

Groupe – Technologie

Une force d'innovation

Exterior lighting with low blue content

André Laperrière, Institut de recherche d'Hydro-Québec

Patrick Martineau, Hydro-Québec

Chrisnel Blot, Spectralux

2015 Biannual Joint Meeting of CIE/USA
and CNC/CIE

University of Toronto

October 19th 2015



2015 International year of light



Festival Montréal en lumière



RENDEZ-VOUS POUR LA 17^e ÉDITION
DU 18 AU 27 FÉVRIER 2016

Source : <http://www.montrealenlumiere.com/multimedia-fr.aspx>

Light and blue content

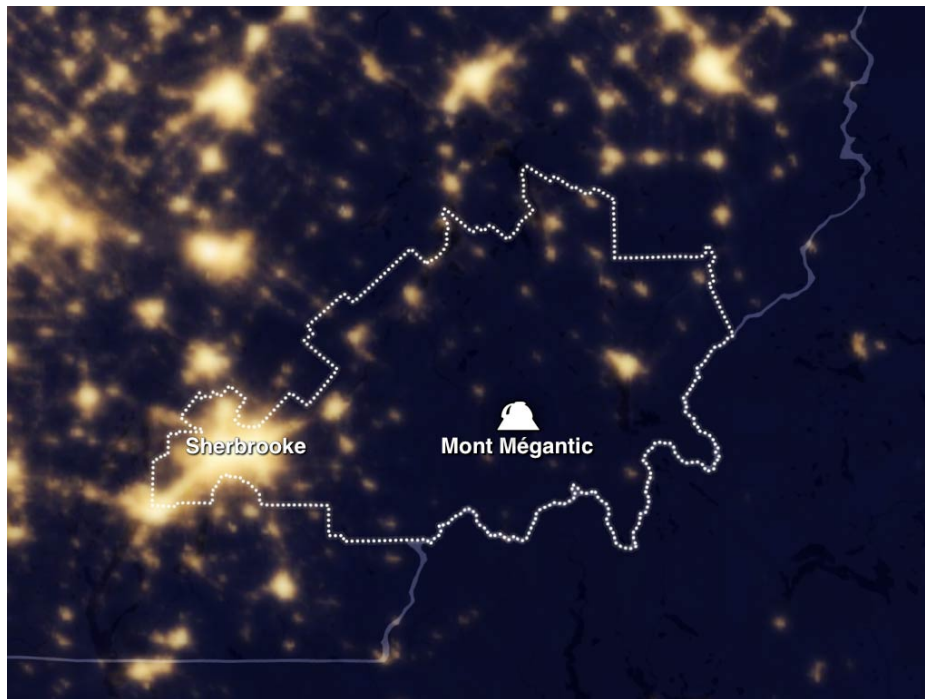
Réserve internationale de ciel étoilé du Mont-Mégantic (RICEMM)



Concern of the blue content for light scattering and LED technology

RICEMM

« And on September 21, 2007, it was with great pride that the Mont-Mégantic region was officially designated by IDA as an International Dark Sky Reserve, the first one ever to be certified in the world! »



<http://ricemm.org/reserve-de-ciel-etoile/>

Groupe – Technologie

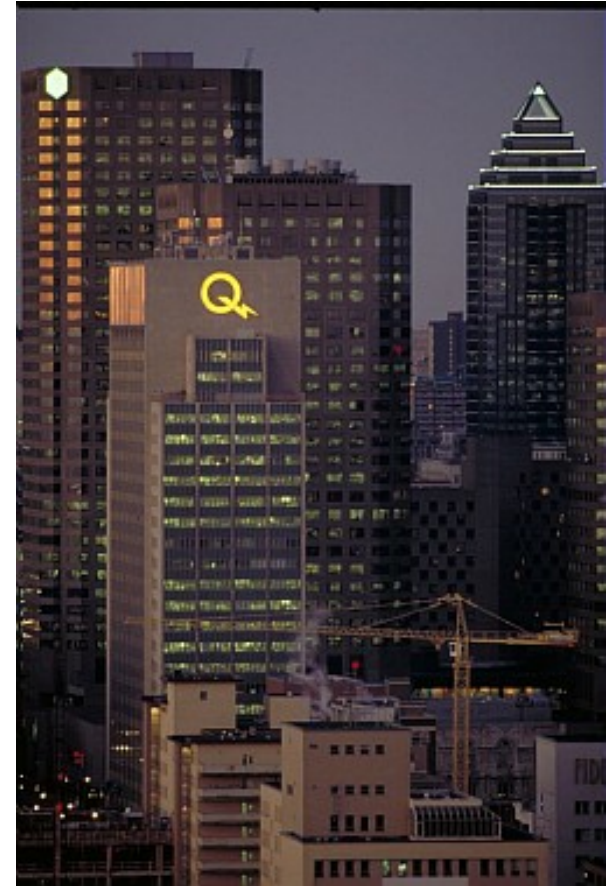
The concern...

Energy efficiency with LED technology

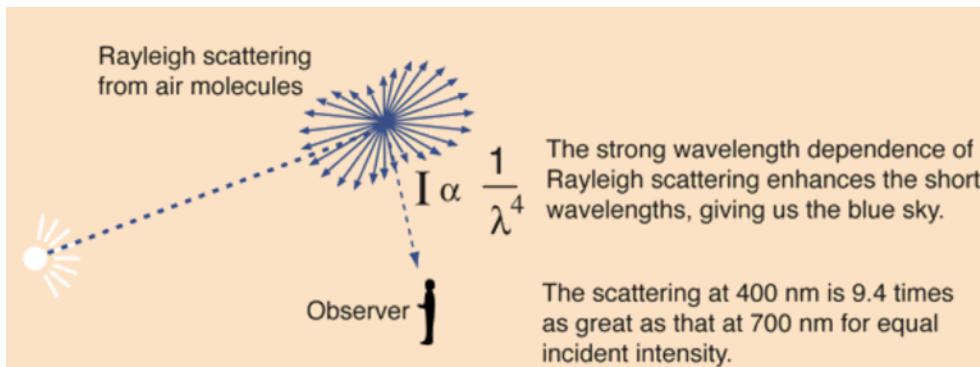
THE CONCERN : Municipalities closed to the ASTROLab moving from High Pressure Sodium (HPS) to LED technology



See the light at the end of the tunnel...



