Color rendering Index (CRI)

history, usage and outlook to new metrics

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Agenda

1. Quality of light – tasks light fulfills

2. What is the best light source?

3. Metrics to describe the „quality of light“
   Color rendering vs. Color Preference

4. Overview of some „quality metrics“

5. CRI explained

6. TM-30-15, a new two metric approach

7. When will CRI be replaced?

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  - To let us feel **comfortable**
  - To be **represantive** for „as many as possible“ light sources
  - To serve as a visual **reference**

2. What is the best light source?

Suggestions please ☺

- Nice
- Natural
- Differentiate
- Orientation
- Comfortable
- Representive
- Reference

3. The quest for a metric for „quality of light“

Time-proven “good” light sources

1. Daylight

2. Incandescent lamps

→ **compare** test light source **to** those **reference light sources**

3. The quest for a metric for „quality of light“

Up till now:

One metric (Color Rendering Index, CRI or Ra) widely used to try to cover all aspects of lighting quality.

One metric <u>cannot</u> be sufficient, because of the different needs in different use cases.

3. Fidelity vs. Preference

- **Fidelity** metric describes the **color rendering** of a light source

- **Preference** metric describes **other aspects** including if we like to see higher (or lower) saturated colors, “feeling comfortable” …

Definition of color rendering:

Effect of an illuminant on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant [CIE 17.4]

4. Overview of most prominent color fidelity and preference metrics

- **CRI** – has served fairly well for most light sources (fidelity)

- **Color Quality Scale (CQS)** – solves CRI issues, but still has some drawbacks of CRI (never gained widespread acceptance) (preference)

- **CIE** – Two committees; official standards awaited 2016 (fidelity, preference)

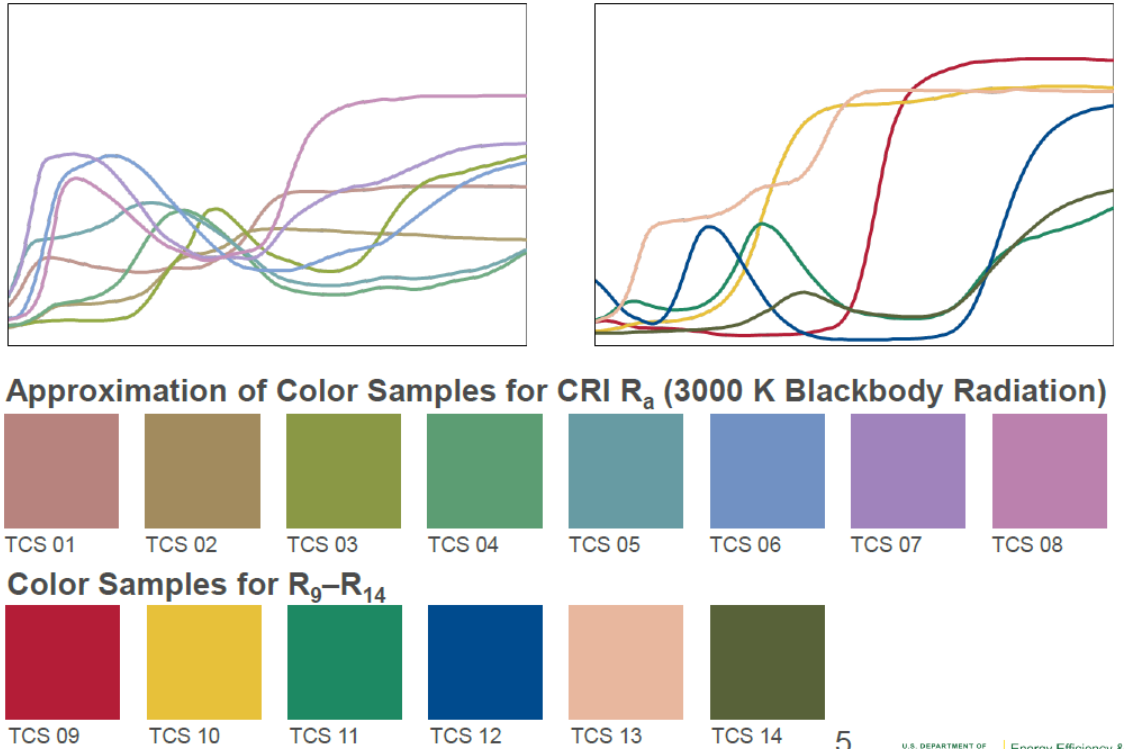
- **TM-30-15** – published by IES (Illuminating Engineering Society) submitted to CIE, today unclear if / when it will become an CIE standard (fidelity + additional information → also for "preference")

