The impact of light spectrum on night environment

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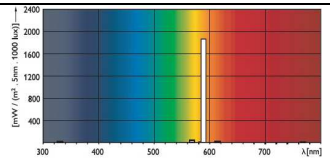
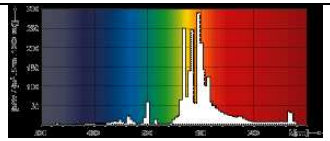
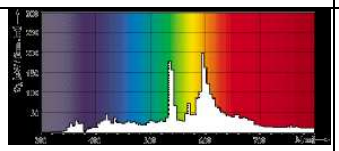
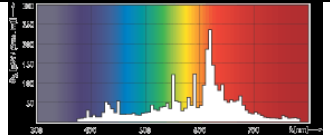
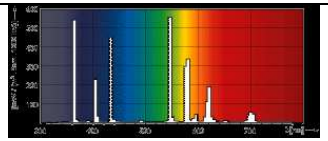
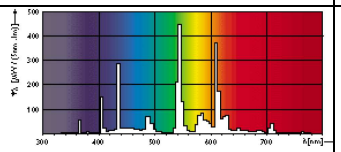
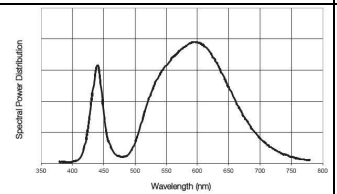
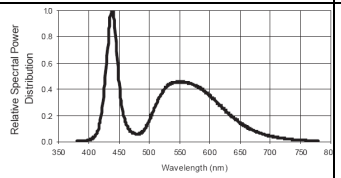
		Light efficiency (in lm/W) for different human eye sensitive range					
Lamp used	Spectrum and correlated color light	Photopic (L > 3 cd/m^2)	Mesopic* (L = 0,5 cd/m^2)	Scotopic (L < 0,001 cd/m^2)	Amplification factor for Rayleigh diffusion with respect to High Pressure Sodium light in the scotopic range	Possible economy saving (in %) using white light with respect to High Pressure Sodium light for a luminance of 0,5 cd/m^2	Minimum impact on night environment
Low Pressure Sodium (Philips SOX 90W)	 T=1800 K	152	146	33	0,41	37,7	0,26
High Pressure Sodium (Philips SON-T 70W)	 T=2000 K	95	106	64	1	0	1
Ceramic discharge metal halide 1 MASTER CityWhite CDO-TT 70W	 T=2800 K	86	116	86	1,92	8,6	1,75

Ceramic discharge metal halide 2 MASTER CosmoWhite CPO-TW 90W	 T=2880 K	112	148	144	2,49	28,4	1,79
High Pressure Mercury Philips HPL 4 80W	 T=4200 K	50	61	50	0,87 (actually 1,51) in order to reach the same luminous flux as HPS !	-73.8	1,51
Induction PhilipsMASTER QL 85W	 T=4000 K	82	114	121	2,05	7	1,91
LED Luxeon K2 blanc chaud	 T=3000 K	62	82	80	1,29 (actually 1.67) in order to reach the same luminous flux as HPS !	-29	1,67
LED Luxeon K2 blanc froid	 T=5500 K	84	129	160	2,91	17,8	2,40

*The human eye sensitivity curve for mesopic vision is used here for an average photopic luminance level of 0.5 cd/m^2 (corresponding to even lower limits prescription given by EN 13201 norm) is calculated from the Bullough & Rea (2008) work called « *Innovative, Energy-Efficient Lighting for New York State Roadways : Opportunities for Incorporating Mesopic Visibility Considerations Into Roadway Lighting Practice » carried out at « Lighting Research Center Rensselaer Polytechnic Institute ».*

The minimum impact on night environment is calculated by assuming that the scotopic range of human eye sensitivity is near the night vision of fauna. One can notice that this is really a minimum impact because for instance the insects' vision is much more sensitive below 400nm than the human eye which reaches its detection limit at that range. Particularly, the high pressure Mercury lamp appears not as bad as in reality because the near UV light emitted, very harmful for insects, is not visible by human beings.

This table shows different important results. First, the Low Pressure Sodium lamp is the best light for the protection of night environment and this should remain the common choice near astronomical observatories even if the color rendition is poor. Cool white lights (T~5500K) thus has an impact 10X greater than Low Pressure Sodium ones !

We can see that white light sources, even if we tune down the illuminance levels to keep the same luminance level for public lighting (taken here to be 0.5 cd/m^2 in average) in order to have the same visual abilities as high pressure sodium lights while doing some energy savings (which are most of the time really low) lead to an increase in light pollution between 50 and 140 %. We assumed here that road reflectivities is the same for the different kind of spectra lights. The inclusion of the road spectral reflectivity do not modify the results by more than 2%.

To conclude, white light sources have to be used with parcimony, for inner city centers and have not to be generalized in order not to damage more our night environment. However, for much less illuminance levels in the photopic range L~0.05 cd/m^2 (similar to ground illuminance near but lower to one lux for typical road properties in France (R2 type)) which are useful for pedestrian paths or residential areas lighting, white light sources could be used efficiently, particularly for LED lightings coupled with motion detectors, while having an impact on night environnment similar to high pressure sodium lighting. The ground illuminance could be well enough for these applications in this mesopic range with an equivalent illuminance of 3 lux !

But even in this last case, LEDS spectra will have big impact on astrophysical studies because the radiation emission produced by LEDS is a not filtering continuum extending also in the near infrared contrary to discharge lamps having spectra with a finite number of features we can partly avoid by using high resolution spectroscopy.