We get a lot of questions from customers about why we recommend Red LED bulbs behind red lenses, and Green LED bulbs behind green lenses. We also get many questions about why we recommend Cool White behind clear lenses, and Warm White behind Bi-Color or Tri-Color lenses. The answers sometimes seem counter-intuitive to many customers, but it can be quickly explained with simple physics. Hopefully the following explanation will make it more clear. We don't know the author of the original version of this, which was written in French, but we hope he or she is okay with us translating it and using it here to educate more people on this interesting subject.

Light Sources: LED vs Incandescent

Light sources, such as the sun, incandescent filament bulbs, and LED's, emit light in wavelengths of various amplitudes and various frequencies. It is the combination of these wavelengths which determines the color of the light perceived by the eye. Each source of light is characterized by its spectral distribution (the combination of wavelengths that they emit, and their amplitude).

This curve (Fig. 1), is typical of incandescent bulbs, which emit a white light known as hot (slightly red white light).

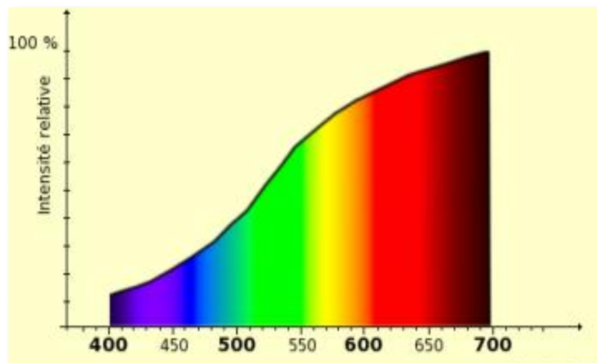

Figure 1: Typical Incandescent White Light

This curve (Fig. 2), is typical of cool white LEDs. White LEDs, are by construction, made up of Blue LEDs, to which a layer of phosphor elements is added. In the case of cool white LEDs, these phosphors absorb the light, and re-emit the light in a wavelength centered on the yellow. Therefore one can see a peak in the blue and another in the yellow zone.

