HYBRID LIGHTING SYSTEMS

The 5th International Conference ILUMINAT 2009

Sustainable Lighting

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Daylight in buildings

- Provision of daylight is a powerful design aspiration for modern buildings
- Daylight as a substitute for electric lighting can offer energy savings
- User preference for daylight in working interiors has implications for user satisfaction and well-being

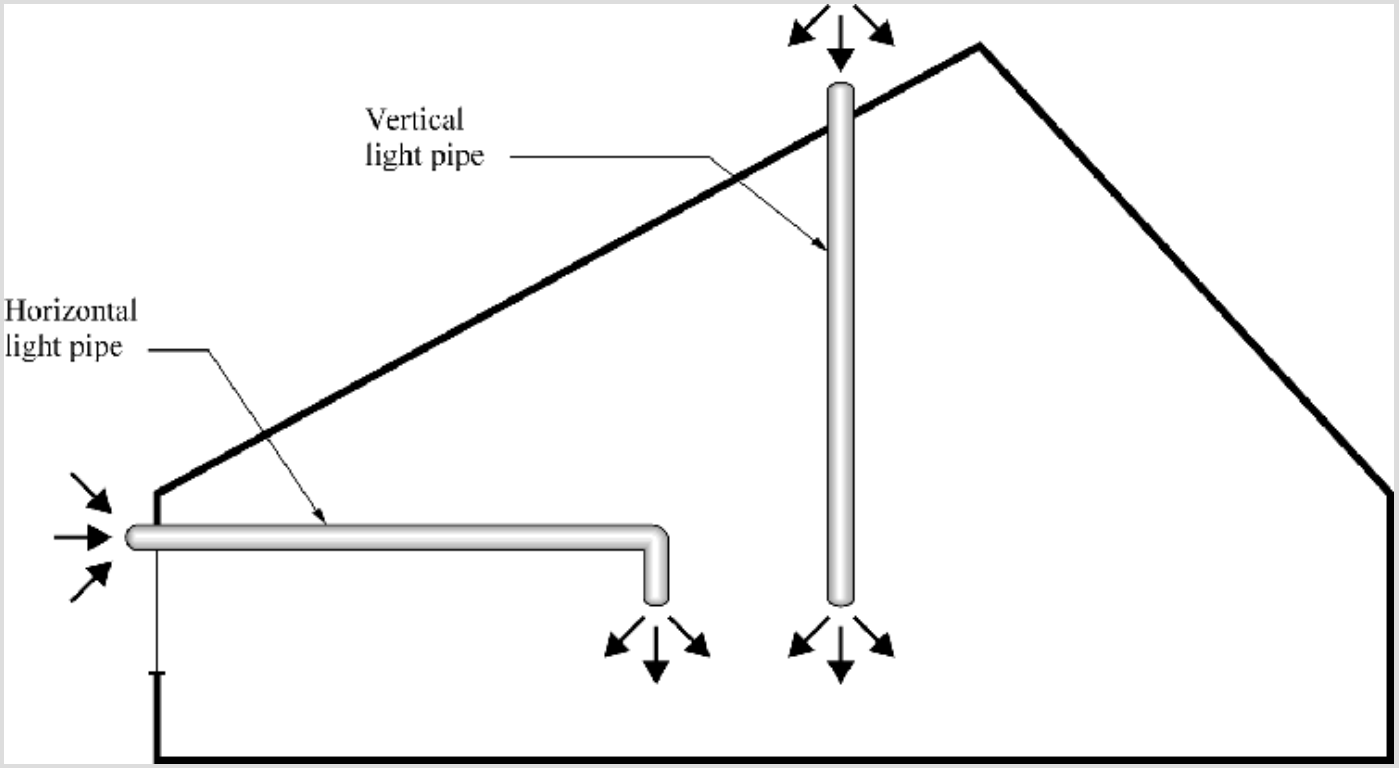
Delivery of daylight

- Windows – limited light penetration and possible thermal and acoustic problems
- Enhanced windows – ‘smart windows’and louvre systems
- Daylight guidance can deliver light to deep plan buildings
- Problem of integration of electric light and daylight

Approaches to delivery of daylight and electric light

- Tubular daylight guidance + electric lighting
- Integrated lighting systems
- Hybrid lighting systems

Tubular daylight guidance systems (TDGS)

