Photobiological lighting adaptation scenarios for healthy adaptive buildings

Presenting by

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Lighting adaptation scenarios

Protocols and profiles to provide and adjust indoor lighting environment to occupants' needs and the local climate

Local climate

Photoperiods
Daylighting

Buildings

Smart/Intelligent
Adaptive/Responsive

Occupants' needs

Photobiological
psychological
Biophilic

Local climate

Buildings

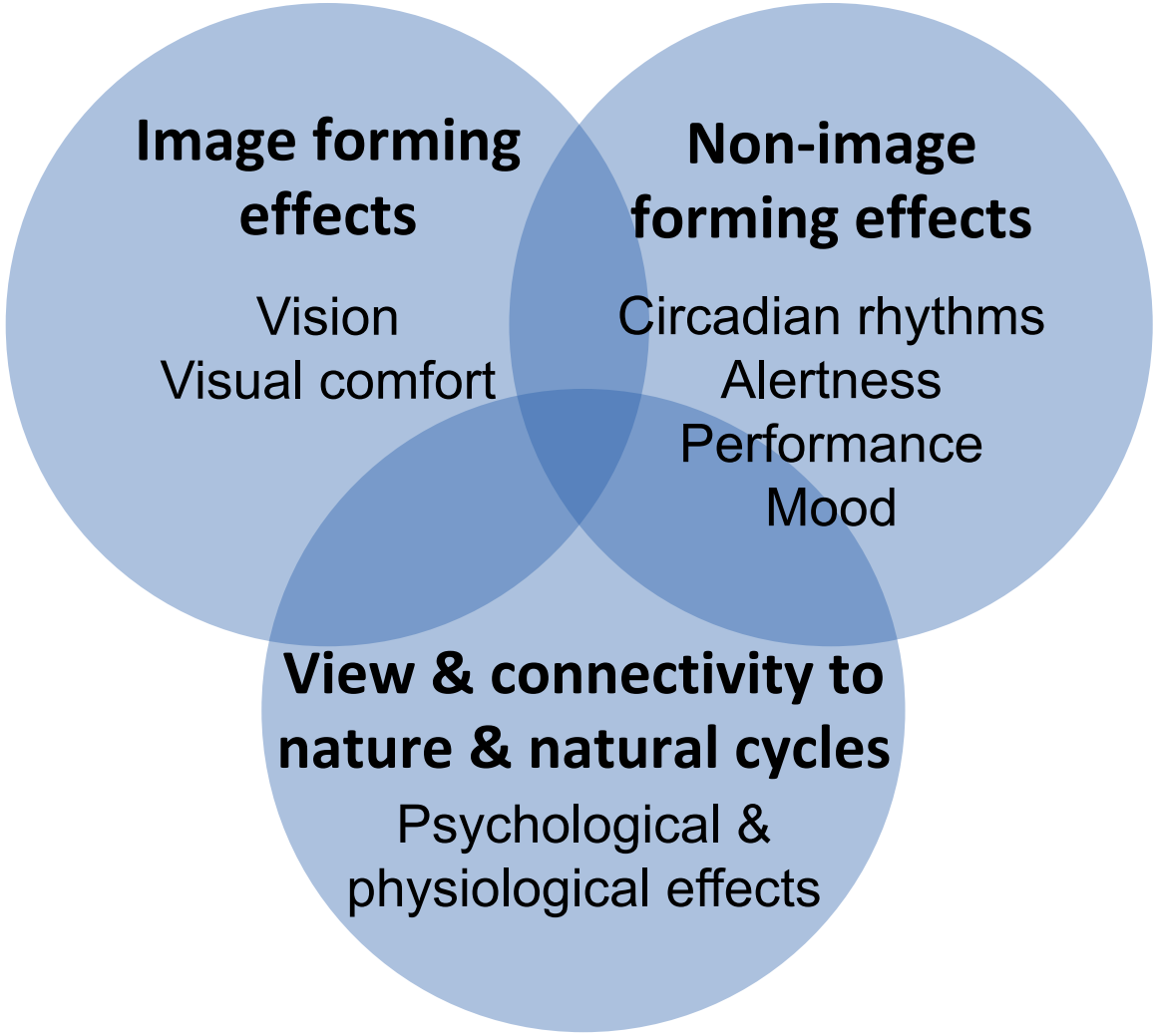
Occupants' needs

Lighting Adaptation Scenarios

Photoperiods
Daylighting

Smart/Intelligent
Adaptive/Responsive

Photobiological
psychological
Biophilic

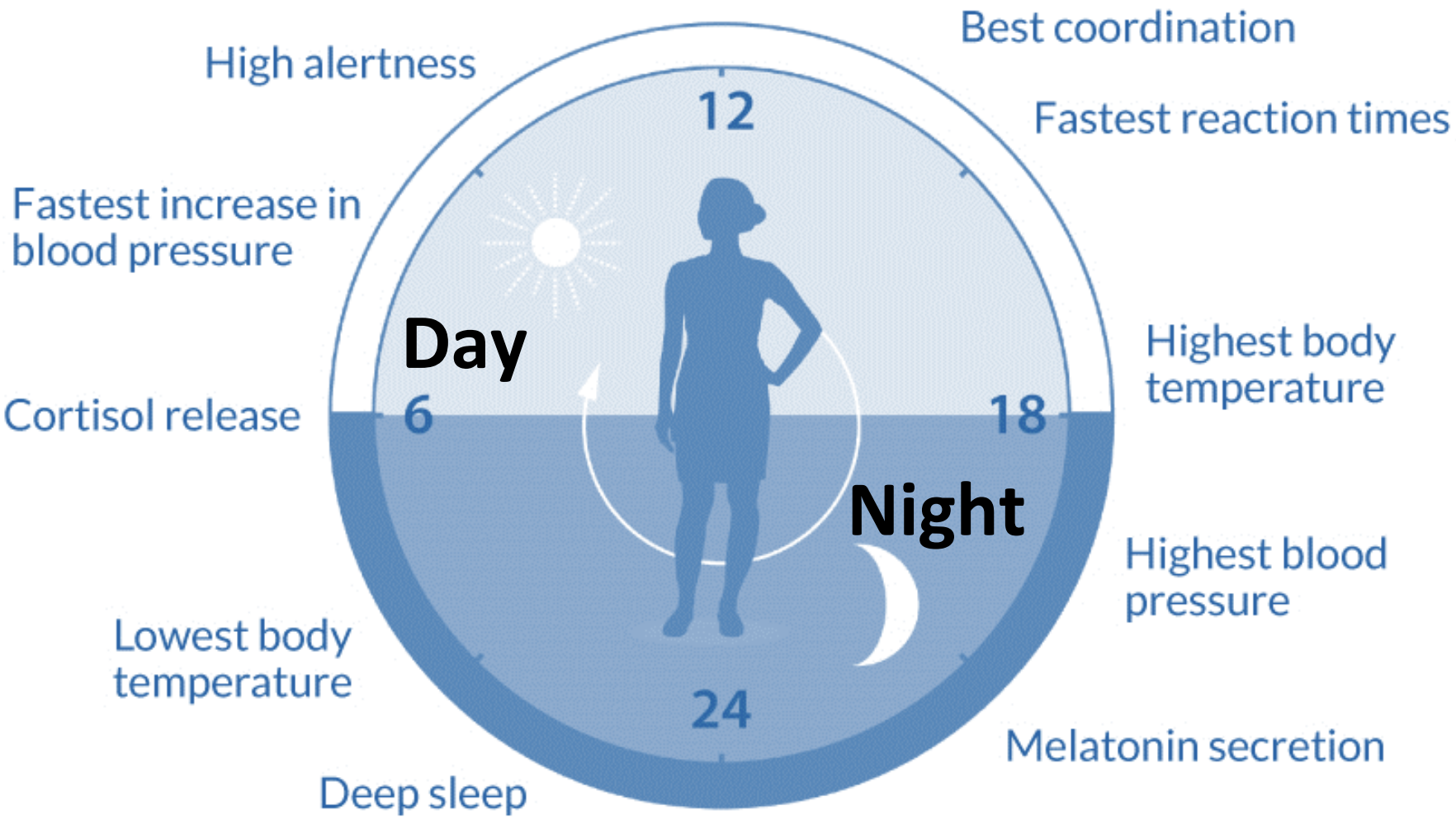


Occupants' needs

Photobiological
psychological
Biophilic

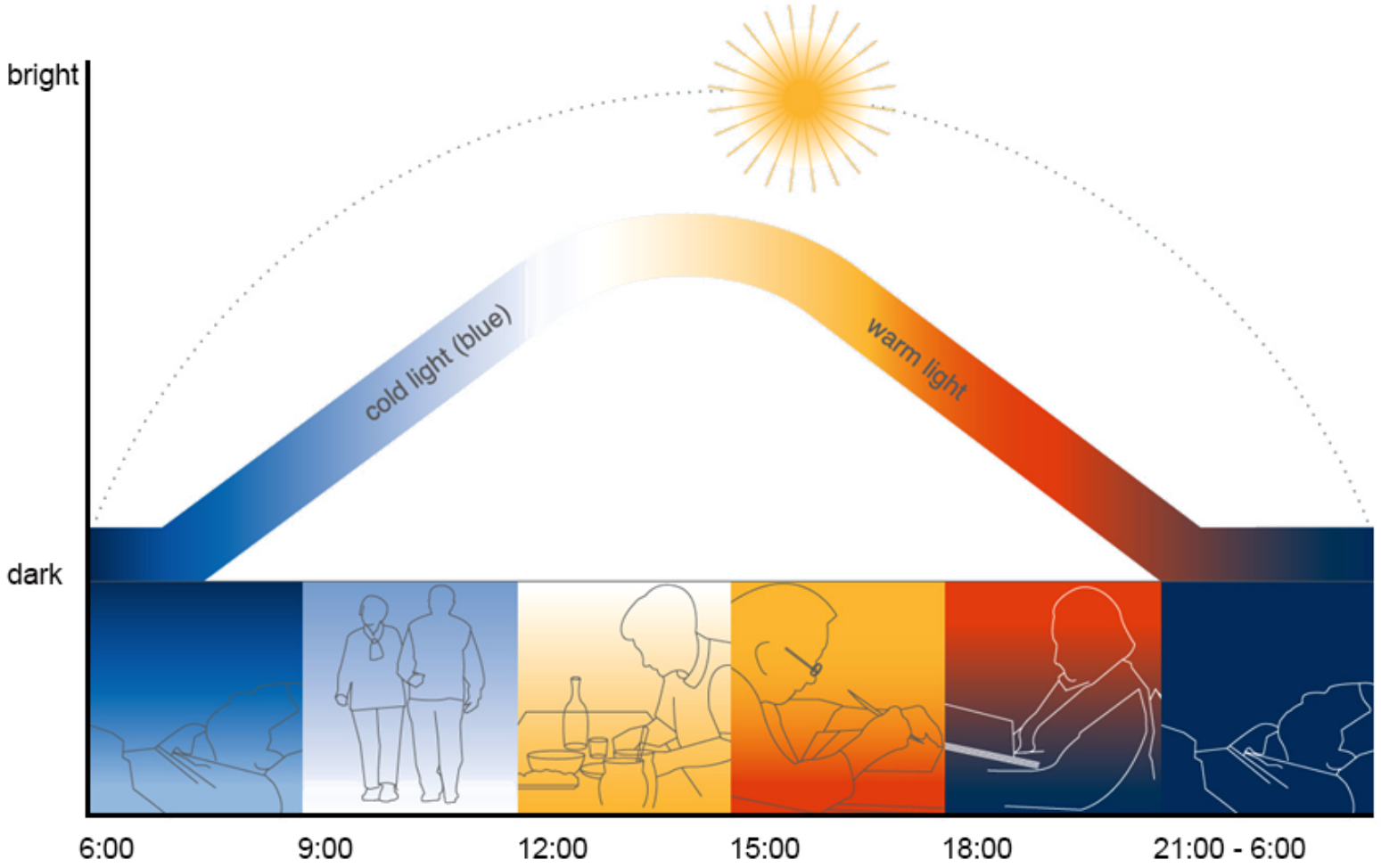
Refer to: (CIE, 2018, 2019; Dai, Huang, Hao, Lin, & Chen, 2018; DiLaura, Houser, Mistrick, & Steffy, 