



IEA 4E SSL ANNEX – 3RD TERM, TASK 1 WORK PLAN

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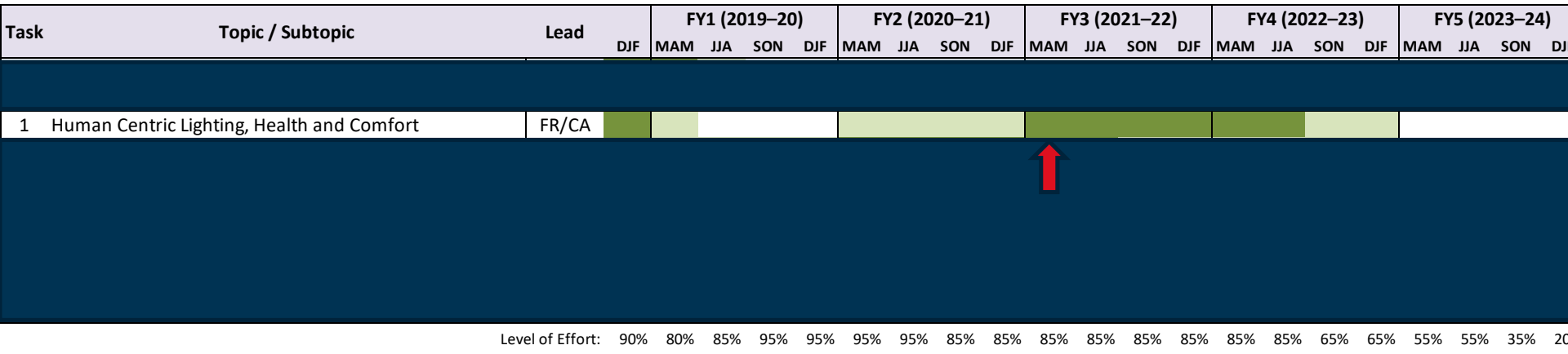
3rd Term Work Plan – Task 1

Objectives:

To study the health impacts on people of solid-state lighting, considering issues that concern both large fractions and small sensitive groups of the population.

Provide interpretation and guidance to policy-makers on setting appropriate requirements on health-related metrics for all forms of solid-state lighting.

“Official” planned schedule



Level of Effort: 90% 80% 85% 95% 95% 95% 95% 85% 85% 85% 85% 85% 85% 85% 85% 65% 65% 55% 55% 35% 20%

Key:

- More intense period of work by Task Leader and Experts
- Less intense level of effort, preparation or completion of work, mainly by Task Leader
- DJF December, January, February
- MAM March, April, May
- JJA June, July, August
- SON September, October, November

Description of work

Subtask 1: Completion of the study on Temporal Light Modulation (TLM) started in 2018 during the Annex 2nd term.

→ Completed, not discussed further.

**Subtask 2: Detailed review of positive and negative health impacts of SSL.
Update the health report published in 2014.**

→ **In progress**, see next slides.

Subtask 2 : Update the 2014 Health Report

Health: broadly defined according to WHO (1948) definition: *Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.* (World Health Organization (WHO) 1948)

Do:

- Identify the psychological and physiological processes that light can affect, based on scientific evidence,
- Focus on areas where regulation or consumer advice might help to prevent adverse effects – identify how to identify products that work for people, or ways to apply them that will be beneficial (or avoid harm)
- Identify areas where metrics and test methods don't exist yet; but

Don't:

- Specify the lighting design choices that deliver the desired conditions. This is a review of the evidence not a guide to how to do lighting correctly.



