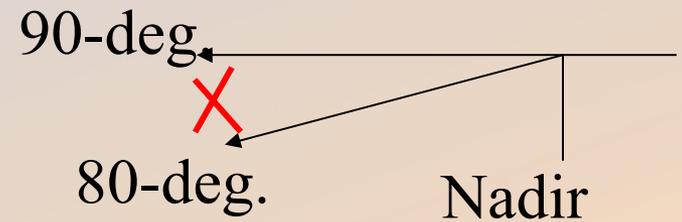
FCO?



Poor control between 90° - 80°
from nadir

Glare across neighbourhood

Remedy: Sharp Cut-off (SCO)



- 80 - 90° from nadir $< 1\%$ (more stringent than older 10% IES recommendation)
- eliminates glare down the road
- minimizes light trespass into bungalow homes

Uniformity

Shielding is not enough

⬇ Uniform illumination levels

- Prevent nadir bright spots
- Wider target area per watt



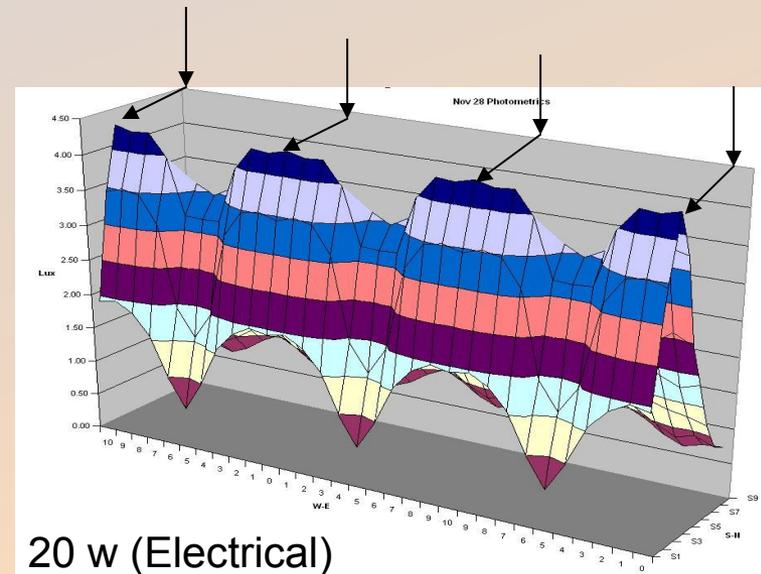
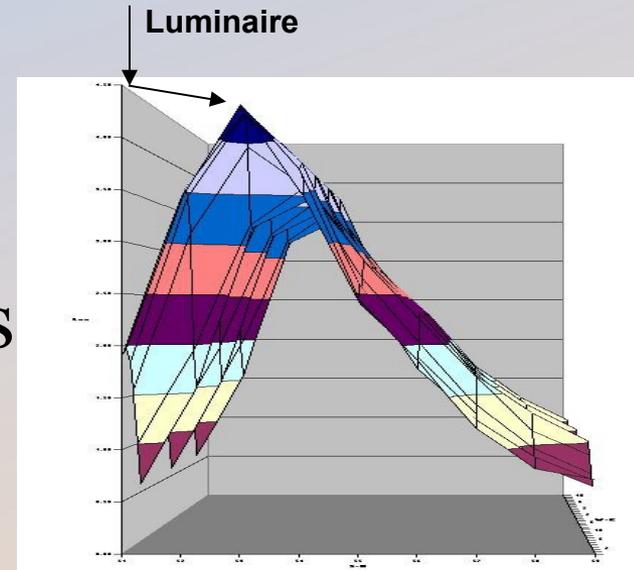
Uniformity

Project more light at higher angles

Older streetlights typically 6:1

CSbG Luminaire (2.65 x ht.)

- 1½:1 along track
- 3:1 across track (1.5 x ht.)



Baffle Against View of LEDs

LED Luminance ⌚ Bare Tungsten Filament!

