Glare

MSc Architecture, Energy & Sustainability
Module ADP033
Daylighting & Energy Efficient Artificial Lighting

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Contrast

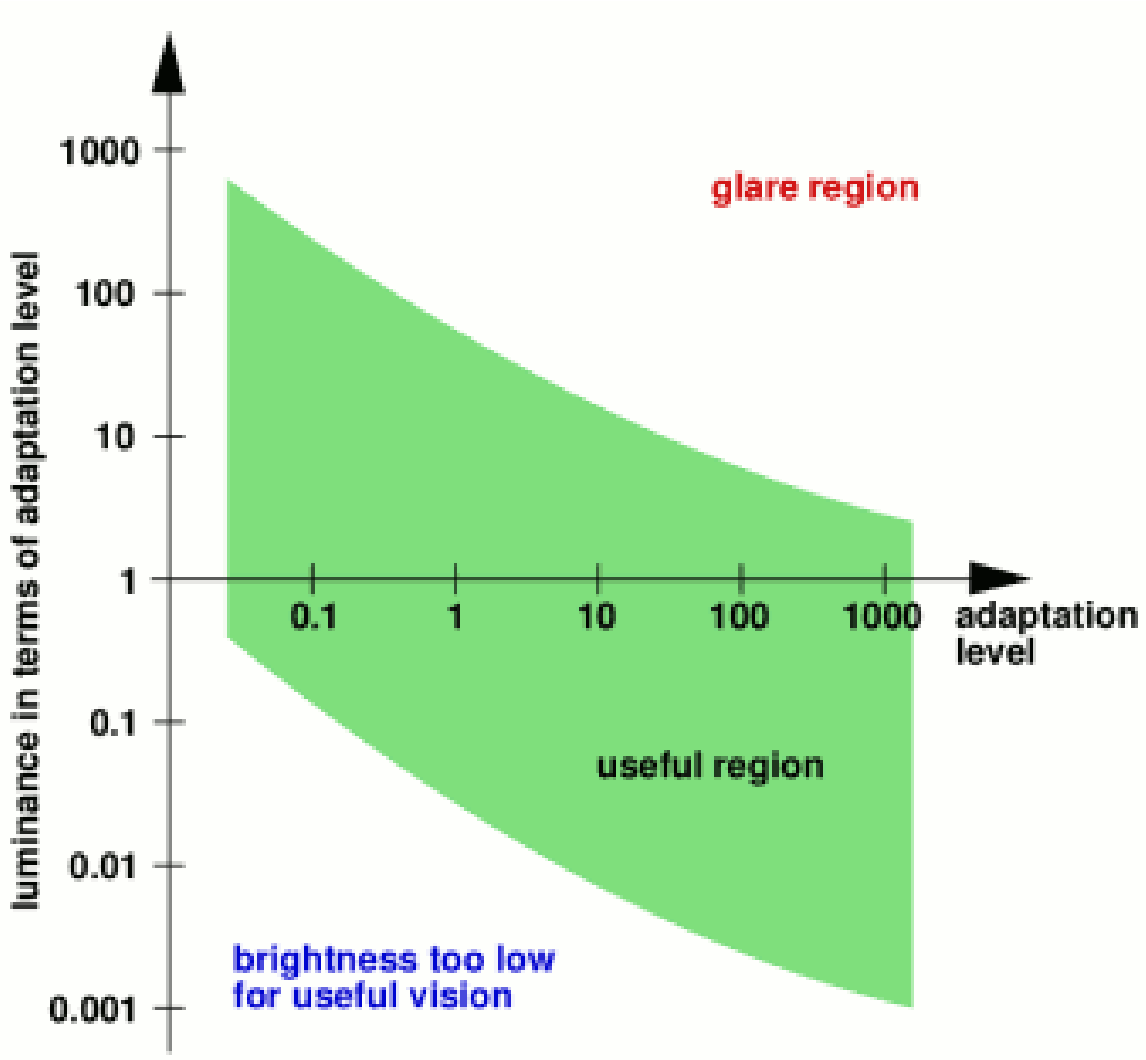
- Measure of the difference in luminance between an object and its background:

$$L = \frac{L_{object} - L_{background}}{L_{background}}$$

- The eye can adapt to a wide range of luminance (about 14 OoM).
- This range is much lower for any given scene (4 to 5 OoM): If very dark objects and very bright objects are in close proximity, the dark one will look black, while the bright ones will appear washed out.