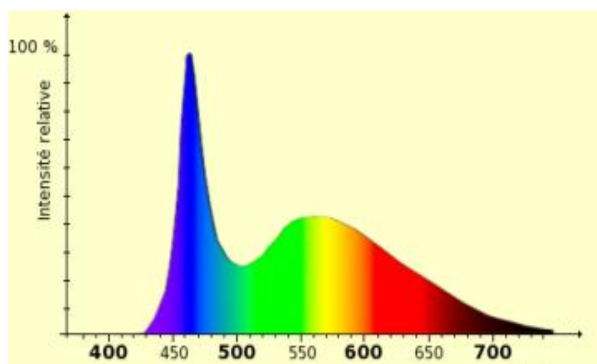

Figure 2: Typical LED "Cool White" Light

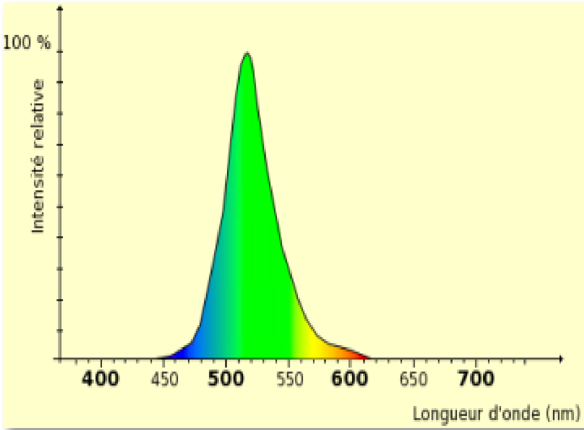

Figure 3: Green LED Distribution

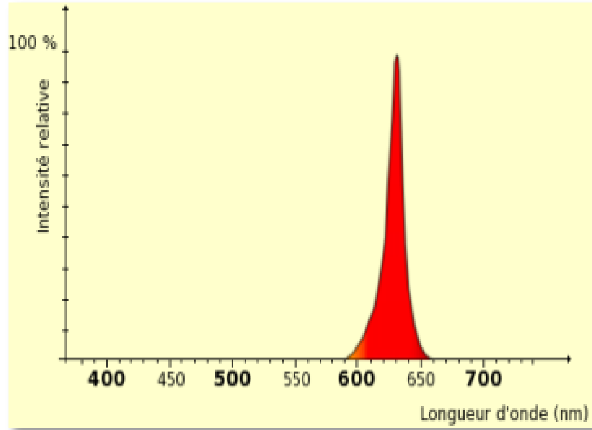

Figure 4: Red LED Distribution

While it is difficult for LED's to make a full-spectrum white light, LED's are very good at creating either red or green light naturally, without the use of filters, coatings or phosphors. Figures 3 and 4 above show the typical distribution of green and red LED's, respectively.

How colored lenses affect light transmission:

The principle of colored lenses, which are really filters, is to attenuate certain wavelengths of the light which pass through them. This attenuation coefficient is called transmittance, and it varies from 0 (the light is completely blocked) to 1 (the filter lets the light pass through entirely). One can represent the filters in the form of a curve of transmittance, of which here are some examples (Fig. 5 and Fig. 6):

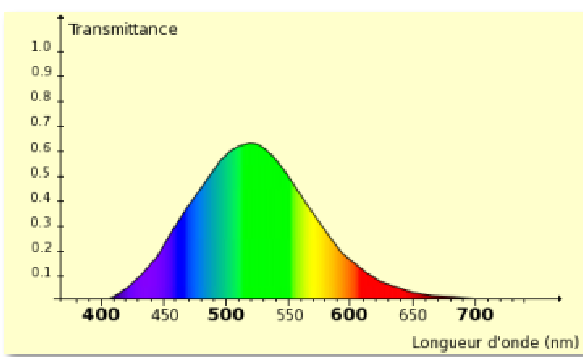

Figure 5: Transmittance through Green Lens

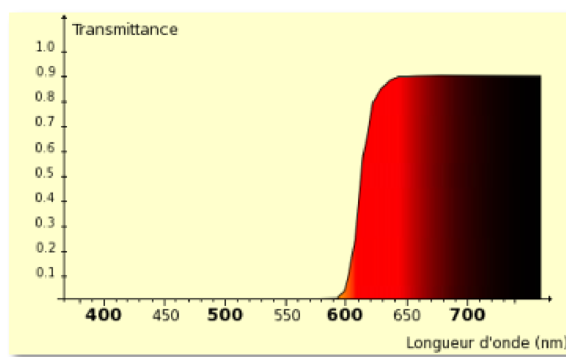

Figure 6: Transmittance through Red Lens

So, we know the relative intensity of our light sources, and we also know the transmittance of green and red filters. We can now calculate the amount of light emitted after filtration by the lens by multiplying the relative intensity percentage by the coefficient of transmittance and show it graphically as follows (Fig. 7):

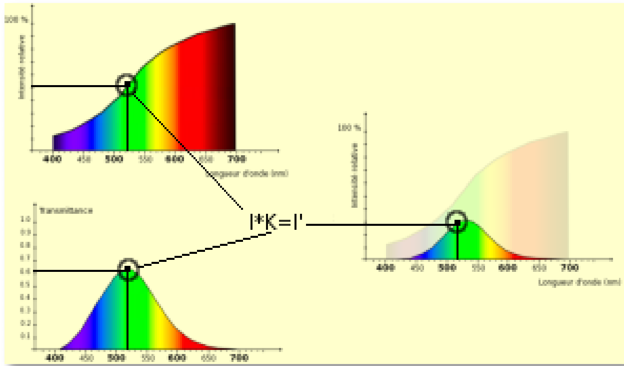

Figure 7: Light emitted through Lens

Have you ever wondered why a typical tri-color uses a 10W incandescent bulb for the 'all-around" anchor light with the clear lens, but uses a 25W bulb behind the Red/Green?   It is because the incandescent is making very little green light to begin with, so the green light emitted through the lens is also very low.   So it follows that we must start with a much higher intensity incandescent bulb if we expect to meet the requirement for visibility of green light through the green lens. On the other hand, the 'hot' incandescent bulb is making a large amount of red, so it fairs much better on the red side.   The transmittance through the green and the red using an incandescent bulb can clearly be seen graphically below (Fig. 8 & 9).

