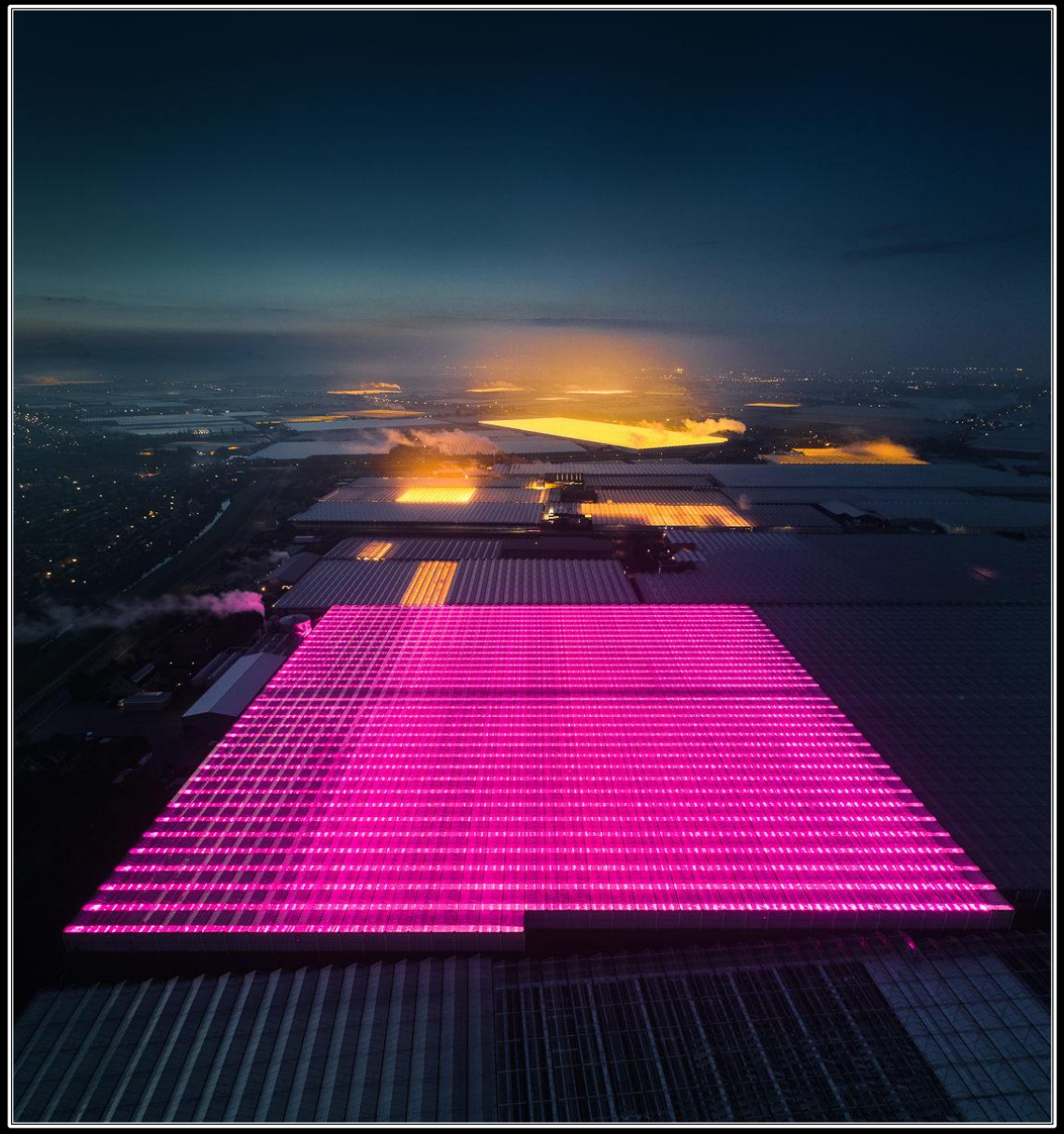
APPENDIX:
GLAZING -INTERNAL LIGHT SPILL
May 2021

Contents



Credit Tom Hegen; https://www.tomhegen.com/

1 Internal Light Spill - Glazing

1.1 Glazing Principles

The spill of light through windows can create significant amounts of light pollution. Internal illuminance demands can greatly exceed most types of domestic and commercial rural lighting, so the impact on dark skies can be significant. In general, internal glazing will cause light to spill horizontally and – in the case of sky lights – directly upward, which are the most damaging paths of light. Internal spill can – and will – have a similar impact to external lighting, particularly in interrupting and disrupting the continuity of the dark landscape.