Contrast: Example

Useful luminance



Glare

- Glare is a reduction of object visibility when very bright objects or light sources are in the field of view.
- Two types of glare:
  - Discomfort glare: Difficulty in seeing task, desire to look away from bright source
  - Disability glare: Task is impossible to see (e.g. oncoming headlights at night)

Glare Sources

- Direct glare: Lamps, bright parts of a fitting
- Reflected glare, veiling glare: Glossy magazines, computer screens

Discomfort Glare

- Attempt to avoid by looking away, shading eyes, squinting
- Magnitude depends on:
  - Luminance of glare source, L
  - Luminance of background, L_b
  - Size of glare source, ω
  - Position of glare source relative to direction of view: position index, p
- Affects performance, leads to tenseness, fatigue

UGR

$$UGR = 8 \log \left[\frac{0.25}{L_b} \sum \frac{L^2 \omega}{p^2} \right]$$

- CIE Unified Glare Rating
- Only valid for artificial light sources
- NOT valid for windows!
- All glare metrics are valid only for a specific observer (position and direction of view)

Reaction to Glare

- Change of a single step: just about detectable
- Change of three steps: noticeable difference

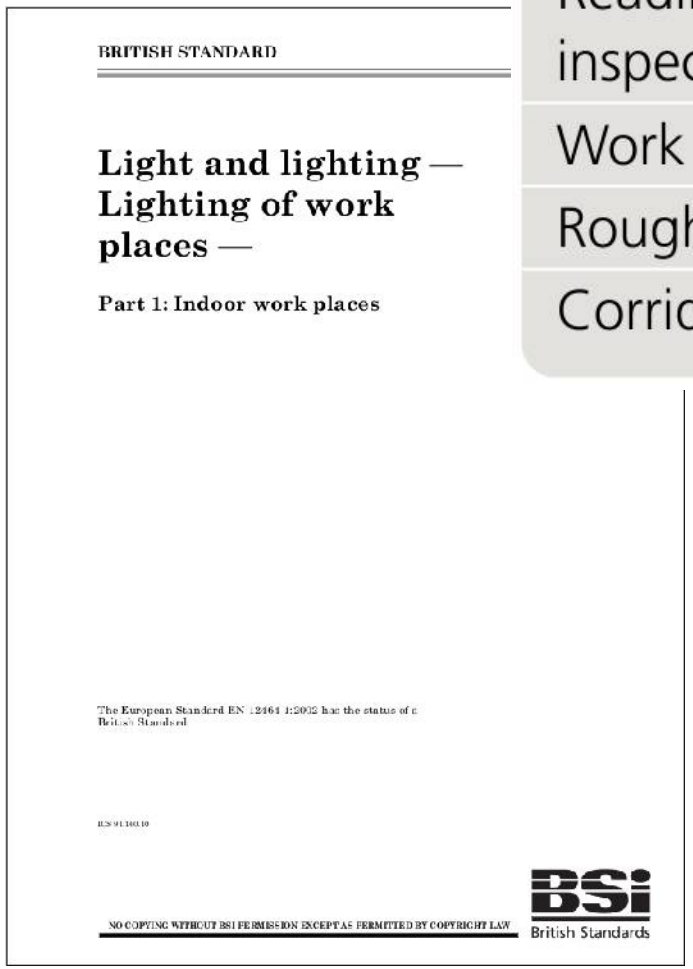
Glare index	Reaction
0 - 10	Imperceptible
10 - 16	Noticeable
16 - 22	Acceptable
22 – 28	Uncomfortable
> 28	Intolerable

BS EN 12464-1

3	Offices				
Ref. no.	**Type of interior, task or activity**	**$\bar{E}_m$** lx	**UGR_L** -	**R_a** -	**Remarks**
3.1	Filing, copying, etc.	300	19	80	
3.2	Writing, typing, reading, data processing	500	19	80	DSE-work: see 4.11.
3.3	Technical drawing	750	16	80	
3.4	CAD work stations	500	19	80	DSE-work: see 4.11.
3.5	Conference and meeting rooms	500	19	80	Lighting should be controllable.
3.6	Reception desk	300	22	80	
3.7	Archives	200	25	80	

Limiting Glare at Work

Technical drawing	≤ 16
Reading, writing, classrooms, computer work, inspections	≤ 19
Work in industry and craft workshops, reception	≤ 22
Rough work, staircases	≤ 25
Corridors	≤ 28