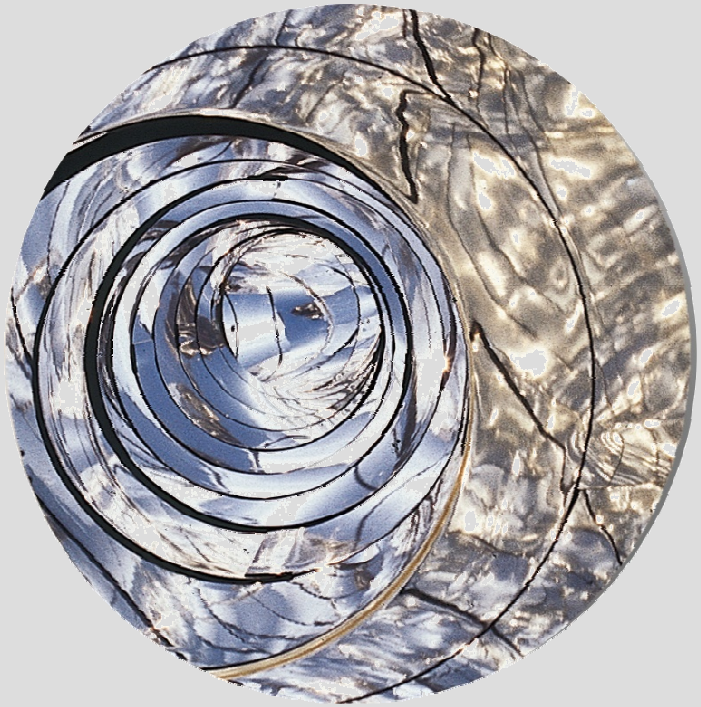


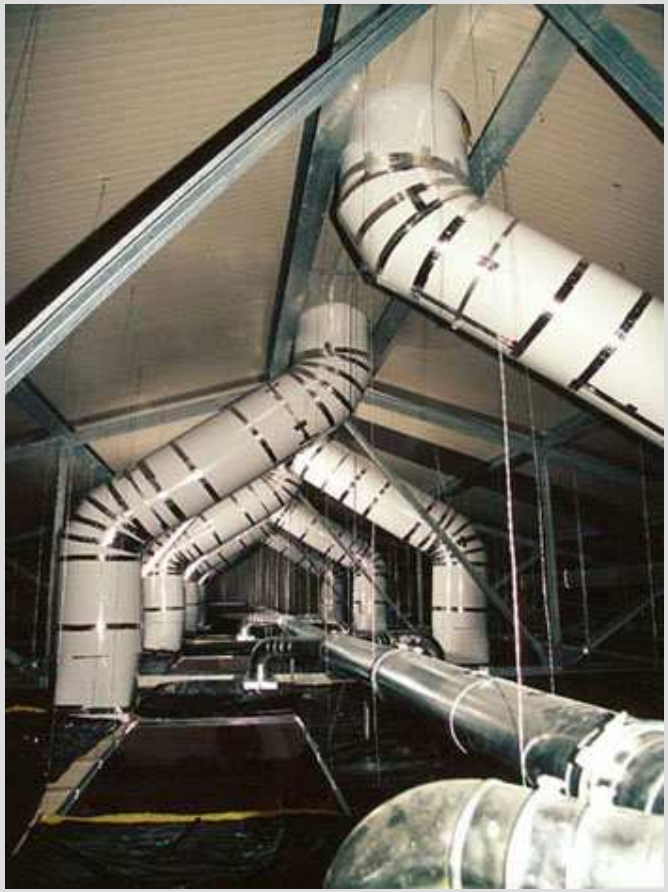
Light collectors

Passive collector system on the roof level

Active sun track system

Tubular light guides





Guides made of aluminium sheet coated with either silver (95% RF) of multilayer plastic (99% RF)

Straights and bends available

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Passive zenithal emitter (1)

Passive zenithal emitter (2)

