Daylighting controls: some ‘dos and don’ts’

Daylighting in Buildings: Energy, Health and Well-being

John Aston MSLL
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Daylight is considered to be ‘renewable energy’
Daylight is a high quality light source – good CRI!

Daylight is only available at certain times of day but we cannot restrict our working hours to those times!

So artificial light is also required.

But applying daylight linked controls needs care.
Content

• A little bit about controlling artificial light
• Taking daylight into account
  – Light sensing approaches
  – Managing the artificial light
  – Operating modes
• Application issues
• Conclusion
Controlling artificial light:
Switching

- Lights are turned ON and OFF
- Manually by a switch
- Instead of a switch, a control system uses:
  - A relay
  - A contactor
  - A digital signal to a controller
- All lights can be turned ON and OFF

230V ac → Light
Controlling artificial light:

Dimming

• A dimmer can change the intensity of the light
• Dimming can be done in a number of ways:
  – 230V ac mains control
  – Via control gear using either analogue or digital inputs
• Not all lights are readily dimmed

![Dimmer Diagram](image)
Switching v dimming - lamp life and other issues

**Switching**
- Frequent events shorten life.
- Delay to OFF
- HID and re-strike times.
- Parasitic losses (in control system)
- Load characteristics

**Dimming**
- Cost – real and perceived
- Better control strategies
- Deep dimming can impair some discharge lamps
- Loss of efficiency
- Standby and parasitic losses
- Additional cabling
- No sudden changes
- Greater user acceptance

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Dimming – the potential power savings
Dimming - typical fluorescent light v. power curve

Dimming to 80% saves 13% power

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Lighting control technology
Switching to dimming

- Switching is perceived to be a lower cost, simpler solution.
- Electronic control gear developments have brought economic dimming to fluorescent, HID and LED lighting.
- Dimming will always deliver better savings when daylight control is used.

Don’t cover your roof-lights in!
Taking daylight into account

- Daylight varies in intensity and colour
- People prefer working in day-lit conditions
- Daylight can cause contrast problems and create both glare and heat
- Blinds manage daylight…….
Daylight linked operation
Daylight sensors
Daylight sensing methods

Sensors can be applied:

• External
  – One for the whole building
  – One per aspect

• Internal
  – One per aspect – looking out
  – Locally – looking out
  – Locally – looking down
  – Locally – per luminaire

• Human response

Photo-diode

Light dependent resistor
Daylight sensing methods
Pull switch to multi-sensor – and beyond

Not to scale!
Daylight & early lighting control projects

- Local operation
  - A switch on every light
- Manual ON, automatic OFF
  - People had to turn ON the lights – NOT the system
- Conditional control
  - Daylight reference used as a ‘GO – NO GO’ gate
- Scheduled events
  - Conditional operation at convenient times of day

Effectively the human response to daylight
Daylight sensors

- A typical outdoor mounted photocell. These are usually designed to sense light levels at dusk and dawn operating the lights when daylight falls below 70 lux – or even less.
- Internal cells need to operate at much higher levels; typically in excess of 300 lux – and need to integrate both natural and artificial light.
Light sensors

- This multi-sensor contains four elements:
  - A photocell / daylight sensor
  - A movement detector (PIR)
  - An infra red receiver
  - A set-up button

Designed to be mounted on (or in) the ceiling, looking down.
Mounting heights are important when assessing the required coverage.
Locating the daylight sensor

External options:
- Per building
  Samples light from the sky and data used to set levels on all aspects
- Per façade
  Data used more locally

Issues:
- Blinds
- Seasons
- Commissioning
Locating the daylight sensor

Internal options:
• One per façade – looking out
• Locally – looking out
  Uses external conditions only and takes into account any blinds.

Issues:
• Low sun angles; snow

• Locally – looking down
• Locally – per luminaire
  Uses much more local data, still account for blinds.

Issues:
• Location; reflectance; acceptance angles
Locating the daylight sensor
Luminaire mount example

- Simple, low cost solution
- Simple commissioning
- No local user input
- Maximum mounting height: 3,5m
- Beware suspended fixtures below
Ceiling mount light sensor - “Field of view”

\[ Y = 0.7 \times H \]

- Photocell
- Window
- Windowsill

Field of view

<table>
<thead>
<tr>
<th>H [cm]</th>
<th>Y [cm]</th>
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<tbody>
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<td>100</td>
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<tr>
<td>120</td>
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<td>260</td>
<td>130</td>
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<tr>
<td>280</td>
<td>140</td>
</tr>
</tbody>
</table>
Ceiling mount light sensor - “Field of view” issues

Reflection factor (outdoor part) can change due to weather conditions! In case of snow, the task light level will decrease because the average reflection factor has increased.

Windowsill with a high reflection factor is reflecting sun light to sensor. Due to this, the task light level can become too low.
Daylight linked operation
More things to bear in mind

• Street lighting: dusk – dawn
• Hysteresis and nuisance switching
• The additive effect of light
• Dimming or

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Daylight linked control
What should happen

How dimming controls alter the lighting proportionally within a space.
Daylight sensing
Different operating modes

- A lighting control system can be programmed to behave in different ways according to the time of day:
  - The functions of sensors can be altered.
  - The light levels can be limited.
  - The assignment of inputs to outputs may be altered.
Operating modes
Offset control behaviour

Light level [%]

Corridor light level
Window light level

30% offset
Operating modes – or parameters

Rate of change

Down regulation speed 1 step/sec  (170 seconds from 100% to 1%)
Up regulation speed  4 steps/sec  (42.5 seconds from 1% to 100%)
Dimming – another benefit
Controlled illuminance and maintenance factors

• The lighting maintenance factor affects the degree of ‘over design’.

<table>
<thead>
<tr>
<th>Maintenance factor</th>
<th>‘Headroom’ required</th>
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<tbody>
<tr>
<td>90%</td>
<td>+ 11%</td>
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<tr>
<td>80%</td>
<td>+ 25%</td>
</tr>
<tr>
<td>70%</td>
<td>+ 43%</td>
</tr>
<tr>
<td>60%</td>
<td>+ 67%</td>
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</table>

• A control system can save much of this energy use.

Illustration of light loss over time

18th March 2014
What next?

- Changing the colour temperature?
- Matching roof-lights to artificial sources?
- Moving clouds across the ceiling?
Conclusions

• Daylight linked lighting controls are possible and practical
  – Equipment selection is important
  – Application knowledge is required
  – Dimming offers more options than switching
    • Better savings potential
    • More acceptable to staff

Set up, commissioning and user training are also vital!
Conclusions
The importance of commissioning and user training

- Effective Commissioning ensures:
  - Sensors are calibrated correctly
  - Light levels are correct
  - the design intent is met

- Training means:
  - The controls are understood by:
    - Owners and users
    - Maintenance staff

- All leading to:
  - better lighting
  - more productive and satisfied occupants
  - and less cost and CO₂

……..and finally……..
Daylight controls do work
Real electricity savings can be made

Measured results with dimming by simple ambient light sensor

With occupancy sensors a decrease from 51% to just 30% use is realistic.

…but that’s another story!
Daylight linked lighting control

ANY QUESTIONS?