BRITISH STANDARD

Light and lighting — Lighting of work places —

Part 1: Indoor work places

The European Standard EN 12464-1:2002 has the status of a British Standard

ICS 91.160.10

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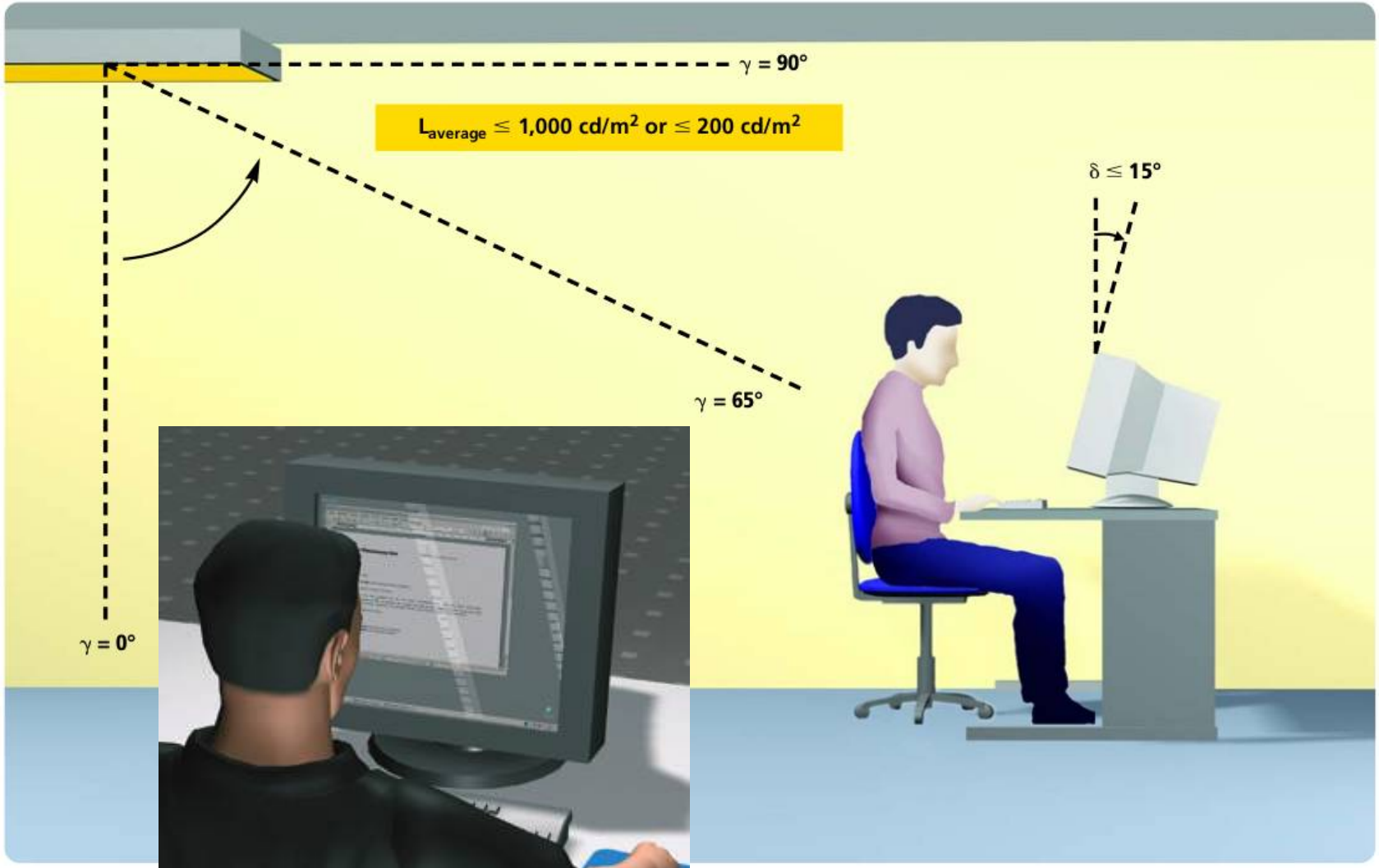
BSI British Standards