Fits 600mm ceiling module

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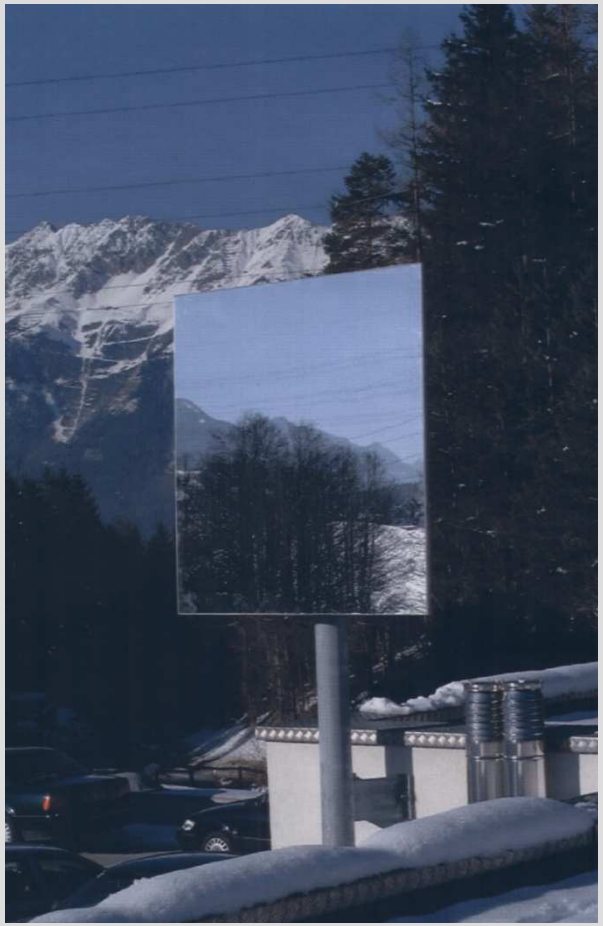
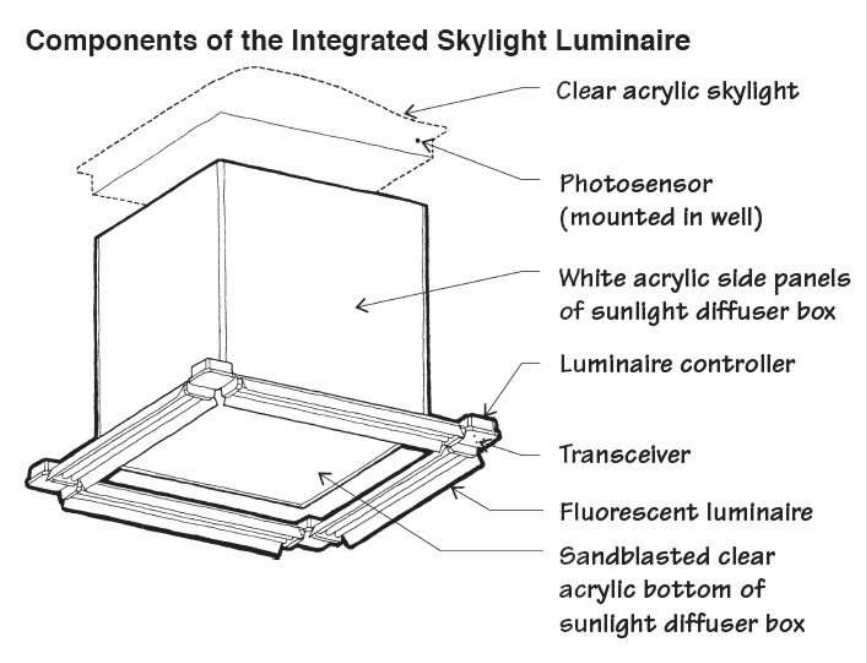
Active systems



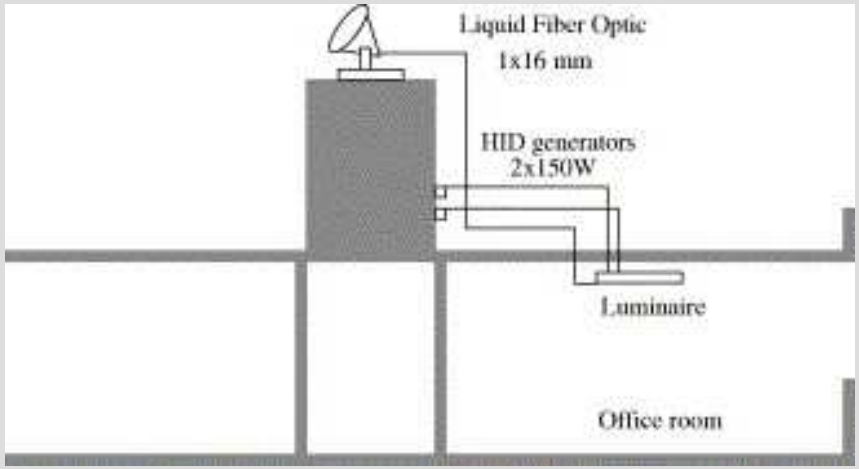
Active systems

Integrated lighting

- Systems delivering daylight and electric light separately but equipped with control to maximise use of available daylight
- Either uses custom made daylight devices with adjacent linked electric sources.
- Or effectively an ‘intelligent’ electric lighting system with enhanced controls which seek the maximum benefit from any source of daylight.

