



# **Color temperature, chromaticity and color rendering (Ra and TM-30)!**

## **What is it all about?**

Colorimetric information which really matters

Peter Karp, Konica Minolta Sensing B.V



# Agenda

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1. Why do you measure light?
2. What do you measure?  
→ From spectral to colorimetric values
3. Absolute and relative evaluation
4. Two applications: color of light vs. color rendering
5. When to use ... color temperature  $T_f$ ?
6. When to use ... chromaticity?
7. When to use ... spectrum?
8. Which color rendering metric to use?
9. Beyond color rendering – color preference!
10. Questions? → Answered!



# 1. Why do you measure light?

## Fluorescent Light



$L^* = 56.84$   
 $a^* = 6.76$   
 $b^* = -23.14$

## Incandescent Light



$L^* = 55.68$   
 $a^* = 4.79$   
 $b^* = -24.01$

Color is a property  
of light!



# 1. Why do you measure light?



## Tasks

- Specification
- Development
- Installation
- Design
- Quality control
- Production



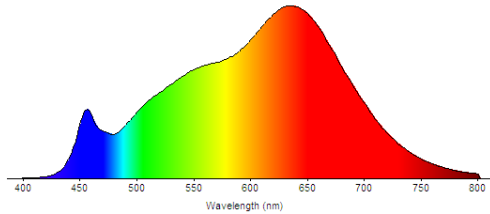
## Goals

- Natural looking colors
- Let us feel „comfortable“
- High uniformity for color and brightness
- High efficacy
- Long lifetime
- ...