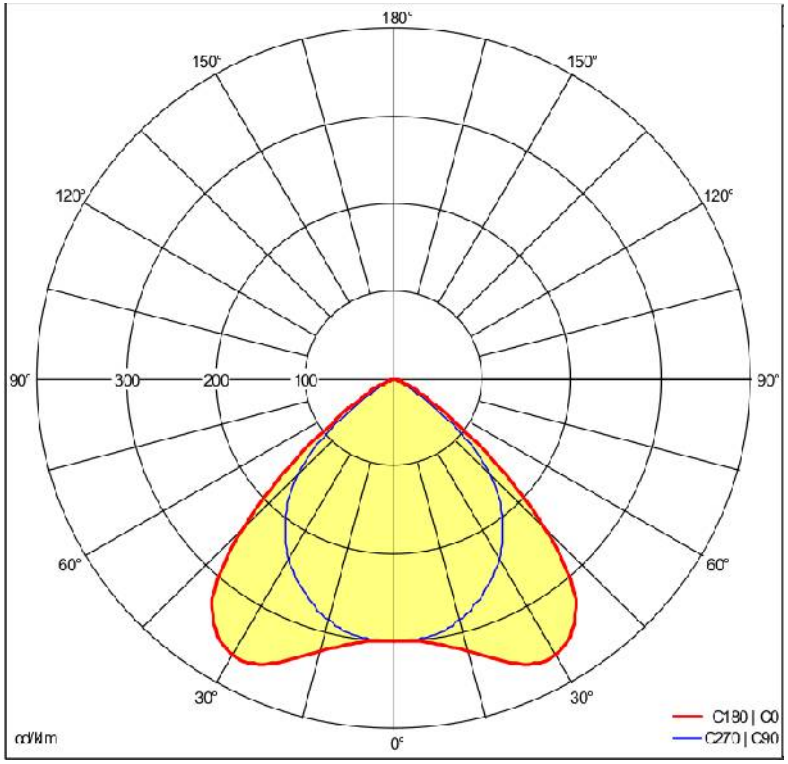
Veiling Glare



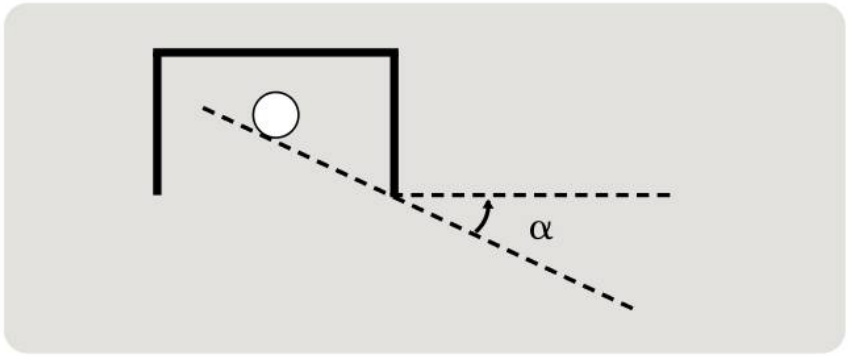
Luminaire Luminance

- Limit luminance above 65°
- “bat-wing” luminaire

VDUs	mean luminance of luminaires and surfaces which reflect on screens
Positive display VDUs	≤ 1000 cd/m²
Negative display VDUs with high-grade anti-reflective system Evidence of test certificate required	
Negative display VDUs with lower-grade anti-reflective system	≤ 200 cd/m²



Shielding Angle



Lamp luminance in cd/m²	Minimum shielding angle
20,000 to < 50,000 e.g. fluorescent lamps (high output) and compact fluorescent lamps	15°
50,000 to < 500,000 e.g. high-pressure discharge lamps and incandescent lamps with matt and inside-coated bulbs	20°
≥ 500,000 e.g. high-pressure discharge lamps and incandescent lamps with clear bulbs	30°

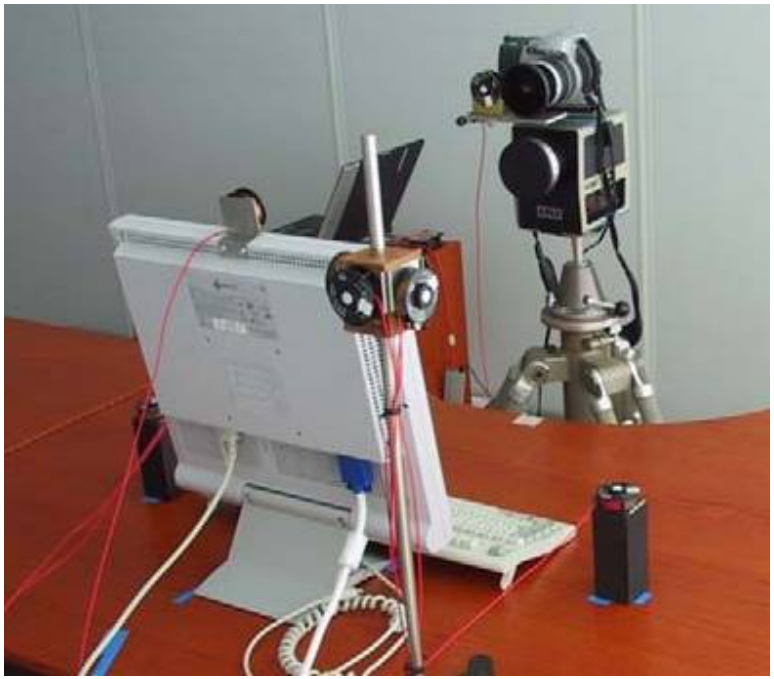
Complete cut-off above certain angles

Avoid Veiling Glare

- Arrangement of luminaires and work places: direction of view
- Matt surface finishes
- Luminance restriction of luminaires,
- Increased luminous area of the luminaire,
- Bright ceiling and bright walls increase background luminance