2011; International WELL Building Institute, 2018; Jung, 2017; Jung & Inanici, 2019; Konis, 2017; Lucas et al., 2014; Parsaee, Demers, Hébert, Lalonde, & Potvin, 2019; Rea & Figueiro, 2016)

Non-image forming effects



Proper Light at Proper Time

CIE (October 3, 2019), Position statement on non-visual effects of light



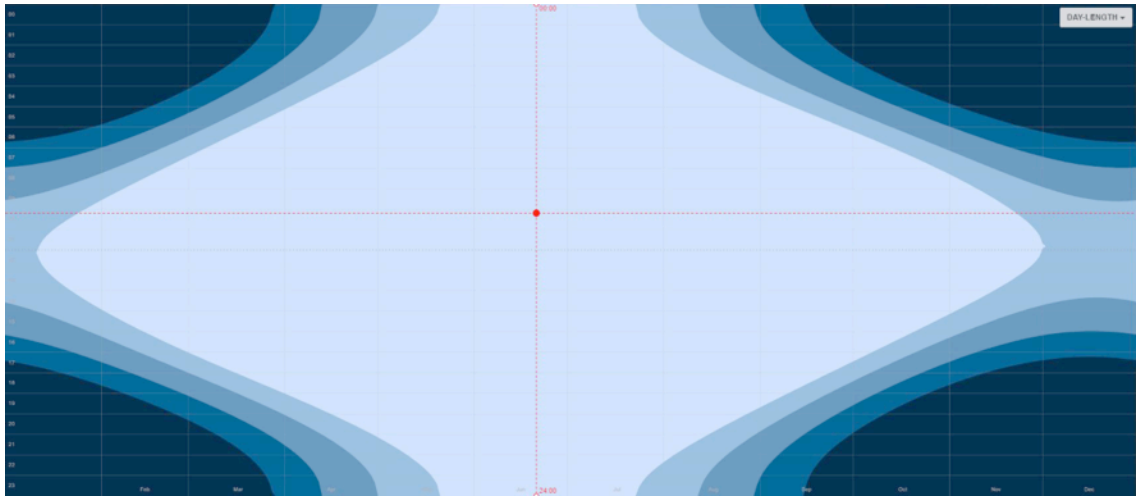
Connectivity and accessibility to nature and natural cycles

