Anthropogenic Light At Night
Towards Standardized Measurement Methods & Criteria as a Policy Tool

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Chair of CIE TC2-95 “Measurement of Obtrusive Light and Sky Glow”

“State of the art” in Obtrusive Light (light pollution)

The triplet of “success”

- Increase of outdoor lighting
- Bad design & engineering
- Inappropriate products

“State of the art” in Obtrusive Light (light pollution)

- Microscopic or Near-field

“State of the art” in Obtrusive Light (light pollution)

- Macroscopic or Far-field

Mitigation of negative effects

- Numerous recommendations
- Local laws are initiated by various stakeholders
- Laws target to various mitigation strategies
- Law makers seek for scientific evidence
- Laws frequently follow other laws or adopt international guides
- Decision makers want to have strong argumentation
- **Law “enforcement” is secured by field measurements**

Image source: brake.ork.uk

Metrology of … things

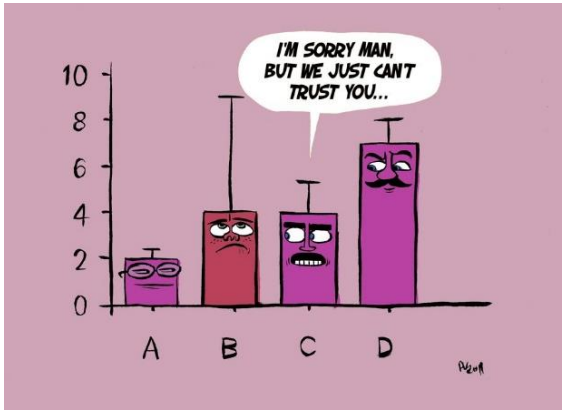
Measurement Quantity

… well-“defined”

Measurement Devices

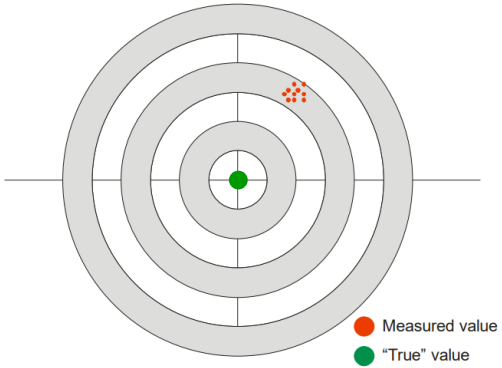
... well-“prepared”

Measurement Uncertainty (& Conformity Assessment)

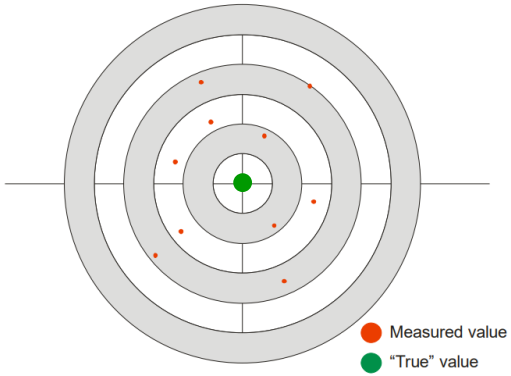


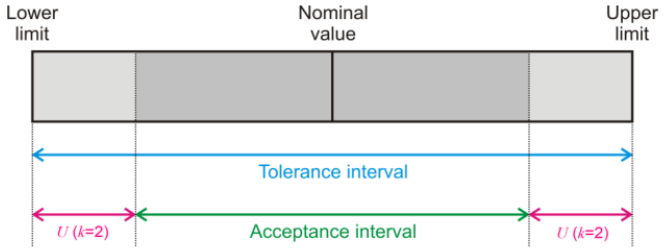
... well-“estimated”

Need for metrology base on obtrusive light



… accuracy, precision, error, uncertainty, tolerance …





Source: ***CIE TN 009:2019*** *- The Use of "Accuracy" and Related Terms in the Specifications of Testing and Measurement Equipment*

