Aiming to achieve net zero energy lighting in buildings

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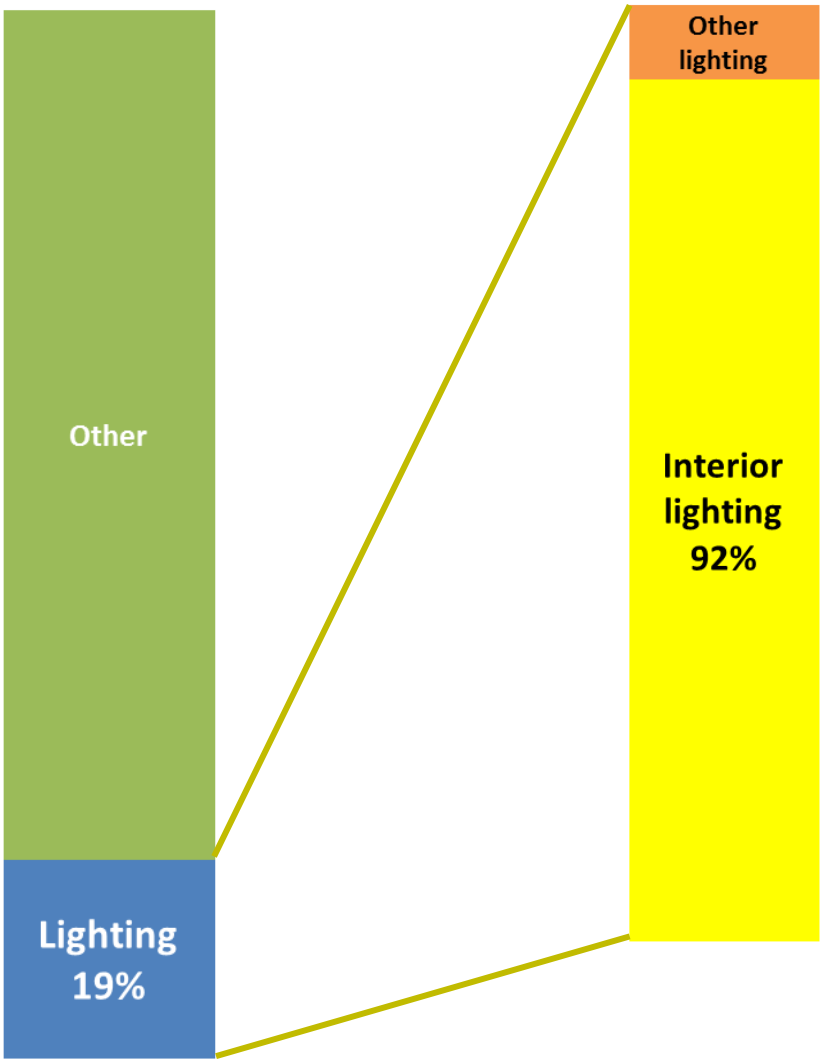
Part of the BRE Trust

Current background

1

Energy use for lighting

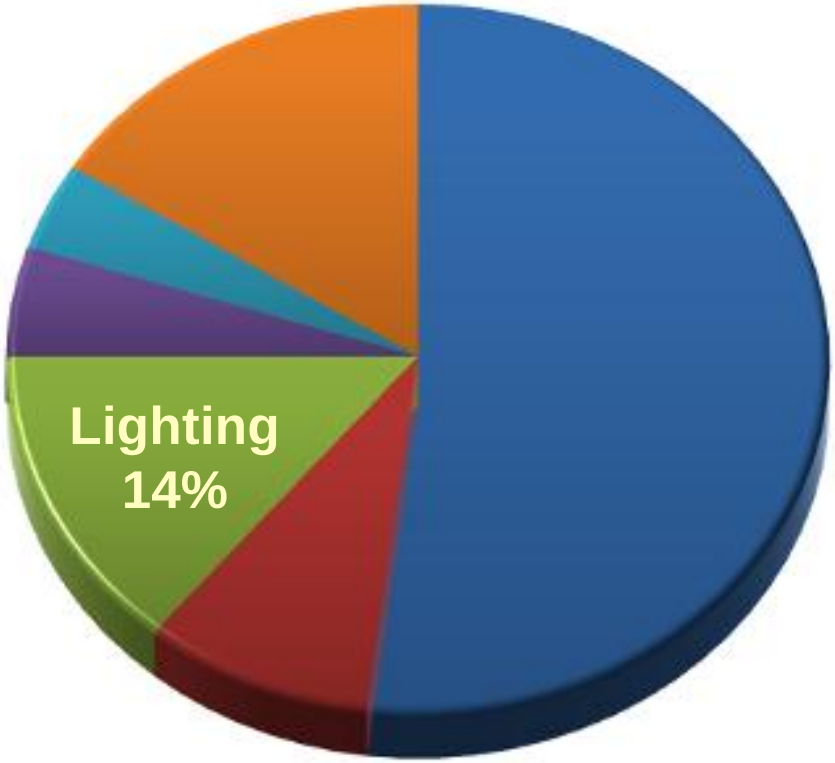
– Electricity consumption for lighting relative to total global electricity consumption in 2005