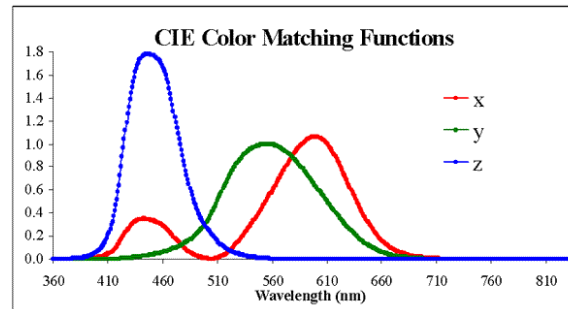


## 2. What do you measure?

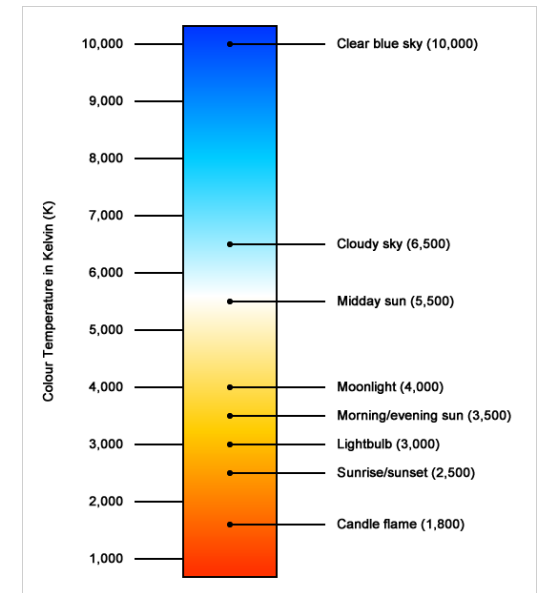
→ From spectral to colorimetric values



**SPD**  
(Spectral Power Distribution)



**Colorimetric values**  
(tristimulus values)



**Color temperature**  
(correlated color temperature)

- Calculation-Flow



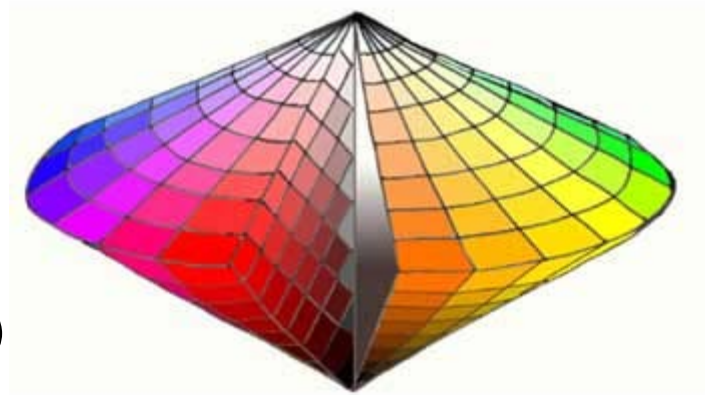
### 3. Absolute and relative evaluation

Absolute evaluation → Brightness unlimited

Relative evaluation → Lightness (normalized to 1 or 100)

Advantage of relative evaluation:

- Separation from
  - Lightness
  - Chromaticity (Hue and Saturation combined)



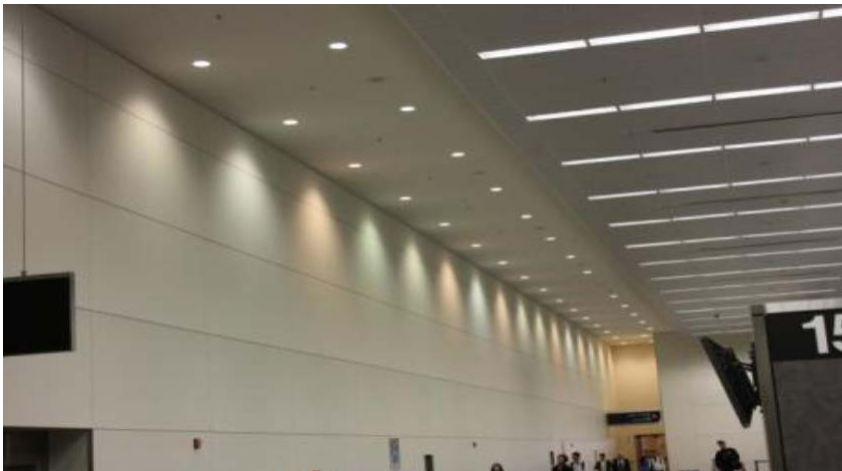
→ correlates to how we think:

for example: „higher saturated“, „not green, but blue“, „darker“



## 4. Two applications: color of light vs. color rendering

### Color of light



- Color appearance of the **light source itself**

### Color rendering



- Effect of a light source on the color appearance of **objects** (compared to a reference light source)