5. Color Rendering Index CRI (Ra)

- since 1965, last update 1974
- compares chromaticity of eight (pastel) test color samples under test illuminant to reference illuminant
- Reference (at same CCT as test illuminant, valid for sources near blackbody locus)
  - blackbody radiation (< 5000 K)
  - representation of daylight (> 5000 K)
- averages and scales differences of each sample to result in single number, maximum score of 100, negative values possible, (often wrongly interpreted as a percentage)

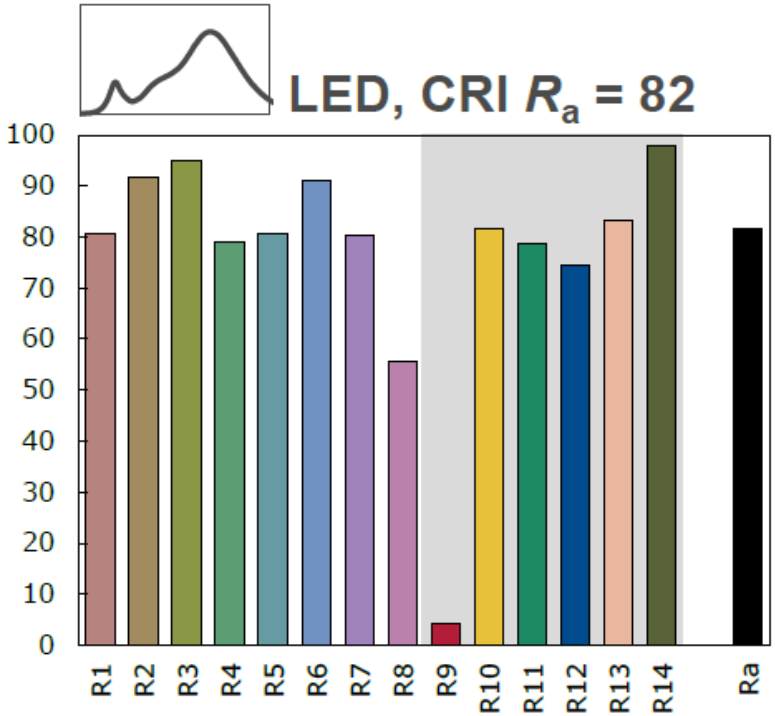
CCT = correlated color temperature

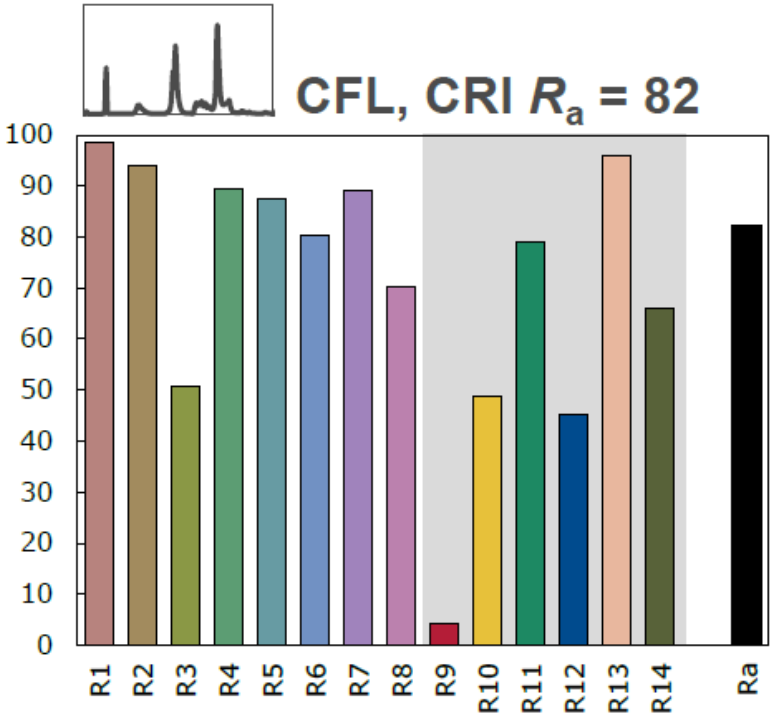
5. Color Rendering Index CRI (Ra) – Limitations