Source: Halonen, Tetri & Bhusal, 2010

Energy use for lighting

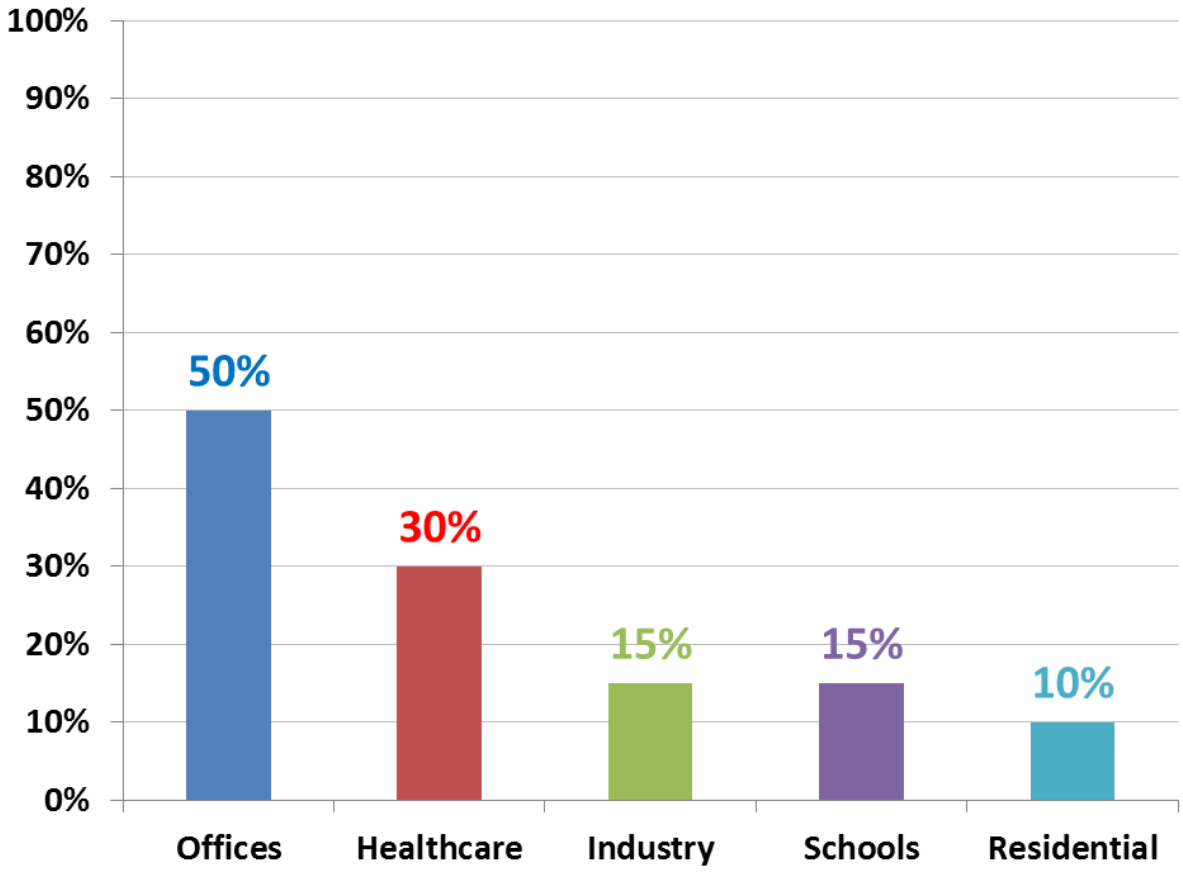
– Energy consumption in EU commercial buildings



Source: IEA

Energy use for lighting

– Electricity used for interior lighting by building type in Europe



Source: EC

Drivers towards energy-efficient lighting

- More than 50% of all lamps installed in Europe still not classed as energy efficient
- Increases in energy price
- EU aims for 20% cuts in Europe's annual primary energy consumption by 2020
- Energy efficiency initiatives
- Trend to reduce yearly electricity consumption for lighting to below 10 kWh/m^2

European legislative instruments

– Ecodesign Regulations 244/2009, 245/2009 and 1194/2012
  - ➢ Phasing out inefficient lamps and gear