Subtask 2: Revised Report scope

- Literature search will encompass light effects on health regardless of source (to capture relevant papers).
- Conclusions will focus on products: lamps & luminaires (both consumer and commercial) for general interior lighting; street lighting; ~~emergency or egress lighting~~, with the caveat that these are products designed to emit white light.
 - Focus on emissions (from products), but with commentary on exposures (products in use)
- Out of scope: automotive, light sources that are not lighting products (e.g., battery powered: toys, portable lamps) and displays
- In general, the conclusions will address products in the Task 1 performance tiers, when used as intended in everyday applications; highlighting risks than could emerge if used incorrectly by consumers (where engineering controls don't apply); providing guidance relevant to sensitive populations; but excluding exposures during manufacturing or installation.

Subtask 2 – Updated plan

2014 Report	Revision	Responsible team
Electrical safety	Out of scope, covered by existing standards. State this in Introduction	
EMF	Out of scope, covered by existing standards. State this in Introduction. This includes WiFi-enabled devices	
Glare	Yes, especially including new CIE report on UGR adaptation If possible, include subsection on identifying sensitive people & the conditions that cause problems for them	Christophe, with input from CSTB and ENTPE colleagues
Photobiological safety	Yes, but reduced length – no need to describe or derive action spectrum or risk categories (as was previously done) – being concise If possible, include subsection on identifying sensitive people & the conditions that cause problems for them	Christophe
TLM [formerly, flicker]	Yes If possible, include subsection on identifying sensitive people & the conditions that cause problems for them <i>LiFi / visible light communication?</i>	Jennifer
“Non-visual” effects	Yes Beneficial effects – e.g., higher light exposure, adding UVR & NIR? Adverse effects – e.g., circadian shifting, effects of badly-timed light exposure If possible, include subsection on identifying sensitive people & the conditions that cause problems or that benefit them Evaluate some product claims	beneficial - Jennifer adverse - Sarah
	<i>Ecological effects of exterior lighting</i>	Christophe leads, with support from Jennifer & Sarah
Conclusions	Draw the individual issues together to help to identify what a “good” product might be and identify how they might combine	

Subtask 2 – Literature Review Criteria

Seek papers in the range 2012-2021 only (building on the prior Annex report, not repeating it)

Base conclusions on papers that meet criteria for scientific quality:

- Peer reviewed publications, from journals, conference, or in grey literature if it is apparent that some form of review process took place (e.g., ANSES 2019)

Seek those with good-quality metrology, look for work in which it is possible to assess the accuracy of exposure measurements

Evaluate research design quality against published criteria,

- Veitch, Fotios, & Houser checklist
- How to measure light for ipRGC effect (CIE S026:2018)
- Evaluate effect sizes , consider practical vs statistical significance

Research quality criteria: CIE TN 011:2020

CIE has published guidance on what researchers ought to document and to report when studying the effects of light on outcomes mediated by the ipRGCs

Our review will use this guidance to identify the most suitable papers (noting that research prior to 2020 might be less likely to fulfil all requirements)

Available for free download:

<https://cie.co.at/publications/what-document-and-report-studies-iprgc-influenced-responses-light>