- does not predict appearance of specific objects (like all metrics)
- limited sample set → does not cover “enough real world colors”
- Uses outdated color math (Kries chromatic adaptation, CIE 1964 USC)

5. Color Rendering Index CRI (Ra) – Limitations





- Small sample set → allows to "cheat" (optimizing spectra to give higher numbers, but visually possibly worse)
- No information for which colours and how the differences to the reference are.
- Does not work as well for very discrete SPDs (i.e., RGB LED)

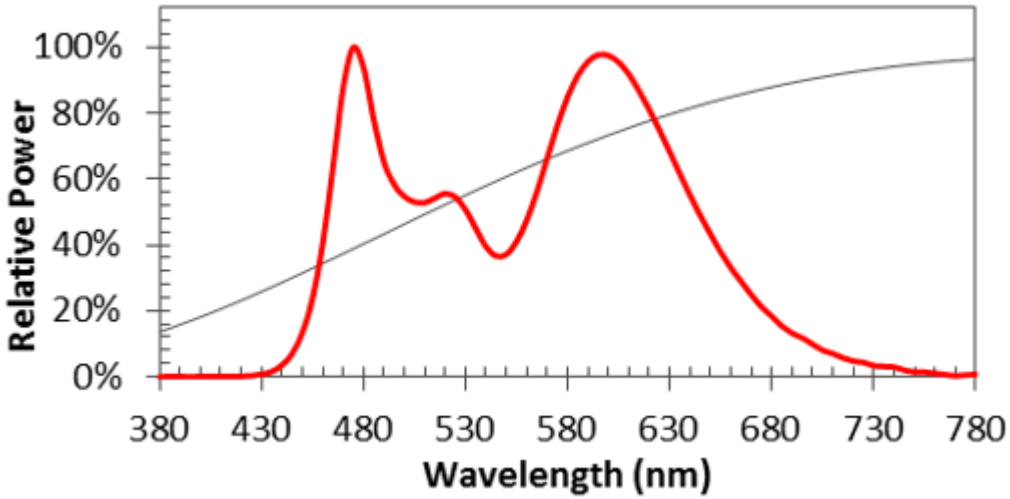
5. Color Rendering Index CRI (Ri) – R9

For later reading

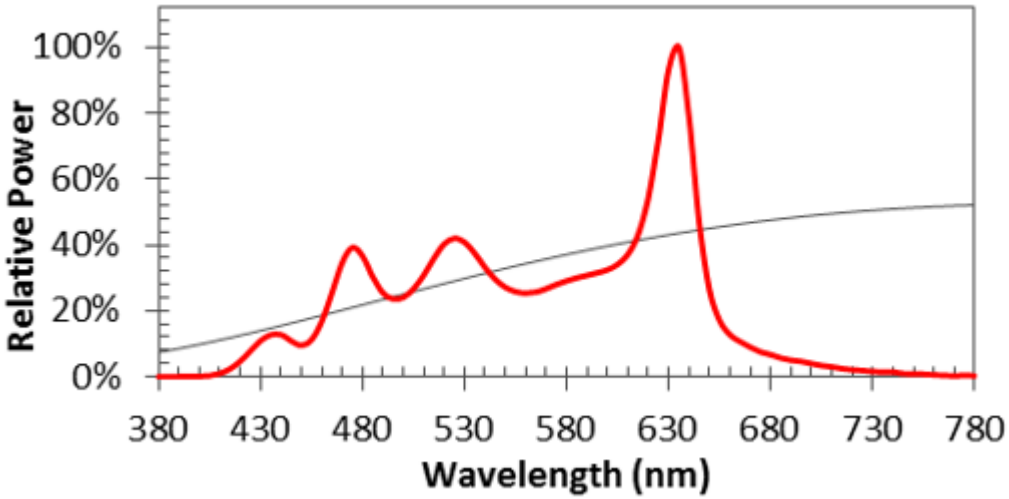
- Ri = special color rendering index R1 .. R14
- Ra = general color rendering index (average of R1.. R8)
- R9 = saturated red
- red is particularly important for human skin
- Often considered a valuable supplement to CRI Ra

- Because color space is skewed at red…
  R9 = <0 is Not Good
  R9 = 0+ is Good
  R9 = 50+ is Very Good
  R9 = 75+ is Excellent

5. Example where CRI “fails”



- 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 “prefered” by far

6. TM-30-15 – new approach for color rendering + “more”

Improvements of fidelity metric compared to CRI:

- 99 samples
  - representing real world objects
  - evenly distributed in color space
    → covering low to higher saturated colors