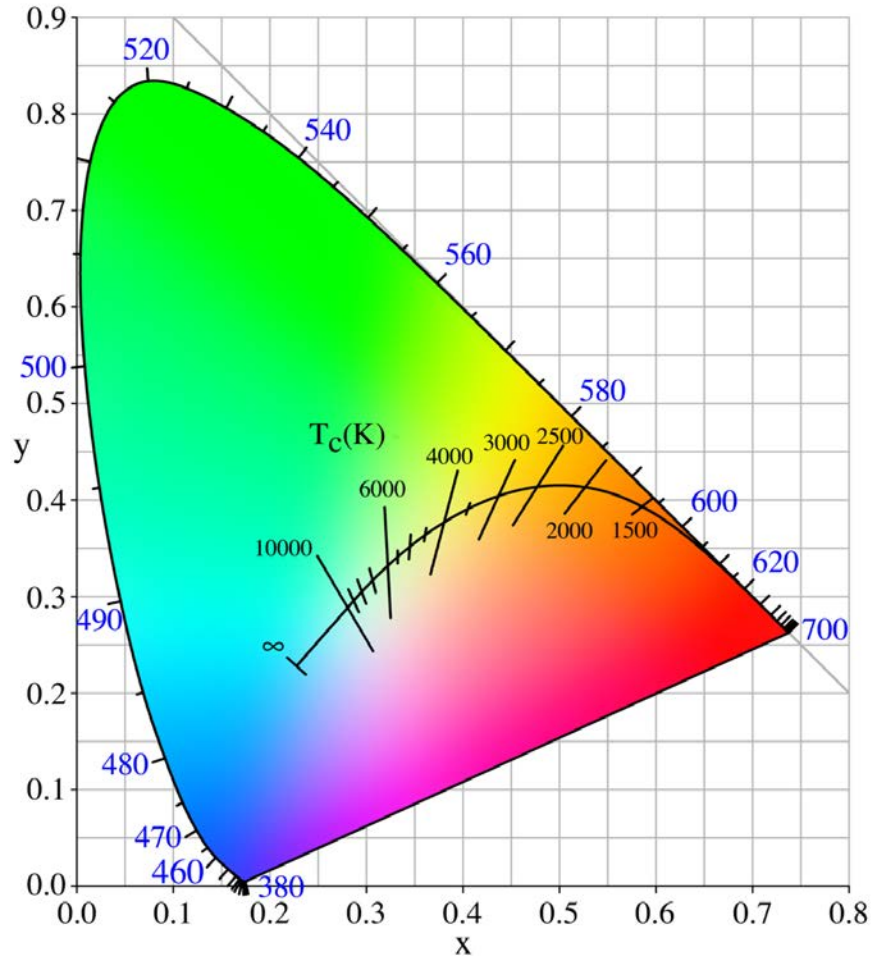


## 5. When to use color ... temperature Tf?

- Single number to describe the color of a light source

### Pros and Cons

- + easy to understand and compare
- no information if light is more or less greenish / yellowish
- different lights with same color temperature can look very different
- valid only for white lights







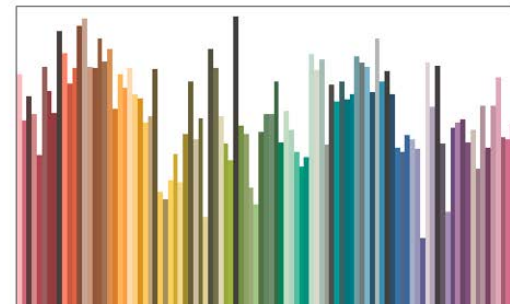
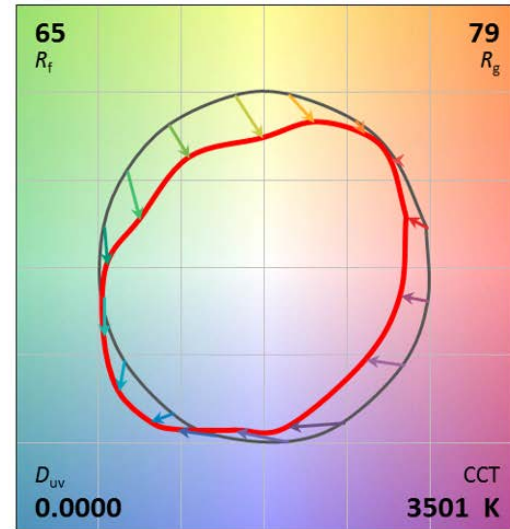
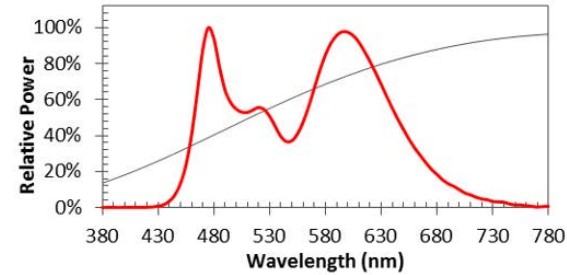


## 6. When to use ... spectrum?

- Multiple values (~ 40 to 400) for
  - Color rendering calculation
  - Research
  - Analysis