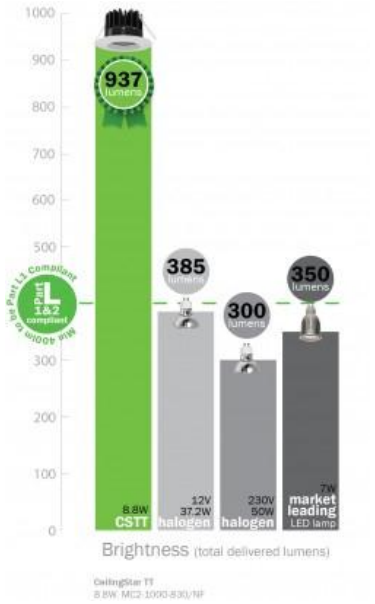

European legislative instruments

– EPBD 2010/31/EU
  - ➢ Minimum energy performance requirements
  - ➢ Energy certification

EPBD

– Methodology includes impacts from daylighting and built-in lighting systems

– UK Building Regulations Part L
  - ❑ Office, industrial and storage: 60 llm/cW
  - ❑ Other non-domestic spaces: 60 lm/W
  - ❑ Display: 22 lm/W
  - ❑ New dwellings: 75% low energy lamps, 45 lm/W
  - ❑ Alternative based on LENI



European legislative instruments

- Labelling of energy-using products / EU Regulation 874/2012
- Green Public Procurement criteria
  - Includes indoor and street lighting
  - Lamp efficacy
  - Overall system power consumption
  - Other parameters

BREEAM

- Environmental performance of new and existing buildings
- BREEAM International for buildings outside the UK
- Voluntary scheme often required by specifiers
- Lighting credits
  - Minimum floor areas adequately daylit
  - Suitable shading
  - Right quality of light according to codes and standards
  - Appropriate lighting system zoning and control
  - Separate sub-metering of energy use
  - Energy efficient external lighting

The future

- Substantial potential to reduce further the energy consumption for lighting and the associated carbon emissions
- Advanced optimised daylighting and of state-of-the-art electric lighting based on renewable energy sources
- Push forward the target by

AIMING TO

ACHIEVE NET ZERO ENERGY LIGHTING

IN BUILDINGS

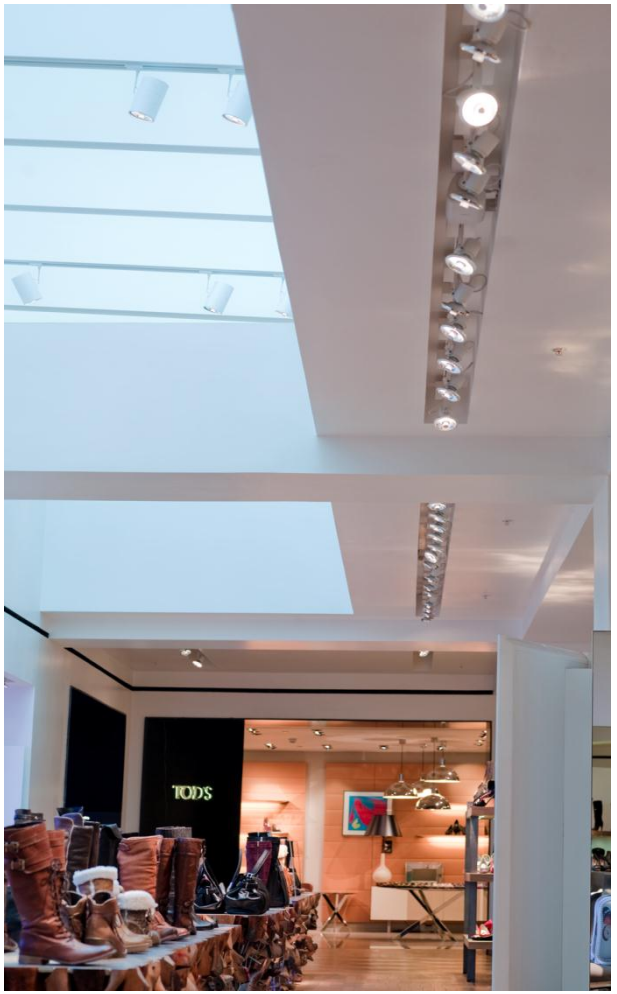
Methods to achieve net zero energy lighting

2

Minimise lighting energy consumption

- Minimise lighting power density
  - Optimise lighting strategies
  - Optimise levels of illuminance
- Use highly-efficient lighting technologies
- Use appropriate lighting control systems
- Maximise daylight use