PROJECT DETAILS
People (see CIE 213:2014, Subclause 4.1.2.1, including examples) <i>Who are the people who took part in the experiment?</i>
number of participants, age, sex, general ophthalmic health status, including colour vision status, specify the wearing (or not) of spectacles or contact lenses, material and treatment of spectacles or contact lenses.
Project-specific specialized descriptors: chronotype, light history, sensitive individuals
Context (see CIE 213:2014, Subclause 4.2, examples in 4.2.3) <i>What are the characteristics of the space used in the experiment?</i>
date and time of day of measurements or exposures, setting, geographical location
photographs from the participants viewpoints (fish-eye are preferred), verbal or quantitative specifications (e.g. room dimensions) where required
parameters related to the indoor environment such as air temperature
participant characteristics such as clothing and activity
Lighting (see CIE 213:2014, Subclause 4.3, examples in 4.3.3) <i>What provides light to the space?</i>
specify electric lighting: pictures or drawings and description of lamps, luminaires and control systems, SPD, colour rendering properties, CCT, chromaticity coordinates of the lighting, direction of illumination, temporal light modulation
specify daylight provision: drawings and description of windows, window view and orientation, daylighting systems, prevalent weather or sky condition
STIMULUS (INDEPENDENT, DEPENDENT OR CONTROL VARIABLE)
General considerations
specify measuring equipment and measurement details: manufacturer, model, serial number and calibration status of measuring equipment, measurement grid, location, and direction of measurements
use SI units and definitions from accepted vocabularies and CIE publications where these exist
Luminous exposure
five α -opic quantities (e.g. α -opic irradiance or α -opic equivalent daylight (D65) illuminance (α -opic EDI)) at eye level on a (usually vertical) plane perpendicular to the direction of view for laboratory setting; five average α -opic quantities (e.g. α -opic irradiance or α -opic EDI at eye level on a (usually vertical) plane perpendicular to the direction of view in field studies
the spectral irradiances (or radiances, as appropriate to the investigation) always for laboratory investigations, and for field studies when possible
illuminance at identified locations, for comparison to the established literature and application documents
luminance distribution from the observer's viewpoint
Duration (including temporal variability, see CIE 213:2014, Subclauses 4.10.2.1 and 4.10.2.2)
timeline of experiment, including overall duration of the experiment, timing of luminous exposure (in clock time), dim luminous exposure, duration of the luminous exposure (in min or h), duration of dim up and dim down (in min), and pattern.
MEASURE (DEPENDENT VARIABLE)
specify what was measured and how it was scored, demonstrate validity and reliability
STATISTICAL ANALYSIS
sample size, effect size, descriptive statistics (means, standard deviations, medians, maximum, minimum) for all measures, statistical tests, decisions and assumptions

Subtask 2: Work plan (updated March 2021)

2019

Refine list of review topics, Develop review criteria; Assign topics to leaders.
Done, revised plan shown here.

Jan 2020 to Dec 2021

Literature search, develop databases; Review key papers, inter-compare reviewing results; Refine criteria; Continuous coordination with CIE & ISO committees; continue reviewing & developing recommendations. In process.

Dec 2021 to Aug 2022

Writing report.

New aspects of glare

Most published research deals with discomfort glare (disability glare is rather well understood)

New CIE publications:

Indoor lighting: CIE 232:2019 Discomfort Caused by Glare from Luminaires with a Non-Uniform Source Luminance (new UGR)

Outdoor lighting: CIE 243:2021 Discomfort Glare in Road Lighting and Vehicle Lighting (review of models, metrics, new aspects to consider)

Research topics:

Action spectrum of discomfort glare, glare from several sources

Individual sensitivities including age

Physiological responses to glare such as:

- Pupil response, direction of gaze, blinking rate
- Use of EMG to measure “squinting” through electrical activity of muscles surrounding the eye,
- Brain activity (fMRI, EEG)

New research methodologies

New aspects of photobiological safety and retinal phototoxicity

Latest specific statements, opinions and standards:

ICNIRP Statement 2020 : Light-emitting diodes (LEDs): implications for safety

ANSES Opinion 2020 : Blue-light exposure limits for the general population (scientific arguments supporting a request to the European Commission to revise the exposure limits for visible light.

ANSI / IES RP-27-20+E1 2020 : Photobiological Safety for Lighting Systems

Research topics:

Dosimetry of ocular exposure to environmental light (daylight and artificial light)

Toxicology research on blue light retinal phototoxicity in animal models:

- Results obtained with new animal models (diurnal rodents)
- Influence of the timing of the exposure on retinal phototoxicity (phototoxicity vs circadian rhythm)

Phototoxicity of violet-pump phosphor-converted white LEDs (GaN on GaN LEDs for instance)

Influence of long wavelengths (red and near infrared light) on phototoxicity

Epidemiological studies (long term effects of cumulated exposure, ocular pathologies such as AMD)

Children and other sensitive populations

Effects on ecosystems

Recent reviews and meta-analyses

Sanders, Dirk, Enric Frago, Rachel Kehoe, Christophe Patterson, et Kevin J. Gaston. « A Meta-Analysis of Biological Impacts of Artificial Light at Night ». *Nature Ecology & Evolution* (2020).