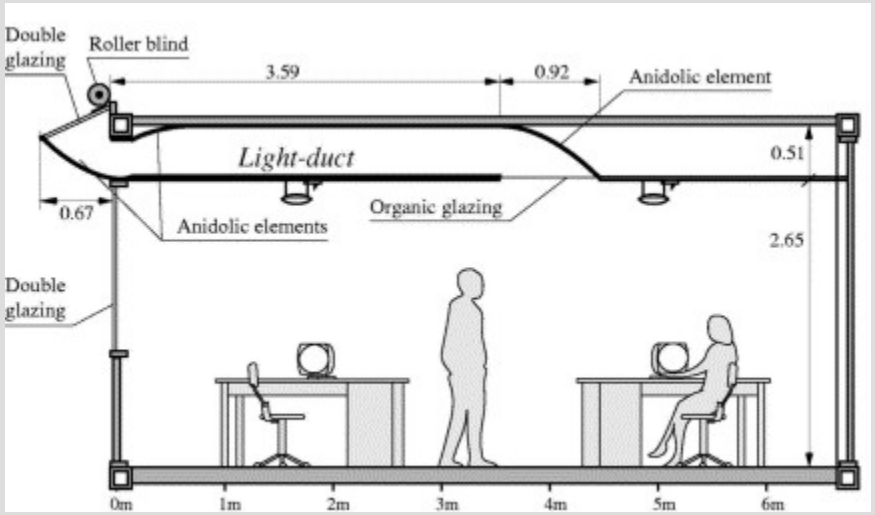


Principle of hybrid lighting



- Simultaneously deliver daylight (mainly sunlight) and electric lighting to interior space
- Daylight combined with electric light within luminaires
- Equipped with controls that maximise use of available daylight
- Optical control similar to an electric-only luminaire
- Collectors on facade or roof

Façade mounted collectors - deflecting mirrors



- Collector on façade deflects daylight into duct using mirrors
- Light delivered into room up to 10m from façade
- Orientation of façade critical factor in performance

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Façade mounted collectors - Solar Canopy

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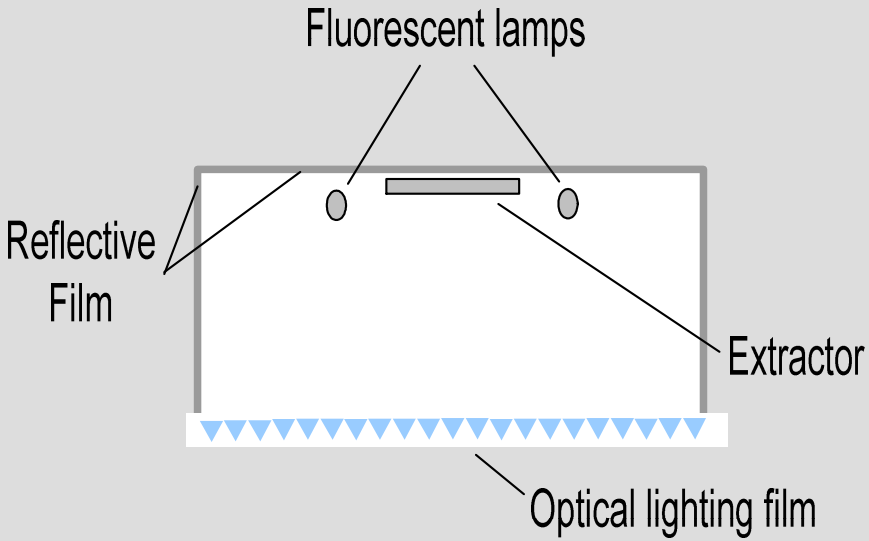
Solar Canopy