Units and quantities

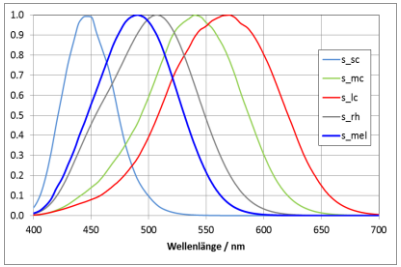
Quantities shall be expressed in internationally agreed units (i.e. reference quantities): The SI

Just an example: Effective irradiance

$$E_{\mathrm{act}} = \int E_{\lambda}(\lambda)\, A_{\mathrm{act}}(\lambda)\, \mathrm{d}\lambda$$

Units: $\mathrm{W \cdot m^{-2}}$ $\mathbf{W \cdot m^{-2} \cdot nm^{-1}}$ **dimensionless** nm

Different quantities may have the same units.



Example of action spectra
ipRGCs : Intrinsically-Photosensitive Retinal Ganglion Cells

In obtrusive light we may define more complicated action spectra including directionality, time dependency, distance, etc.

Aspects of obtrusive light

- photons propagate
- photons are reflected
- photons intrude

Intrusive light

Glare for drivers, pedestrians, animals

Advertising and signage

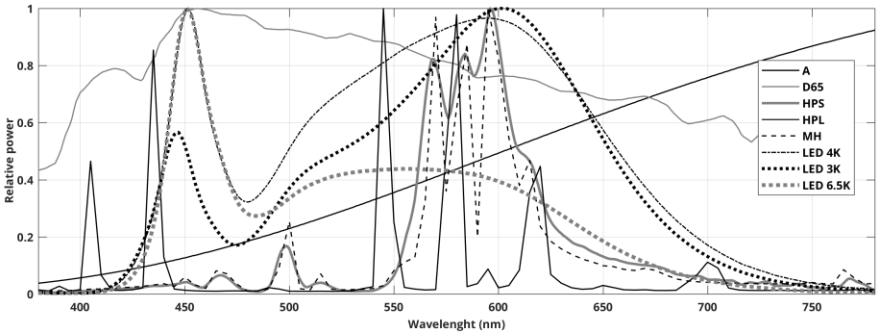
Upward light

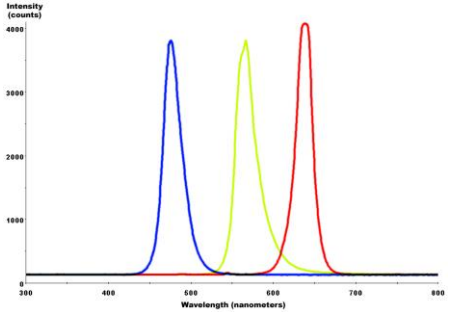
Colorful and dynamic & Illuminated facades

Intrusion in ecosystems

The “sources” of the problem

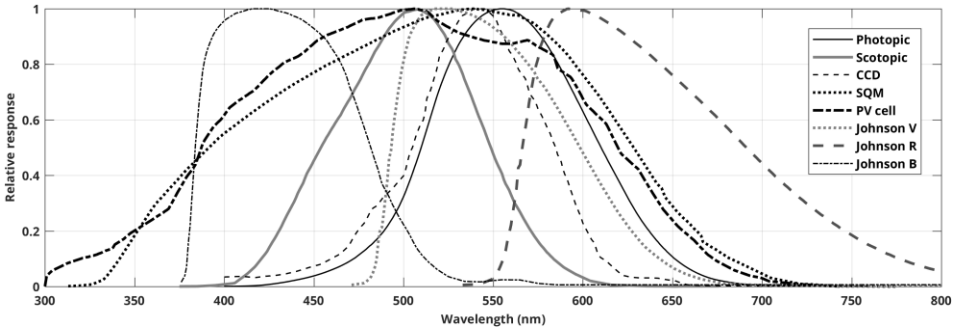
- Domination of LED in new installations
- Combination of conventional and colorful light sources
- Dynamic character especially on colorful scenes
- Luminous intensities and lighting distributions can vary significantly