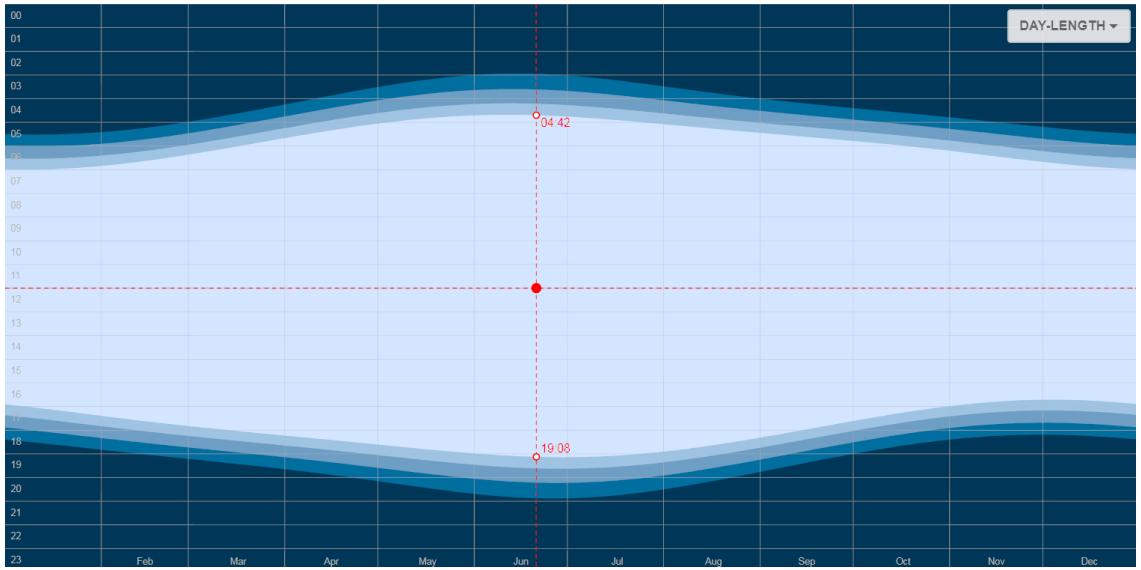
Local climate

Cambridge Bay [69°N]

Los Angeles [34°N]

Photoperiods
Daylighting

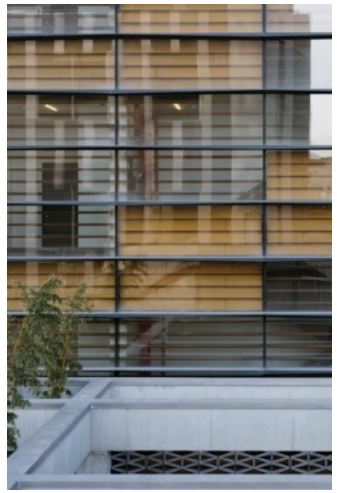




Buildings

Lighting Adaptation Scenarios

Façade system



Smart/Intelligent
Adaptive/Responsive

Artificial lighting (LED)

Question

What lighting scenarios must be followed in the building to adjust indoor lighting to occupants' needs for a particular task and maximize the positive use of outdoor nature?

Systemic literature review

Premise

Lighting standards
Photobiological studies
Biophilic guidelines

Criteria

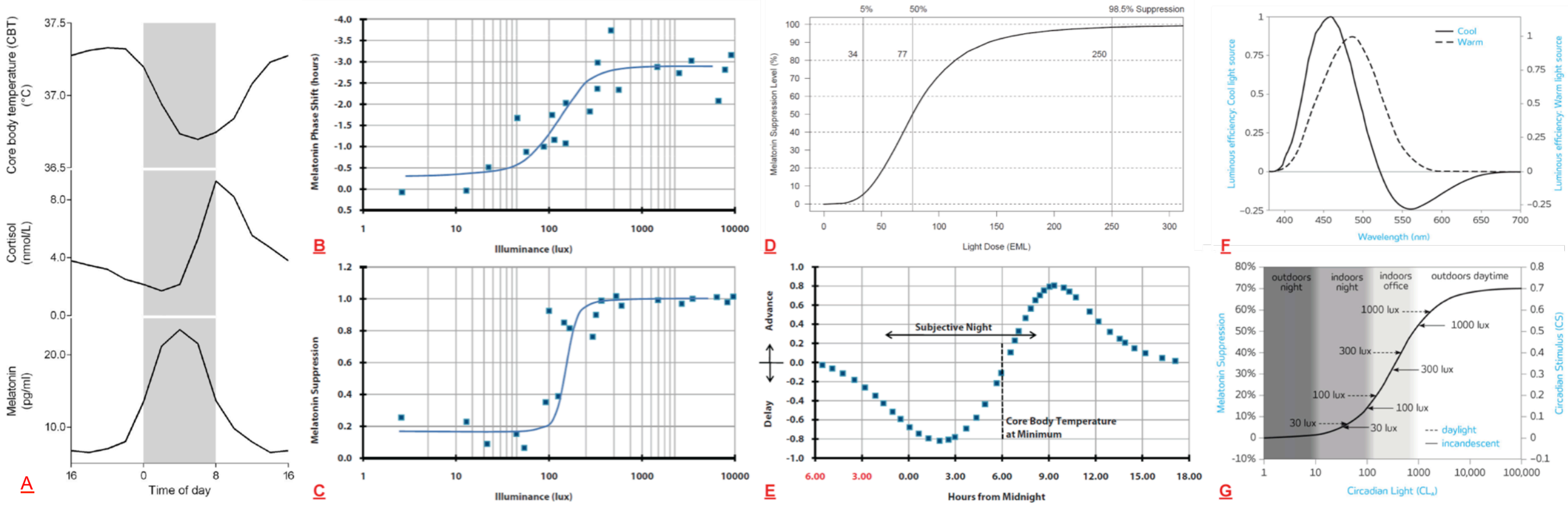
Image forming
Non-image forming
Task requirements
Daylight availability

