Visual Comfort and Energy Efficient Lighting

Ashish Bahal, Architect
• Lighting

• Parameters of Lighting – visual comfort

• Energy Efficient lighting
“Light is beauty - without it the world would be dark and dreary.”

“Light is a kiss from the Sun.”

“Light is the truth, security, life and happiness.”

“Light is sight and color and vibrancy. Light gives us the ability to see, and its brightness adds life to the colors and things we see.”

“What light means to people?

“Light is holding hands on a first date.”

“Light is the oxygen for our eyes.”

“Light is a source of energy and comfort.”

“Light makes life work.”

“Light is like a little ray of hope.”
What light means to designers?

“Architecture is the learned game, correct and magnificent, of forms assembled in the light.”

Light is of decisive importance in experiencing architecture.

Light controls people, people’s behavior and emotions.

Lighting involves its relationship with society, the city.

Is there form without light?

Where there is no light, there is no beauty.
Light is ... Sustainable

“LED lighting can save more electricity than solar will produce”

Roland Haitz

Bloom by Philips Design - 2008

Little Sun by Olafur Eliasson and Frederik Ottesen
© frederik ottesen and olafur eliasson

Solar Impulse HB-SIA – first solar powered intercontinental plane
Light is ... Better Food

A plant only uses part of the solar light wavelength to grow.
Light is ... Wellbeing

Light does have an incredible influence on your physical and mental state

Philips School Vision

Olafur Eliasson – The Weather Project at Tate Modern

Philips Ambient Experiences

Day & Light Luminare by Philip Bogaert
Light is ... Health

Patients always heal faster at the south side of the hospital

Philips Heal Well

Philips Bilirubine Blanket
Light is ... Experience

Digital light in all color spectrum brings unbelievable experiential possibilities
Light is ... Different

LEDs can completely disturb the current lighting archetypes.
Simply enhancing life with light
The Philips Lighting difference

People focused + Partners in innovation = Meaningful solutions
• Lighting

• Parameters of Lighting – visual comfort

• Energy Efficient lighting
Lighting Trends was driven by technology

• ‘70’s /’80
  – Standards Compliance & Product Efficiency
    → Visual Performance

• Late 80’s-90’s
  – Glare, Colour Rendering
    → Visual comfort, Glare

• mid‘90’s -early 2000
  – Spatial Light Distribution, Optics
    → Ambience in Workspace
In this millennium... Human Needs drive Technology to bring in Innovation

Influence on Human Being

– Visual and Biological Need
– Impact of Lighting on Mood, Alertness and hence Performance
Visual effects of light

The visual part of light influences the way we work

- Lighting level
- Colour rendering (task recognition)
- Glare free environments
- Even light distribution
- Task, Orientation, Safety, Guidance
Primary Lighting Objectives

1. Meet the User needs of the Space

2. Meet the Lighting Technical Standards
   a. Visual Performance –
      • Lighting Level, Uniformity
   b. Visual Comfort
      • Glare, Colour Rendering, Colour Appearance

3. Evaluate Energy Performance Requirement
Factors influencing lighting design

• Function of space
• Dimension and detail of space
• Furnishing and layout
• Style & Décor
• Lighting budget
Lighting Parameters

Basic Parameters
– Lighting Level
– Uniformity
– Glare
– Brightness distribution
– Modelling
Lighting Parameters

- Lighting Level
  - Average value specified over the surface

- Specified as range of values (300-500-750)
  - Lower Value
    - High Reflectance
    - Speed /Accuracy is not important
    - Task is Executed occasionally
  - Higher Value
    - Unusually low reflectance
    - Visual Work is critical
    - Errors are costly to rectify
    - Visual capacity of worker is below normal
Luminance Distribution

Brightness distribution happens because of differences in surface reflectance.
Glare

- Various glare sources
  - Bright sources
    - Windows
    - View
    - Direct sun
    - Lamps
  - Reflective material
    - Glossy desk
    - Glossy magazine
    - Computer screen
    - Any glossy material
    - Luminaire (optics)
Light and Productivity