Falcón, Jack, Alicia Torriglia, Dina Attia, Françoise Viénot, Claude Gronfier, Francine Behar-Cohen, Christophe Martinsons, et David Hicks. « Exposure to Artificial Light at Night and the Consequences for Flora, Fauna, and Ecosystems ». *Frontiers in Neuroscience* 14 (2020)

New regulations and guidelines

Worldwide local regulations for protected areas (shores, etc.), creation of dark corridors in urban areas

French nation-wide regulation (27 Dec 2018) to limit light nuisance of outdoor lighting

EU Green Public Procurement Criteria for Road Lighting and traffic signals (2019)

New SSL technologies on the market

Amber LEDs, red LEDs and other “dark-sky friendly” luminaires

Research topics

Impacts of outdoor lighting on animals, plants and ecosystems

Measurements and mapping of night sky quality (ground-based measurements, satellite studies, mapping algorithms)

Environmental quality criteria of outdoor lighting beyond the standard LCA approach : inventory of light-sensitive species, indicators of light exposure, indicators related to lighting masterplanning

Further considerations regarding TLM

Veitch, J. A., Martinsons, C., Coyne, S., & Dam-Hansen, C. (2021). Correspondence: On the state of knowledge concerning the effects of temporal light modulation. *Lighting Research and Technology*, 53(1), 89-92. <https://doi.org/10.1177/1477153520959182>.

CIE TN 012:2021: Guidance on the measurement of temporal light modulation of light sources and lighting systems <https://doi.org/10.25039/TN.012.2021>

CIE TC 1-83 Visual Aspects of Time-Modulated Lighting Systems should conclude its report in the next 6 months (ballot forthcoming)

ipRGC-influenced light responses

Céline Vetter, P. Morgan Pattison, Kevin Houser, Michael Herf, Andrew J. K. Phillips, Kenneth P. Wright, Debra J. Skene, George C. Brainard, Diane B. Boivin & Gena Glickman (2021) A Review of Human Physiological Responses to Light: Implications for the Development of Integrative Lighting Solutions, LEUKOS, <https://doi.org/10.1080/15502724.2021.1872383>

Frontiers in Neuroscience special issue, 13 papers:

Translation and Processing of Light by the Non-Image Forming Visual System – Context, Mechanisms and Applications

Non-visual effects (Adverse)

Circadian regulation, sleep, other physical health consequences (mostly adverse)

Ocular light exposure influences many aspects of human physiology and behaviour, including circadian rhythms, alertness and sleep, mood, neuroendocrine and cognitive function

There is a substantial amount of recent evidence that shows light exposure patterns have negative impacts on health and productivity

Several recent publications have looked at human physiological responses to light and the implications for lighting design and practice

Early indications suggest that there is a substantial amount of research in this area since the 2014 health report - this is important for the Annex because with more substantial evidence we can better determine exposure recommendations that avoid unnecessary health impacts

Subtask 2: External context – slow movement

ISO/TC 274/JWG 4 and CIE JTC 14 – Integrative lighting

ISO/CIE TR 21783 expected publication fall 2020 – final ISO editing under way.
[J. O'Hagan, convenor; J. Veitch is an expert member]

Illuminating Engineering Society – Light and Human Health committee

Draft document under revision
[J. Veitch & J. O'Hagan are members; J. Veitch has authored sections.]

Underwriters Laboratories

Design Guideline: UL 24480 - Design Guideline for Promoting Circadian Entrainment with Light for Day-Active People published December 2019

Design guidance on one aspect of the topic; its development and contents don't represent international expert consensus