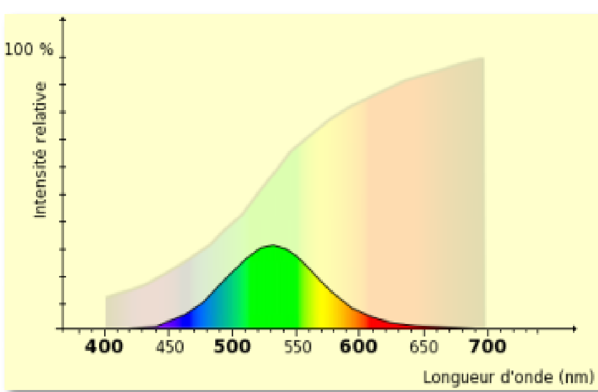

Figure 8: Incandescent Transmittance through Green

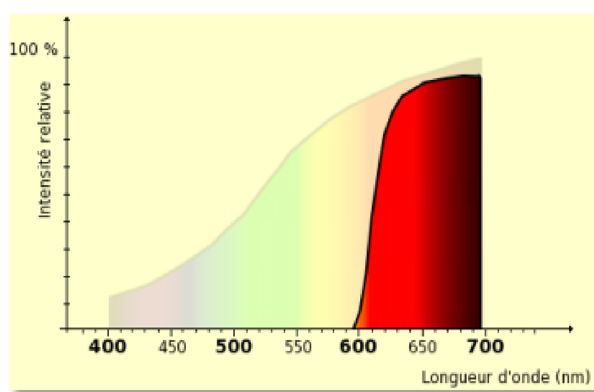

Figure 9: Incandescent Transmittance through Red

Comparisons

Green Lens: The figure on the left below (Fig. 10), is the transmittance through the green lens using an incandescent, while the figure on the right below (Fig. 11), is the transmittance though a green lens with a Cool White LED. We can see the high attenuation levels with both incandescent and LEDs through the green lens. A great amount of the white light energy from both bulbs is absorbed by the green lens, which is why we want high output light sources when trying to transmit white light through a green lens.