Glare from Windows

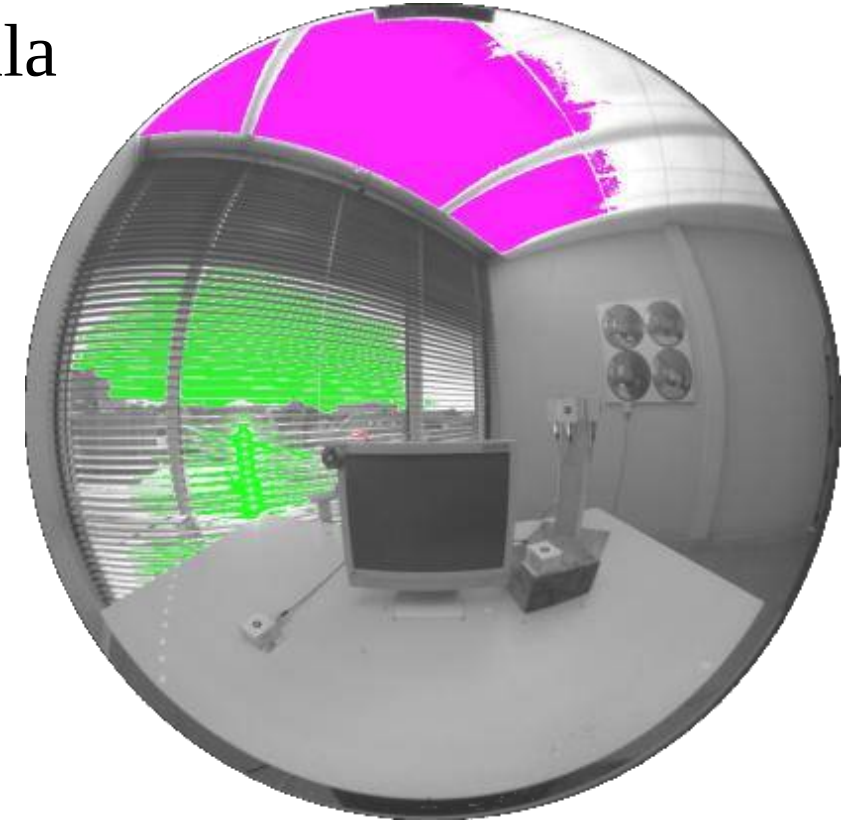
- UGR rating only applicable to small sources
- Hopkinson and Bradley: A study of glare from very large sources, Illuminating Engineering, 55(5), 1960
- Daylight Glare Index, DGI, has been shown to make unreliable predictions whether people experience glare from windows (large sources)
- Recent laboratory studies in Germany and Denmark
- Wienold and Christoffersen: Evaluation methods and development of a new glare prediction model for daylight environments with the use of CCD cameras, E&B 38, 2006