To avoid glare

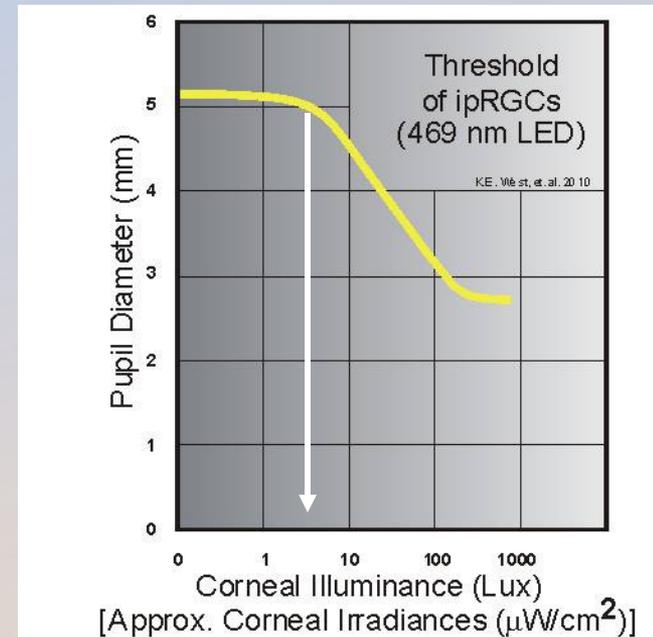
- Prevent LEDs from being seen by drivers
- Ensure luminaire outside FOV of pedestrians

CSbG Luminaire - Avoids eye damage

- Use baffles to prevent direct view of LEDs
- Increase “apparent” emitting area

Illumination levels

Maximum set by ipRGCs
and scotopic vision (1-3 lx)
Max. at Full Moon 0.27 lx



Suggested illumination levels

- Residential - < 3-lx max.
- Parks / pathways - < 2-lx max.
- Non-critical uses - timer, motion sense, dim
- Commercial signs - 3-lx above ambient

CSbG Luminaire – 3-lx, 15 w at 5-m ht.

Spectrum

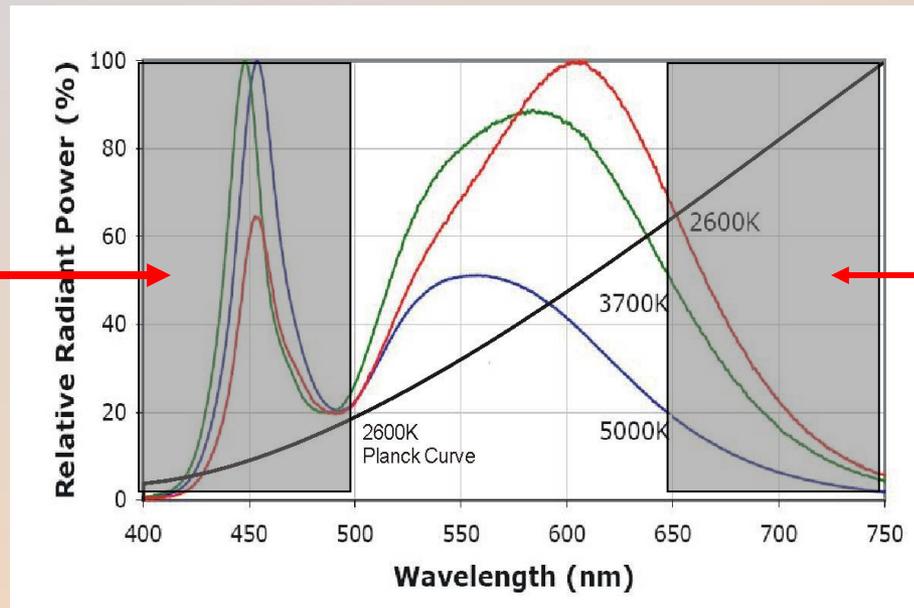
“Biology does not perceive colour, it reacts to it”

Colour Temperature versus Spectrum

C_T - “Apparent” colour of a hot surface

\neq Spectrum Temperature (Planck Curve)