- up-to-date “color math”
  - uniform color space
  - stability over CCT

- Mixed reference between 4500K to 5500K
  → eliminates discontinuity at 5000K

6. A Two-Metric System for Average Characterization

$$0 < R_f \leq 100$$

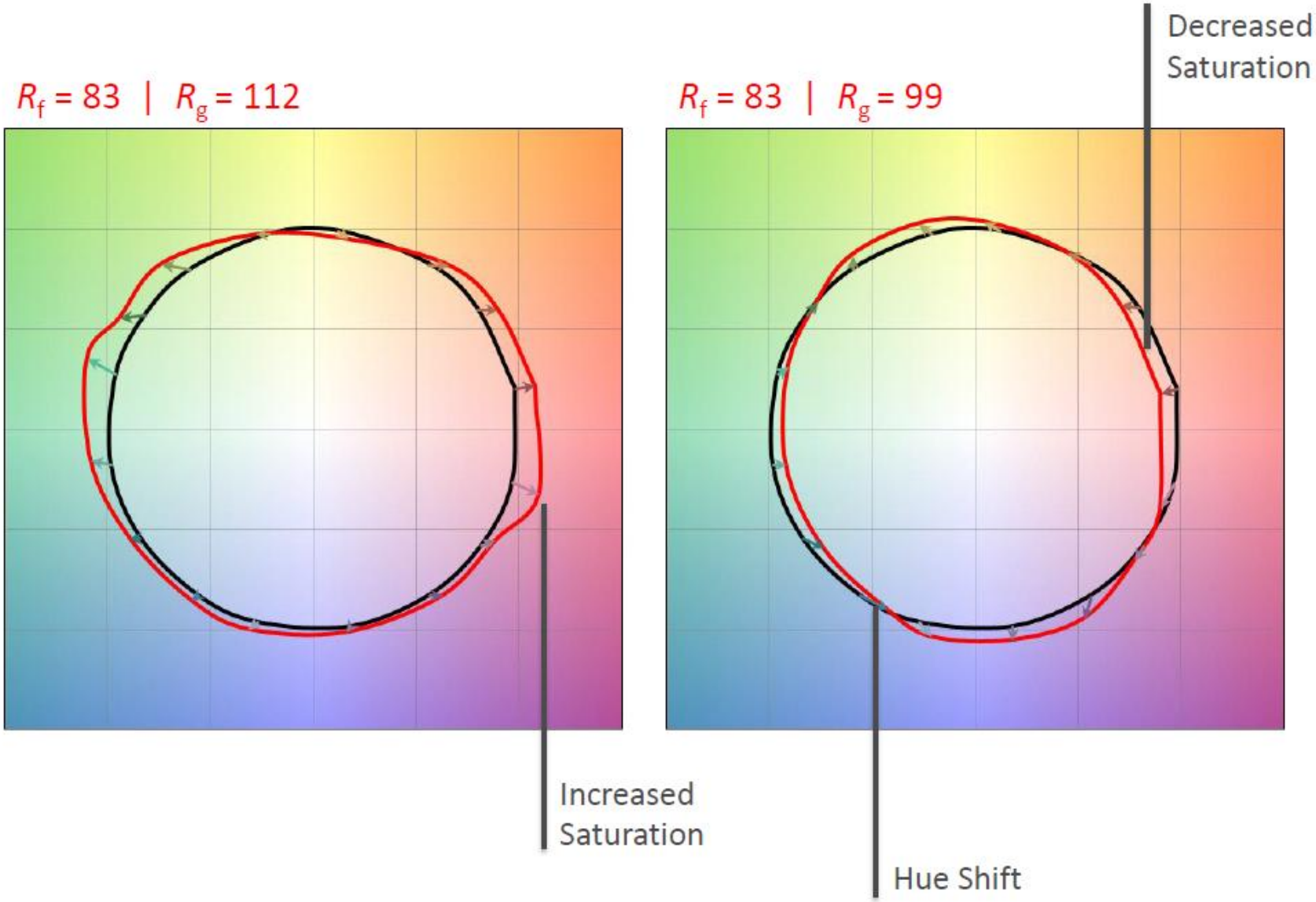
Fidelity

When $R_f > 60$:

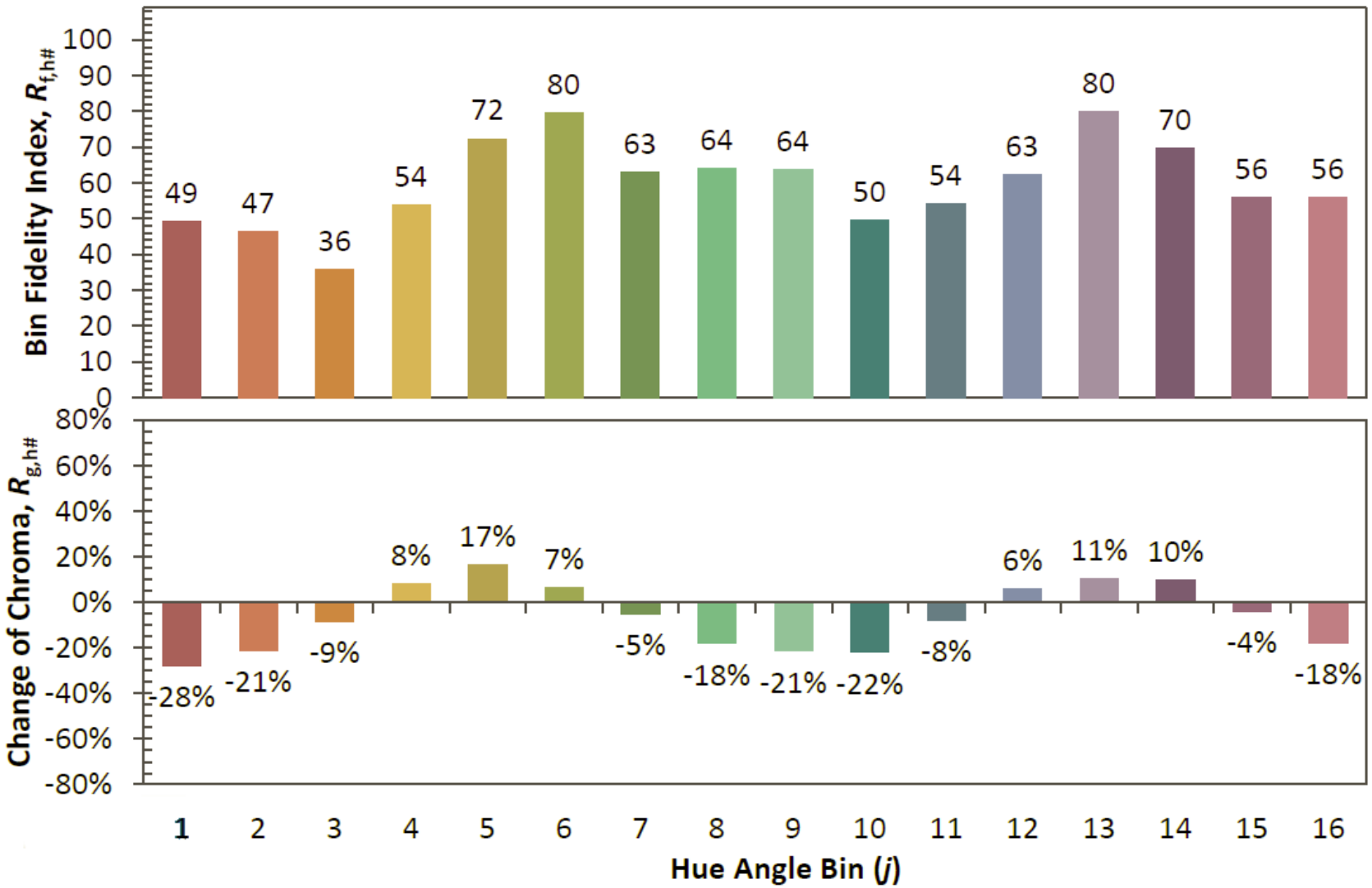
$$60 < R_g \leq 140$$

Gamut (Saturation)