### Pros and Cons

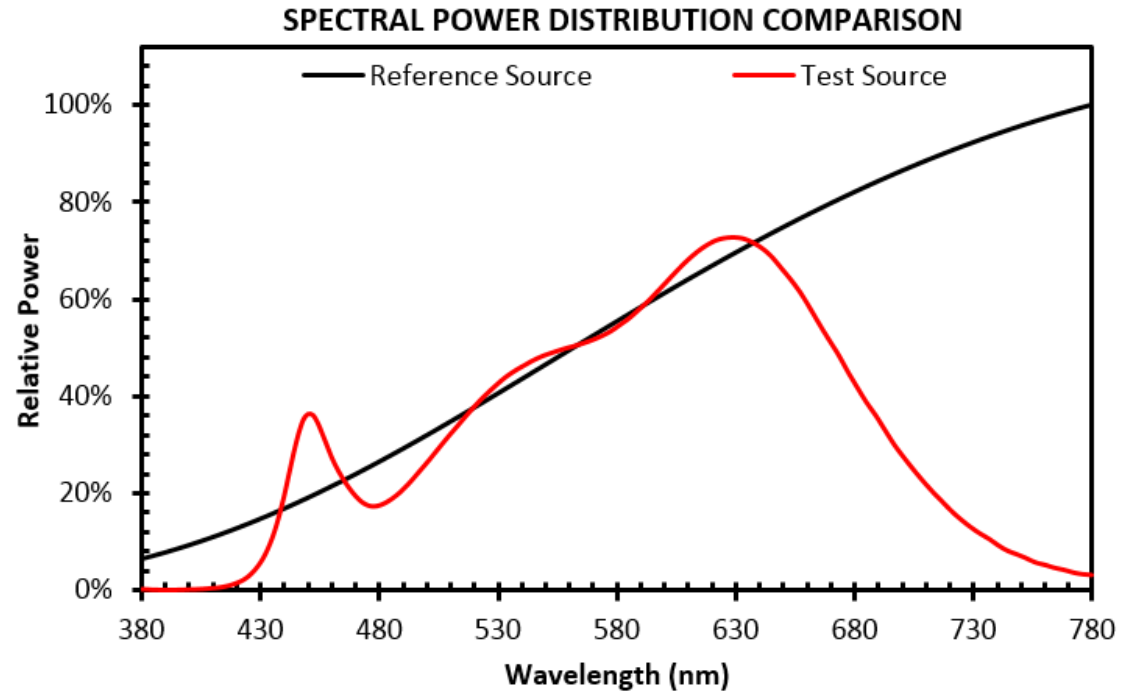
- + complete information
- not self explaining
- meaningful evaluation methods needed  
(which can be hard to define and agree on)





## 8. Beyond color rendering – color preference!

$R_f$	93
$R_g$	101
CCT (K)	3074
$D_{uv}$	-0.0004
$x$	0.4312
$y$	0.4010
CIE $R_a$	95

