IEA Technology Collaboration Programme
on Energy Efficient End-Use Equipment

Smart Lighting – New Features impacting the Energy Consumption

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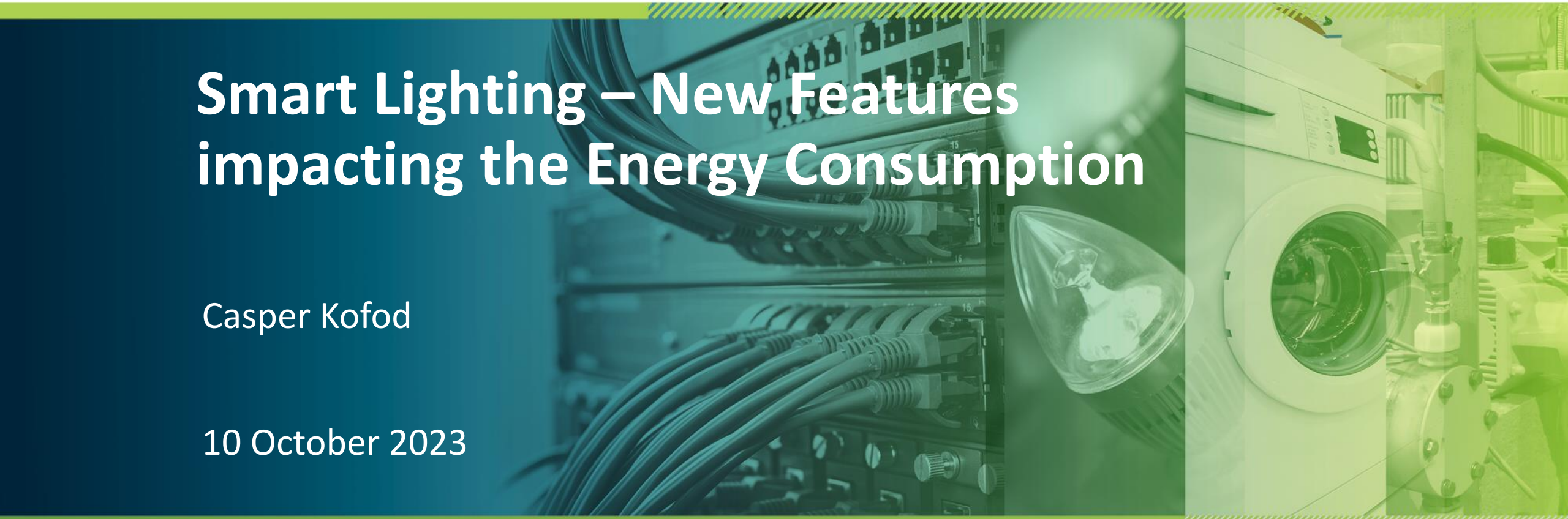
10 October 2023

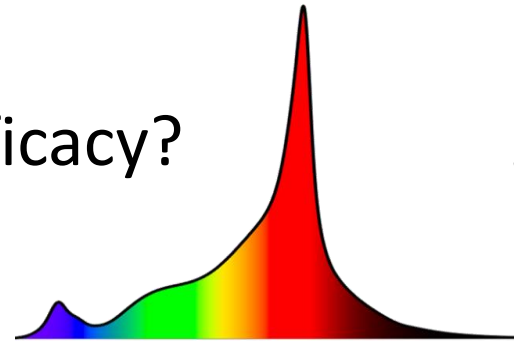


International IEA 4E SSL Annex Webinar

iea-4e.org

Agenda

1. Status for use of Smart Lighting
2. Market Barriers and Potential
3. IEA 4E SSL analyse Impact, Performance and Efficacy?
4. Smart Lighting Report 15 Nov 2022
5. Test method
6. Standby power measurements, analysis and saving potential
7. Efficacy when dimming or changing colour
8. Standards and Regulation
9. Recommendations



Smart Dynamic Lighting is Gaining Ground

Domestic Sector

- *Comfort: Change colour, Timers, Scenarios, Music, Camera, WiFi booster, …*
- *Energy Savings: Dimming, Sensors, Programming*
- *Network: Support other Services/IoT's (e.g. security and HVAC), logging of energy use*

Health Care Sector and Offices

- *Energy Savings: Dimming, Programming*
- *Health: Mimic the rhythm of daylight with control of the colour temperature during the day*
- *Navigation: In shopping centres and museums, use of the light sources as WiFi navigation nodes where you can activate visual and aural information*

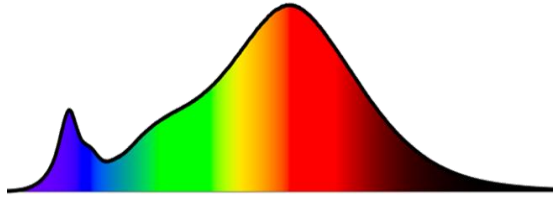
Market Barriers and activity to lower them

- High cost – most manufacturers decrease the prices
- Complexity – simplification, plug and play, higher user-friendly-ness
- Lack of open systems, interoperability, and consistent systems, ... Gateways from two wireless smart lighting protocols to wired controlled (DALI) lighting which will support use of connected lighting in the commercial sector
- Lack of standards and regulation – improvements on the way.

Market Potential

- In the domestic sector, implementation of **movement and/or daylight sensors** might increase the energy savings substantially.
- More use of **daylight sensors** in Circadian Lighting systems may also improve the mimicking of daylight variation for the benefit of the user's wellbeing, mood, and cognitive **performance.**
- **Offices** might become the next area of application for Circadian Lighting**.**
- In the tertiary sector, implementation of **gateways from wireless to wired control** (DALI) will bring **connected lighting** forward.

IEA 4E SSL analyse Impact, Performance and Efficacy?

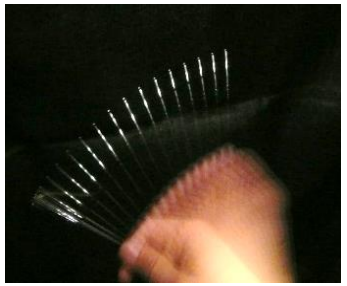


Colour Quality?