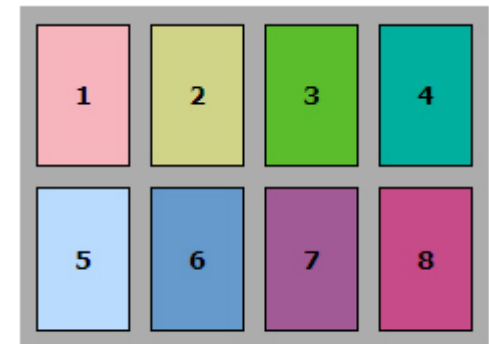
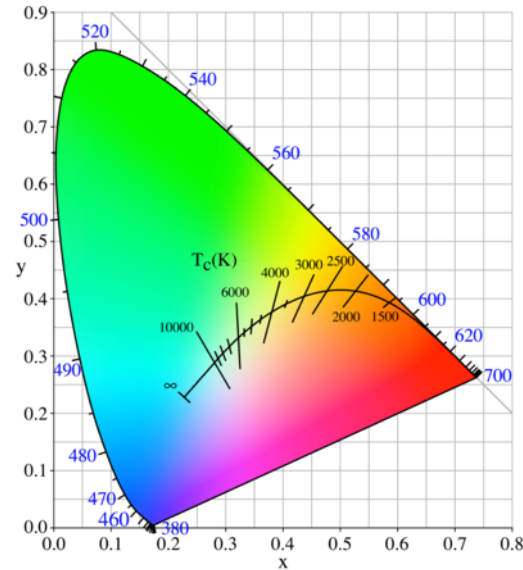
Project of Eastmain-1-A -Sarcelle-Rupert (768 MW.)



<http://hyperphysics.phy-astr.gsu.edu/hbase/atmos/blusky.html>

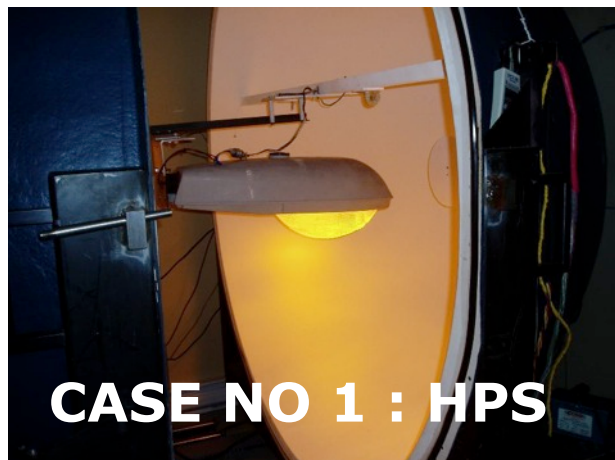
CRI (Color Rendering Index) and Correlated Color Temperature (CCT)

Temperature	Source
1,700 K	Match flame, low pressure sodium lamps (LPS/SOX)
1,850 K	Candle flame, sunset/sunrise
2,400 K	Standard Incandescent lamps
2,550 K	Soft White Incandescent lamps
2,700 K	"Soft White" compact fluorescent and LED lamps
3,000 K	Warm White compact fluorescent and LED lamps
3,200 K	Studio lamps, photofloods, etc.
3,350 K	Studio "CP" light
4,100–4,150 K	Moonlight ^[2]
5,000 K	Horizon daylight
5,000 K	Tubular fluorescent lamps or cool white/daylight compact fluorescent lamps (CFL)
5,500–6,000 K	Vertical daylight, electronic flash
6,200 K	Xenon short-arc lamp ^[3]
6,500 K	Daylight, overcast
6,500–10,500 K	LCD or CRT screen
15,000–27,000 K	Clear blue poleward sky
These temperatures are merely characteristic; considerable variation may be present.	

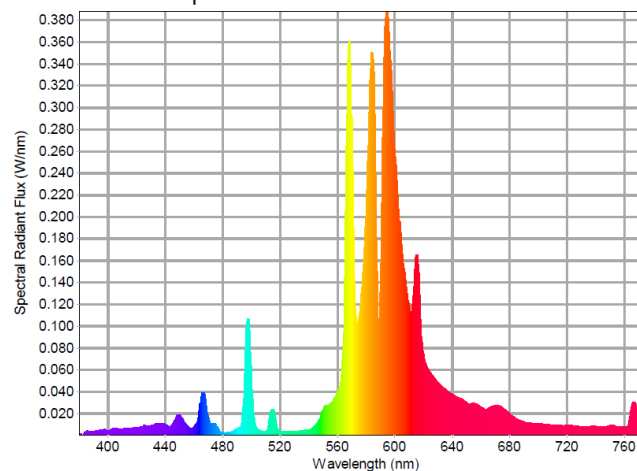


https://en.wikipedia.org/wiki/Color_temperature#Correlated_color_temperature

Physical Principle Light Scattering



Spectral Power Distribution

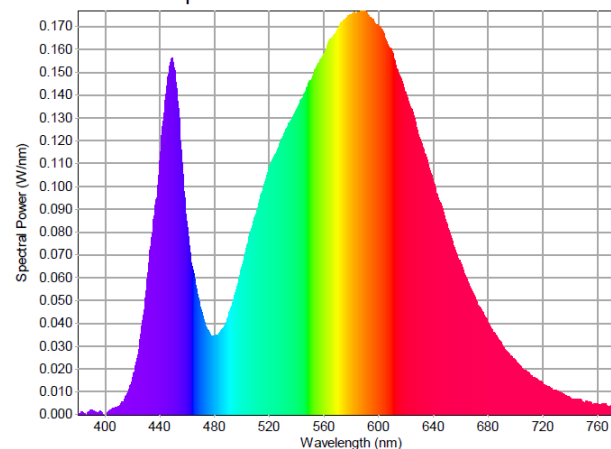


Peak Wavelength 594 nm
 Luminous Flux 6645 lm
 Input Power 116.84 W
 Lumens/Watt 56.9

x 0.5269
 y 0.4169
 CCT 2020 °K
 CRI 15



Spectral Power Distribution

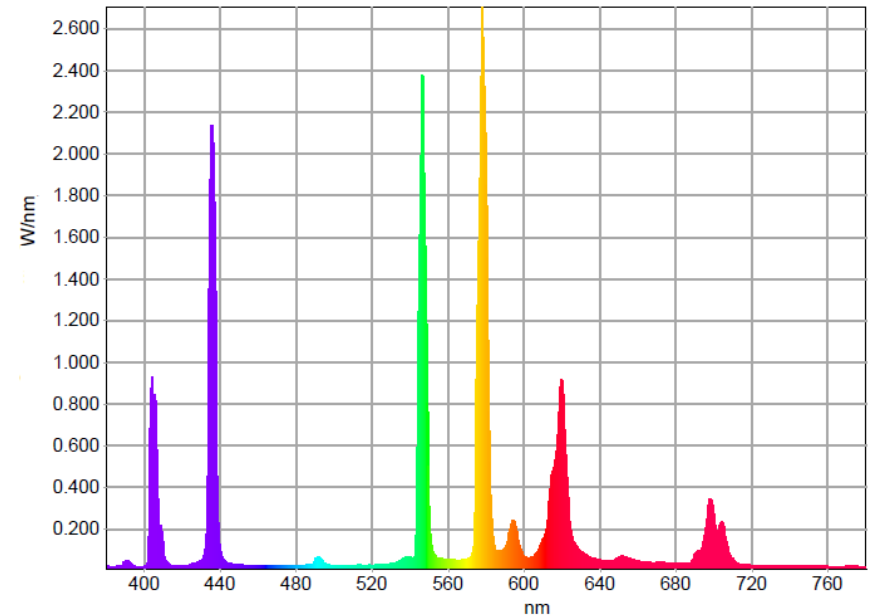


Peak Wavelength 590 nm
 Luminous Flux 9980 lm
 Input Power 103.84 W
 Lumens/Watt 96.1