! Do not neglect **QUALITY** when implementing energy-efficiency measures



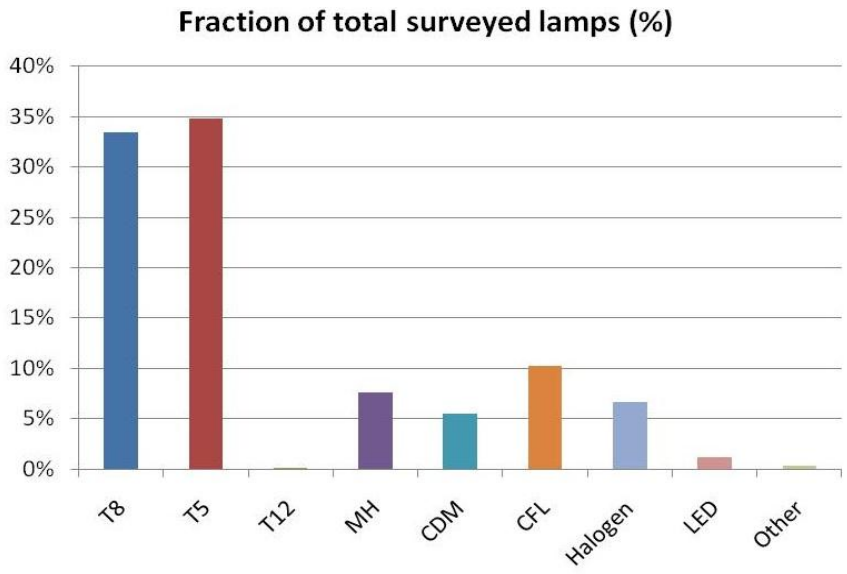
BRE survey of retail lighting

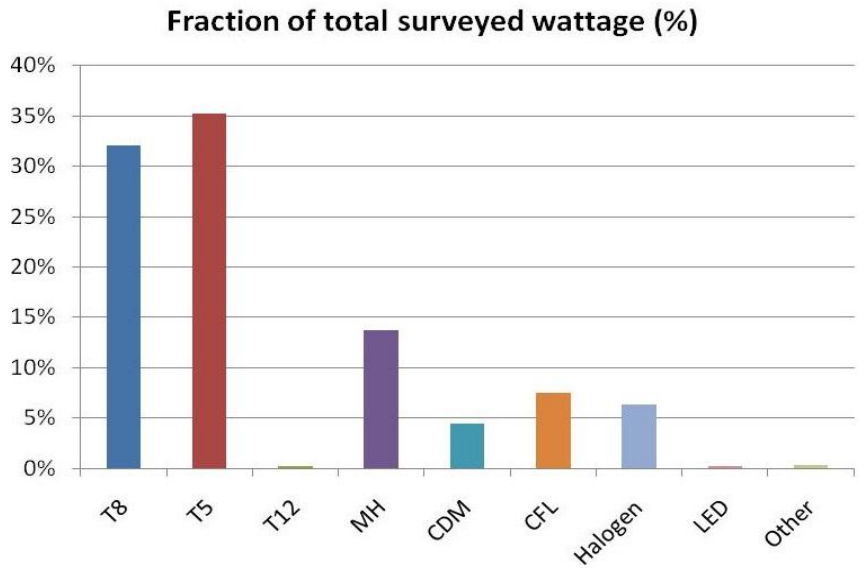
– Total LPD:

36 W/m^2; 122 kWh/m^2,year

– General lighting alone:

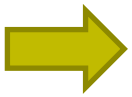
637 lux; 24.2 W/m^2; 5.77 W/m^2/100lux



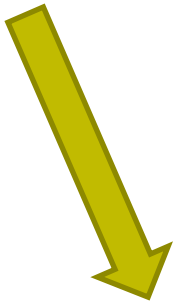


Minimise lighting loads

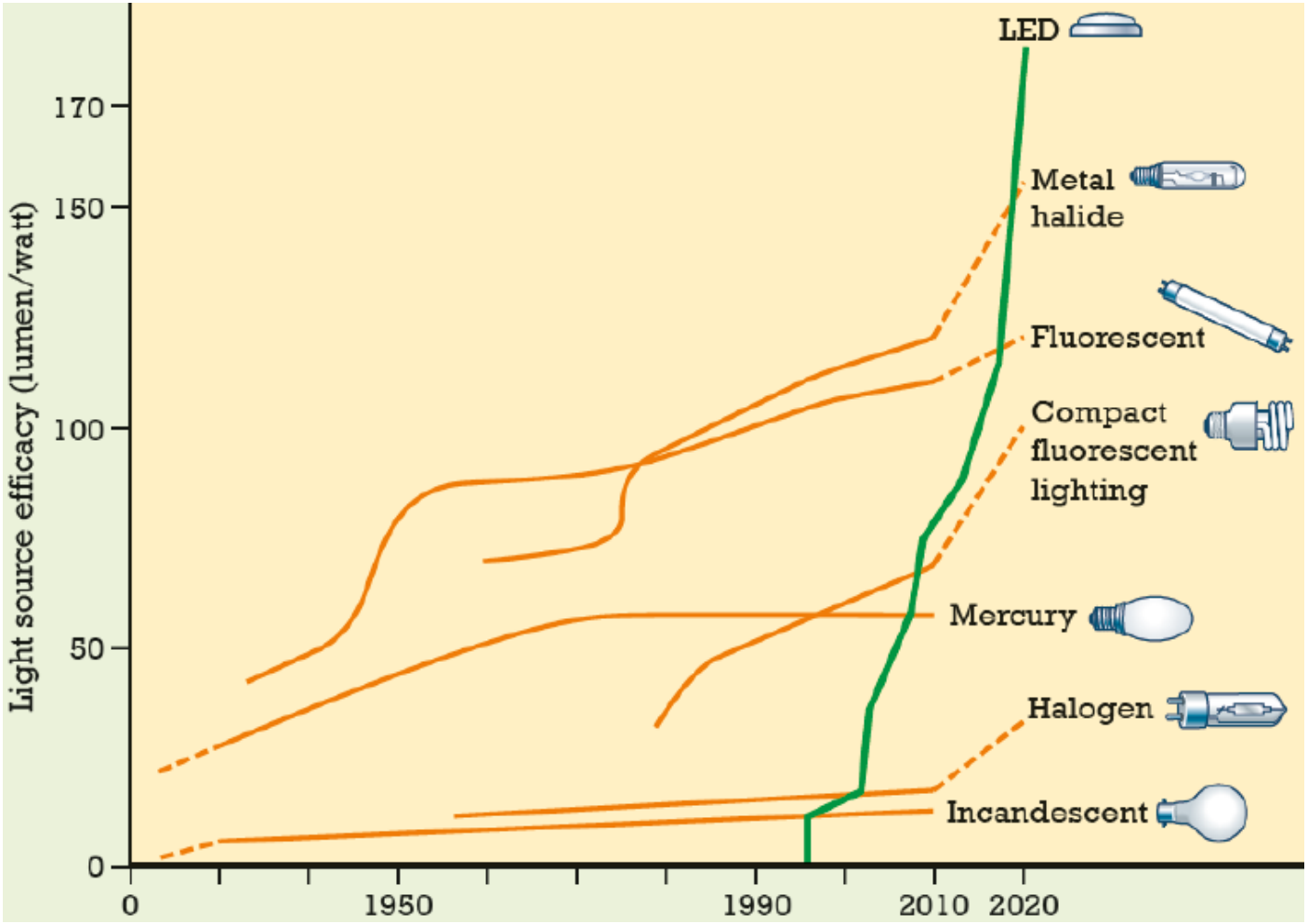
- Reduce illuminance levels to values recommended by standards and codes
- Optimise lighting strategies
- Change the lighting design philosophy
- Focus on the lit effect
- Deliver the right light where and when required



- ✓ Lighting power density (W/m^2)
- ✓ Normalised lighting power density (W/m^2.100lux)
- ✓ Energy use for lighting (kWh)



Use highly-efficient lighting technologies



Use highly-efficient lighting technologies

– CFL technology

– Osram DULUX L 40 W/830

– GE Biax L F40BX/830

– Philips MASTER PL-L 40W/830/4P

– Lamp efficacy **88 lm/W**
– Non-integrated ballast
– 4 pin 2G11 base

Use highly-efficient lighting technologies

– Metal halide technology

– Philips MASTERColour CDM-T Evolution 35W/930
– Lamp efficacy **110 lm/W**
– EEL A+

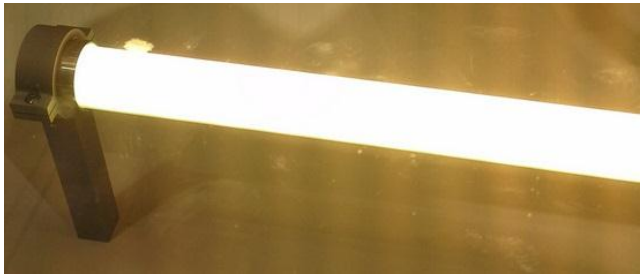
– Osram Powerball HCI-T 50 W/830 WDL PB
– Lamp efficacy **105 lm/W**
– EEL A+

Use highly-efficient lighting technologies

– LED technology

– Philips MASTER LEDtube T8 21W/840
– Lamp efficacy **100 lm/W**
– EEL A+

– Osram LED Tube 19W, 3000K
– Lamp efficacy **215 lm/W**
– Driver efficiency 95%
– Expected end of 2015



Source: LEDinside

Use highly-efficient lighting technologies

– High-efficiency optics for luminaires
– Optimised lamp-gear system

– Photonstar Nemesis 3000K / Ra>80 / 2593lm
– **101 llm/cW** / 50,000 hours / 25.6W system load
– Equivalent to 2x32W CFL

– Philips PowerBalance gen2 4000K / Ra>80 / 3400lm
– **100 llm/cW** / 50000 hours L80 / 34W system load
– Dimmable