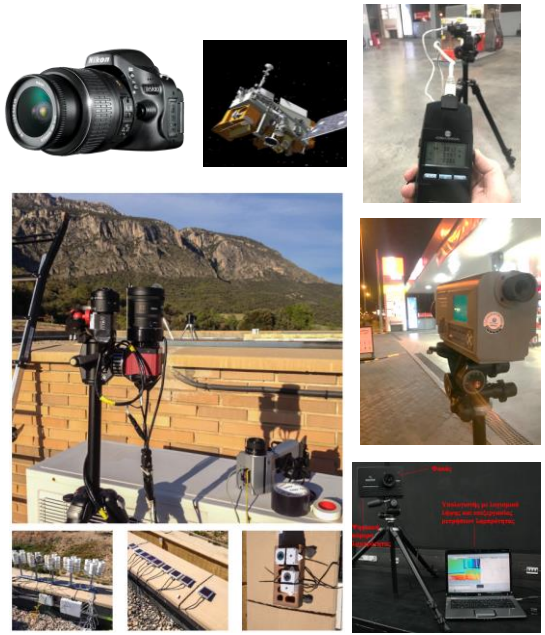




Our current fight tools

- Various spectral responsivities
- Each instrument was developed for different purpose
- Possible issue for the measurement of narrow band sources
- Limited number of filters are standardized or well defined
- Most of them do not offer traceability





Metrology of obtrusive light

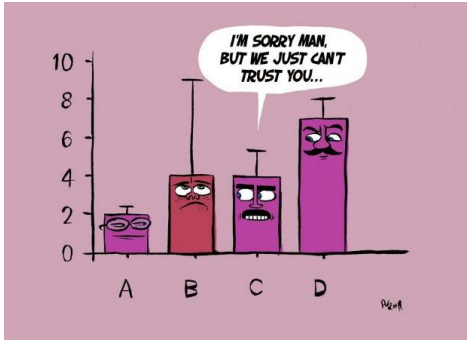
Measurement Quantity

- *Link to photopic units*
- *Link to radiometric units*
- *New quantities?*
- *New action spectra?*

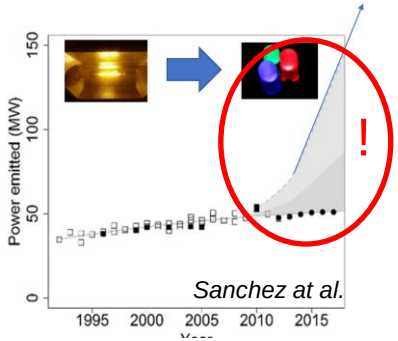
Measurement Devices

- *Many types*
- *Lack of standardization*
- *Lack of calibration*
- *Lack of methods*
- *Lack of traceability*

Measurement Uncertainty (& Conformity Assessment)



- *Metrics?*
- *Uncertainty evaluation?*
- *Lot of work ahead*



Need for a metrology base on obtrusive light

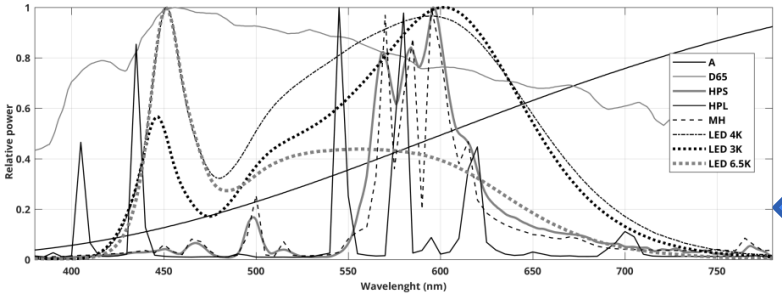
Action spectra
- Human based
- Species based
- Sky glow based
- … other

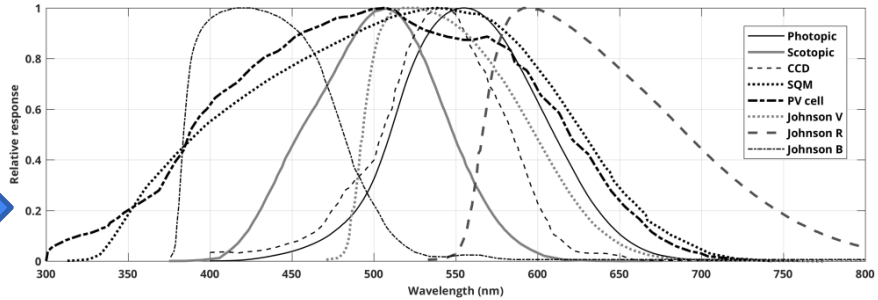
Quantities
- Photopic
- Radiometric
- … other