x 0.3883
 y 0.3877
 CCT 3875 K
 CRI 76

Physical Principle Light Scattering

x	0.3941	Peak Wavelength	578 nm
y	0.3799	Luminous Flux	20865 lm
CCT	3671 K	Input Power	423.76 W
CRI	43	Lumens/Watt	49.2



400 Watts Mercury Vapor
in the sphere

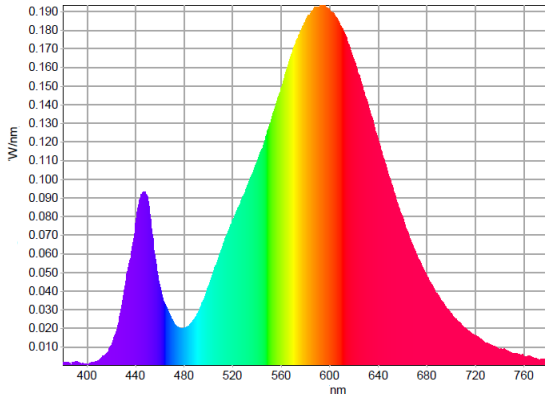
Mercury Vapor Lamps and the old days....

TEST NUMBER	Lamp	Designation	Power (Watts)	Lumens	Lumens / Watt
L1407223-C1	Coated 400 Hg BT37	H33	423,76	20 865	49,2
L1407224-C1	Coated 250 Hg BT28	H37	270.64	11450	42.3
L1407225-C1	Coated 175 Hg BT28	H39	195.00	8019	41.1

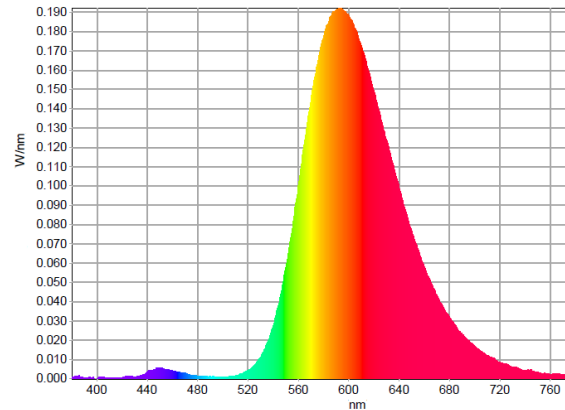
TEST NUMBER	Lamp	Designation	CCT (K)	CRI
L1407223-C1	Coated 400 Hg BT37	H33	3 671	43
L1407224-C1	Coated 250 Hg BT28	H37	4 043	41
L1407225-C1	Coated 175 Hg BT28	H39	4 061	42

Mercury Vapor : CRI \approx 42
 CCT (K) \approx 4 000 K

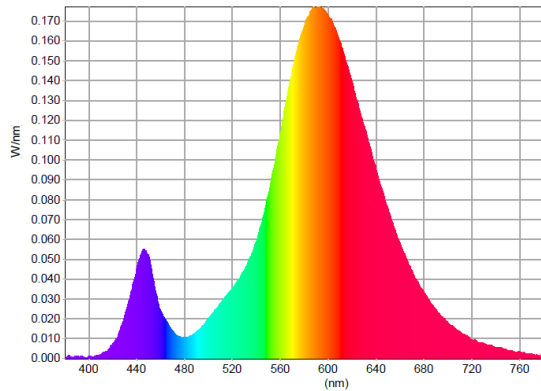
LED Spectral Power Distribution, blue content and CCT



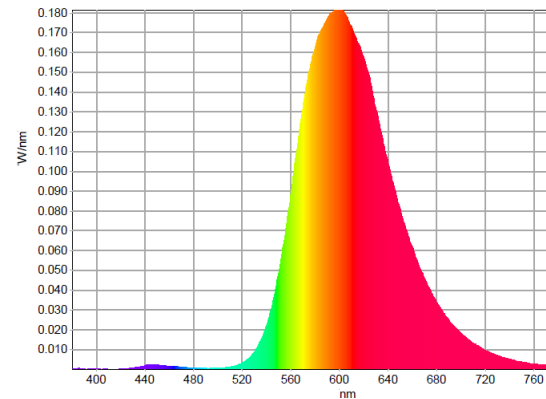
Spectral Power Distribution
LED - L1312123-C1 (2 997 K)



Spectral Power Distribution
LED - L1311292-C1 (1 912 K)