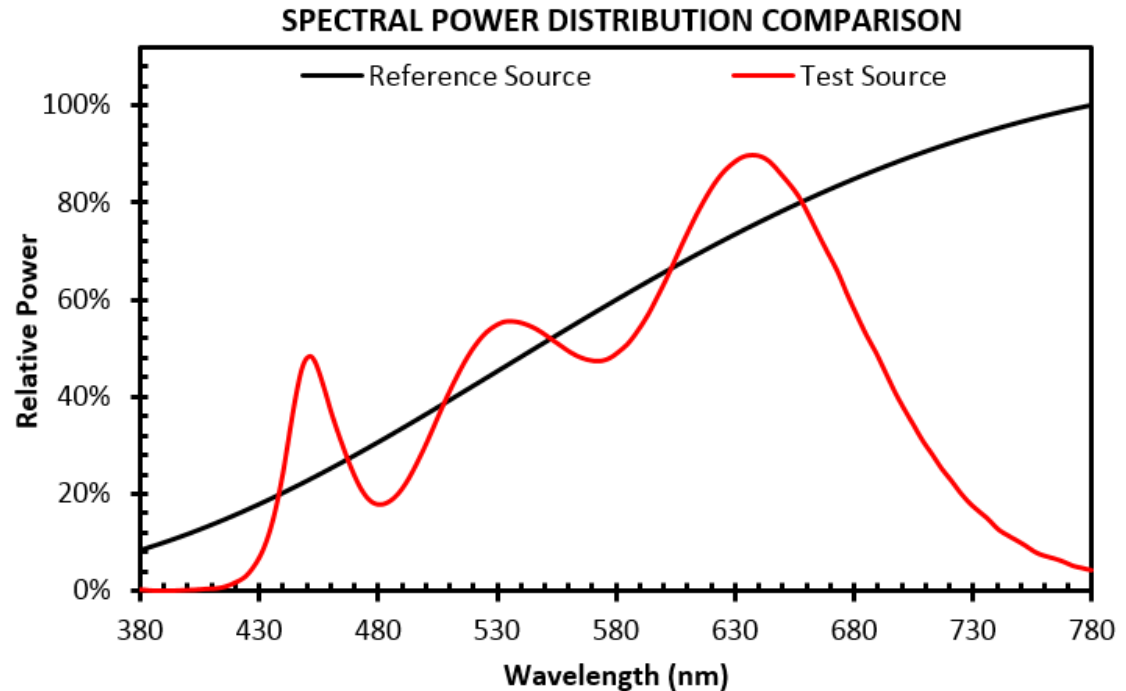


- Osram Brilliant White – (CRI-rating = 95)  
→ could color rendition, natural looking objects



## 8. Beyond color rendering – color preference!

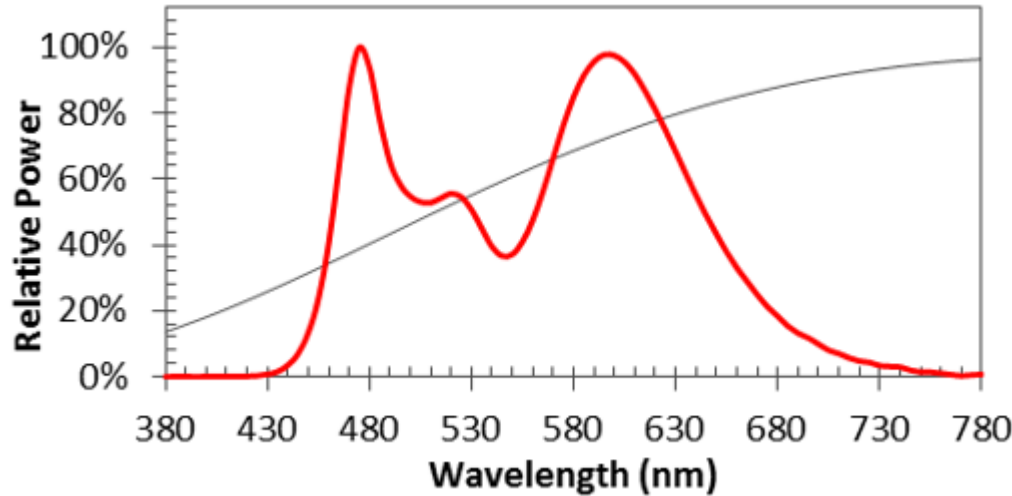
$R_f$	92
$R_g$	107
CCT (K)	3193
$D_{uv}$	-0.0030
$x$	0.4200
$y$	0.3906
CIE $R_a$	90