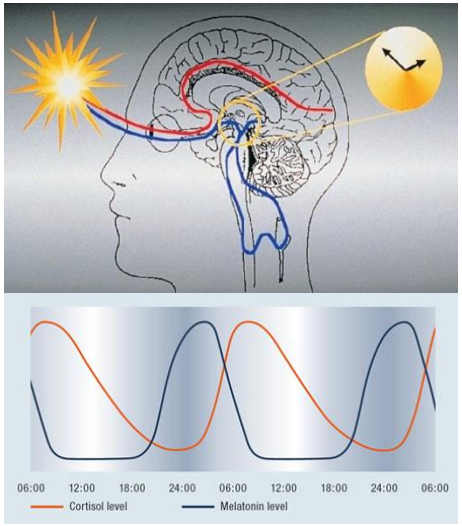
Use adequate lighting controls

- Flexible manual control including infra red switching
- Occupancy sensing, especially valuable for infrequently used spaces
- Photoelectric control, switching or dimming the lamps in response to daylight
- Time switching, sometimes in conjunction with flexible manual
- Lighting energy management systems

- **Effective lighting controls can save 40-60% of the building's lighting energy use**
- Early dimming in maintenance cycle can save 10-15% of lighting energy use

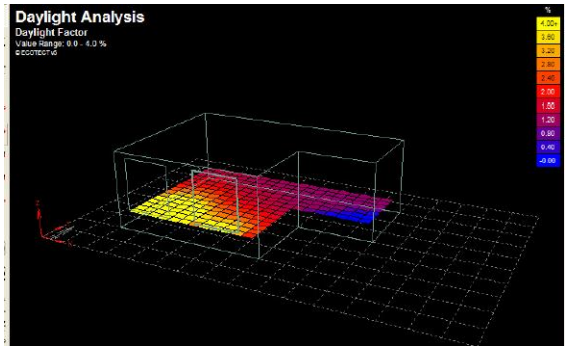
Maximise daylight use

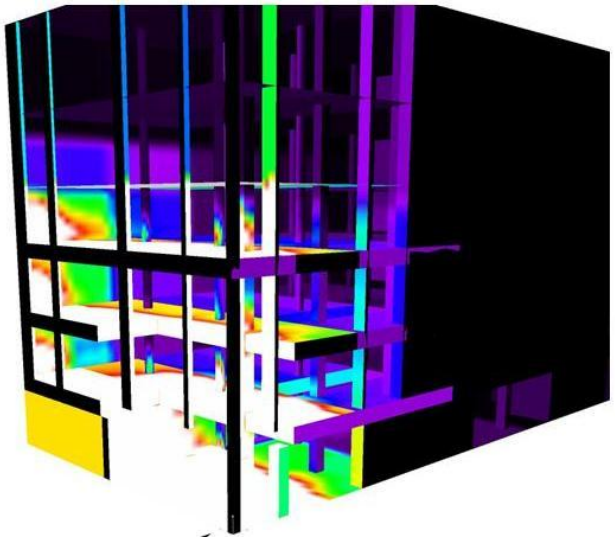
- Energy savings for lighting
- Improved quality of indoor environment
- Health and wellbeing benefits
- Innovation and design
- Credits under green schemes or standards



Key aspects in daylighting design

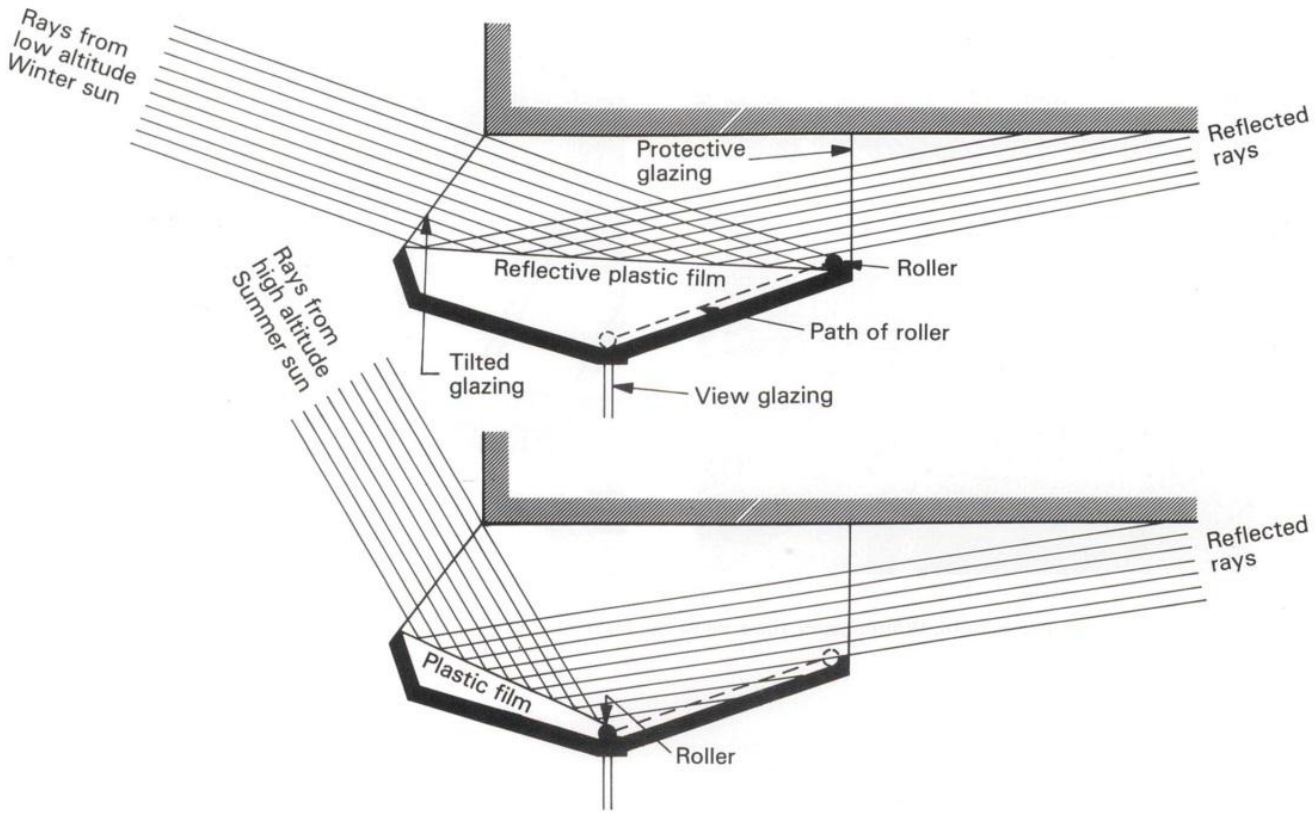
- Balance of brightness inside space
- Control of glare
- Integration with electric lighting (e.g. photoelectric dimming and zoning)
- Control of heat gains