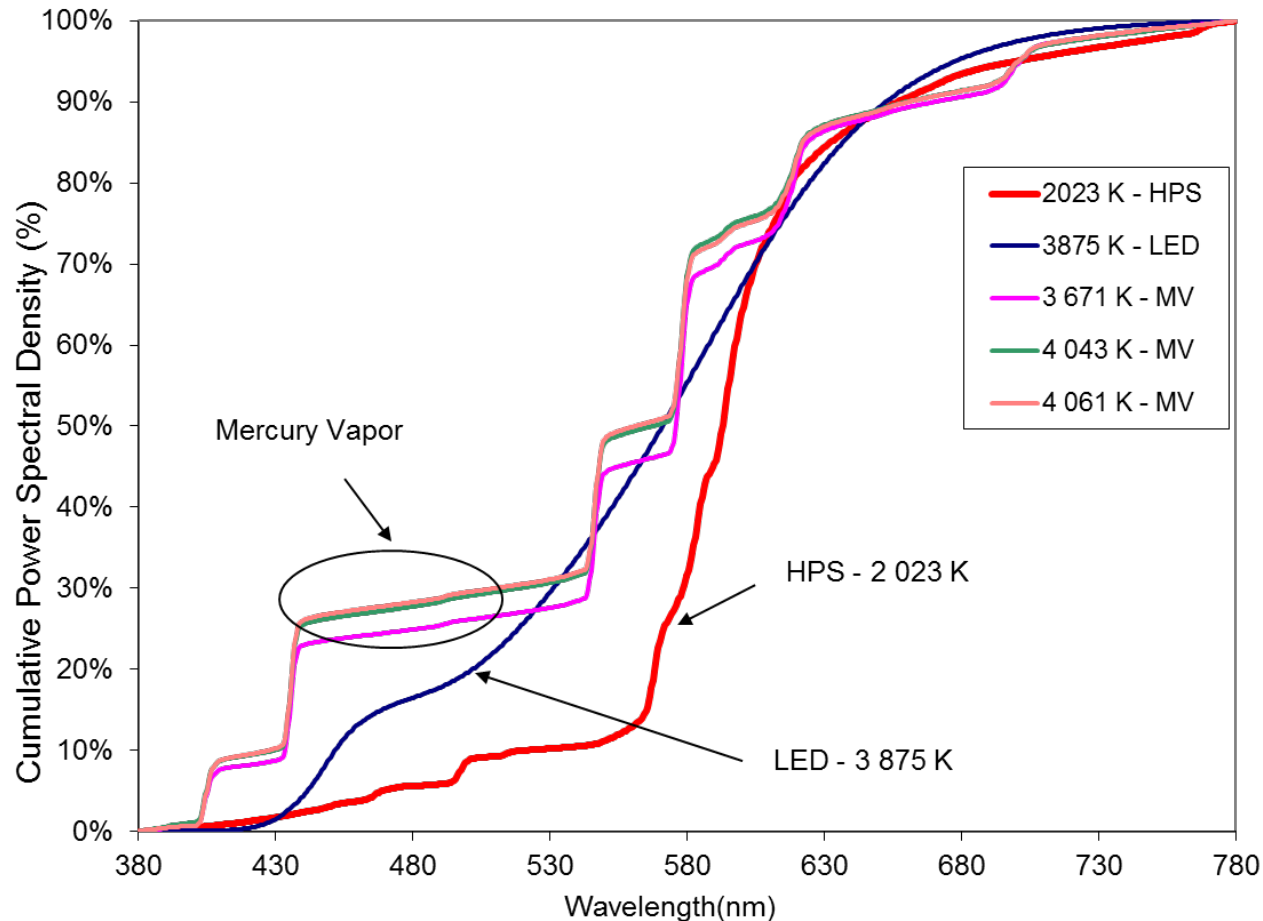


Spectral Power Distribution
LED - L131112282 - C1 (2 468 K)

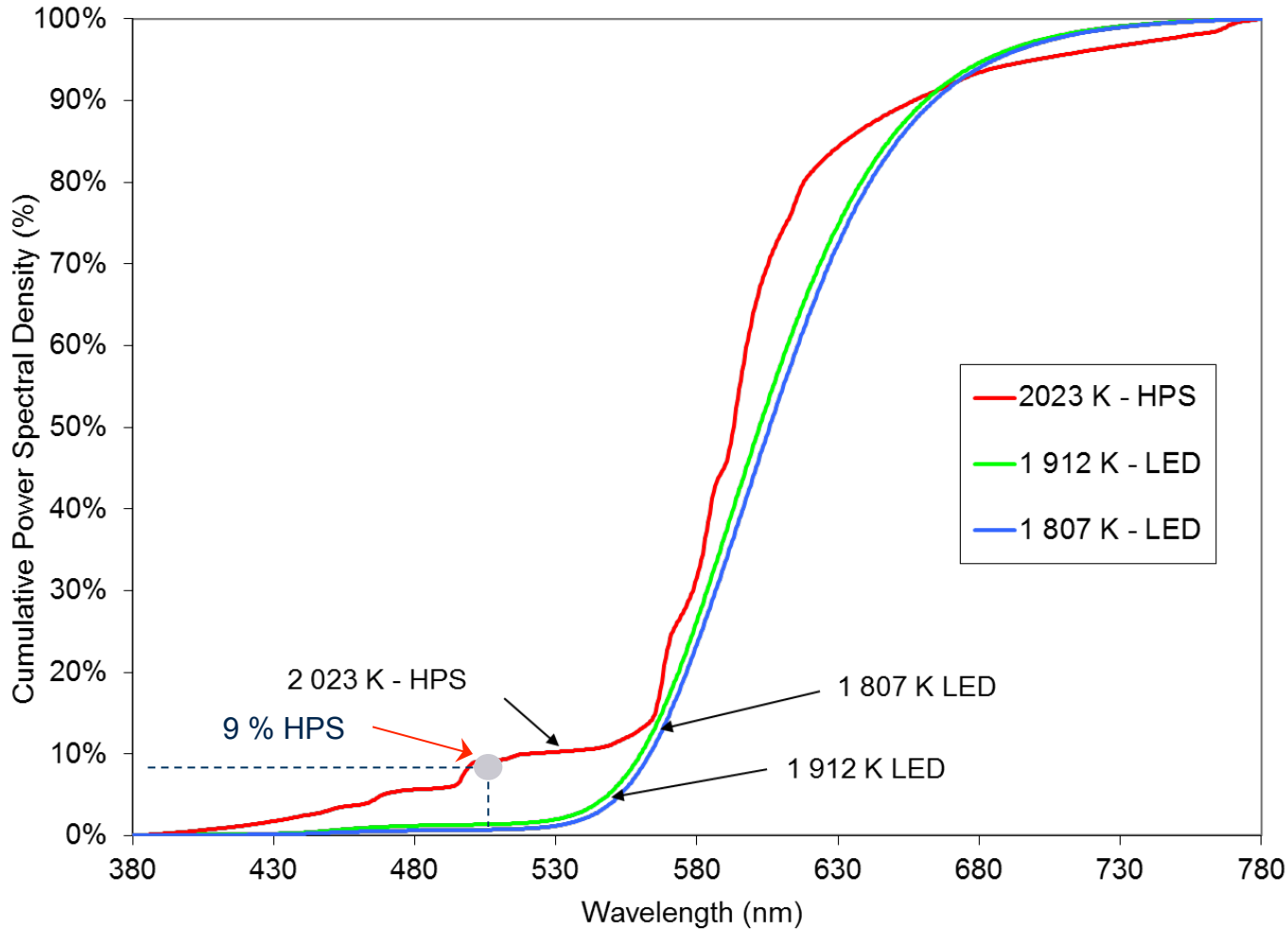


Spectral Power Distribution
LED - L1403058 - C1 (1 807 K)