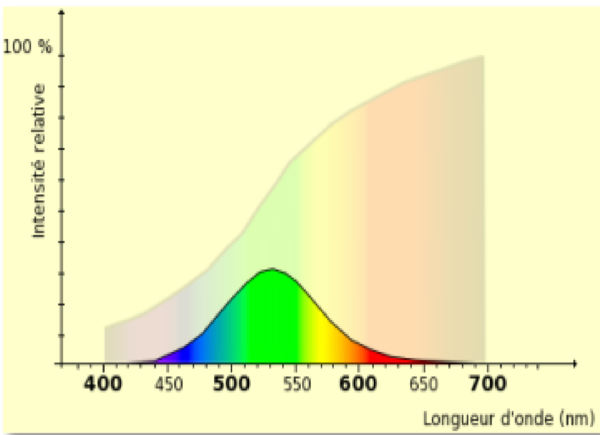

Figure 10: Incandescent + Green Lens

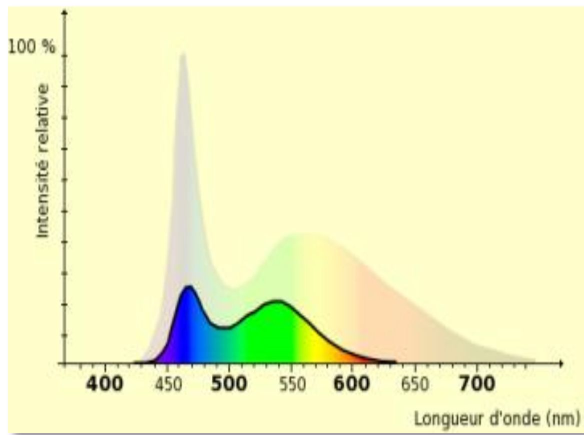

Figure 11: Cool White LED + Green Lens

What is also apparent is that the Cool White LED has a very high relative intensity in the blue wavelengths relative to green, so even though the transmittance of blue through the green filter is highly attenuated, when the relative intensity is multiplied by the transmittance, the amount of green and blue light emitted after filtration is very similar, which results in a light with a blue-green color. This illustrates why we do not want to use a Cool White LED behind a green lens.

Red Lens: The figure below left (Fig. 12), shows the transmittance of a 'hot-white' incandescent through a red lens. What is immediately apparent is the high relative intensity of the red wavelengths in the supposedly 'white' incandescent light. We also see that this high intensity, coupled with the high transmittance coefficient of a red lens (Fig. 6), results in a very high amount of light energy transmitted through the red lens using an incandescent.

Unfortunately, we don't see the same high amount of red light energy using the Cool White LED through the red lens (Fig. 13) in the graph on the right. Hopefully, it is now obvious why. While we have very high transmittance of red light energy through the red lens, we have very low relative intensity of the red wavelengths from the LED, resulting in relatively low amounts of light energy transmitted.

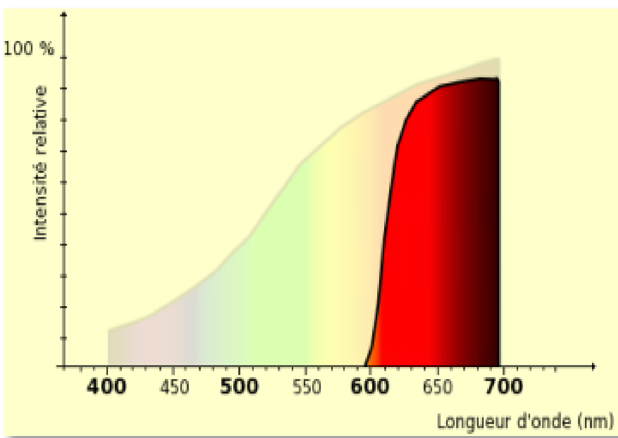

Figure 12: Incandescent + Red Filter

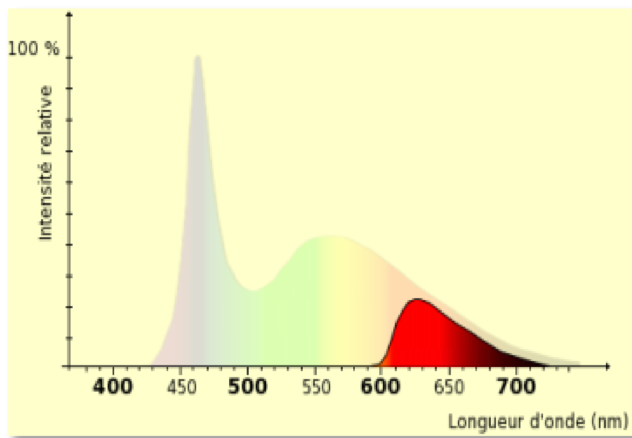

Figure 13: LED + Red Filter

While this has been mainly a discussion of 'hot' white incandescent light and 'cool white LED light through red and green lenses, we can apply these principals to 'warm' white LED light, as well as 'red' LED light and 'green' LED light. We can see if we add 'red' and "green' phosphor elements to create a 'warm' LED light, then we can get more total red and green light energy through the red and green lenses. We can also see by looking back at Figure 5 and 6 that a red LED behind a red lens or a green LED behind a green lens, would have high transmittance levels indeed; much higher than either an incandescent white light or an LED white light would.