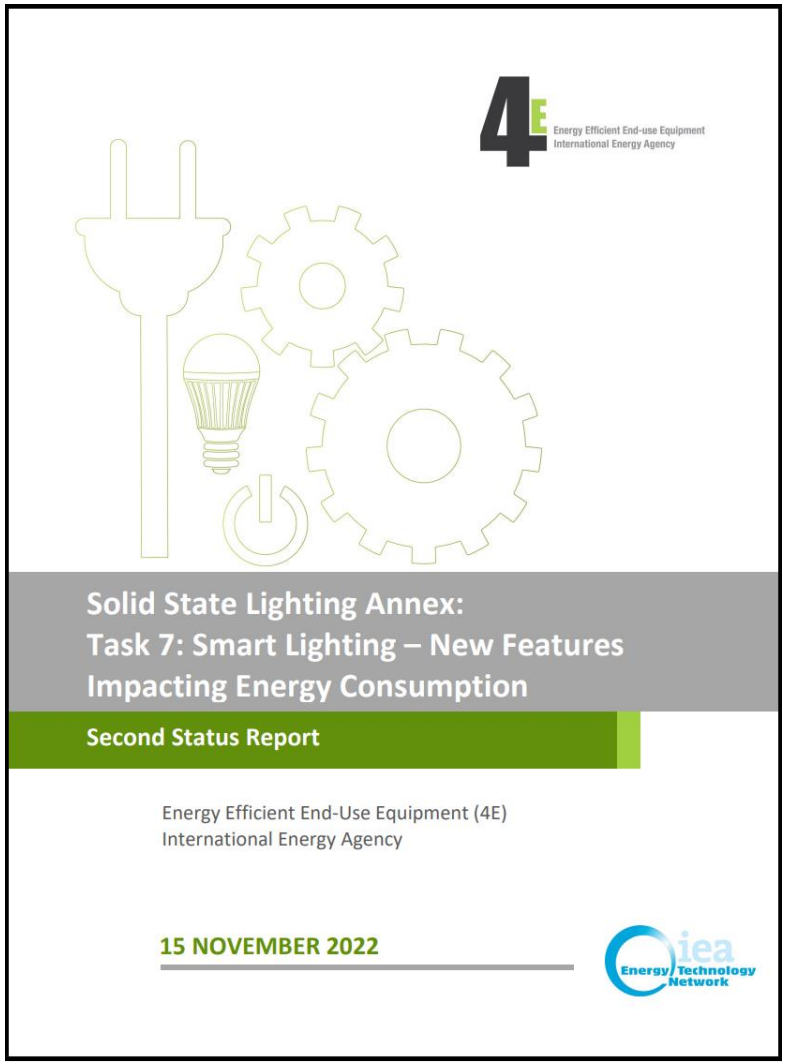
Standby Power?

Efficacy?

Flicker



Smart Lighting Report 15 Nov. 2022



- Key Terms, Protocols and Network Architectures
- Test Method
- Results from Testing
- Saving Potential
- Market Potential and Barriers
- Recommendations for Policy makers.

Test Method - IEC/CIE standards (1)

- The Report outlines an **interim test method** for laboratories to conduct **benchmark testing**, and potentially for future compliance or enforcement testing.
- This test method was developed with reference to the following international test standards:
- • CIE S 025/E:2015 Test Method for LED Lamps, LED Luminaires and LED Modules
- • IEC 63103 Ed. 1.0 en:2020 Lighting equipment - non-active mode power measurement
- Besides the method provides optional steps and practical notes for the person conducting the test.

Test Method – Information to record (2)

- Identity
- Purchase information
- Smart features
- Gateway
- Communication (user interface and protocol)
- Electrical supply, ON power, Standby power, Light output, colour quality (CCT, RGB, CRI, preset scenes)

Each item includes a number of details

Test Method – Testing in the lab (3)

- Samling (1-3 light sources per model for benchmark testing)
- Laboratory and Envirommental conditions (CIE S 025/E:2015)
- Configuration (factory default setting)
- Operation, Elec. test conditions and Stabilisation (CIE S 025/E:2015)
- Measurement period and equipment
- Standby power measurements (with and without network)
- Gateway
- Handling of dimming

Test Method – ON Measurements (4)

- ON measurements

Table 5. ON Measurements (combinations of CCTs and lighting output) to be included in testing

		CCT						
		Default	Min	2700K	4000K	5000K	6500K	Max
Light Output[1]	100 %	M	M	M	M	M	O	M
	75 %	M	O	O	O	O	O	O
	50 %	M	O	O	O	O	O	O
	25 %	M	O	O	O	O	O	O
	Min	Only measure the luminous flux and the lamp/luminaire power						