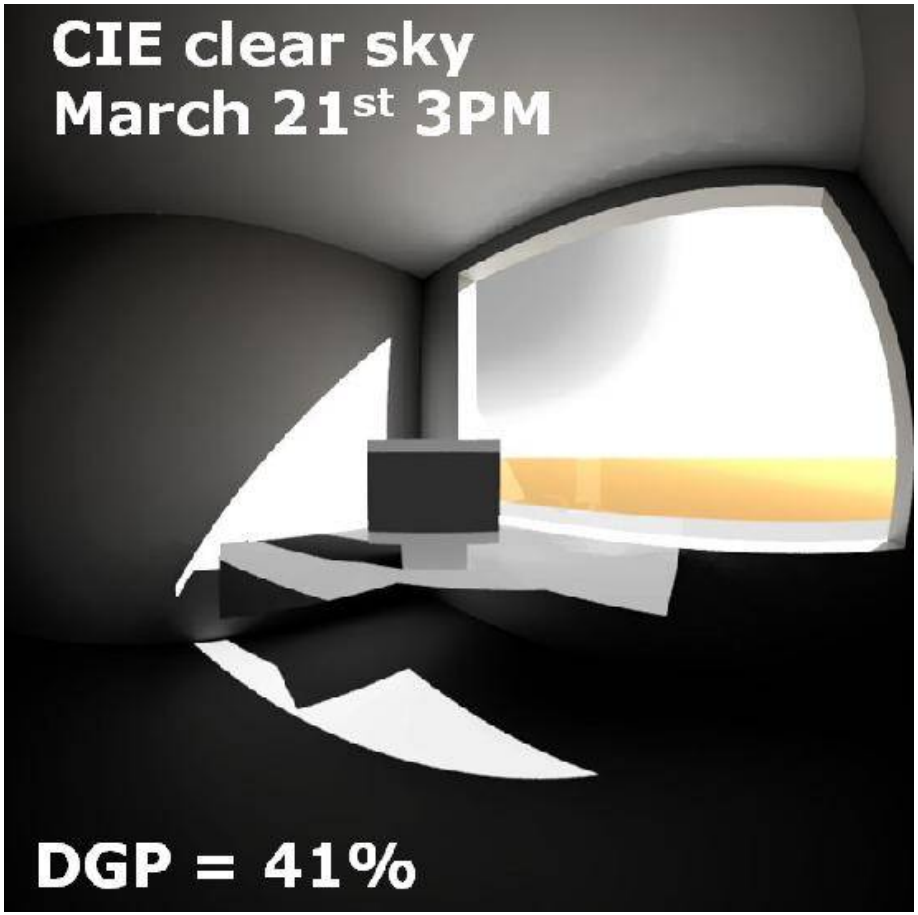
Daylight Glare Probability

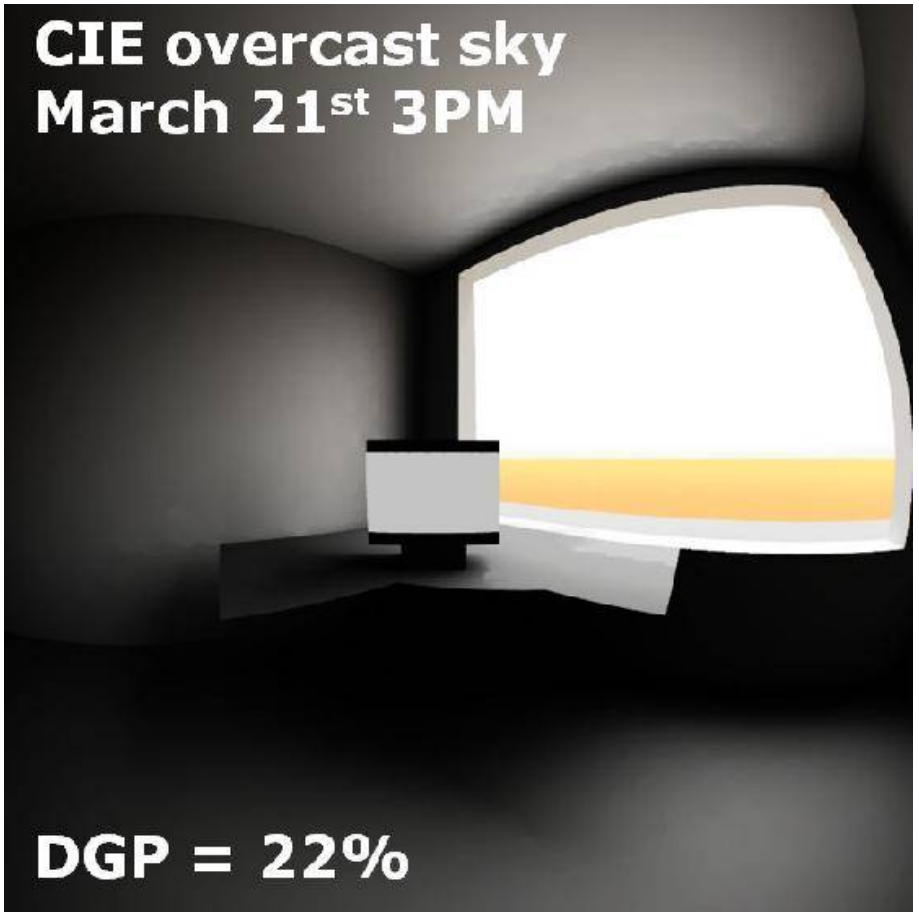
$$DGP = 5.87\times10^{-5}E_v + 9.18\times10^{-5}\log\left(1+\sum_i \frac{L_{s,i}^2\,\omega_{s,i}}{E_v^{1.87}\,P_i^2}\right)$$

- Unlike other glare ratings, formula includes illuminance at the eye
- Evaluation possible with HDR photographs
- evalglare tool for Radiance
- An age-factor was recently added to above formula