Visibility,
Health

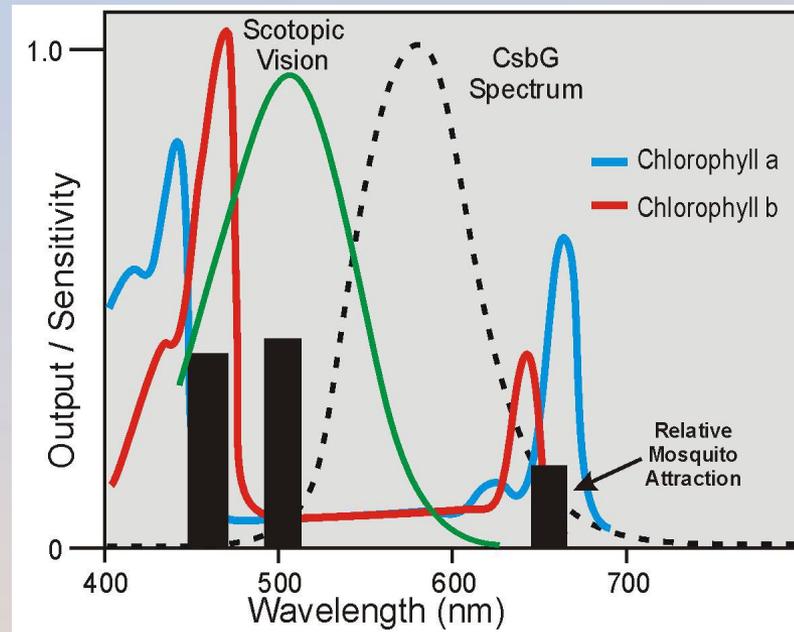


Ecological
Impact

Colour

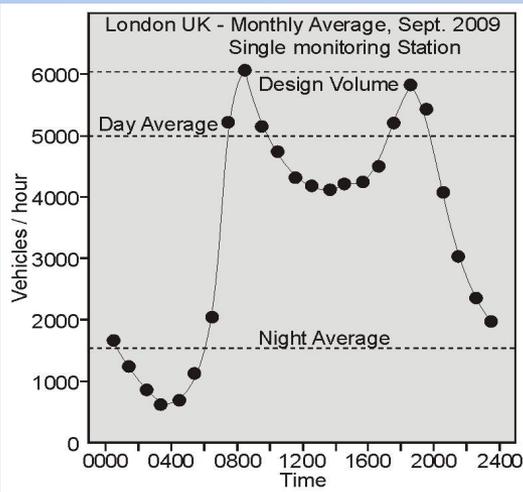
Blue components in “white”:

- Degrades health
- Scatters in dust, smoke, fog reducing visibility



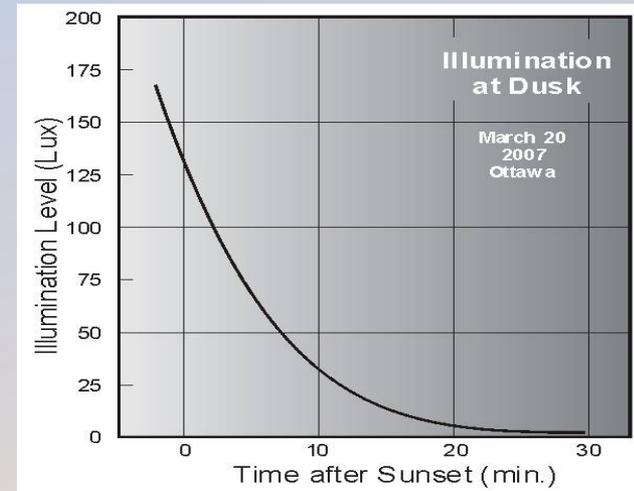
CSbG Luminaire spectra > 500 nm and < 650 nm

- “Looks like” HPS but w/o health effects
- Reduced impact: insects, plants, night vision
- minimal impact on biochemistry
- Less scattered light than for “white” light
- Less affect on our night vision



Duration

Policy should encourage good health for general population



Peak night-vehicle traffic < 25% of daytime (>10 pm.)