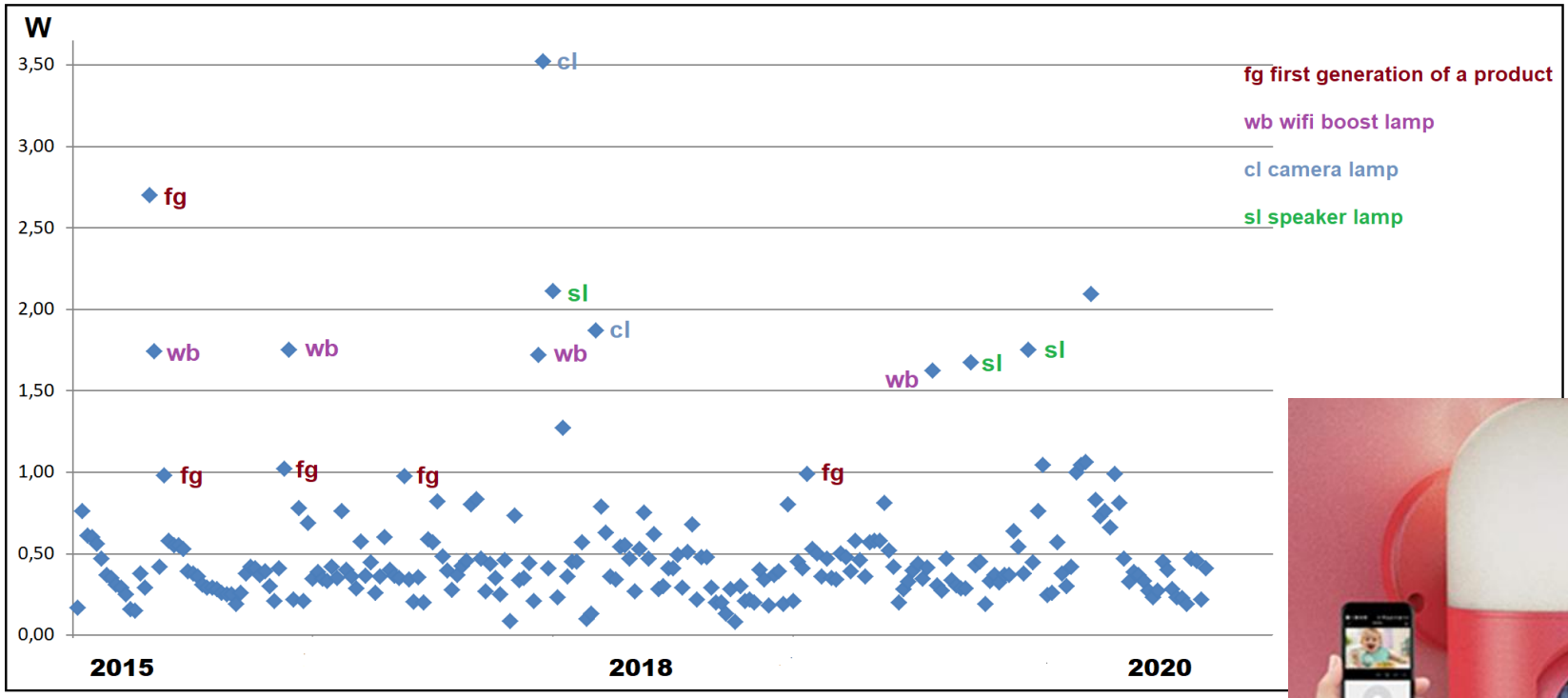
M= Mandatory O = Optional

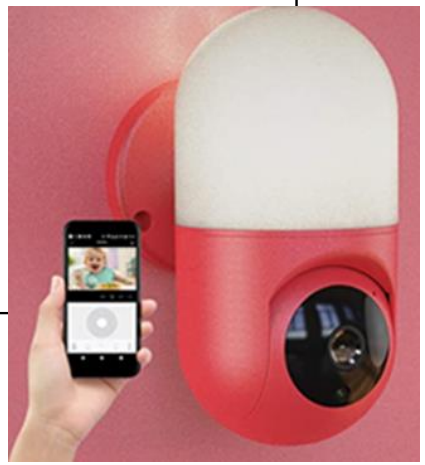
[1] Dimming can be conveyed as the relative reduction in the light output or the lamp/luminaire power. If this information is provided. then it is to be reported.

Extra optional testing could be:

- *Measurements for all nominal CCTs (see Table 3).*
- *Measurements for CCTs that are of interest to the requesting party.*
- *Measurements for other settings.*
- *Measurement of CCT (e.g. every minute) from cold start until lamp/luminaire has stabilised and eventually for restart of lamp/luminaire after cooling.*
- *Test repeatability of selection of CCT under various control scenarios including approaching selected CCT from higher and lower CCTs.*

Standby Power for 236 lighting products





- Lowest 0.08W and highest 3.5W
- Average 0.51W (median 0.39W)