(linked to SI units)

Metrics
- For sky glow
- For reflected light
- Environmental impact
- … other

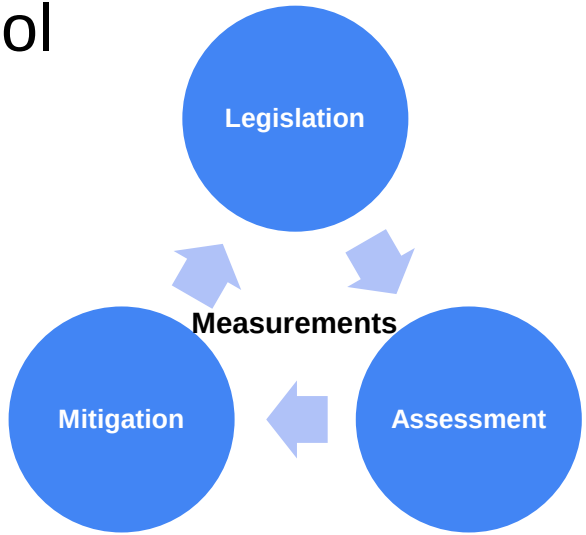
Instrumentation
- Proper for each quantity
- Ensure traceability
- Estimate uncertainty
- Establish interoperability

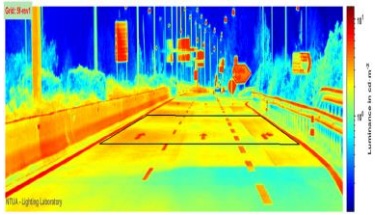


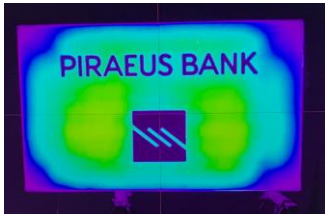


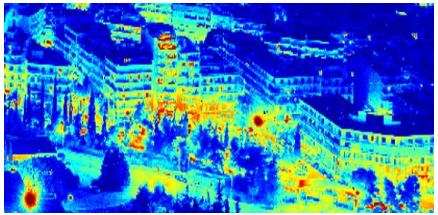
Metrology of obtrusive light as a policy tool

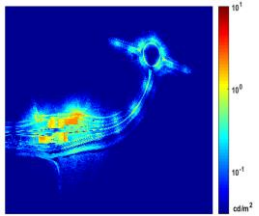
- Measurement and monitoring of all aspects
- Dedicated methods and instrumentation
- Inter-disciplinary adoption
- Dedicated assessment criteria
- Verification of lighting installations.
- Measurement schemes should be implemented in regulations.
- Mitigation and restoration when scientifically justified thresholds are exceeded.

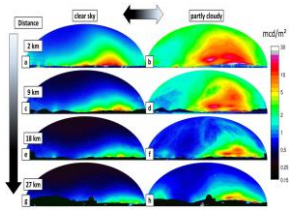












CIE TC2-95 “Measurement of Obtrusive light and sky glow”

Terms of Reference

To provide guidelines and examples for metrics, measurement methods and corresponding instrument specifications for the measurement of obtrusive light and sky glow including the estimation of measurement uncertainty contributions for the measurement, necessary to validate assessment criteria of its effects on the environment. The proposed guidelines and examples can be used as a common base with reliable and traceable techniques for various disciplines that are dealing with obtrusive light and sky glow measurements, light pollution assessment and research.

TC work ⇨ Internationally agreed Technical Report ⇨ Adoption by local laws

more at: https://cie.co.at/technicalcommittees/measurement-obtrusive-light-and-sky-glow

CIE – International Commission on Illumination

“Takeaways”

- Standardized measurements, methods, and criteria
  - support research
  - strengthen evidence
  - ensure communication
  - validate mitigation measures
  - support legislative actions
- Towards standardization
  - combination of research evidence
  - develop quantities, metrics and assessment criteria
  - develop measurement standards and guides
- Long-term target: Integration into national and international laws

Thank you for your attention!

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