- High density/speeds require photopic lighting
- Lighting levels set by peak traffic volumes
- reduce lighting levels after peak periods

Limit light to periods of activity (season dependence)

- Turn off when facility/business is closed
- Dim / turn-off ALAN < 2-hrs after sunset, or < 11 pm for active public spaces

Keep it Cool

Marketing “Spin” 100K hr

[at 25C junction temp]

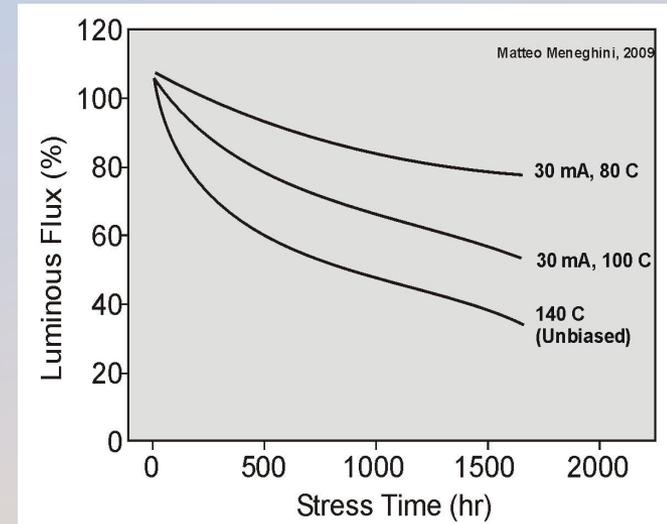
[LEDs only]

- Phosphors are temperature limited (85C)
- Plastic lenses darken at high temperatures
- Arrhenius Relationship 1/10 life per 40C

CSbG Luminaire

- 10C/W from Jct. to Case [per LED]
- 2C/W from Case ↴ heatsink surface [per LED]
- 2C/W Heatsink ↴ ambient air [per emitter plate]

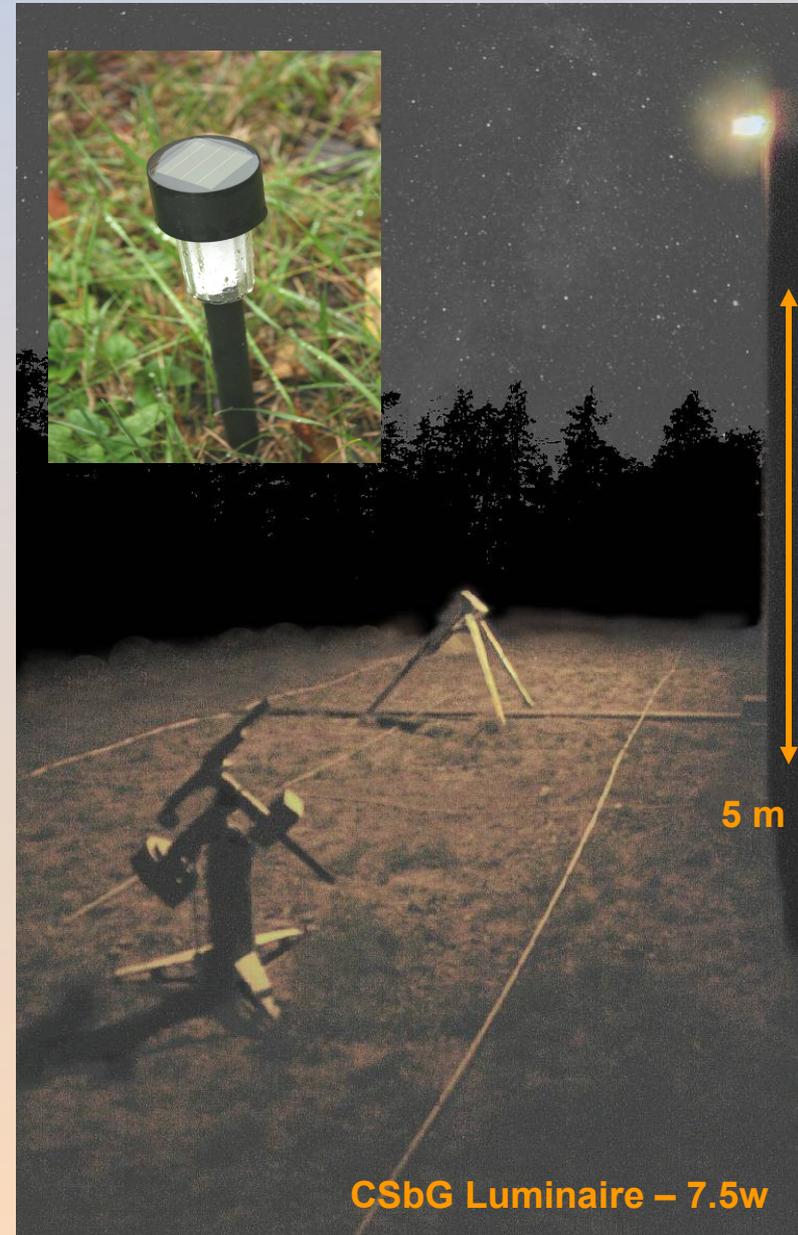
Jct. ↴ ambient air < 60C [system]