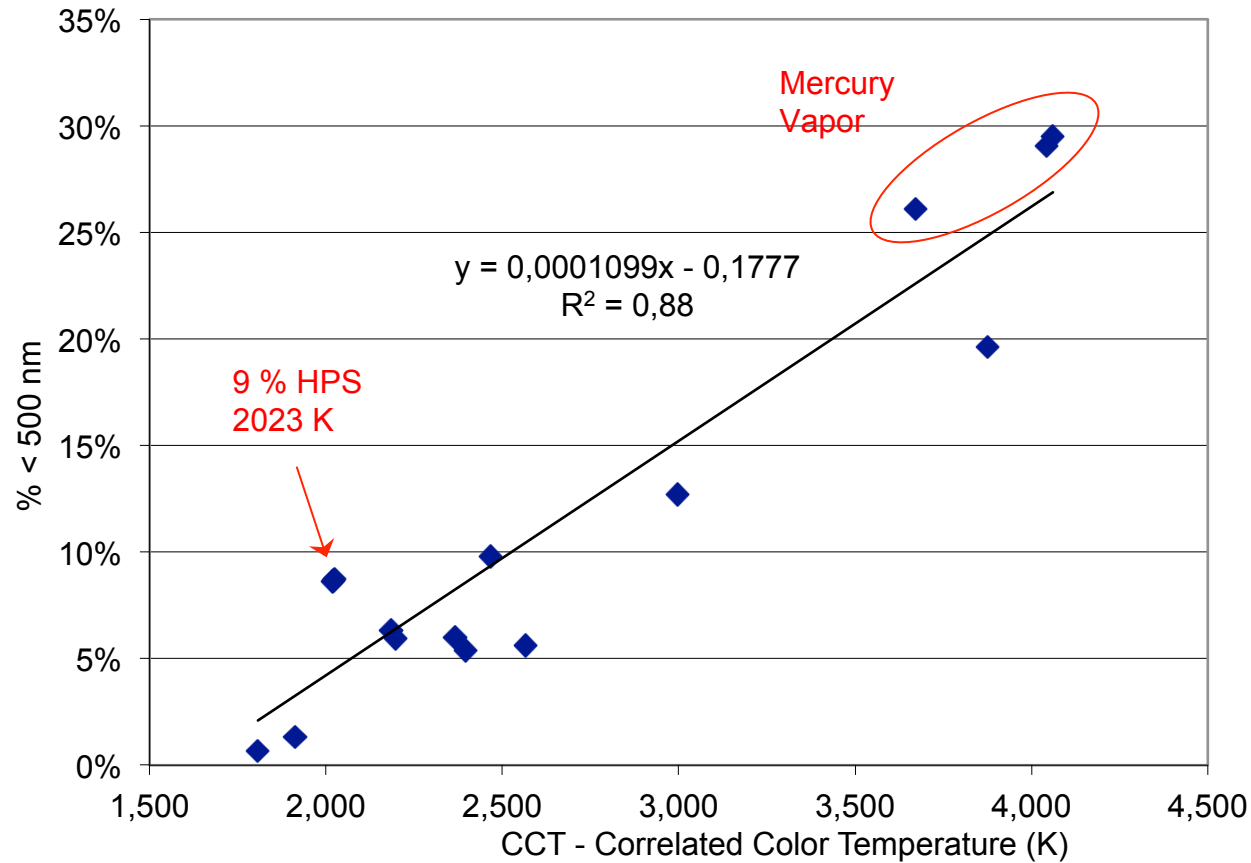
Cumulative Spectral Power Distribution (%) – Mercury Vapor



Cumulative Spectral Power Distribution (%)



% < 500 nm versus CCT (K)



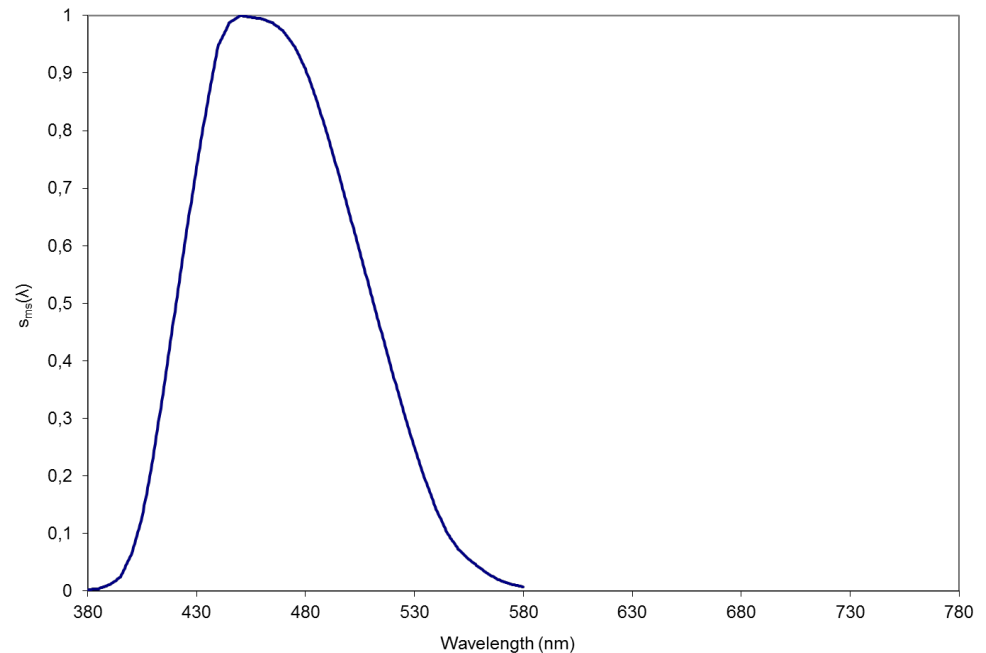
Blue content and melatonin suppression

« It is well known that the melatonin secretion is deeply involved with sleep and the daily amount of light exposure affects melatonin secretion. It is recommended to be exposed to much daylight in the morning and to avoid excessive light exposure in the night time, especially to the light with short-wavelength, for smooth melatonin secretion. »

ISHII, C., MOCHIZUKI, E., COMBINED EFFECTS ON SLEEPING QUALITY OF LIGHTING ENVIRONMENT IN THE DAYTIME AND THAT IN THE NIGHT TIME, Chiba Institute of Technology, Narashino-city, Chiba, JAPAN, CIE conference April 15/16, France

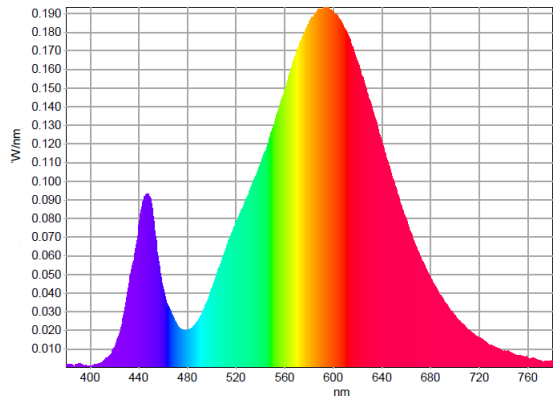
Dr. Brainard and Action spectrum

BRAINARD G., et al., 2001. Action spectrum for melatonin regulation in humans: evidence for a novel circadian photoreceptor. *Journal of Neuroscience* 21:6405-6412.