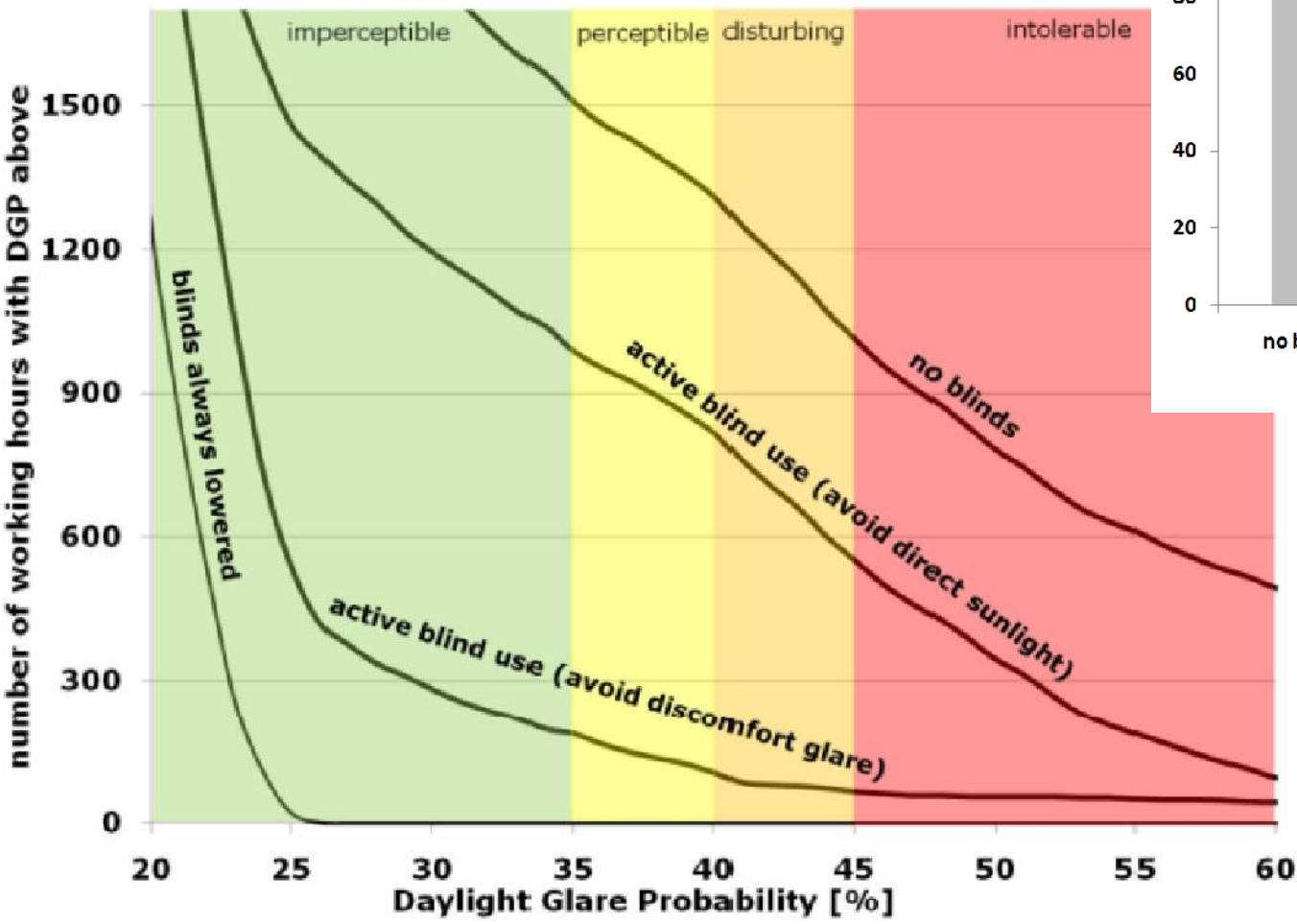
DGP Example

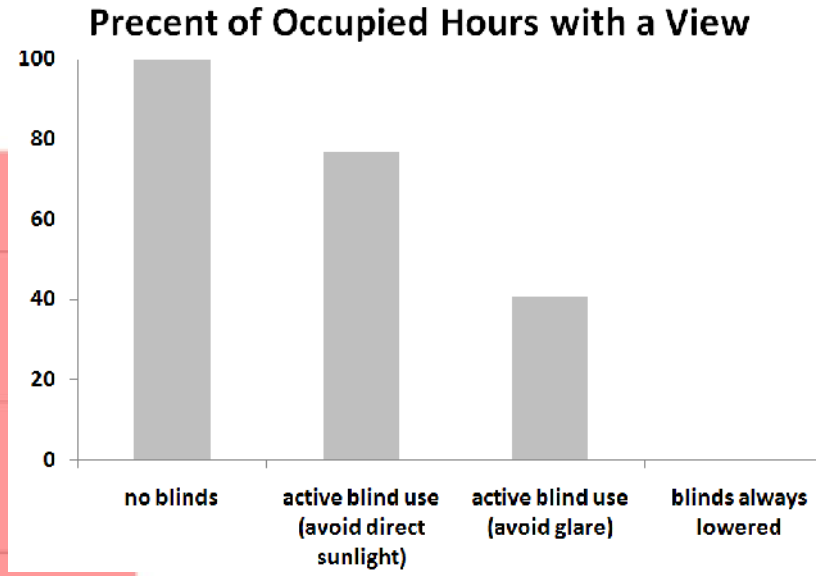




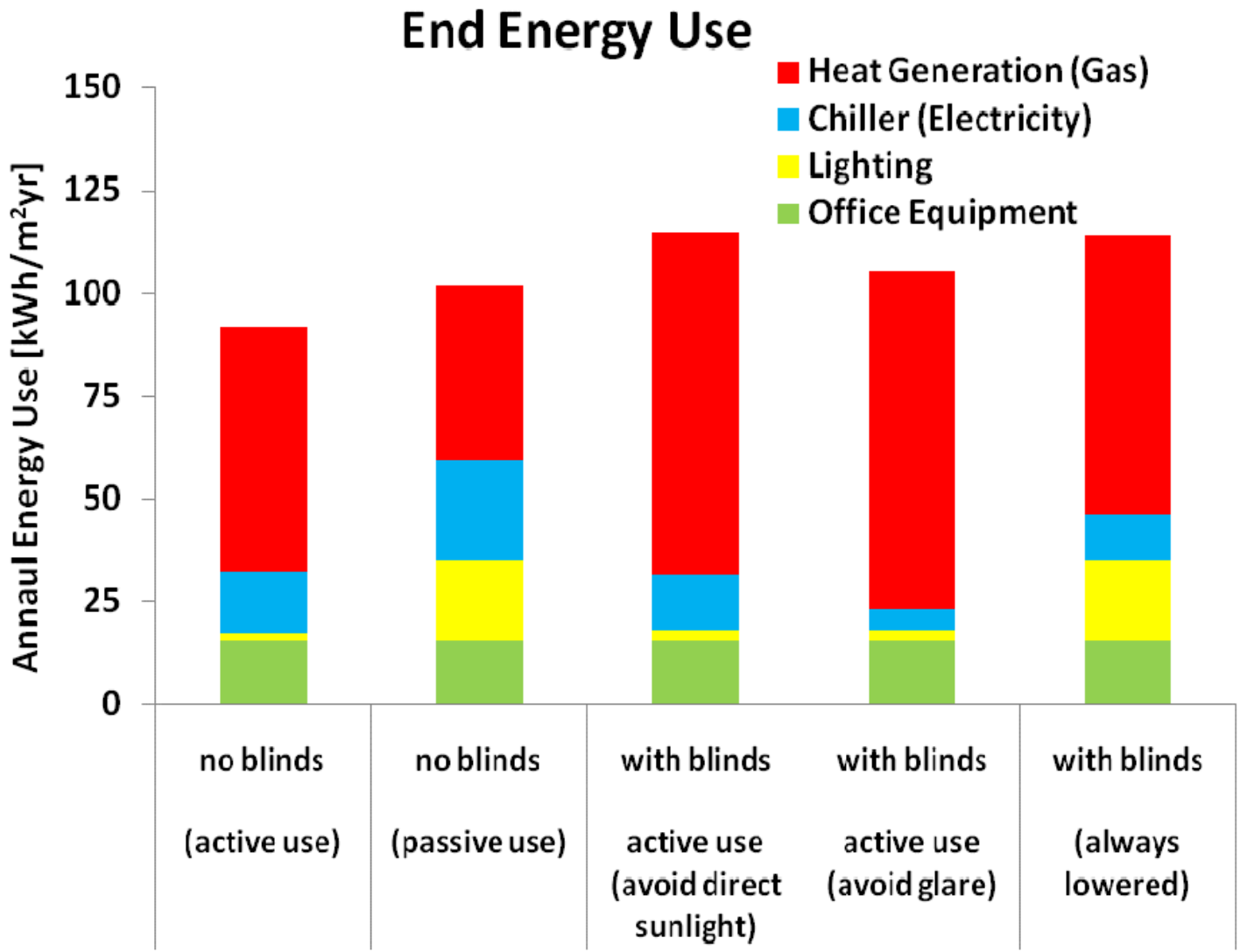
Reinhart and Wienold: Daylighting Dashboard

Combine with Weather Data...



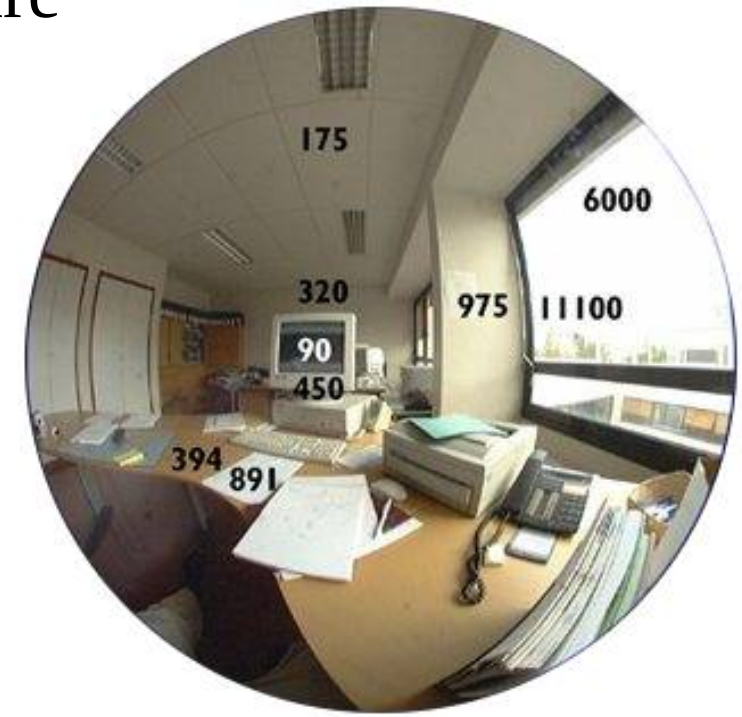


... to Get Energy Use



Avoid Daylight, Sunlight Glare

- Daylighting systems should have adequate solar shading to protect against overheating, preferably on the outside
- Additionally, internal user-operable blinds are necessary against glare



Avoid Hight Contrasts, Veiling Glare

- Splayed reveals reduce the contrast between window and wall
- Place computer monitors perpendicular to the facade to avoid veiling glare from windows