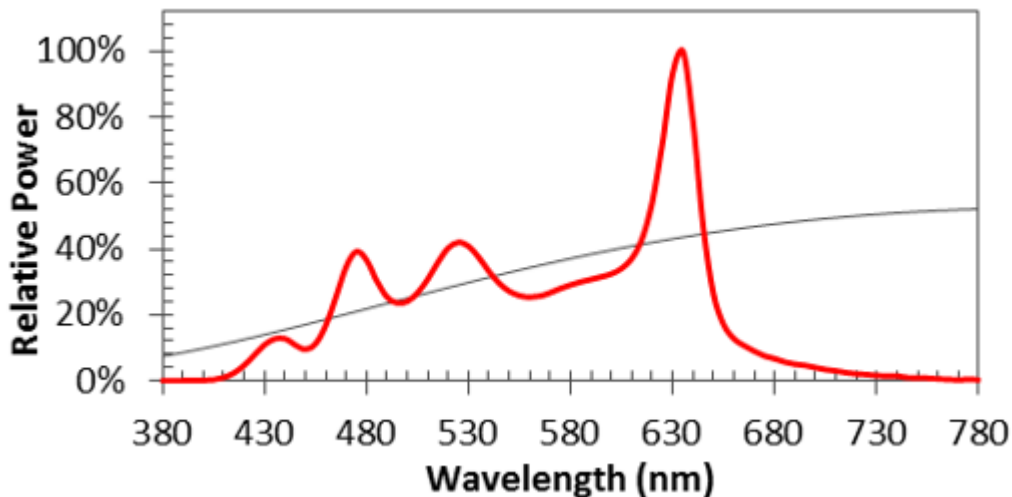
- Osram Brilliant Color (Wide Gamut) – (CRI-Rating = 90)  
→ higher saturated colors (but less natural looking), will be preferred for some applications



## 9. Which color rendering metric to use?



- Sample 1  
Ra = 75, R9 = 20



- Sample 2  
Ra = 77, R9 = 22

Almost same Ra and R9  
→ Second light source much closer to the reference (Illuminant A) and also “preferred” by far



## 9. Which color rendering metric to use?

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- Many different applications in lighting  
→ **No single metric to describe „quality of light“ can cover all aspects.**

### TODAY

- **CRI** describes **how illuminated objects appear** compared to a reference (Ra, R1 .. R8, R9 .. R15)
- **Color Rendering Index CRI** has been proven to be **useful**
  - In some cases limited correlation with visual experience

### FUTURE

- A **two-metric approach** (developed from the CIE, maybe based on TM-30-15) can cover **almost any lighting applications**
  - Fidelity (color rendering)
  - Gamut (color saturation) → relates largely to „preference“



## 10. Questions? → Answered!

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- How are color temperature and chromaticity related?  
→ Color temperature is calculated from the chromaticity!
- What is the difference between them and do you know if or how they influence color rendering?  
→ Color temperature is one-dimensional (no green information)!  
→ Both do not influence color rendering!
- Is a higher value for Ra or TM-30 Rf always better?  
→ Often yes, but depending on the application not always!



## 10. Questions? → Answered!

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- When is the spectra more important than chromaticity or visa versa?
  - Spectra is important for color rendering (how objects look like)!
  - Chromaticity is (mostly) important how the light source itself or neutral (white or gray) objects appear!
- Last but not least – Do light sources with a higher color temperature have a better color rendering?
  - No, the color rendering is independent from the color temperature. Each light is tested against a reference light of the same color temperature!



# 11. Which devices do I need for light measurement?

→ **Konica Minolta solutions overview**



KONICA MINOLTA

## KONICA MINOLTA SENSING

▀ **Konica Minolta** offers a Total Solution for Light and Display Measurement through its products and the products of Group companies

- **Instrument Systems GmbH**
  - Munich, Germany
- **Radiant Vision Systems**
  - Redmond, Washington State, USA





## 12. Outlook – day seminar “Language of light”

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Full day seminar on light and light measurement

topics among others:

- Color Vision
- Color measurement
  - Illuminance and luminance
- Which type of measurement device do I need?
  - How to choose?
  - Specifications / brochure data explained
- Color of light
  - MacAdam Ellipses
  - Color rendering and color preference



## Contact

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### **Peter Karp**

Light and Display, Sales and Application Engineer

Konica Minolta Sensing Europe BV

Edisonbaan 14-F

NL-3439 MN Nieuwegein

Phone: +31 30 248 1195

Fax: +31 30 248 1211

Mobile: +31 6 25 63 93 62

Email: [Peter.Karp@seu.konicaminolta.eu](mailto:Peter.Karp@seu.konicaminolta.eu)

Website: [www.konicaminolta.eu](http://www.konicaminolta.eu)