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EU regulation: Max 0.5 W

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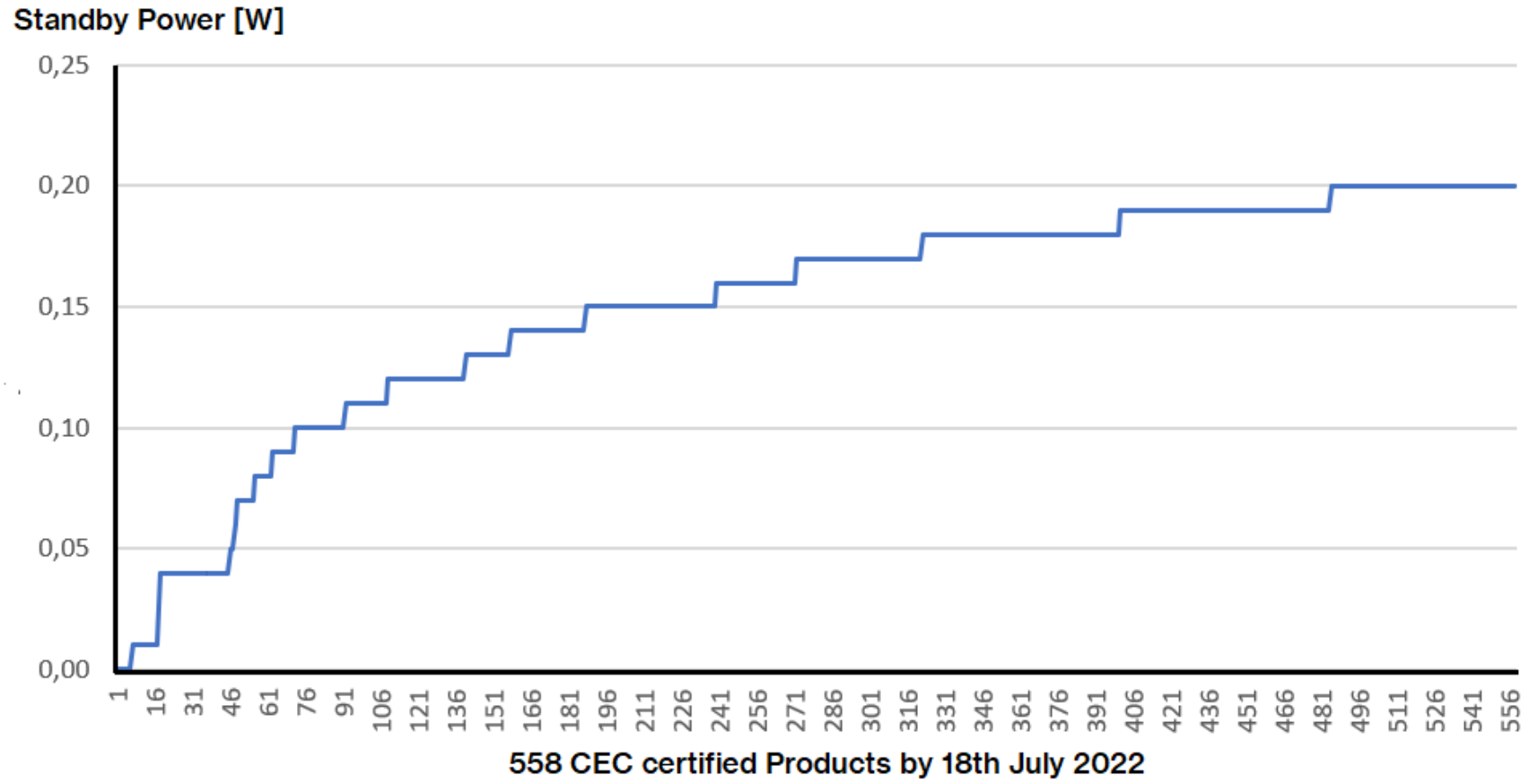
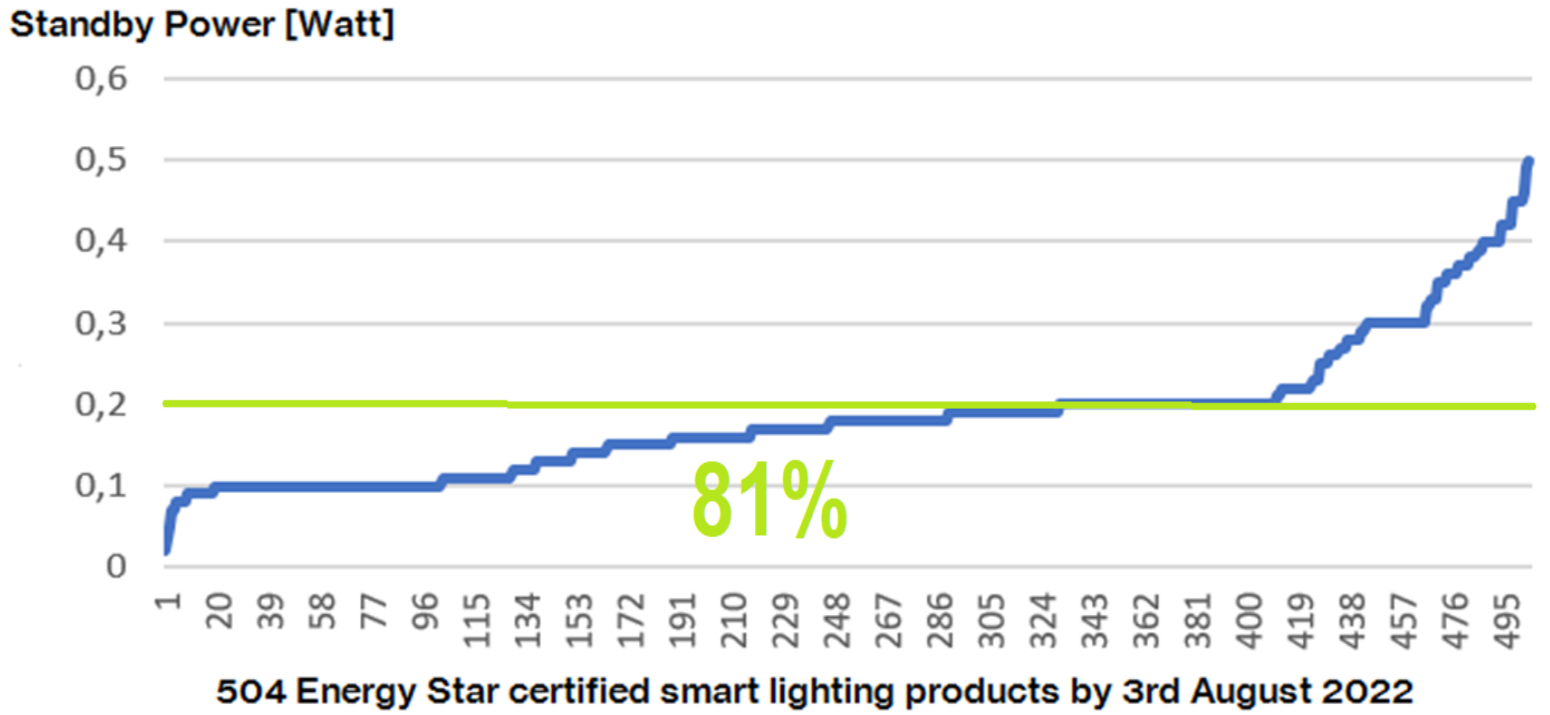
Standby Power Regulation in California

1/9 2019 California the standby power ≤ 0.2 W.



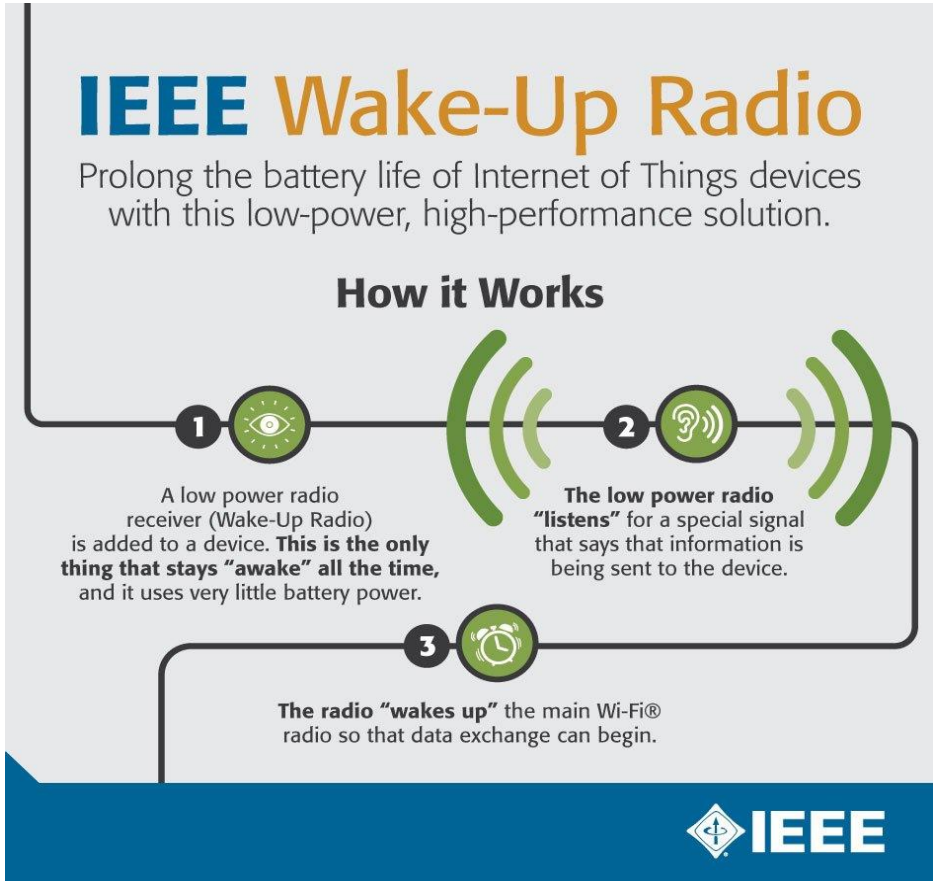
Standby Power for Energy Star certified products