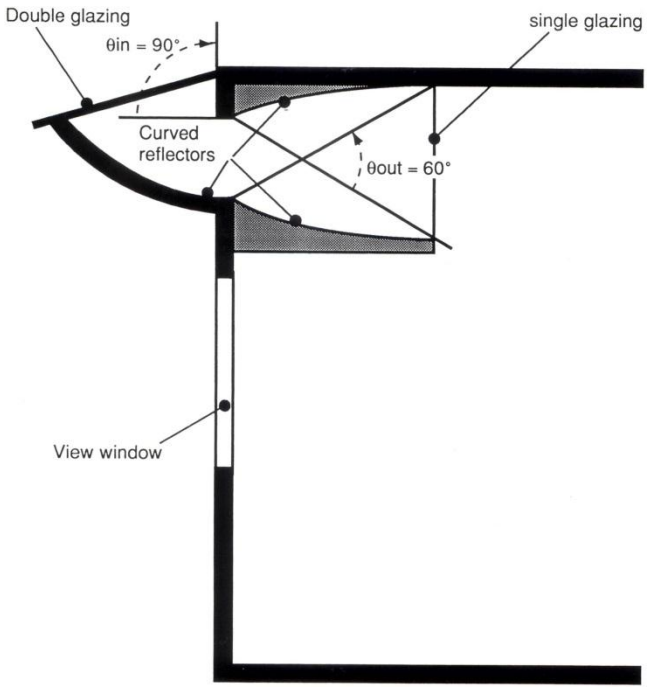
Advanced daylighting techniques

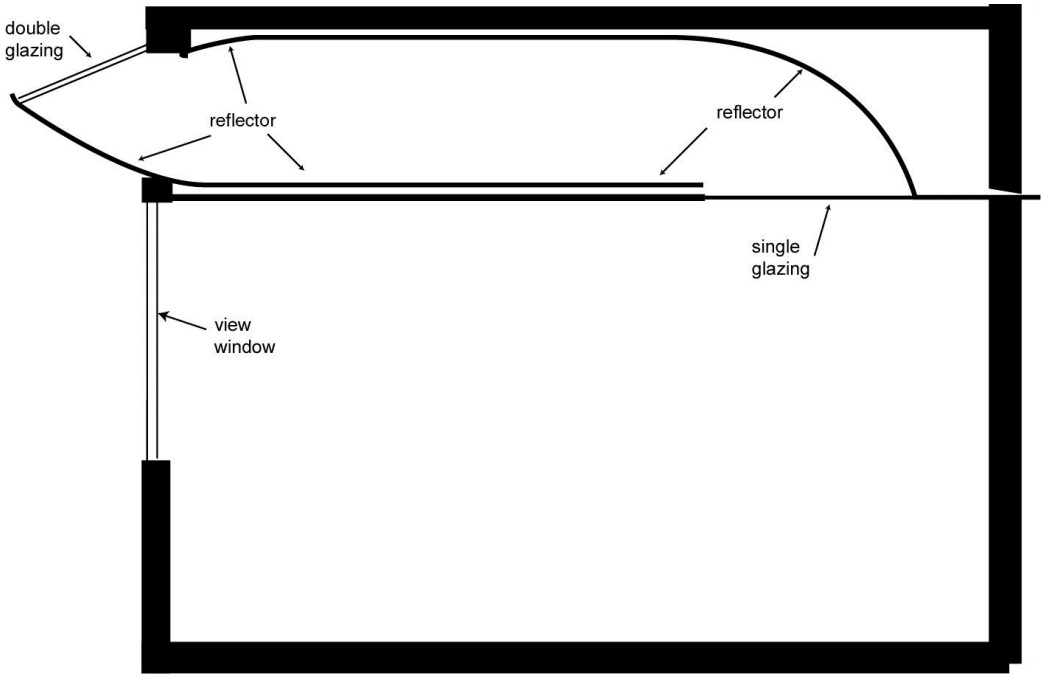
– Variable area, light-reflecting assembly