Due to the variability of internal lighting requirements and glazing design, the determination of impact is not as clear-cut as it is for external lighting. This is due to the lack of professional evidence and guidance material that stipulates appropriate illuminances. The SDNPA has collected evidence to show that glazing has two significant impacts

- The reduction in sky quality in the immediate area (measured up to around 100m away for a brightly lit internal space)
- The disruption of the dark sky landscape as seen from the surrounding area

In these respects, the following principles should be followed to reduce these impacts.

The SDNPA is <u>not</u> looking to ban glazing outright as a general principle, but to ensure that designs and additions are appropriate and have had regard for light pollution. This may result in an objection, but in principle, glazing will not be banned as an intrinsic inappropriate form of development.

General glazing design principles;

1. **Should not exceed 25% of the floor area[1]**
2. **Avoid large single continuous areas[2] of glazing such as multi-floor to eaves glazing/cart shed openings or single elevations**
3. **Should not be on roofs or ceilings without sufficient mitigation**
4. **Use an appropriate visible light transmission(VLT) factor as a <u>primary means of mitigation</u> on different applications to reduce internal light spill**
5. **A maximum target upper VLT limit of 0.65 +/-0.05 should be applied in all glazing applications**
6. **High impact commercial Greenhouses should be avoided**

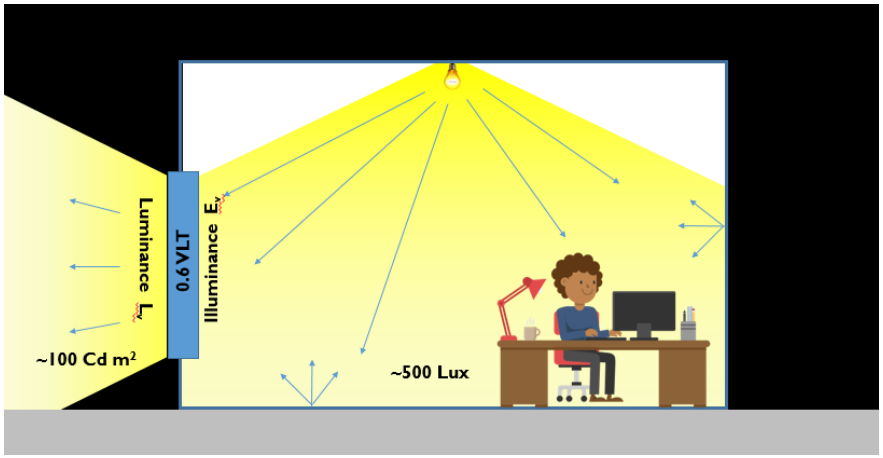
[1] Using Elemental Method Energy Efficiency as reference (building regulations)

[2] >50% glazing on a single elevation is becoming 'large'.

1.1.1 'Effective' Luminous Surface – Visible Light Transmission

When glass is illuminated from internal sources, it will approximately receive the same amount of light that hits other opaque surfaces and objects within rooms, i.e. floors and walls, tables and chairs.

Although visible light passes through glass, it makes glazing – when viewed from a sufficient distance outside in the landscape - an 'effective luminous surface', where the level of luminance (light emitted from the surface) will be a function of the internal illumination (light falling onto the glass from inside) and visible light transmission (VLT) properties of the glass. In this respect, glazing can be categorised as a 'special' type of illuminated advertisement.



Manufacturers glazing VLT specifications can then be compared and 'adjusted' - in general levels - to the recommend advertisement luminance E1-zone levels to achieve, 100 cdm², as referenced in section 8.1.2 of the main external lighting document. This allows the selection of appropriate levels of VLT glazing specifications for a dark sky landscape to achieve comparable levels of luminance to illuminated adverts. (see below for example calculation).

