ADVANCES IN DAYLIGHT SIMULATION

A joint event by the CIBSE Building Simulation Group and the CIBSE Daylight Group

Why is Daylight design the Cinderella of Building Modelling

David Mooney Regional Associate PB
People like natural light
Are you wasting 10% of your electricity?

Are your lights on during daylight hours?

*Lights on Blinds Down = Bad Design*
1. Why daylight modelling is increasingly important
2. Project Constraints.
3. What Tools do we need for Daylight Modelling.
4. What and when Sunlight Modelling is Important.
5. Sunlight and Daylight Products.
6. Integrating Lighting Control Design with Daylight Modelling.
7. Case Studies.
8. Conclusions.
Why daylight modelling is increasingly important
Why is daylight modelling important

- Energy consumption.
- Statutory/regulatory change.
- Benchmarking.
- Quality of Internal environment
- User satisfaction and wellbeing
The Headlines

• Electric Lighting currently consumes 19% of current total global electricity
  \[= 1.9 \text{ Gt of CO}_2/\text{yr}.\]
• If current energy efficiency polices do not change will increase to
  \[= 3 \text{ Gt of CO}_2/\text{yr by 2030.}\]

IEA/OECD Lights Labours Lost 2006

There is no viable alternative to electric lighting during darkness hours that meets current design standards.
Figure OR.1  Estimated per-capita consumption of electric light* in 2005

- North America: 101 Mlmh
- Europe: 42 Mlmh
- Japan/Korea: 72 Mlmh
- Australia/New Zealand: 62 Mlmh
- China: 10 Mlmh
- Former Soviet Union: 32 Mlmh
- Rest of world: 8 Mlmh

* Source-lumens.
Abbreviation: Mlmh = megalumen-hours.
Regulations, Standards and Guides

Regulations

• European workplace directive - Access to daylight required
• Building Regulations - No minimum daylight standards

Standards

• BS 8206-2 2008 Code of Practice for daylighting.
• BREEAM 2008 (four points only !!!!!)
• Building Bulletin 87 Guidelines for environmental design in schools

• Lighting design for schools Building Bulletin 90
• Designing schools for the future Building Bulletin 95
• CIBSE LG2 Lighting for Healthcare buildings

Guides

• CIBSE SLL Daylighting and window design LG10 1999
• BRE Designing buildings for daylight.
• BRE Designing with innovative daylighting
BREEAM 2008

- HEA 1 Daylighting 1pt= 2%av 1pt Multi St 3%av Uo 0.4  single st  4% av Uo  0.4
- HEA 6 Lighting zones and controls 1pt.
- HEA 2 View to outside 1pt
- HEA 3 Glare 1pt

LEED

- Credit 8.1 Daylight and views—Daylight, 1 point
- Credit 8.2 Daylight and views—Views, 1 point
Wellbeing

Human Performance

Visual Performance

Motor Performance

Cognitive performance

Task performance

Visual Message

Context

Culture

Retinal luminance

Retinal image quality

Colour difference

Luminance contrast

Visual size

Fatigue

Eye strain / Ill health

Lighting

task

Retinal luminance

Retinal image quality

Colour difference

Luminance contrast

Visual size

Management

Personality

Motivation

Mood

Expectations

Phase shift

Circadian system

Alerting Effect

Time of day

Retinal luminance

Light spectrum

Peter Boyce Human factors in lighting
Photobiological Effects

Stimulation of Cone Receptors

- Non Visual Cones
- Photopic Vision

Eye's response to light
Levels of Attentiveness over a 24 Hour period

1. Dangerous need for sleep
2. Reduced attentiveness
3. Slightly reduced
4. Highest attentiveness

Daily ups and downs of body rhythms

- Body temperature (°F)
- Systolic blood pressure (mm Hg)
- Cortisol hormone secretion (µg/dl)

Sleep patterns

Hormone Production

midday

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Project Constraints.
Who is responsible for daylight design

- Architect
- Electrical engineer
- Mechanical engineer
- Environmental Specialist
- Lighting Designer/Specialist
- Lighting Supplier
Daylit architecture
When does Daylight Design Happen

A Inception

B Feasibility

C Concept

D Scheme

E Detail

F-H Production

J Tender

K Construction

L Handover
What Tools do we need for Daylight Modelling
Modelling Tools

- Physical Modelling
- Computer Modelling
- Manual Modelling
Physical Modelling

- Build a scale model of the building or section of the building.
- Use external daylight to simulate conditions
- Use Artificial skies
Hybrid post Ray Tracing and Radiosity packages

- Dialux
- Relux
- AGI 32
- Lumen Designer
- Revit
- 3D Studio Max

Backward Ray Tracing packages

- Radiance
- Superlite
- Adeline
What and when Sunlight Modelling is Important.
• We need to consider shading.
• We need to look at sun patches and the dynamic quality of daylight in the space.
Sunlight and Daylight Products
Sunlight and daylight products 1
Sunlight and daylight products 2
Integrating Daylight with Electric Light
For successful daylight/electric lighting integration

- Appropriate luminaire and lamp packages
- Appropriate control systems
- Understanding the client’s expectations and needs
- Understanding the client’s occupation patterns
- Correct commissioning of the systems
- Respecting the users.
Appropriate lamp and luminaire packages

- We need dimmable sources
- We need digital control gear technologies
- We need luminaires with appropriate optical distributions.
- We need luminaires that can still maintain their lit form through a range of luminances.
Typical daylight penetration diagram

Single sided daylit room

- Daylight distribution curve
- Position of sensor
- Electric lighting output curve
- IRC daylight

Depth of room from window wall

Direct & IRC daylight

Output of luminaires

daylight factor
Appropriate Control Systems

• We need open protocols such as DALI
• We simple yet effective control philosophies.
• We user interfaces that are simple and intuitive
• Our control systems must deliver daylight lumen for electric lumen savings.
Lighting Integration

Minimum daylight factor in the working area (orientation factor = 1.0)

- Probability of switching on lights (%)
- Time of day

0.1%, 0.2%, 0.5%, 1%, 2%

10% probability at 8:00
Case studies
Worked example of good practice daylight design
We predict that Model 2 would save in the order of \(8153 \text{ kWh/yr}\) which equates to \(3441 \text{ kg of CO}_2/\text{yr}\). This represents 80% of the artificial lighting load (based on artificial lighting load of \(11 \text{ w/m}^2\) and 8hrs/day daylight).
SAR-H Hanger Options

Hanger (with side windows) / Light scene 1 / False Colour Rendering

Hanger (with rooflights) / Light scene 1 / False Colour Rendering
Scottish and Southern Energy Havant
Conclusions

• Daylight is a renewable source it is carbon neutral.
• Good daylight design is for all buildings
• Controlled daylight can replace up to 80% of lighting energy consumption during daytime hours.
• Daylight design needs to be combined with intelligent lighting control.
• Increased regulation will limit lighting energy usage. good daylight design will become essential.
• The UK should incorporate minimum daylight standards to access carbon savings.
• Daylight design can create dynamic internal visual environments.
• Daylight improves health, wellbeing and attentiveness of occupants
• Lights on blinds down = bad design
• We need a professional to lead on daylight.
• Daylight needs coordinated design.
• Artificial lighting design and daylight design are linked.
• Intelligent lighting controls are an essential component of daylight.
• The correct contractual procurement method needs to be entered into to deliver the optimal design.
People *like* natural light
BIM needs to deliver buildings that can replace electric lumens with useful daylight lumens

CINDERELLA STILL HAS HER BALLROOM TICKET IN HER HAND
Thank you for your attention.

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