Main parameters

Parameter	Metric	Unit
Intensity	Illuminance	lux
	Luminance	Cd/m2
	Equivalent Melanopic Illuminance	EM lux
	Equivalent Melanopic luminance	EM cd/m2
	Circadian stimulus	CS
Timing	Time	second
Duration	Time	second
Color	Correlated Color Temperature (CCT) CIE Chromaticity (CIE xyz) Color Rendering Index (CRI)	Kelvin

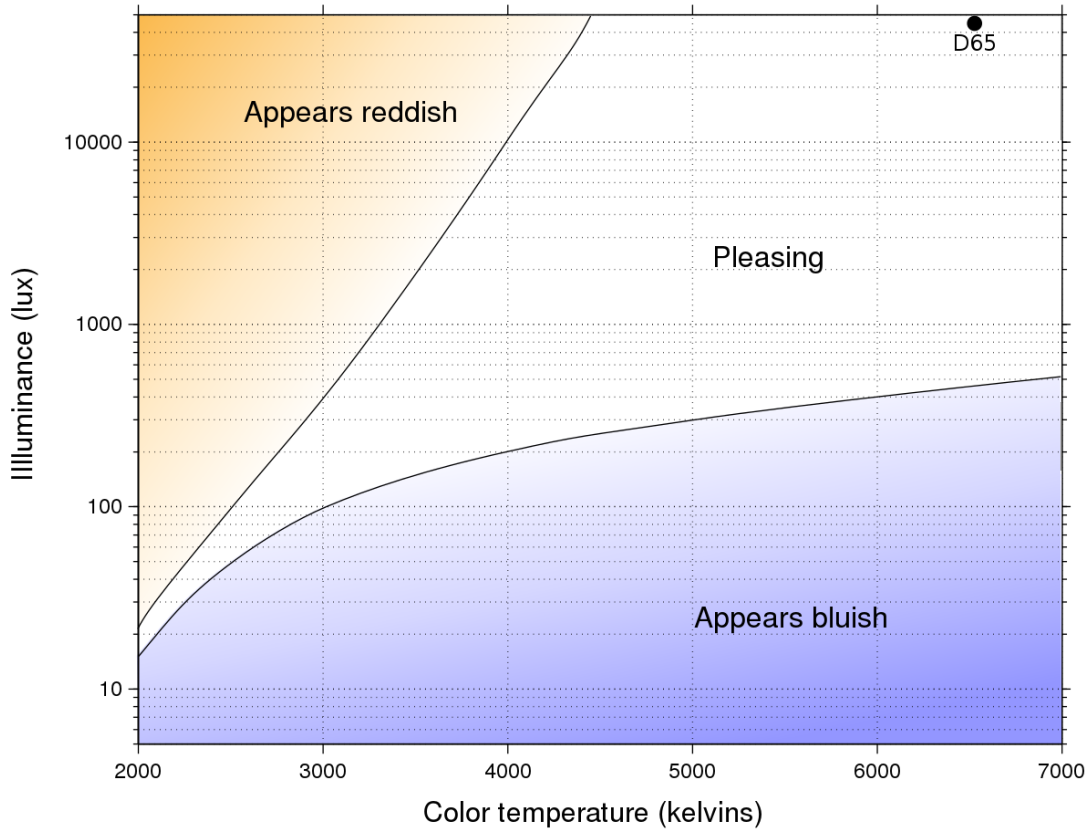
Refer to :
CIE, 1955, 2014, 2018a, 2018b, 2019; Dai, Huang, Hao, Lin, & Chen, 2018; DiLaura, Houser, Mistrick, & Steffy, 2011; Enezi et al., 2011; International WELL Building Institute, 2018; Jung, 2017; Jung & Inanici, 2019; Konis, 2017; Lucas et al., 2014; Parsaee, Demers, Hébert, Lalonde, & Potvin, 2019; Rea & Figueiro, 2016; Rea, Figueiro, & Bullough, 2002