In addition, visible light through horizontal flat or angled glazing will exacerbate loss of sky quality, as the upward path of light creates more pronounced pollution. In these circumstances more stringent values of VLT are required in combination with additional mitigation.

Note that;

- Illuminated advertisement recommendations generally apply to surfaces less than 10m². This area size will cover most vertical domestic glazing projects, e.g. standard size windows, roof-lights. For other glazed surfaces significantly above 10m², additional VLT restrictions will apply due to the range of internal illuminances and potential harm to dark skies.
- Generalised internal illuminances (lux levels) have been assumed with reference to existing professional guidance's e.g. CIBSE[3].
- Recommended VLT's are consistent with recommended manufacturer options for glazing to suit these installation purposes; they are not overly stringent and are easily achievable for the interior and exterior illumination.
  - E0 zone illuminated advert requirements are not appropriate as this implies zero light spill through any window at all times.

The SDNPA will set a target upper limit to the VLT (0.65 +/- 0.05) that all glazing should meet, regardless if the internal illumination low enough to suggest higher light transmission values. This is to safe guard any future changes to internal spaces.

[3] Internal illuminances on domestic purposes are highly variable – unlike external lighting projects.

1.2 Glazing Recommendations

The following table summarises the glazing recommendations and mitigations for common types. The primary mitigation is the Visible Light Transmission (VLT). For practical considerations of product options, the acceptable target and range is **0.65 +/- 0.05** (which is comparable to +/- 50 lux E_v). This is a common glazing option for domestic glazing brands and will not significantly darken an interior space – it is an acceptable option for domestic purposes. While there is some small latitude beyond the range due to manufactures variance, excessive deviations from the target (+/- 0.05), should not be accepted.[4]

CATEGORY	GLAZING APPLICATION	IMPACT AND AVOIDANCE	TYPICAL TASK LUX[5]	PRIMARY VLT[6]	SECONDARY MITIGATION	ALTERNATIVE MITIGATION
Domestic Vertical Glazing	Standard Vertical Domestic single room window 	Low impact	300-500	≤**0.65**	• Promote curtains and blinds, smart lighting	None.
	Continuous Vertical Domestic windows significantly exceeding 10m^2 and covering multiple interior spaces, 	Medium impact To be avoided unless sufficient mitigation	500-800	**0.65 to 0.4**[7]	• Break up continuity either with rolling blinds or shutters • Shielded by immediate vegetation or buildings	• Reduce glazing extent

[4] **Applicants should aim to achieve these targets within reason and without excessive deviation. For example, a 0.8 VLT should not be accepted when achieving 0.65 (+/-0.05), whereas 0.72 (perhaps due to applicants manufacture choice) is 'within reason'.**

[5] Based on a number of sources: CIBSE, HSE, Lighting text books.

[6] Calculated using equation (1) to reduce spill to 100 cdm^2 reference to Illuminated advert. An allowance of +/- 0.05 is assumed.

[7] To be determined by design

CATEGORY	GLAZING APPLICATION	IMPACT AND AVOIDANCE	TYPICAL TASK LUX[5]	PRIMARY VLT[6]	SECONDARY MITIGATION	ALTERNATIVE MITIGATION
Upward Facing Glazing	Domestic bedroom skylights 	Medium impact	500	≤**0.5**[8]	• Black out blinds • Smart indoor lighting	• Artificial Skylights • Light tubes • Reduced use if many are used
	Conservatories, lanterns, Skylights 	Medium impact To be avoided unless sufficient mitigation or alternative considered	800	≤**0.4**	• Black out blinds • Roller blinds • Smart indoor lighting	• Artificial Skylights • Light tubes
	Commercial 'modular' Sky lights 	High impact To be avoided unless sufficient mitigation or alternatives	500	≤**0.3**	• Black out blinds • Off at close of business • Diffusing covers	• Artificial Skylights • Light Tubes • Reduced extent

[8] Based on VLT calculation referenced against common brands typical glazing skylight specifications