Energy Star (USA and Canada) certified LED products with standby power ≤ 0.5 W ¤). The Energy Star product database show 81% of the products fulfill the CA requirement ≤ 0.2W.



¤) 1/9 2021 EU Ecodesign regulation also Standby power ≤ 0.5 W

Huge Standby Saving Potential



- Developed for connected devices on battery.
- Wake up 2 millisec. out of every 100 millisecond reduces the average power from 0.5W to around 0.01 W.

Standby Consumption Share of the total

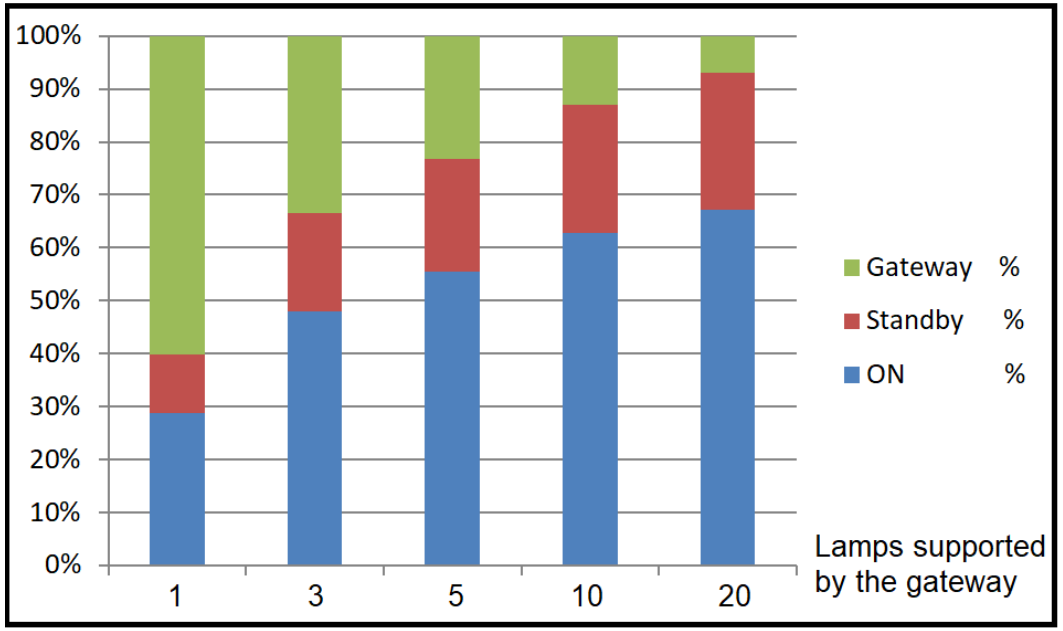
			Usage 1 hour/day				Usage 2 hours/day			
Lamp	ON (W)	Standby (W)	ON (kWh)	Standby (kWh)	Standby (%)	Total (kWh)	ON (kWh)	Standby (kWh)	Standby (%)	Total (kWh)
360 lm 3 W	3.0	0.50	1.10	4,20	**79%**	5,3	2,19	4,02	**65%**	6,2
		0.20		1,68	**61%**	2,8		1,61	**42%**	3,8
		0.10		0,84	**43%**	1,9		0,80	**27%**	3,0
		0.01		0,08	**7%**	1,2		0,08	**4%**	2,3
806 lm 6.7 W	6.7	0.50	2.45	4,20	**63%**	6,6	4,89	4,02	**45%**	8,9
		0.20		1,68	**41%**	4,1		1,61	**25%**	6,5
		0.10		0,84	**26%**	3,3		0,80	**14%**	5,7
		0.01		0,08	**3%**	2,5		0,08	**2%**	5,0

The standby power has to be lowered to around 0.01 W before the standby consumption is insignificant.