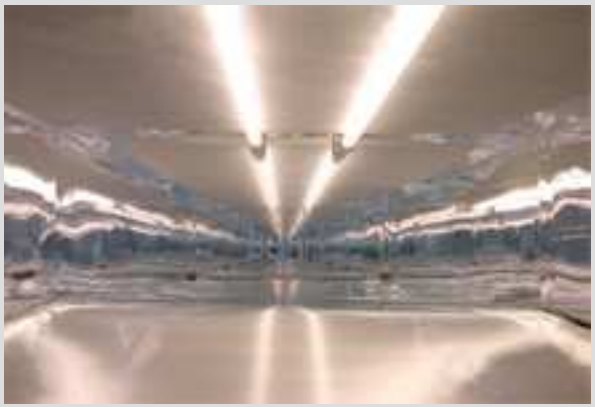
•Developed at University of British Columbia
•Sunlight is mixed with electric light in the horizontal guide
•Each lamp is individually daylight linked to produce a near uniform illuminance throughout the room

Window Covered

Window Uncovered

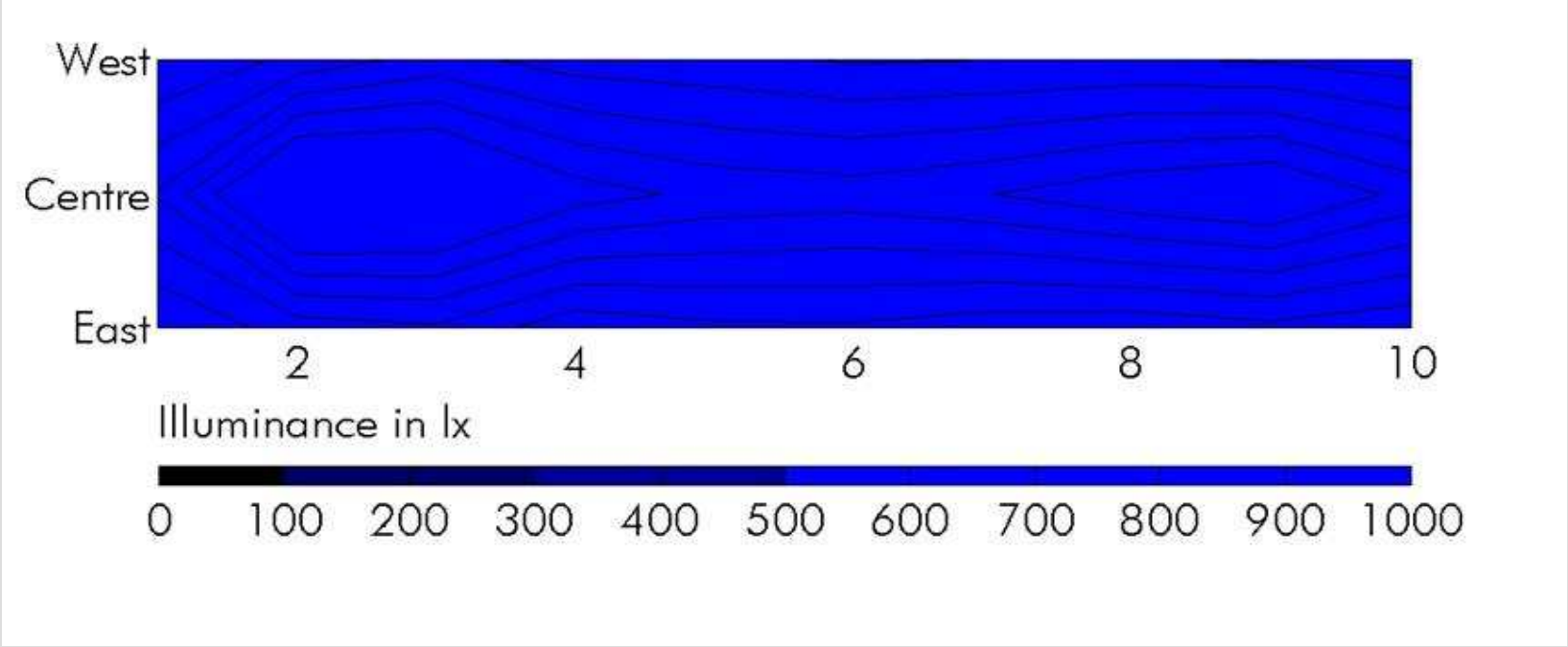
Solar Canopy dual-function light guide





Solar Canopy - daylight-only illuminance via the light guide

Sunny external conditions 90000 lx



Average Illuminance = 742 lx

HSL Heliostat system

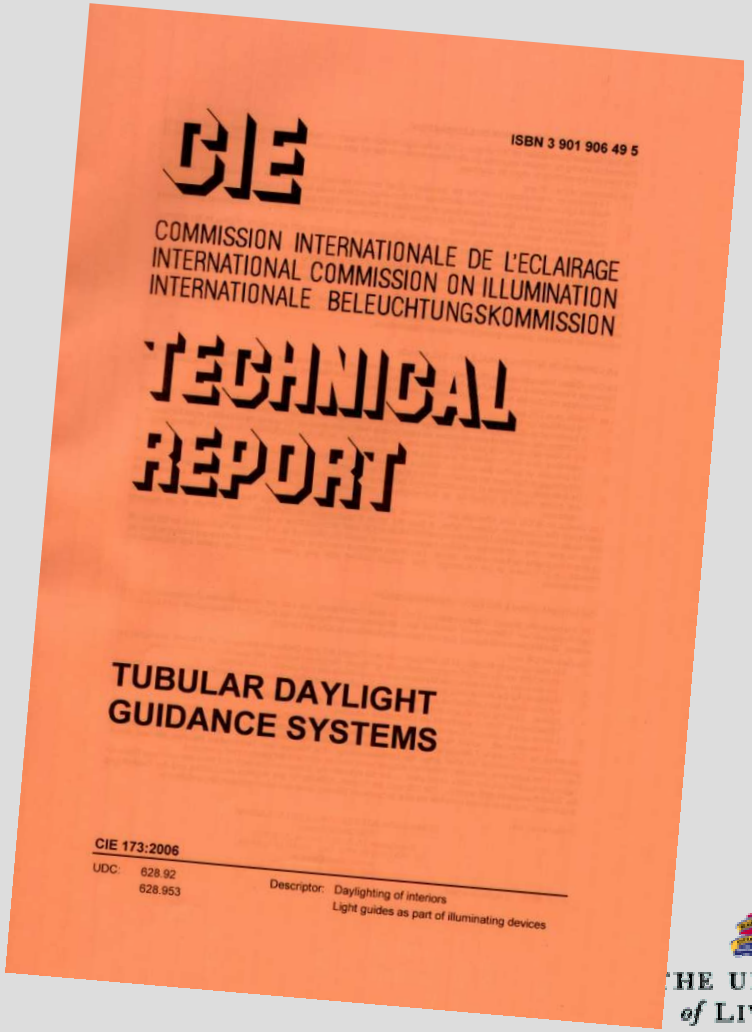
- Developed by US Government Oak Ridge Laboratory
- Light transport by optical fibre cable
- Each luminaire has output of about 6000 lm from an external illuminance of 100000 lux
- Light control similar to diffusing electric luminaire
- Commercially available

Parans system

- Light transport by optical fibre
- Luminaire output 7500 - 10000 lm from sunny conditions (external 75000 lux)
- NOTE: Under cloudy conditions (external 10000 lux) output is about 1000 lm
- THUS: of limited use in UK latitudes
- Commercially available

Are systems easy to design?
Use CIE Report 173:2006
Tubular daylight guidance systems

- Test method for passive zenithal systems
- Design method for installations to give ‘daylight penetration factor’
- Cost/value
- Human response to systems/ design recommendations for comfort
- Case studies for good practice



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Use of TDGS in buildings

*Passive systems mainly used for single storey buildings

*Better light delivery than roof-lights in deep roof constructions

*Buildings Regulations in effect treat collectors as rooflights, transport elements as pipes or ducts and emitters as luminaires

* Systems may occupy valuable floor and roof space

Use of hybrid systems in buildings

- All require collectors in prominent unobstructed locations on building envelope
- Can be used for up to three storey building if using optical fibre light transport
- Light output by luminaire – good light control but danger that building occupants do not realise that it is daylight
- Daylight contribution sufficient to replace electric light during peak daylight hours
- Possibility of use of colour matching lamps to mimic daylight

Cost and benefit - what do they cost?