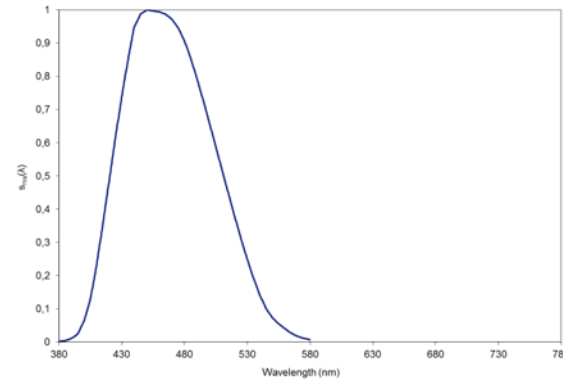
DIN V 5031-100: Strahlungsphysik im optischen Bereich und Lichttechnik – Teil 100 :Über das Auge vermittelt, nichtvisuelle Wirkung des Lichts auf den Menschen – Größen, Formelzeichen und Wirkungsspektren - 2009

a biol calculation makes sense....



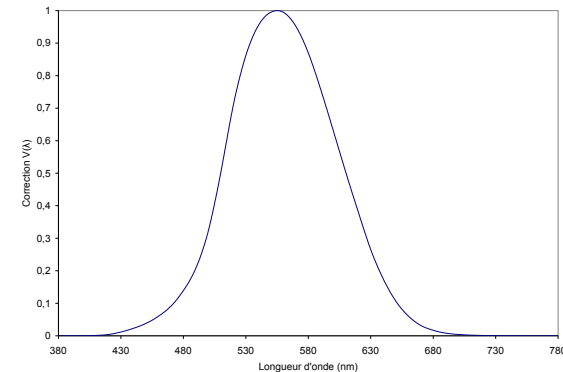
X

S biol (λ)