Gateway consumption per Lighting Source

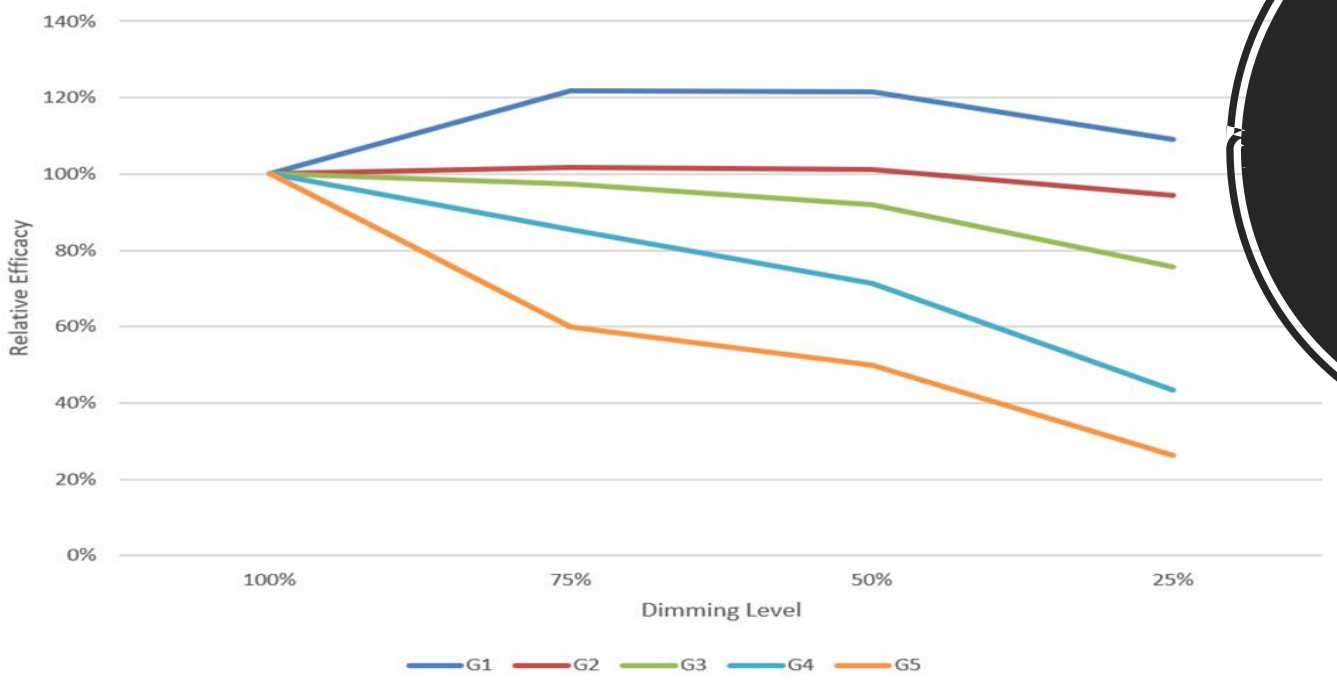
Standard
Smart Lamp
9W
806 lm
1.5 W Gateway
0.3 W Standby
700 h/year ON

Lamps/home	ON kWh/year	Standby kWh/year	Gateway kWh/year	TOTAL/lamp kWh/year
1	6,3	2,4	13,1	**21,9**
3	18,9	7,3	13,1	**13,1**
5	31,5	12,1	13,1	**11,3**
10	63,0	24,2	13,1	**10,0**
20	126,0	48,4	13,1	**9,4**



Luminous Efficacy when Dimming

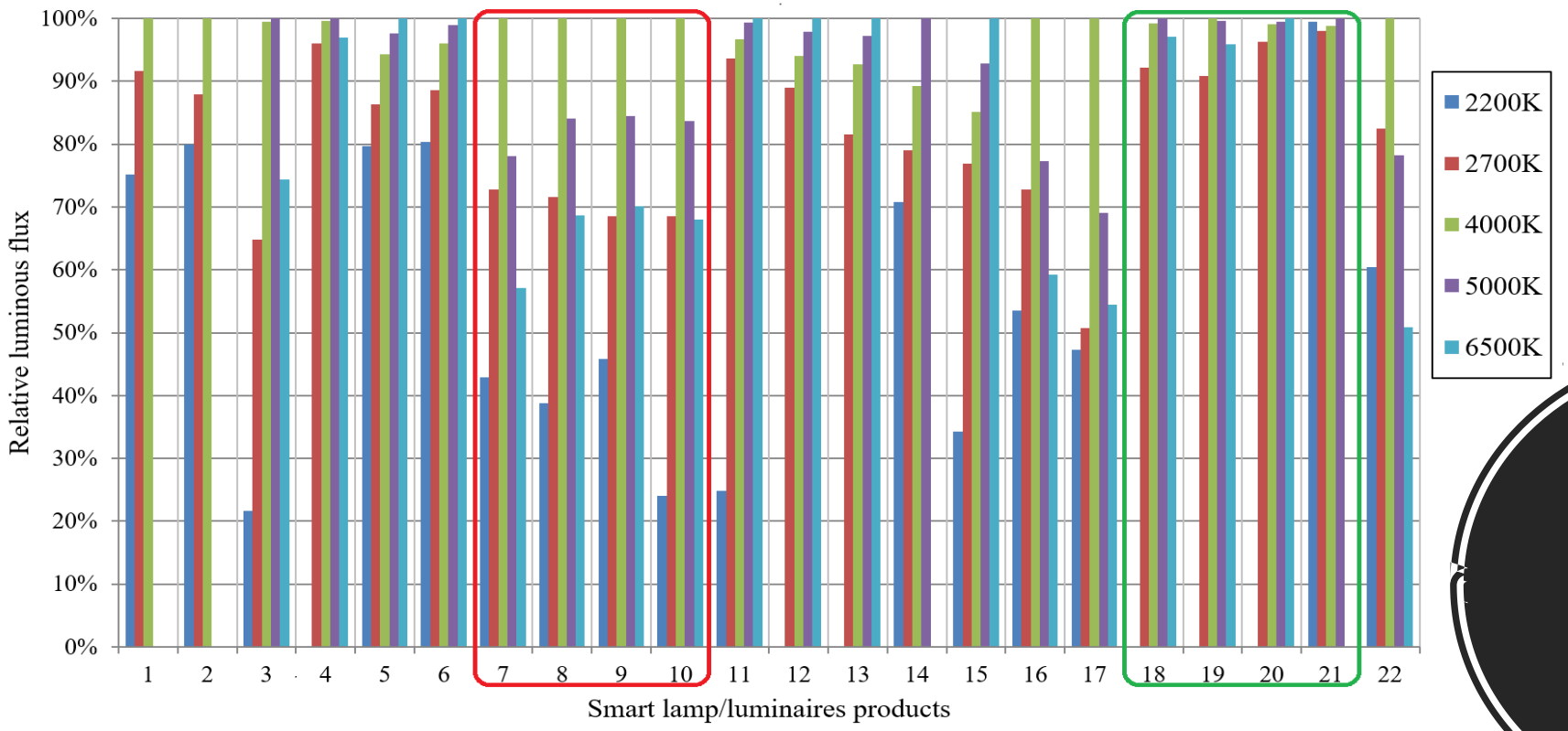
Efficacy relative to the efficacy without dimming



Efficacy when Dimming DOMESTIC light sources

G4 and G5 (24% of the products): Little or no energy savings by dimming.