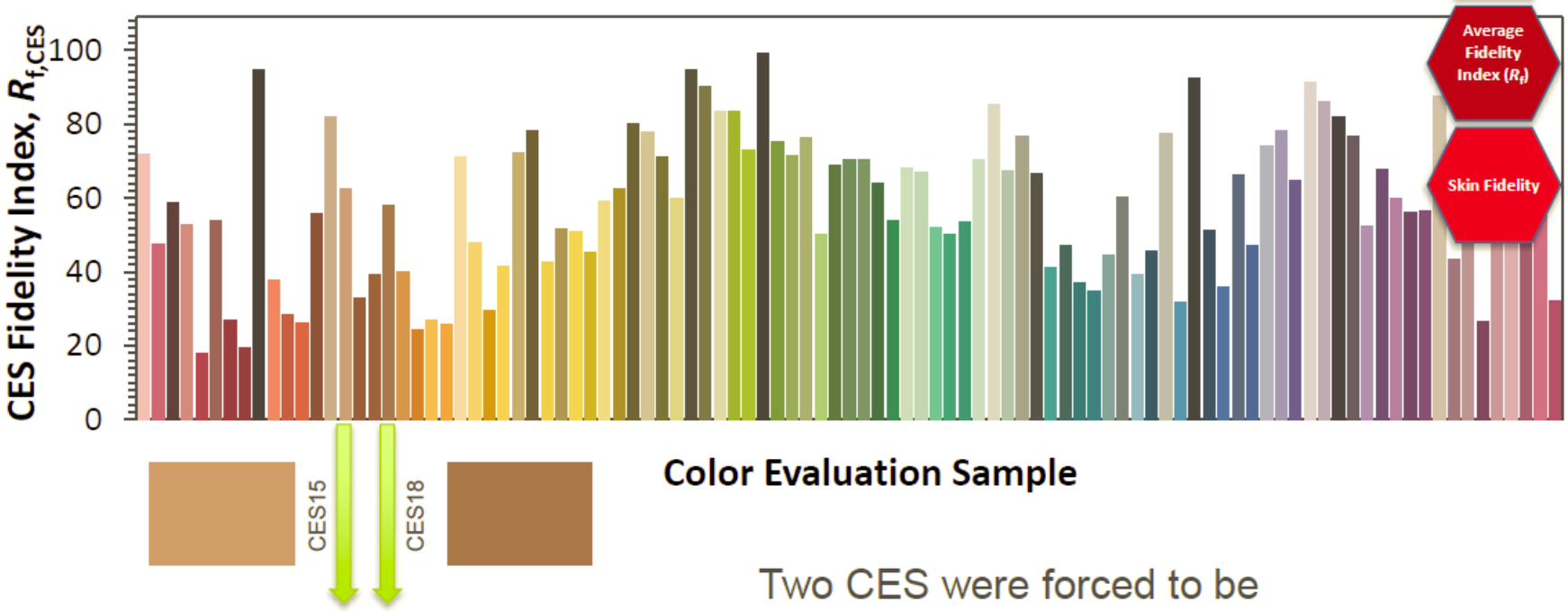
6. Color Distortion Icon



6. Hue Bin Indices



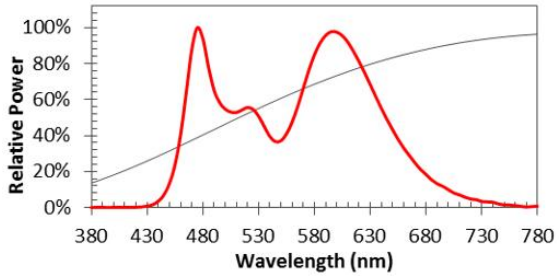
6. Fidelity (skin)



$$R_{f,skin} = \frac{R_{f,CES15} + R_{f,CES18}}{2}$$

Two CES were forced to be measurements of human