Feel good, work better

Hawthorne Effect
Beyond Human: Cost & Environmental Impact

Reduce wastage of energy & impact on eco-system
Content

- Lighting
- Parameters of Lighting – visual comfort
- Energy Efficient lighting
Green Lighting Approach

1. Green Product Approach
2. Efficient Product Approach
3. Energy Saving System Approach
4. Light Pollution Reduction
5. Renewable Energy Approach
Total life cycle impact of lighting
Up to 95% during the user phase
EcoDesign

Life Cycle approach

Philips Green Focal Areas

1. Green Product Approach

Energy Efficiency
- 10% less energy usage
- (e.g. efficacy, LOR or total power consumption)

Packaging
- > 10% less packaging in volume or weight

Hazardous Substance
- > 10% less weight of one of the substances of the restricted and relevant substance list
- > 10% radiation dose reduction

Weight
- > 10% less product weight (incl. accessories), measured in Kg.

Recycling and Disposal
- > 10% higher content of material that can be recycled; Product that contains > 30% recycled material

Lifetime Reliability
- > 10% life time improvement

One or more of our GFAs must be significantly better resulting in a lower total environmental impact.
Life Cycle Analysis of 3 competing technologies

Comparison basis
Number of lamps needed for 25k hr of usage

EnduraLED 12W (25k hr)

Twister T2 14W (8k hr)

Incandescent 60W (1k hr)
Green Lighting solutions

- Total system strategy to reduce lighting energy consumption, incl. efficient lamp, electronic driver, high performance luminaires & LED luminaires
- Controls is a must for earning more Green building points!
2. Efficient Product Approach

**Strategy 1+2- Up-lamping + Up-gearing**

- T5 lamps have **low mercury** content over 50% reduction (vs. T8)
- T5 lamps are **22% more efficient** than standard T8 lamp
- New T5 Eco has additional 10% saving vs. T5; highest efficacy

- CDM lamps have **low mercury**, no lead
- CDM Elite is available for 20-70W, **2~4 times higher efficiency** than halogen
- **Crisp white light** with excellent colour rendering (Ra 90) and stable colour performance during lifetime
- **Reduce maintenance/disruption cost**- Long lifetime 12,000 hrs (avg of 20,000 hrs)
Strategy 3- Luminaire efficiency upgrade

- **Upto 25% greener** (CO2 emission reduction)
- **High** luminaire integral **efficacy**
- **Totally mercury free** - Hazardous material (RoHS compliant)
- **Maintenance free**- Lifetime 50,000

**LuxSpace LED downlight**

- **High efficiency** LED downlights luminaire
- It offers **50% energy saving** vs. std CFL-I downlights
- **Smaller size** of LED lighting source allow sleek luminaire choices
Strategy 3- Luminaire efficiency upgrade

- Omni-directional Lighting Control (OLC)-
  - High efficiency for energy: **effective**
  - Wide delta-shaped beam: **best uniformity**
  - All-around low-brightness: **high comfort**

- TBS 869 has a very high efficiency (Light Output Ratio= LOR up to 78%) with D8H very high output louver (reflection rate is 94%); UGR<19
Lighting Power Density (LPD)

- ASHRAE 90.1-2007 provides guidance of Lighting Power Density (LPD)- the maximum amount of power that can be used for lighting. It varies by the use of the building or the spaces within it.
- Two methods for calculating the LPD:
  
  **“Building Area” approach**
  
  Applies a single Lighting Power Density (LPD) limit in watts per square foot to the entire area of the building

  **“Space-by-Space” approach (in most cases)**

  *Each area of the building is allocated an LPD limit, which varies by the use of the area*
  
  *Special allowances for decorative luminaires (1.0 W/SF) and computer luminaires (.35 W/SF)*