Advanced daylighting techniques

– Anidolic arrangements

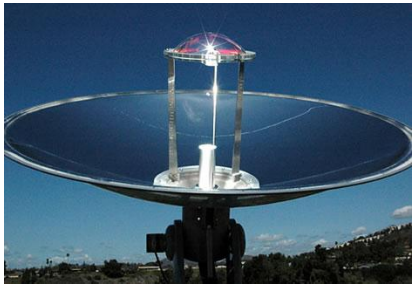




Advanced daylighting techniques

– Optical systems

Passive



Active

Use renewable energy

- Photovoltaic glass
- BIPV
- Wind

Case studies

3

Benetton Fashion Store, Padova, Italy

- LED-only scheme
- Average light level on walkways around 500lux
- Light level of around 900 to 1000lux on specific focal areas of the merchandise
- LEDs: 16W (50lm/W), 3000K, Ra 90
- Installed lighting load 17W/m^2

John Lewis at home & Waitrose, Ipswich, UK

- Fully LED lit
- John Lewis: 3000K, Ra 88
- Waitrose: 4000K, Ra 80

- Lighting load below 9W/m^2
- Less 40% energy use

Tesco Supermarket, Barnstaple, UK

- Rooflights combined with daylight-based dimming
- T5 Eco fluorescent fittings with precise angling to the point of sale
- 28% energy savings for lighting
- 30% reduction in number of lamps
- 25% reduction in installation time

M&S Simply Food, Sheffield, UK

- Ceiling height from 3m down to 2.8m
- Light focused on vertical surfaces of merchandise
- Ambient light level dropped to 300 lux
- All highly-efficient LED + light-pipes for daylighting
- Automatic daylight-based dimming

- Lighting load 7W/m^2
- Less 30% energy use
- Less 23% carbon emission

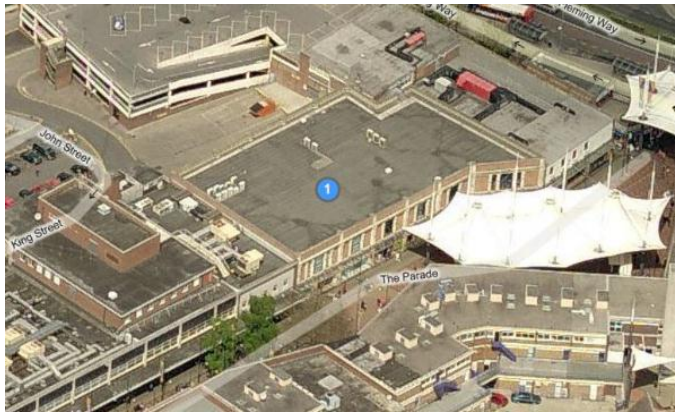
Sainsbury's Supermarket, Dartmouth, UK

- Light pipes in main sales area (∅750mm), offices and other areas
- Automatic dimming lighting controls in store areas
- Daylight-based & occupancy detection controls in staff areas
- 50% energy savings for lighting
- 40% carbon reduction
- BREEAM Excellent rating

Fashion Store, Swindon, UK

- Lighting upgrade to highly-efficient warm white LED
- Right amount of light in each type of area
- Optimise luminaire positions and tilt angles

- 51% less energy and carbon
- Lighting load in sales areas 18W/m^2
- Lighting load in fitting rooms 6 W/m^2
- 83% of LED electricity by PV panels
- PV: 163m^2, 320W_p, 19.6% efficiency



BRE B14 Office Building, Watford, UK

- Current lighting load 14.7W/m^2
- Lighting upgrade to highly-efficient LED

- Lighting load in offices 7W/m^2
- Lighting load in other areas 5W/m^2
- Energy use reduced by 54%

- Daylight-based dimming added
- Energy use further reduced by 29%

- Remaining electricity supplied by PV
- PV: 50m^2, 235W_p, 14% efficiency

Conclusions

4

Conclusions

- Drivers exist towards energy efficiency
- Substantial potential for lighting improvements
- Wide potential for energy savings in interior lighting
- Recent developments in daylighting and LED
- Optimised lighting design strategies
- Appropriate lighting controls
- Renewable energy

- **NET ZERO ENERGY LIGHTING**

Thank you for your attention !