skin. The two samples lead to the highest correlation in R_f compared the full set of thousand of measured skin samples.

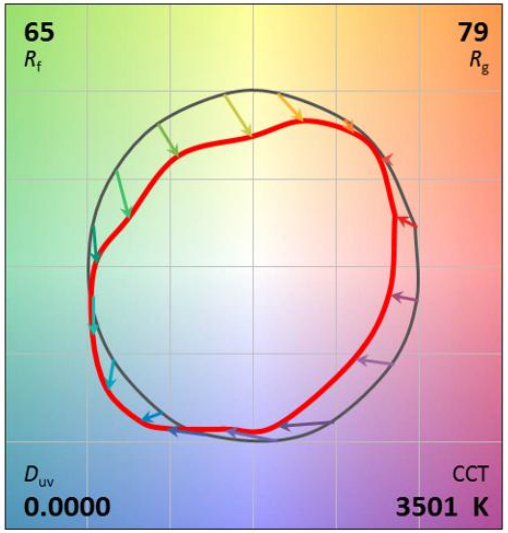
6. Example revisited: CRI compared to TM-30



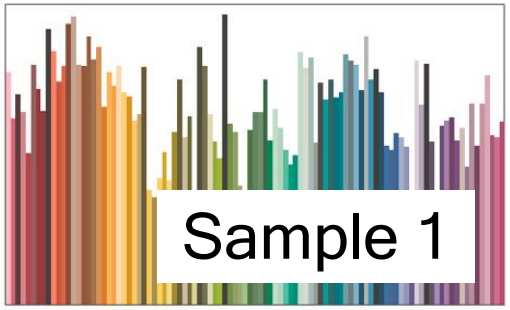
Sample 1:

Ra = 75

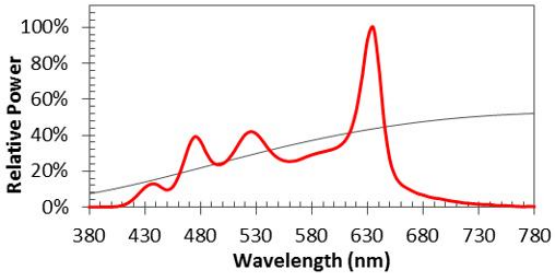
Rf = 65

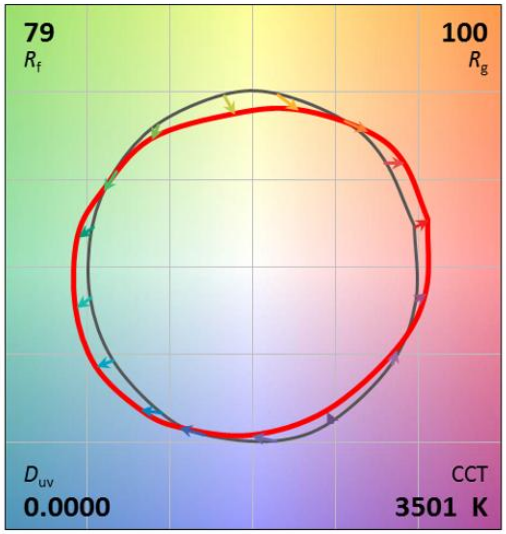


CRI = 75, R_9 = 20



→ Rf shows that sample 2 is clearly closer to the reference
(and also prefered)



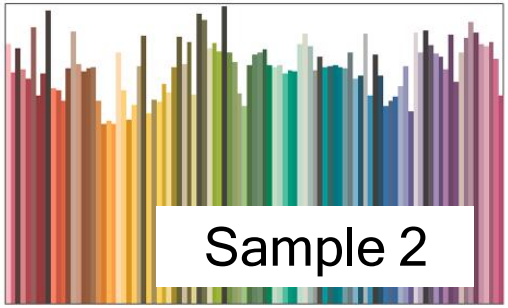


CRI = 77, R_9 = 22

Sample 2:

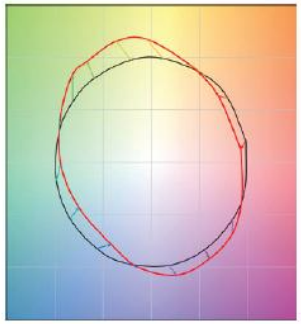
Ra = 77

Rf = 79

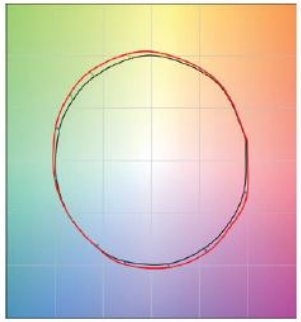


6. Some manufacturers start already using TM-30

Vibrant Series V80

CCT	CIE R_a	GAI	TM30-15 Rf	TM30-15 Rg	Color Vector Graphic	Color Distortion Graphic
3,000K	83	111	77	105		

Vibrant Series V95

CCT	CIE R_a	GAI	TM30-15 Rf	TM30-15 Rg	Color Vector Graphic	Color Distortion Graphic
3,000K	95	120	93	106		

Example:
Xicato

7. When will CRI be replaced?

CIE Position Statement on CRI and Colour Quality Metrics

15. October 2015

- CIE **supports** the **study** of the recently published IES Technical Memorandum **TM-30**
- TC 1-90 [fidelity metric – "new CRI"] and TC 1-91 [preference metric] both plan to complete their **Technical Reports within 2016**
- Current CRI (CIE 13.3) will not be **officially replaced** until a **new metric** is widely **accepted**

7. Take-Home Message

- There are many different applications in lighting
- We want and need is a diversity of light sources

→ **No single metric to describe „quality of light“ can cover all aspects.**

- A **two-metric approach** (like TM-30-15) can cover **almost any lighting applications**
  - Fidelity
  - Gamut (Color saturation) → relates largely to„preference“

  → TM-30 gainingly strong support in the industry (Xicato, Soora …) but future of TM-30 yet undeceided (CIE)

Sources

- TM-30-15 information based on presentations from Michael Royer, Pacific Northwest National Laboratory
- Webinar US Department of Energy (DOE):

  http://energy.gov/eere/ssl/webinar-understanding-and-applying-tm-30-15

  http://energy.gov/eere/ssl/downloads/webinar-technical-discussion-tm-30-15

- CIE Position Statement on CRI and Colour Quality Metrics http://www.cie.co.at/index.php?i_ca_id=981

More questions?

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