### Office Lighting Power Density under Standard 90.1

<table>
<thead>
<tr>
<th>Space</th>
<th>2007 LPD</th>
<th>Convert (W/sqm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosed office</td>
<td>1.1</td>
<td>11.8</td>
</tr>
<tr>
<td>Open office</td>
<td>1.1</td>
<td>11.8</td>
</tr>
<tr>
<td>Conference/ Meeting</td>
<td>1.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Training</td>
<td>1.4</td>
<td>15.1</td>
</tr>
<tr>
<td>Lobby</td>
<td>1.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Atrium (1st three floors)</td>
<td>0.6</td>
<td>6.5</td>
</tr>
<tr>
<td>Atrium (additional floors)</td>
<td>0.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Corridor</td>
<td>0.5</td>
<td>5.4</td>
</tr>
<tr>
<td>Active stairway</td>
<td>0.6</td>
<td>6.5</td>
</tr>
<tr>
<td>Active storage</td>
<td>0.8</td>
<td>8.6</td>
</tr>
<tr>
<td>Restroom</td>
<td>0.9</td>
<td>9.7</td>
</tr>
<tr>
<td>Electrical/ Mechanical</td>
<td>1.5</td>
<td>16.1</td>
</tr>
<tr>
<td>Food preparation</td>
<td>1.2</td>
<td>12.9</td>
</tr>
<tr>
<td>Dining</td>
<td>0.9</td>
<td>9.7</td>
</tr>
<tr>
<td>Laboratory</td>
<td>1.4</td>
<td>15.1</td>
</tr>
<tr>
<td>Building area method</td>
<td>1.0</td>
<td>10.8</td>
</tr>
</tbody>
</table>

2. **Efficient Product Approach**
Strategy 1- Apply Lighting Control (<5,000 sqm)

- **Automatic saving** - Lighting are on when needed
- **DALI system** is the most widely used digital control system in the world

**Motion detector**
- Switch on or dim up when sensing occupants presence
- Up to 30% savings

**Daylight linkage**
- Reduce artificial lighting when daylight is sufficient
- Up to 30-35% savings

**Daylight integration**
- Enable daylight to displace artificial lighting with sensitivity to occupants
- Up to 75% savings

---

**Lights on when needed**

- OccuSwitch

**Perfect regulation for every area**

- LuxSense

**Combination of Daylight & motion detector**

- OccuPlus
- Actilume
Strategy 2- Integrate with Energy Management System (>5,000 sqm; new construction)

- A comprehensive facility-wide networked control solution developed specifically for lighting control, for scaling and integrating extensively with HVAC, BMS, security, fire detection, access control, blinds, motors and other electrical loads systems to provide a comprehensive solution.
4. Light Pollution Reduction

Uniform Illumination
• Uniformity vs. High Light Levels
• Attempt to maintain max 1.5fc for average illumination.

Zero Trespass at Project Boundaries
• Illumination at property lines should be 0fc.
• Exceptions made for areas of high brightness (street adjacency, etc.)

No Up-lighting of Trees, Etc.
• v2.1 allows for minimal up-lighting only in areas of high ambient brightness if all other criteria are met.

Maintain Façade Lighting On The Building Face
Solar Street Lighting System

System Offering
1. LED Solar Street Light with MPPT controller
2. Solar Panel
3. Battery
4. Battery Box
5. Galvanised Pole
6. Pole fixing piece
LEDs have many advantages compared to other lighting sources

Conventional lighting sources
- Incandescent
- Halogen
- Fluorescent
- Gas-discharge (example: neon)

Light Emitting Diode (LED)
- Advantages of LEDs
  - Long lasting and low maintenance
  - Energy efficient
  - Dynamic (digitally) color control
  - Small (design flexibility)
  - Directed light (= increased efficiency)
  - Robust and vibration proof
  - Turn on instantly
  - No IR and UV radiation in the beam
  - Cool beam of light
  - Low voltage
  - No mercury
Overture Center For The Arts, Madison, WI
Architect: Cesar Pelli Associates, Potter Lawson & Flad Architects
Lighting Design: Cline Bettridge Bernstein
Photo Credit: Zane Williams
“Light is like fire, a good servant, but a poor master……It behooves anyone who is involved in the design and specification of lighting systems to be aware of [the] impacts of light on human health”

Peter Boyce, Human Factors in Lighting
“Light is the key to well-being.”

Le Corbusier