= A

X

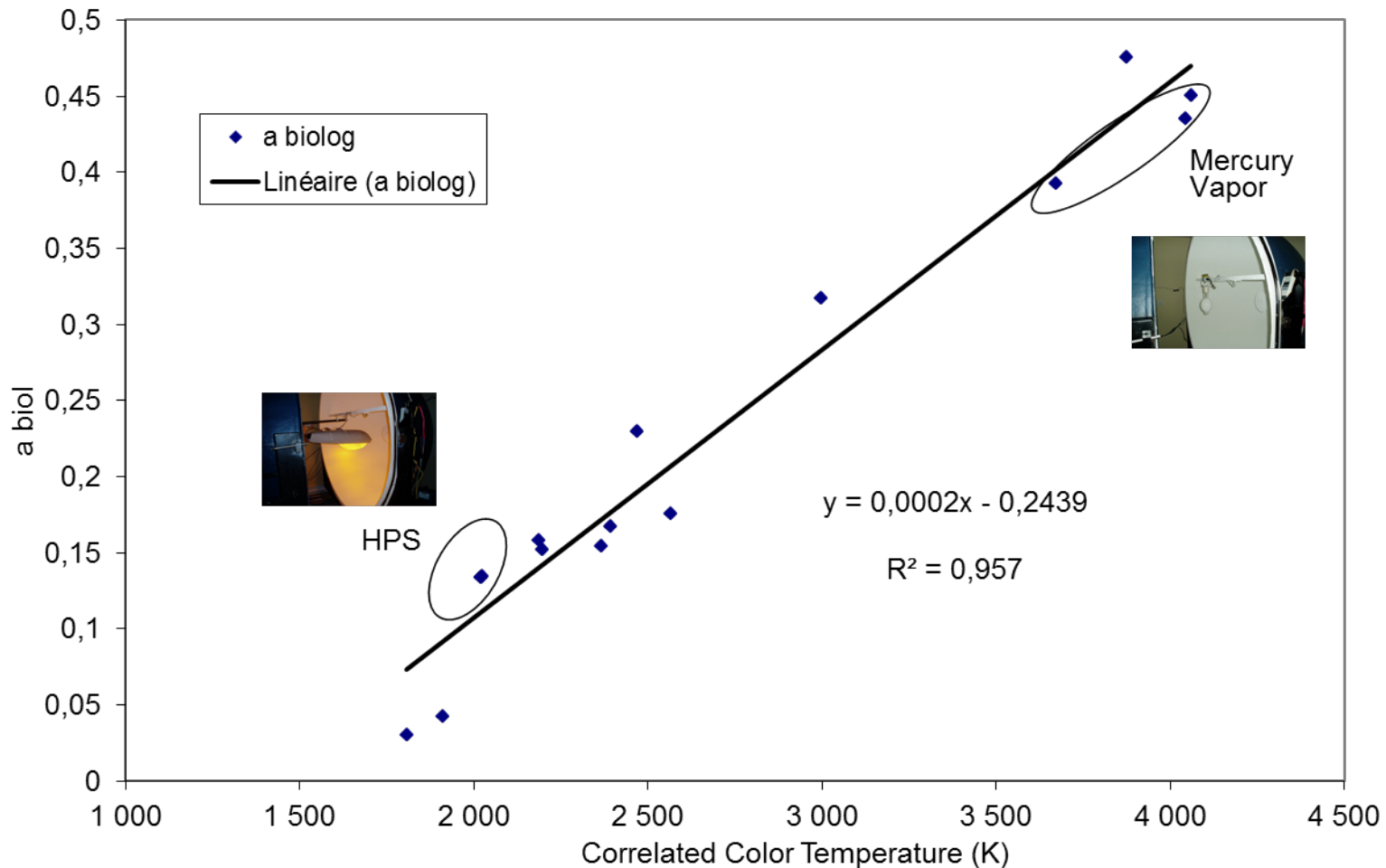


= B

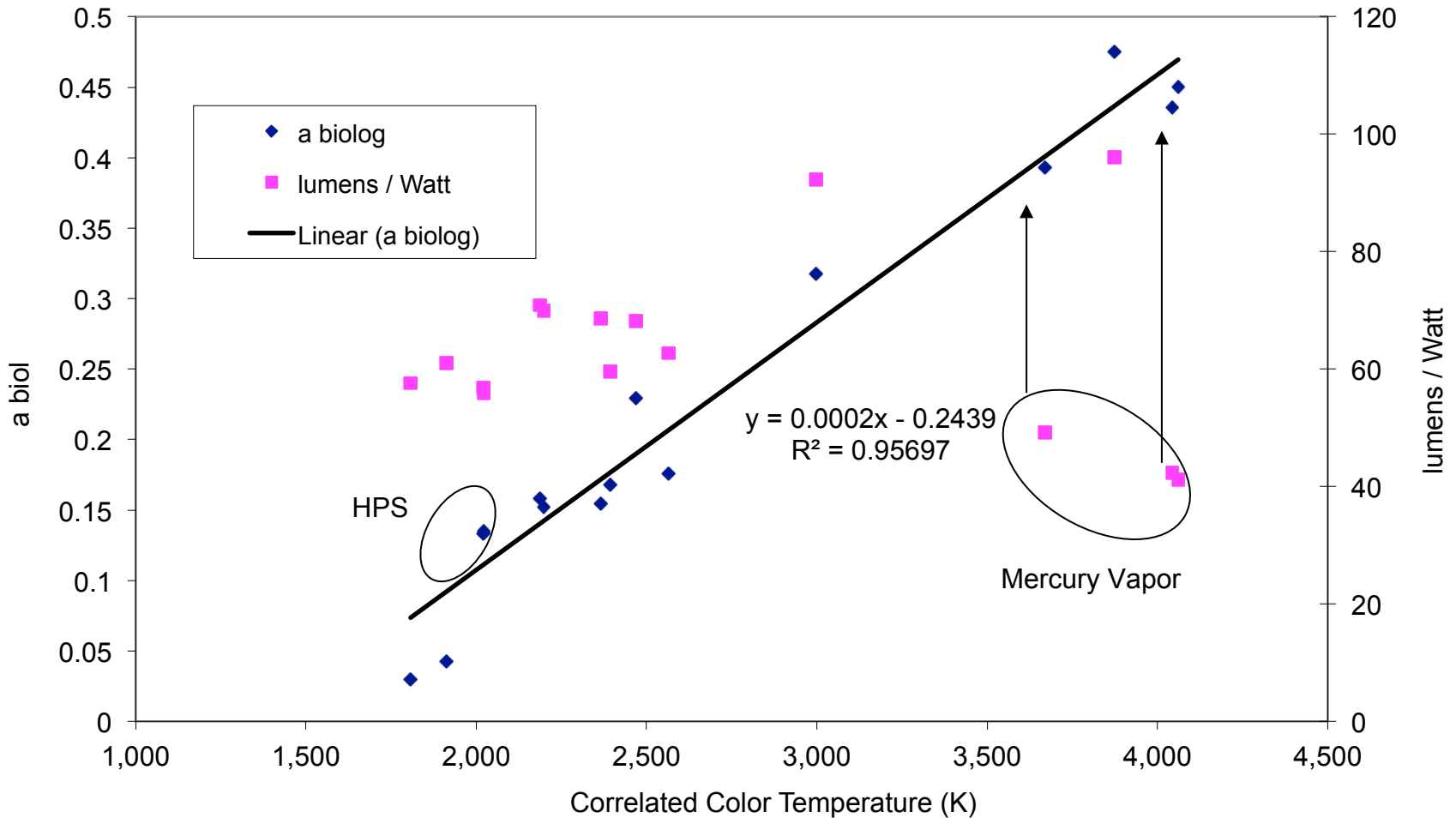
V (λ)

$$a_{biol} = \frac{\int_{380 \text{ nm}}^{580 \text{ nm}} X_{\lambda}(\lambda) \times s_{biol}(\lambda) \times d\lambda}{\int_{380 \text{ nm}}^{780 \text{ nm}} X_{\lambda}(\lambda) \times V(\lambda) \times d\lambda} = \frac{A}{B}$$