Effective patterns

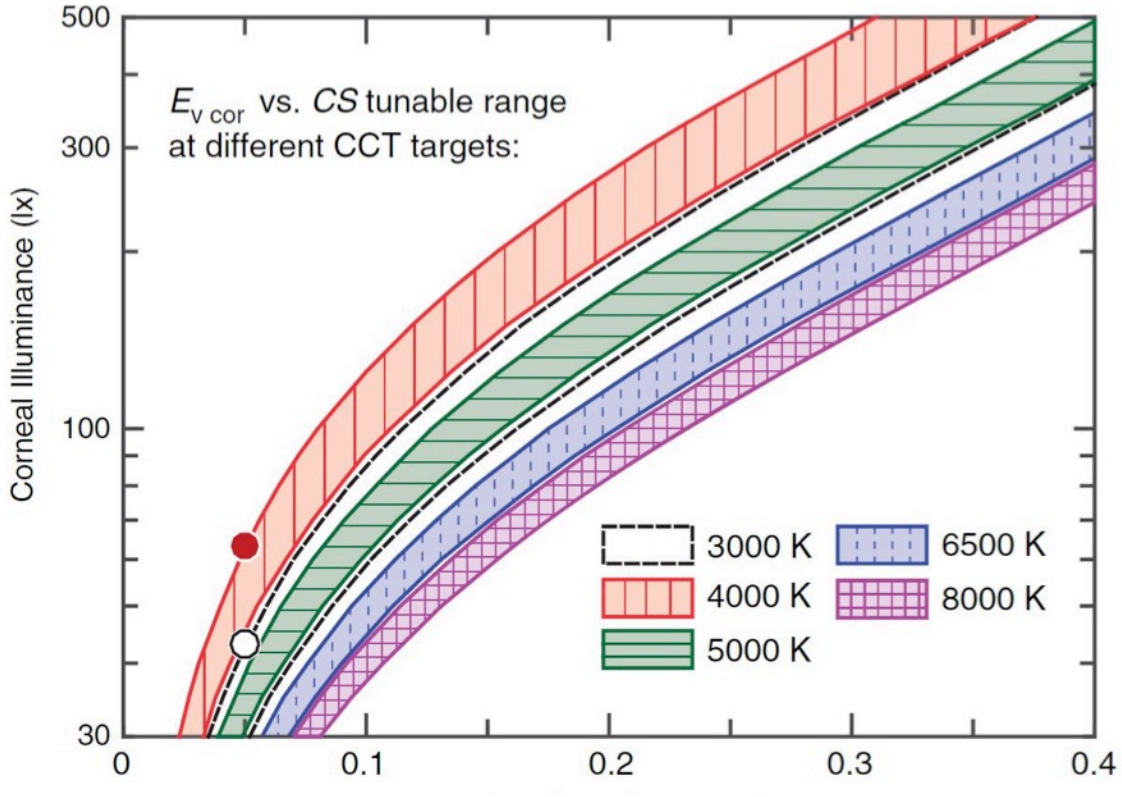


Refer to :
Boivin & Boudreau, 2014; DiLaura et al., 2011; Konis, 2017; Lucas et al., 2014; Rea & Figueiro, 2016; Rea, Figueiro, & Bullough, 2002

Effective patterns



Kruithof curve , Retrived by Hankwang from (Kruithof, 1934; Weintraub, 1999)



(Dai, Cai, Hao, Shi, & Wei, 2018)