Approximate capital cost/sq.m. for a number of actual passive TDGS

Electric lighting £35-£65

Passive zenithal £35- £75

In contrast approx. capital cost/sq.m. of active zenithal and hybrid £100 - £225

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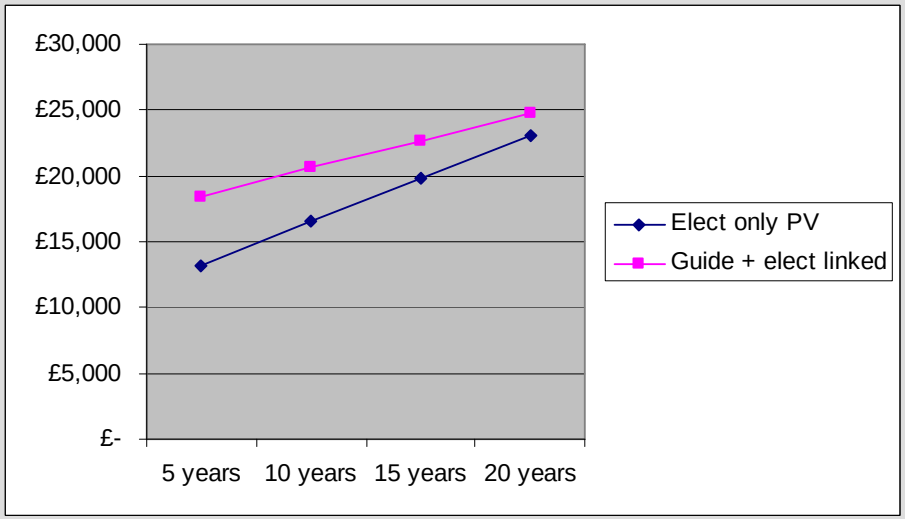
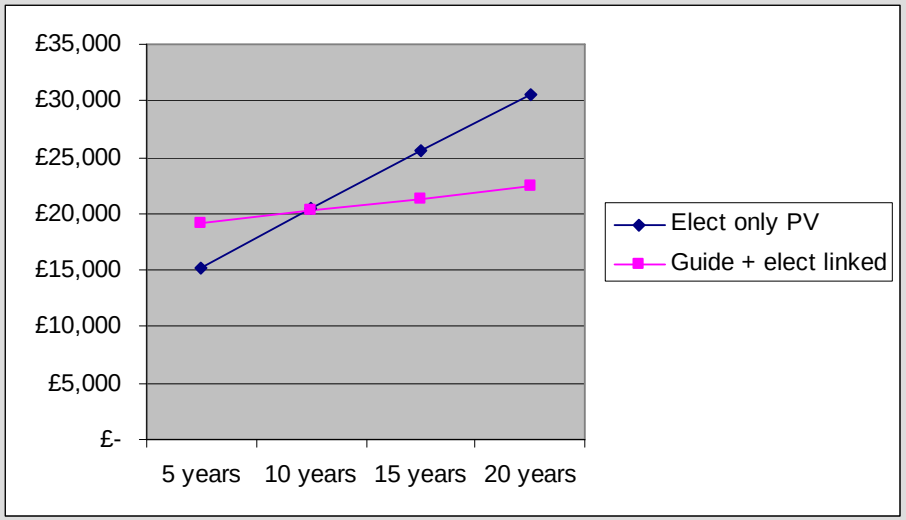
Cost and benefit - what do they cost?

Present value for the top building on previous slide over 20 years





Actual lighting configuration and electricity price £0.07 per KwH

Daylight linking, 2% DPF, and electricity price £0.11 per KwH

Note: Use of TDGS in multi-storey buildings not economic

Benefits - what do they deliver?

Work plane illuminance typically from 50 to 400lux
Average workplane DPF from 0.3 to 1.1%

Surface luminance = 1000 - 3000 cd/sq. m.

Benefits - are they liked by users?

- Surveys of actual TDGS – photometric measurement and user questionnaire.
- Inferior to conventional windows in providing quantity and quality of ‘daylight’
- Current systems do not produce a ‘well day-lit space’
- However systems are acknowledged as ‘daylight’ providers and appreciated as such by users with consequent benefits in a working environment
- No information yet on user satisfaction of hybrid systems

Future for TDGS and hybrid lighting?

New light transport
materials and devices

New products required:

- integral fire protection
- means of passing light through fire barriers

Possible specification to give long term energy saving and user satisfaction:

- Average work-plane DPF close to 2%
- Average electric lighting illuminance 300 lux (possibly using variable CT lamps?)
- Daylight linking