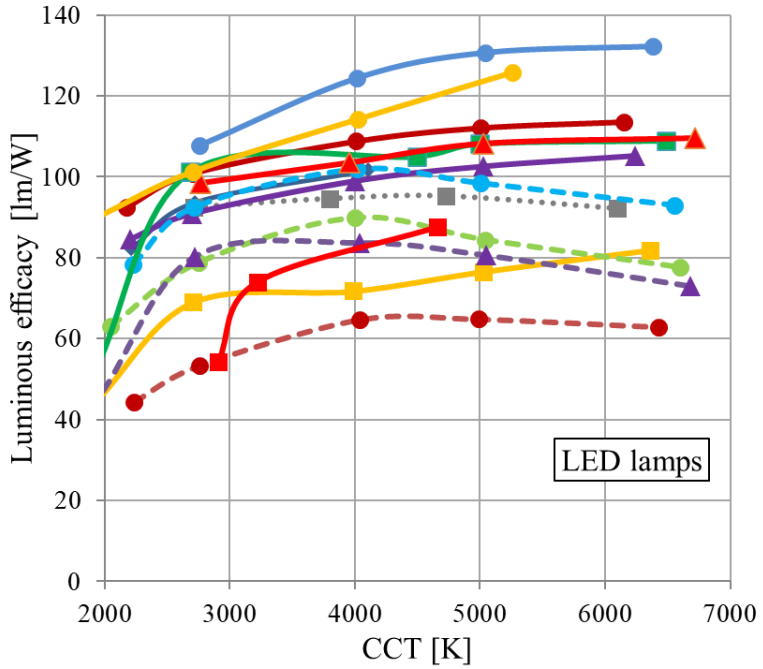
Luminous flux for 5 white Colours



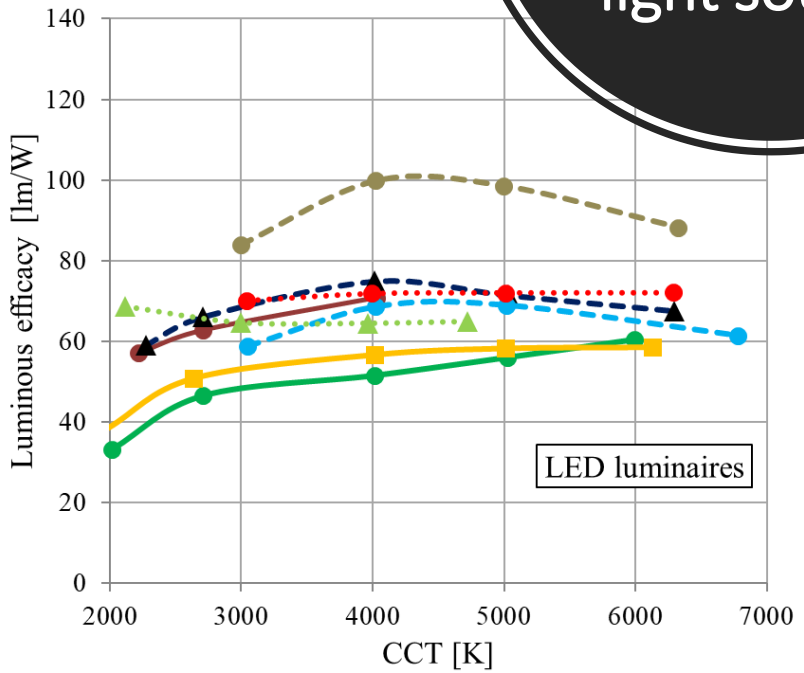
Luminous Flux for DOMESTIC light sources

Product 18-21: Lumen output closed to the claimed for all CCT's,
Product 7-10: Lumen output much lower than claimed for some CCT's.

Luminous Efficacy for 5 white Colours



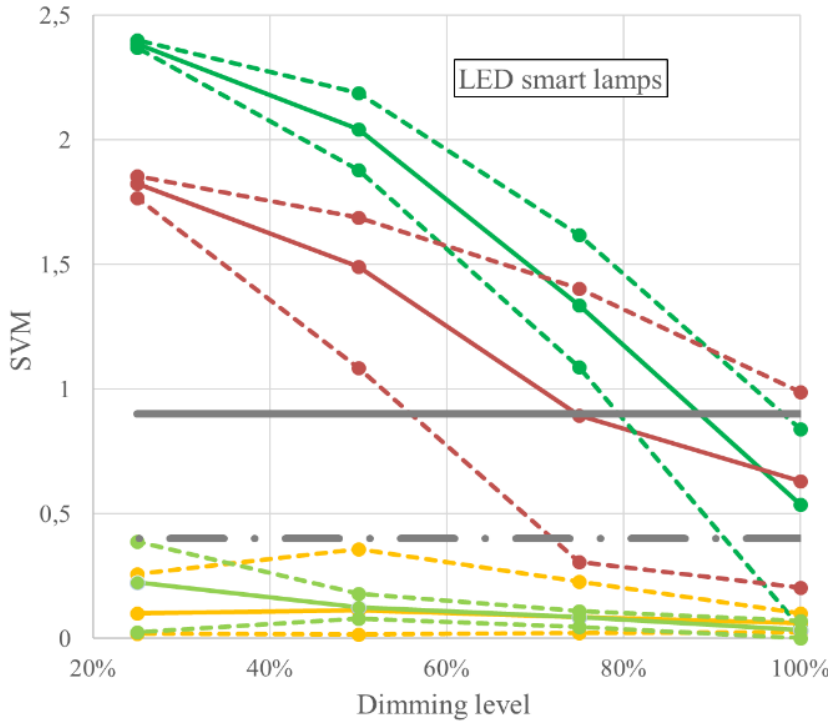
Efficacy when changing CCT DOMESTIC light sources