Timing of light impulse

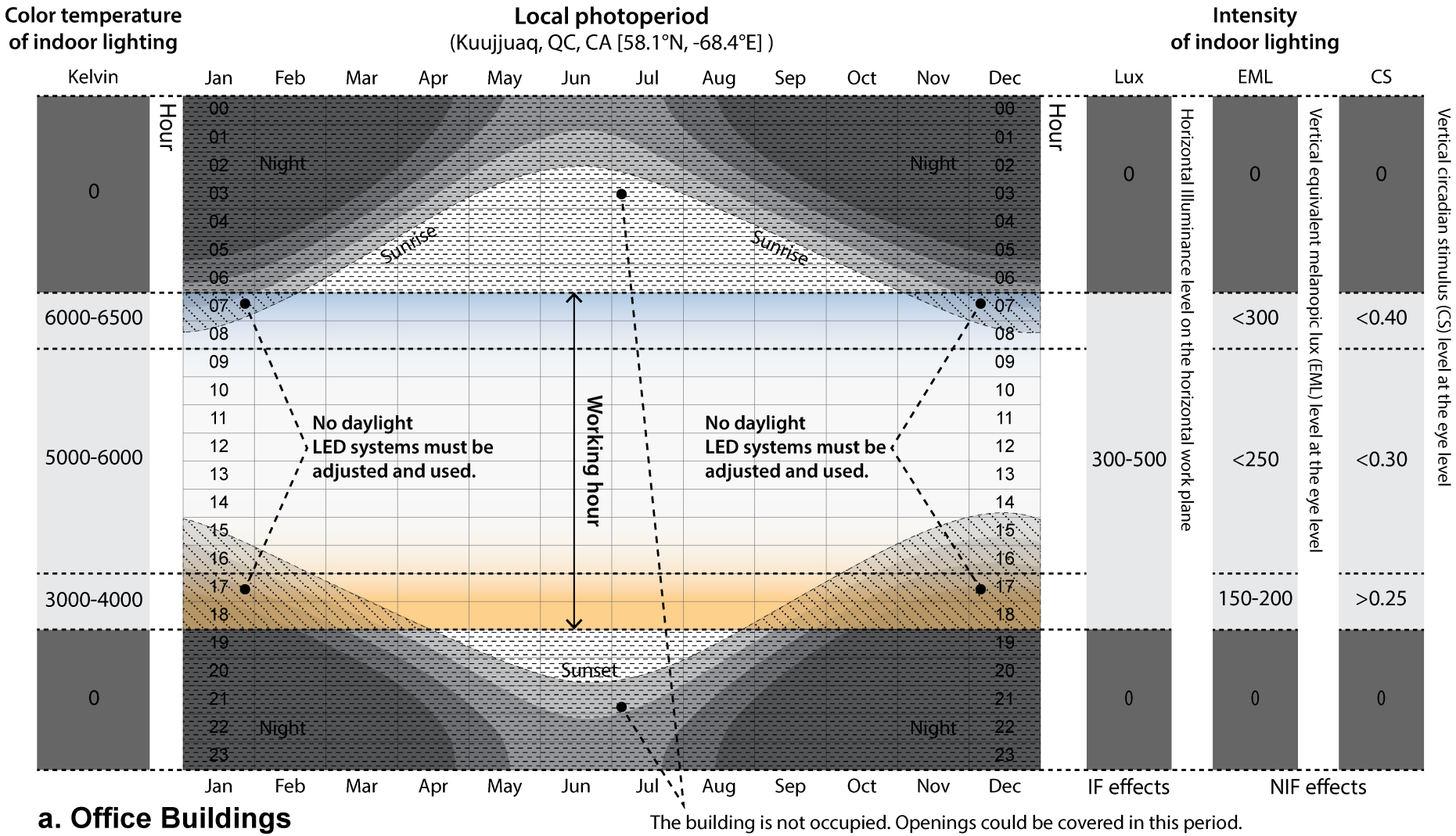
Timing	Note
7h to 9h	the biological waking time and becoming vigilant
9h to 17h	the biological day and being highly vigilante for working
17h to 19h	Preparation for the biological night becoming less vigilant
19h to 7h	the biological night and being less vigilant

Light-related Health & wellbeing

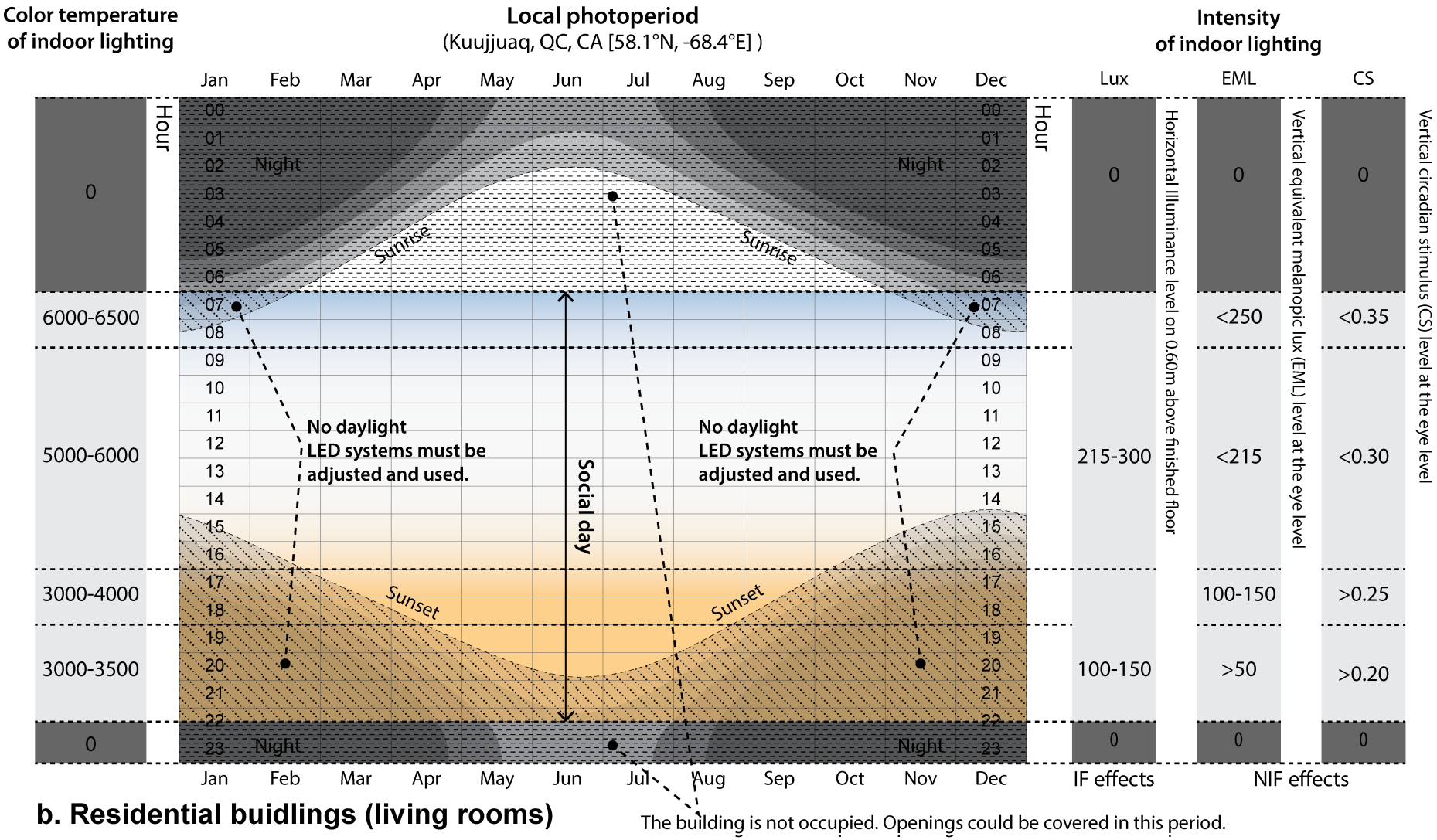
- ✓ An improper balance between these aspects can compromise human well-being, health and functioning related to lighting ambiance.
- ✓ Many lighting products, especially LED systems, are available in the market that are aimed to affect non-image forming aspects.
- ✓ Don’t unnecessarily decrease or restrict availability and accessibility to daylight and outdoor nature inside buildings.

