

Choice of Public Lighting for Healthy Living

1 Motivation

Lighting technology has reached to such an advanced stage that we recognize its importance only when it fails. Artificial lighting technology covers every aspect of our life whether it is home, office or road. Lighting today is dominated by CFLs and LEDs. They are very energy efficient compared to the incandescent and fluorescent lights that were used earlier. Initially, CFL and LEDs were available in intense white only and these are mostly in use in India. Recently, LED lights have become available in a wide range from warm yellow to bright white [1].

2 The Nature of Light

Lights has two important characteristics, **illuminance** and **colour temperature**. Illuminance is the amount of light energy per unit area, usually expressed as lumens/m². Colour temperature (CT) is a measure of the warmth of the light. When a metal is heated, its colour changes from red, to orange, yellow, white and finally blue-white. The yellow-red flames of a fire are perceived as warm and the blue-green colour of light from an overcast sky appear to us to be cool. Thus the higher temperatures (3600-5500 K) are considered as cool, while lower temperatures (2300- 3000 K) are considered as warm (Fig. 1). For visual tasks where contrast is of overriding importance, cool light is preferred, while for living spaces warm light is preferred.

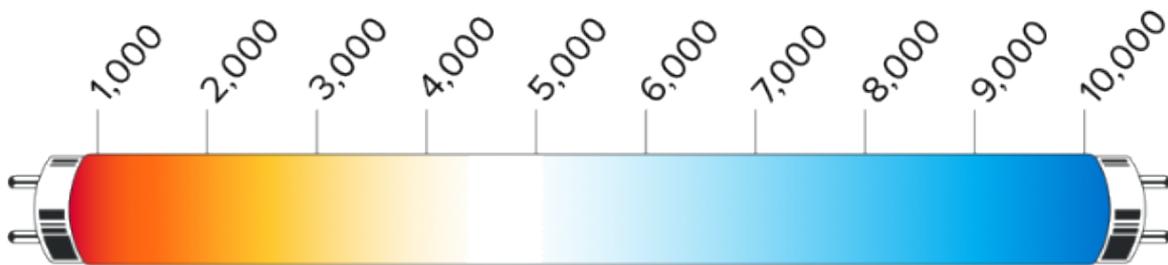


Fig 1. Colour Temperature Chart [2]

3 Light and the Human Body

The colour temperature of sunlight changes during the day. It is around 2000K (warm yellow) at the time of sunrise, 6000K (bright white) during noon hours and 2000K during twilight. Over millennia, the human eyes and body have adapted to this dark-low-high-low-dark daily cycle, known as the Circadian rhythm. Consequently, the human eye is more sensitive to white light in daytime and yellow light at night [2].

Based on cues from our eyes, the body is more active during the daytime when the eyes detect bright white. When the eyes detect warm yellow, they secrete melatonin which induces sleep. Thus exposure to yellow light for a few hours before sleep ensures peaceful sleep. On the contrary exposure to white light before sleep stimulates the body and results in disturbed sleep.

Apart from this, prolonged exposure to very bright light or high CT light can cause retinal damage leading to blindness and to cancer. High colour temperature and high illuminance light is not only harmful to human beings, prolonged exposure to bright light can affect the circadian rhythm of animals and change their behaviour patterns. Their eating and sleeping patterns are adversely affected by long term exposure to bright or white light. Darkness plays a major role in the biological rhythms of plants as well. The natural growth patterns of plants are altered by artificial lighting. Many plants recognise the season by the length of the night, thus extended artificial lighting exposure may affect their biochemistry.

4Current Trends in Lighting

Combining all these factors, the lighting industries are focusing on developing advance technology for production of low colour temperature light sources particularly for night application. In this regard, and considering the colour similarity with candle light (also sunrise and twilight), yellow lights or dim lights with low colour temperature are highly recommended for illumination after sunset. Such lights are good for human health, human eyes, environment, eco-system and night skies. International Dark-Sky Association (IDA) is fighting against installations of blue-rich LED street lighting. The addition of redder phosphors to a white LED results in production of light which looks warmer with eye pleasing property. In recent times, for indoor and outdoor use many public authorities are choosing LEDs of 2,700 to 3,000 K which are close to the hue of incandescent bulbs.

Lighting in outdoor public spaces is intended partly for safety. Many believe that brighter lighting implies greater safety. However, studies show that safety is unrelated to the amount of lighting [3]. Thus, it is desirable to install the minimum lighting required for human activities in each type of public space.

In India, light pollution and the health effects of lighting are still new issues of which the majority of society is unaware. Though lighting has a major impact on health, we often install bright white lights without proper con-

Table 1: Recommended CT and Illuminance: Public Indoor Spaces

Usage	CT (K)	Illuminance (lumens/m ²)
Offices	3000-4000	300-500
Retailers	2700-4000	300-500
High End Restaurants	1800-2700	100-300
Fast-food Restaurants	2700-3500	300-500
Hotels	1800-3000	100-500
Healthcare Centres	3500-5000	500-1000
Hostel Mess	2700-3500	200-400
Classrooms	3500-5000	200-500

Table 2: Recommended CT and Illuminance: Private Indoor Spaces

Usage	CT (K)	Illuminance (lumens/m ²)
Hallways	2300-3000	5-10
Living/Bedrooms	2300-3000	25-50

sideration. Star hotels and high-end institutions do care for the impact and design of lighting but this is a small minority.

5 Recommendations

The light source of specific colour temperature can be recommended on the basis of occasion and environment. Tables 1 and 2 give recommended choices for public and private indoor spaces. The high colour temperature of sunlight at daytime (>10,000K) indicates that indoor offices and classrooms may have high CT light (around 5000 K) to ensure the alertness in the work. Outdoor site lighting, parking garages and security lighting require energy efficiency of the lighting with lower colour temperature (Table 3) [2, 3, 4].

Table 3: Recommended CT and Illuminance: Outdoors

Usage	CT (K)	Illuminance (lumens/m ²)
Street lights	2000-2500	5-35
Footpaths	2000-2500	20-50
Common spaces of public buildings	2700-3500	150-200
Basements and Garages	3100-4500	50-100
Warehouses and Sports Stadia	5000	150-500

It is recommended that the State Government, the Municipalities and Panchayats adopt healthy choices in lighting in public areas. During late night, alternate street lights can be switched off to promote undisturbed sleep without compromising safety.

References

1. Hecht, J. "The Early-Adopter Blues", *IEEE Spectrum*, October 2016, 44-50. *Discussion of the pros and cons of LED lighting for outdoor public spaces. Early experiences with bright white LEDs and recent trends towards warmer LEDs.*
2. "How to choose the right color temperature of LED lighting for home & office", AIS LED Light, <https://www.aisledlight.com/color-temperature-led-lighting/> *Explains colour temperature and how to select CT for various indoor and outdoor uses.*
3. "Guidelines for Outdoor Lighting for RASC Dark Skies Programs", Royal Astronomical Society of Canada (RASC), 2018. https://www.rasc.ca/sites/default/files/RASC-GOL_2018_1.pdf *Explains impact of lighting on safety, health, human activities, animal behaviour, etc. Gives guidelines for illuminance and timings in various public outdoor spaces. Very well written for lay people, backed by scientific research.*
4. "Recommended Light Levels (Illuminance) for Outdoor and Indoor Venues", National Optical Astronomy Observatory, https://www.noao.edu/education/QLTkit/ACTIVITY_Documents/Safety/LightLevels_outdoor%2BIndoor.pdf *Simple definitions of lighting terminology, tables of recommended illuminance levels, and formula for designing light fixtures.*