CATEGORY	GLAZING APPLICATION	IMPACT AND AVOIDANCE	TYPICAL TASK LUX[5]	PRIMARY VLT[6]	SECONDARY MITIGATION	ALTERNATIVE MITIGATION
Non-domestic Vertical Glazing	Office and shop fronts ~ 10m² 	Low impact	500	≤**0.65**	• Off at close of business • Black out blinds for extended night use	None
	Structural Glazing over 10m² 	Very high impact To be avoided	1000	≤**0.4**	• Off at close of business	• Reduced Glazing • Preference for Urban siting • Recued height
Special cases	Commercial Greenhouse 	Extreme Impact (can be seen from space) To be avoided unless lighting footprint at night is zero is guaranteed.	Specific	**N/A**	• Black out blinds • shutters •	• Indoor Natural lights within unglazed building •

CATEGORY	GLAZING APPLICATION	IMPACT AND AVOIDANCE	TYPICAL TASK LUX[5]	PRIMARY VLT[6]	SECONDARY MITIGATION	ALTERNATIVE MITIGATION
	Glazing within or directly adjacent to key or sensitive wildlife/species sites 	High local impact To be avoided	Specific	≤**0.4**[9]	• Black out blinds • Shutters • Off at close of business (e.g. Visitor centres) • Tints (to achieve low VLT)	• Zero glazing • Tube lights • Artificial Skylights

1.3 Glazing Mitigations

1.3.1 Design Options

Design options should be selected after the developments impact has been assessed within the wider landscape.

1.3.1.1 *Inward facing glazing*

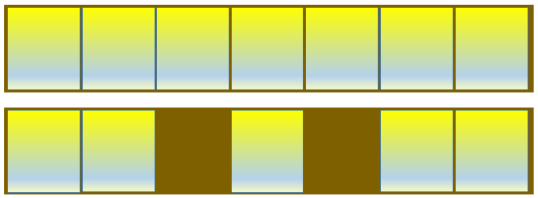
In some circumstances, the impact of glazing can be mitigated nearby buildings or courtyards offer shielding – allows for greater flexibility.

1.3.1.2 *Surrounding vegetation*

If the lighting development is surrounded by sufficiently dense and high vegetation it may offer a suitable mitigation against lighting. In such cases, the vegetation will constrain the lighting footprint closer to the development and prevent wider landscape impact. While this is a sufficient mitigation, particularly if the vegetation is on the property, it is equally important not to use the vegetation as means to over light or ignore lighting impacts; any wildlife within the vegetation could be adversely effected.

1.3.1.3 *Breaking up continuous glazing*

Expansive and continuous 'modern' style continuous glazing can present significant landscape impacts. Where the sensitivity is high, it may be necessary to break up long glazing surface in order to ensure the resultant appearance blends in with the more traditional styles of domestic glazing. Similarly, for remote developments, continuous glazing can be very pronounced intrusions into dark landscapes. Breaking up could include removing sections of glazing for walls, or using exterior shielding (which are sometimes necessary to reduce thermal discomfort.



[9] 0.4 factor is consistent value for wildlife. For example, Florida Ordinance requires 0.4 VLT for the protection of marine life.

1.3.2 Mitigation Option

- Appropriate Visible Light Transmittance

Light transmission through 'tinted' glass can be reduced with specially coated materials, similar to blackout glass or tinted windows, which can reduce visible light transmittance to ~66%

1.3.2.1 *Electronically timed blinds/blackout blinds*

Blackout blinds can be very useful in cutting out light spill, light particularly where glazing design exceeds recommendations. There are a number of brands that offer domestic 'smart' blinds, such as Velux: Integra.

Additional conditions may be placed on non-domestic facilities that have a larger potential for internal spill, that require the installation of more robust electronically controlled, blackout blinds that automatically operate.

Greenhouses – especially commercial – require shutters to eliminate all internal spill.

1.3.2.2 *Security Shutters*

Security shutters are installed on the outside of windows and offer a more robust method of preventing light spill. Designed with security in mind, they can be installed easily and controlled via smart controls. Being of solid material, light spill will be zero. While they are often thought of as a commercial and shop front security consideration, they are a suitable mitigation for light spill.

1.3.2.3 *Tints*

Glass can be treated with a tinted film to reduce light transmission. While lower transmission glass is preferred, the bonding process between glass and film is considered permanent and not susceptible to tampering: damage to glass would result. VLT values can be achieved as low as 5%.[10]

1.3.2.4 Close of business

Commercial lights should be switched off at close of business.