CIE (October 3, 2019), Position statement on non-visual effects of light

Photobiological lighting adaptation scenario



Photobiological lighting adaptation scenario



b. Residential buidlings (living rooms)

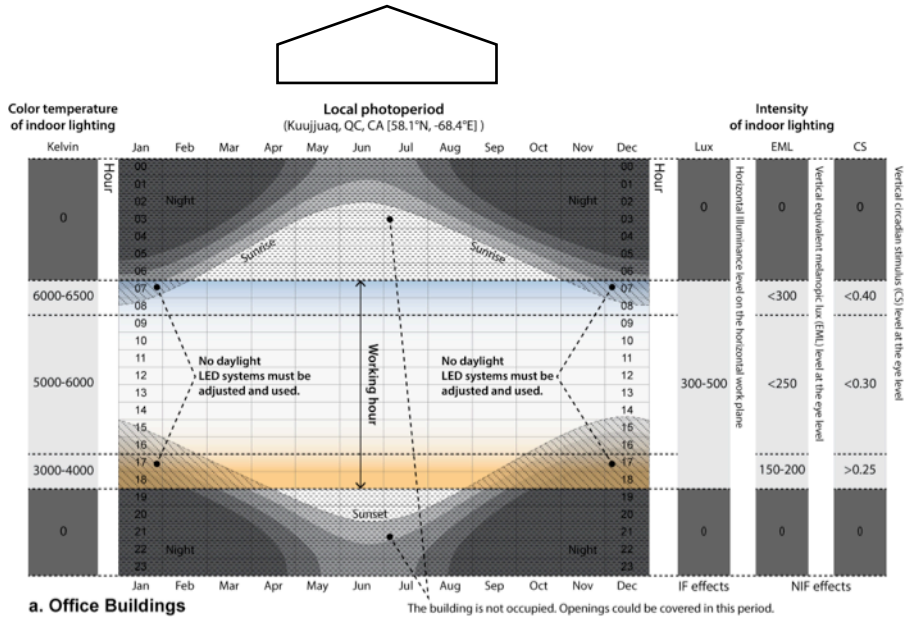
The building is not occupied. Openings could be covered in this period.

Photobiological lighting adaptation scenario

Façade system
Daylighting

Control system

Artificial lighting



Conclusion & future studies

- Lighting adaption scenarios are the essential requirement of climate-responsive, adaptive and healthy buildings.
- Lighting scenarios could adapt the indoor lighting environment to photobiological needs of occupants in a specific space.
- Scenarios could maximize the use of daylighting and natural cycles inside buildings through responding to local photoperiods.
- Control systems could be developed based on lighting adaption scenario.

Conclusion & future studies

- Further studies are required to consider all NIF issues in lighting design and adaptation scenarios.
- Further developments are needed to offer an integrated and unified metric/unit and analysis method representing IF and NIF effects and biophilic quality of lighting.
- Standards and guidelines must be developed regarding vertical and horizontal lighting needs in order to offer simplified recommendations for architects and designers.
- Psychological and cultural aspects as well as individual's preferences must be considered in lighting adaptation scenarios.

Thank you for your attention!
Any question?

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