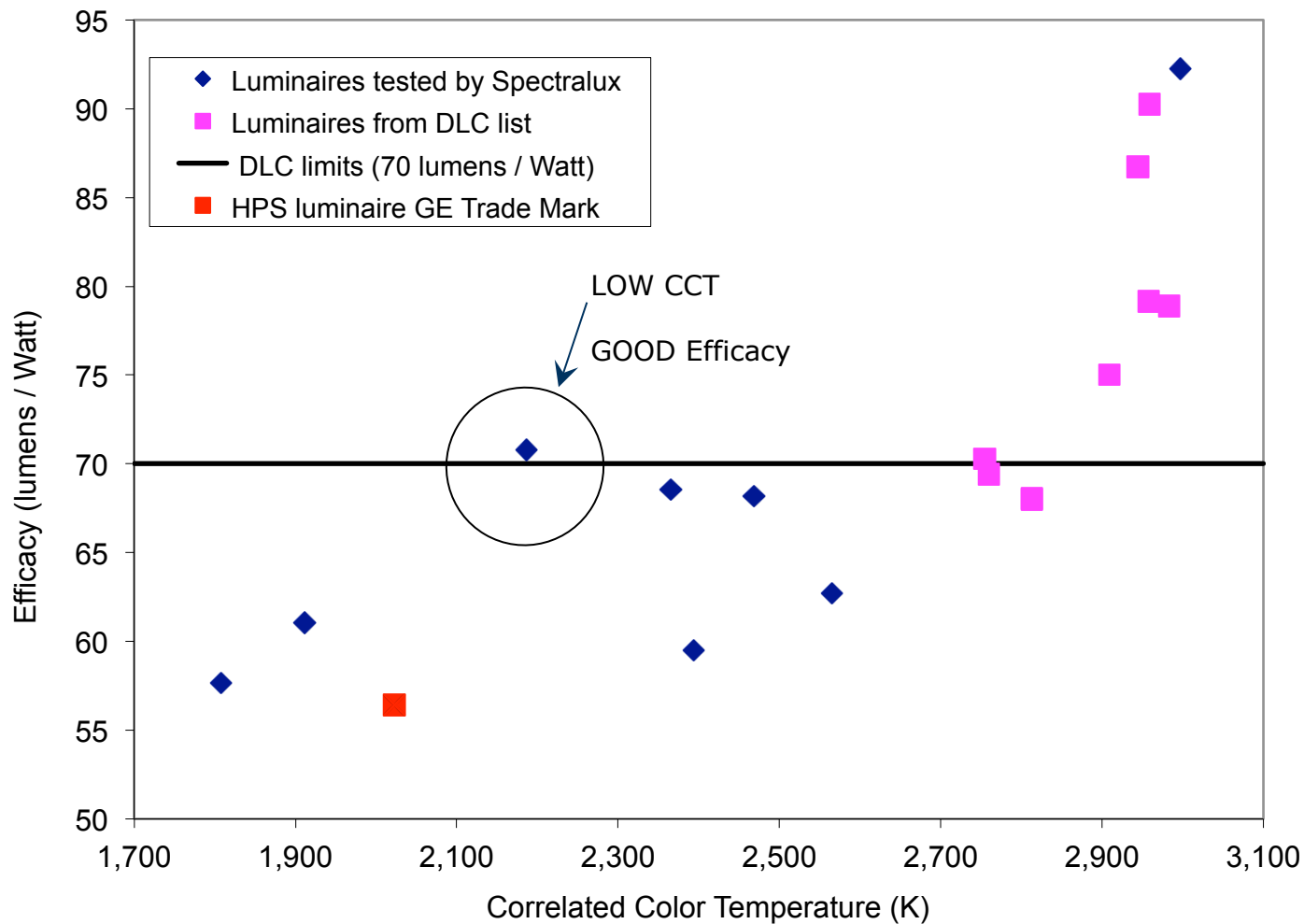
Relationship - a biological and CCT



a biological, CCT , Luminous Efficacy



Luminous Efficacy vs CCT

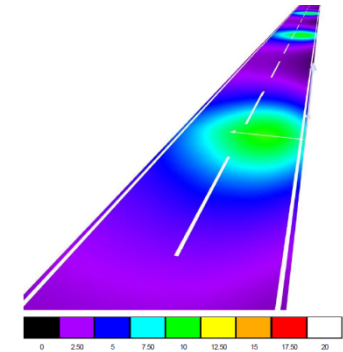


OPTION TO SELECT LED TECHNOLOGY

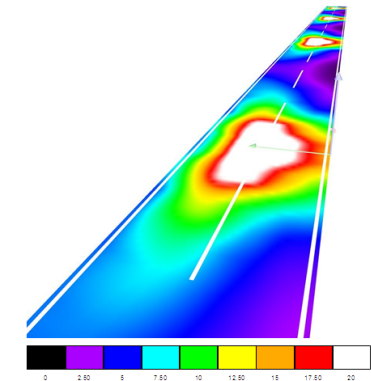
OPTION A	OPTION B	OPTION C
CCT < 2 500 K	CCT \approx 2 500 K	CCT \approx 4 000 K
Low a_{biol}	Intermediate a_{biol} between HPS et MV	High a_{biol}
Lower luminous efficacy (lm/W)	High luminous efficacy (lm/W)	Very high luminous efficacy

Local street simulation (73,8 W < 130 W)

Value	Philips - Lumec	Philips - Lumec	HPS	IES RP-8
Photometric Test	S1311282m-R1	S1307092	S1005121m	
Correlated Color Temperature (K)	1 912 K	3 829 K	2 023 K	
Power (Watts)	73,8	69,1	130	
Initial luminous flux t=0 (lumens)	4420	6 033	7 405	
Luminous efficacy t = 0 (lumens /Watt)	60,0	87,4	57,0	
Average illuminance (lux)	4,02	6,6	7.9	≥ 4,0
Maximum illuminance (lux)	10	15	28	
M i n i m u m illuminance (lux)	1,09	1,83	1,05	
E_{avg}/E_{min}	3,7	3,6	7,5	≤ 6,0
$L_{v\ max}/L_{avg}$ (B)	0,2	0,3	0,3	≤ 0,4
BUG rating	B1UOG2	B1UOG1	B2U1G2	
$E_{avg}/Watt$ (lux/Watt)	0,054	0,096	0,073	



LED 1912 K – 73,8 Watts



HPS (130 Watts)

END RESULTS

Manufacturer	Test	Item	lumens / Watt	CCT	CRI	lumens / Watt	CRI
HPS GE	L1011044	HPS	56,0	2 022 °K	14		
HPS GE	L1011045	HPS	56,4	2 023 °K	14		
HPS GE	L1011043	HPS	56,9	2 020 °K	15		
Philips	L1403058-C1	LED	57,7	1 807 °K	40		
LEDTECH International	L1312032-R1	LED	59,5	2 394°K	72		
Philips	L1311292-C1	LED	61,1	1 912 °K	39		
LEDTECH International	L1312033-C1	LED	62,7	2 565 °K	72		
Philips	L1311282-C1	LED	68,2	2 468 °K	59		
LEDTECH International	L1312042-C1	LED	68,5	2 365 °K	63		
Philips	L1403059-C1	LED	70,0	2 198°K	55		
Philips	L1312122-C1	LED	70,8	2 186°K	55		
Philips	L1312123-C1	LED	92,3	2 997 °K	72		
Philips	L1301162-C1	LED	96,1	3 875°K	76		

Organization	lm/W	CRI	CCT
Design Light Consortium (DLC)	> 70	> 65	
Town of Sherbrooke (Technical requirement - 2013-22 ; January 2014		> 30	Between 1700 K and 2200 K

Model Light Ordinance (MLO)

- > To preserve such type of environment, proper type of light source must be used. Indeed, since 2012, a MLO (« Model Lighting Ordinance ») jointly developed by IES (Illuminating Engineering Society) and IDA (« International Dark Sky Association ») can be used.

Under these rules, several zones exist described by LZ0 to LZ4:

LZ0 : No ambient lighting

LZ1 : Low ambient lighting

LZ2 : Moderate ambient lighting

LZ3 : Moderately high ambient lighting

LZ4 : High ambient lighting

LZO Zone

The ASTROLab region is described as LZ0 and luminaires must be design in such a way:

- 1) no upward light emission ;
- 2) control even turn off artificial lighting when not required ;
- 3) minimise the energy in the blue spectrum ;
- 4) provide priority to the nature and not the human.

« Areas where the natural environment will be seriously and adversely affected by lighting. Impacts include disturbing the biological cycles of flora and fauna and/or detracting from human enjoyment and appreciation of the natural environment. Human activity is subordinate in importance to nature. The vision of human residents and users is adapted to the darkness, and they expect to see little or no lighting. When not needed, lighting should be extinguished. » - Source – MLO – IES and IDA

Conclusion

- > LED Technology can be used in sensible area such as LZO zone but specifications must be adapted**
- > Good correlation between a biol and CCT (Technology independent)**
- > Town of Sherbrooke : (Technical requirement - 2013-22 ; January 2014
CRI > 30
Between 1700 K and 2200 K**

Hydro-Québec involved in lighting



THANKS AND QUESTIONS ?



Leonardo da Vinci : « *Qui est guidé par une étoile ne regarde jamais en arrière* ». (Who is guided by a star never looks back).

http://astro-canada.ca/_fr/a2109.php