How much Light is Enough?

- 1-3 Lux
- “True Amber” preserves dark vision to see stars (transition from light to darker areas)
- Saves circadian rhythm for those who sleep at night
- Darkness for nocturnal animals

Garden lights? – but only in “White”



Scotobiology

(Its not just about astronomy!)

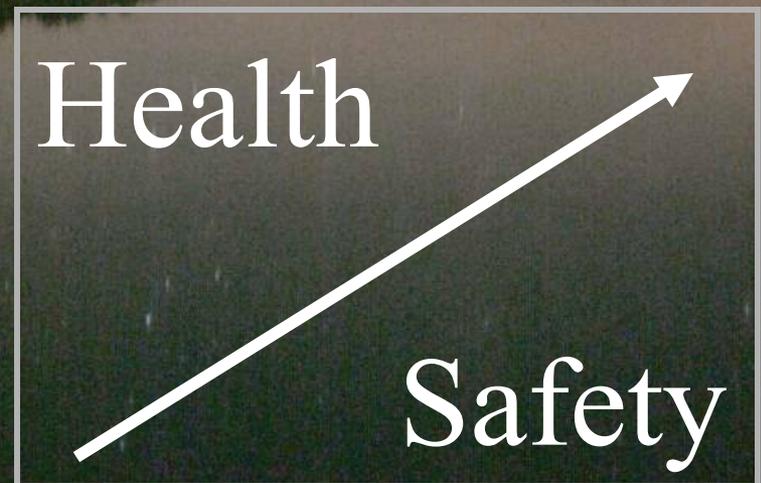
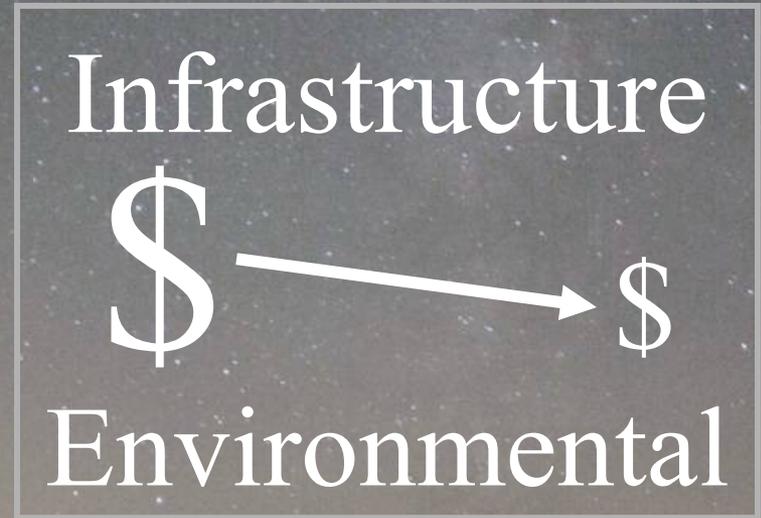
Evolutionary Time Frame

Biological – 100,000 years

Behavioural – multi-generation

ALAN – 50-100 years

1. Reduce light trespass
(FCO Fixtures)
2. Reduce illumination levels
(1-3 Lux max.)
3. Reduce the duration
(Dimmers, Timers)
4. Reduce the blue
(True Amber)



Colour of LEDs

Daytime

– “white” sunlight (130,000 lx)

Evening

– blue & red light (150 \star 0.3 lx)

Night

– minimal light (0.3 \star 0.002 lx)

Restrict all outdoor
white light to within
1-hour during twilight