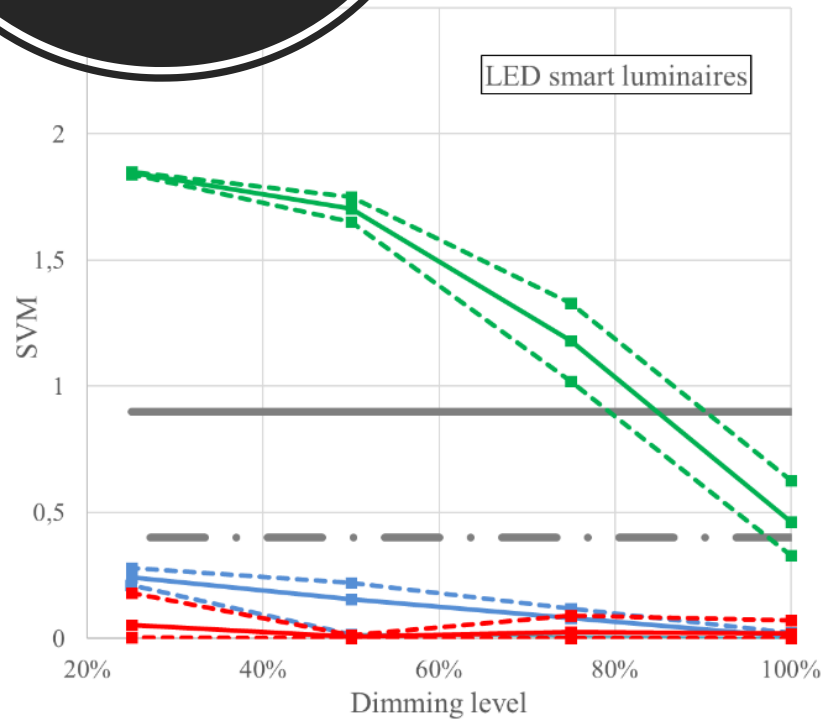
Efficacy down to 20-50% of rated efficacy

Stroboscopic Visibility Measure when Dimming

*OBS: Results found by **analysis in 2023** (thus not included in IEA SSL report from Nov. 2022).*



Flicker when Dimming DOMESTIC light sources



Solid lines: Average for five CCTs

Dashed lines: Max + Min for five CCTs

SVM problems for 3 of 7 products

Misleading Lighting Design?

Actually, with the level of product information, Lighting Designers might assume:

- Energy consumption is linear with dimming light output
- Luminous flux and consumption is constant when changing CCT
- The flicker measures might be constant when dimming

For some smart lighting products, the Customers might experience "Not good Lighting"

Better Characterisation and Data sharing

- How shall the dynamic smart light sources be **characterised**? **Which** lighting **parameters** and how many **settings** shall the characterisation include?
- **How to share the increased amount of data** with all stakeholders to enable efficient and accurate lighting design, energy calculation and light system simulations?

Standards and Regulation - Characterisation

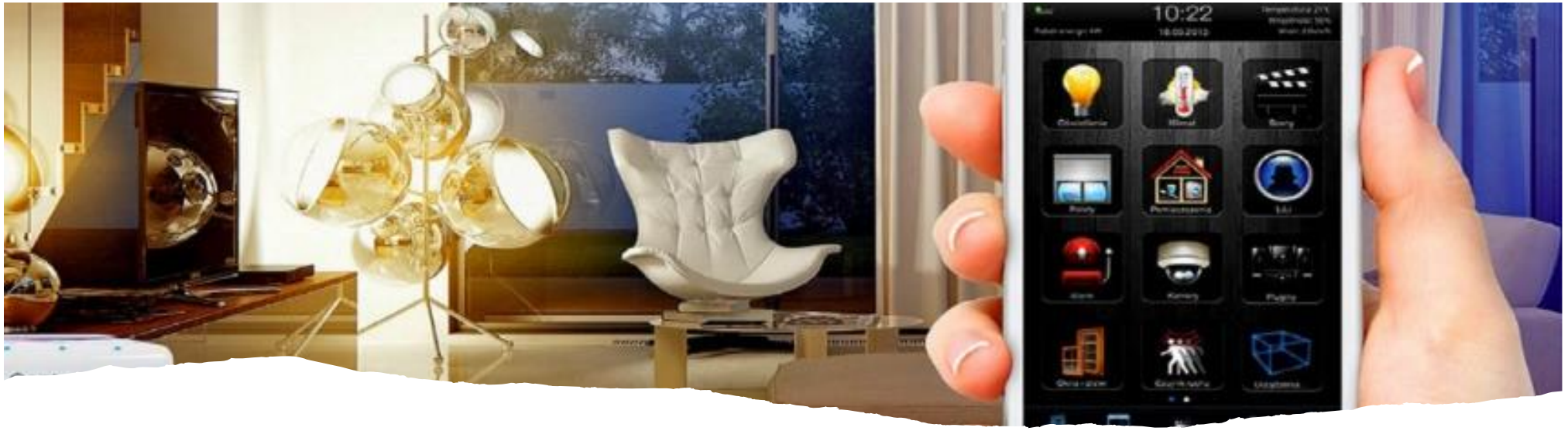
- **Actually**, manufactures only has to provide measured performance for **one setting** at **full load** (often not specifying the CCT for this “factory setting”)
- Data for design and simulation is typically provided in IES and/or EULUMDAT **files** formats only including **one setting**
- American standards ANSI/IES TM-33-18 provides a format that allows adding data for **more settings** and ANSI/IES TM-38-21 specify measurement **for CCT** tunable light sources. But these standards are **not widely adopted**.
- CIE TC 2-97 is **currently revising CIE S 025** which seems to come to include **better characterisation** of smart lighting

Recommendations

- Standby power **≤ 0.2 W** by 2024 everywhere
- Future goal: Standby power **≤ 0.01 W**
- Require **info about** the size of the **gateway power** and **the consumption** should be **lowered by** use of the **IEEE Wake-Up radio concept**
- **Non-lighting features**: Require it is possible to switch them **ON/OFF**. Wake-up radio standby technology might be used.
- Many products don't hold the claimed performance in all stages - need for smart light **characterisation** e.g., for **four lumen output levels** (100%, 75%, 50% and 25%) times **five CCT values** (min (2200K), 2700K, 4000K, 5000K and max (6500K)). This will ensure lighting **design** with **accurate energy** calculations and high **lighting quality.**
- More focus on **energy saving by** sales of more products with integrated **daylight or movement sensors**

Thank you for your attention

Questions?



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