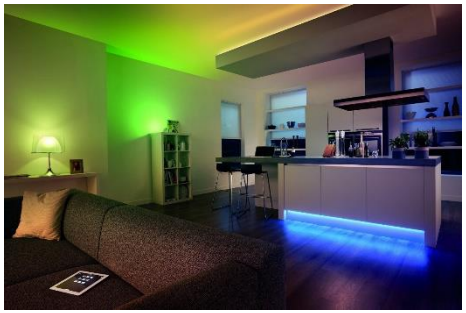
[10] Truevue 5 by Solargard Saint Gorbain

1.3.2.5 Thermal regulation mitigation in larger glazing surfaces

Due to the increasing thermal efficiency of glazing, the heat retention within the development could cause discomfort. A necessary control mitigation is the use of exterior blinds and shutters that can be moved along larger glazed elevations to limit the solar heating. If these shutter systems are necessary, it is recommended that the choice of shutter compliments internal light spill control and act as black-out blinds.

1.3.2.6 *Internal Smart Lighting*

There are many smart lighting systems that can be programmed to operate in many modes. These device friendly systems offer the user to create colourful internal spaces, but also program lighting to be on and off when not in use. Consequently, these systems offer a means to automatically control internal spill and reduce pollution. Examples include Philips Hue, Innr and Ikea.



1.3.3 Alternative Options

1.3.3.1 Artificial Skylight 'Glazing

As an alternative to glass or plastics, rooms that would benefit from natural light can use similar sized 'artificial' natural lighting systems that simulate the blue-sky wavelengths throughout the day. Although they are typically costlier than standard glazed skylights, they do offer a very effective means of providing internal light without emitting any spill to the outside. Some variants allow the user to light internal spaces with a ranger of colours adding to the aesthetic options.

1.3.3.2 *Smart or Electrochromic Glass*

Smart Glass is made by passing electrical current through the material which changes it transparency. Often used as a security mitigation, the cost is relatively higher than other options, but can be adjusted to suit environmental conditions.

1.3.3.3 *Sun Tunnels*

If illuminating indoor spaces solely with sunlight is required, then light tunnels – effectively oversize fibre optic cable – can be alternative to larger skylights.

Light enters the smaller aperture and is reflected inside to a diffuser. These are good options where space for a normal sized roof light is difficult.

1.3.4 Example Calculation Glazing VLT – domestic glazing

Under the special case where glazing is a perfect transmitter[11] and has a visible light transmission of 1, illuminance (E_v) and luminance (L_v) are related by

$$\frac{E_v}{\pi} = L_v \qquad (1)$$

For a typical domestic living room, 500 lux (E_v) illuminance is assumed. This yields a luminance of 160 cdm^2. This is greater than the recommend luminance levels for an advert in the E1 zone (100 Nits). To ratio to reduce the luminance from 160 cd/m^2 to approximately 100 cd/m^2 is;

100/160 = 0.63

This is the required visible light transmission factor to achieve a consistent and appropriate level of internal spill from glazing in this case.

For practical considerations of product options, the acceptable range is **0.65 +/- 0.05** (which is comparable to +/- 50 lux E_v). This is a common glazing option for domestic glazing brands and will not significantly darken an interior space – it is an acceptable option for domestic purposes.

[11] Most glazing will not be available as a perfect transmitter and will have some form of reduced visible light transmission, e.g. 0.85 at the maximum end of the available range.

1.4 Planners Checklist – Glazing

DETERMINE THE GLAZING CATEGORY

- What is the intended purpose of the glazing? Domestic/Commercial
- Are there alternatives?

ASSESS THE GLAZING EXTENT

- Is the amount of glazing appropriate for the use and location?
- The decision should be based on analysis of the development in the landscape taking into account
    - Landscape impact
    - Disruption to dark landscape continuity
    - Visible intrusion
    - Urban/rural density and remoteness
    - Shielding by vegetation and buildings

SET RECOMMENDATIONS FOR VLT

- Use the table to set recommended factors for visible light transmission

APPLY MITIGATIONS

- Determine and set additional mitigations; black-out-blinds, hours of use,