U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

How New Methods for Evaluating Color Rendering will Affect You

Lightfair

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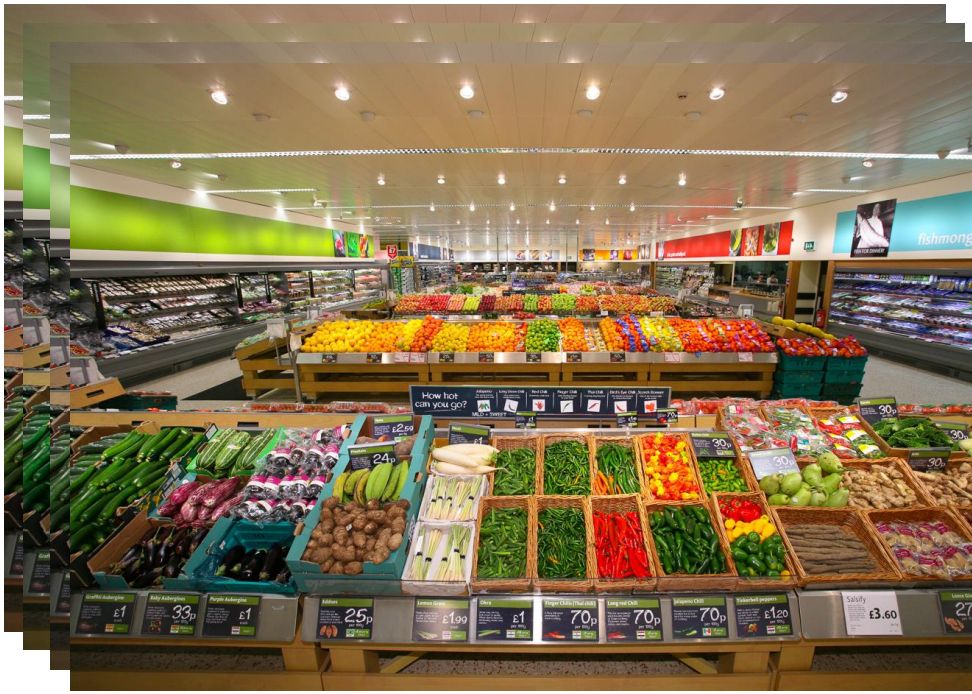
Color Fidelity: A Partial Picture

Reference Image



The CIE Color Rendering Index (CRI)

What CRI conveys:

- Average color fidelity/color shift (but with limitations)
  - Outdated color science
  - Few samples
  - Only pastel Munsell samples
  - Can be selectively optimized

What CRI doesn't convey:

- Direction/type of color shifts
- Increases or decreases in chroma
- Information about specific hue regions
- Human preference
- Color discrimination potential
- Difference in color for any specific object
- How one source will make things look compared to another

One Index is Not Enough.

But how many are needed?

And what should they be?

A Path Forward: IES Color Metrics Task Group

- Technical Memorandum (i.e., calculation procedure), TM-30
- Currently in final stage of balloting
- It draws from a variety of other color perception research
- Based objective/mathematical approach

- Two-metric system (fidelity [R_f] and gamut [R_g]*)* for quantifying *average* color rendition
- 99 color evaluation samples (CES) with color space and wavelength uniformity
  - Excellent correlation to much larger sets of color samples
- Improved color science
- Many additional tools (e.g., color distortion icon) for better understanding rendition of specific hues.

TM-30 IS NOT YET A FINAL DOCUMENT!

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Summary of Notable Features

Calculation Engine

- 99 color evaluation samples
  - Real objects
  - Color space uniformity
  - Wavelength uniformity
- Calculations in CAM02-UCS
  - CIECAM02 chromatic adaptation
  - Most uniform color space
  - Stability over CCT
- Mixed reference (4500 K to 5500 K) eliminates discontinuity

Outputs

- Average Color Fidelity: R_f
- Average Color Gamut: R_g
- R_f Versus R_g Plot
- Color Distortion Icon / Color Saturation Icon
- Color Fidelity by Hue Angle (16 Groups)
- Chroma Change by Hue Angle (16 Groups)
- Skin Tone Color Fidelity
- Color Fidelity by Sample

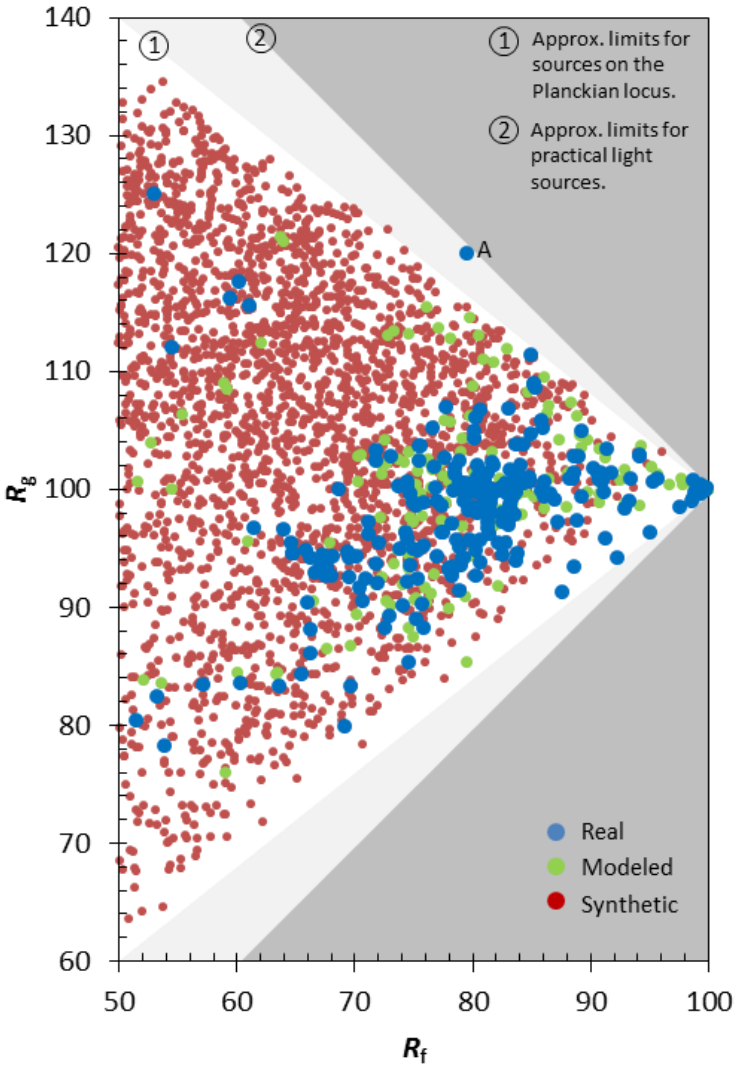
A Two-Metric System for Average Characterization

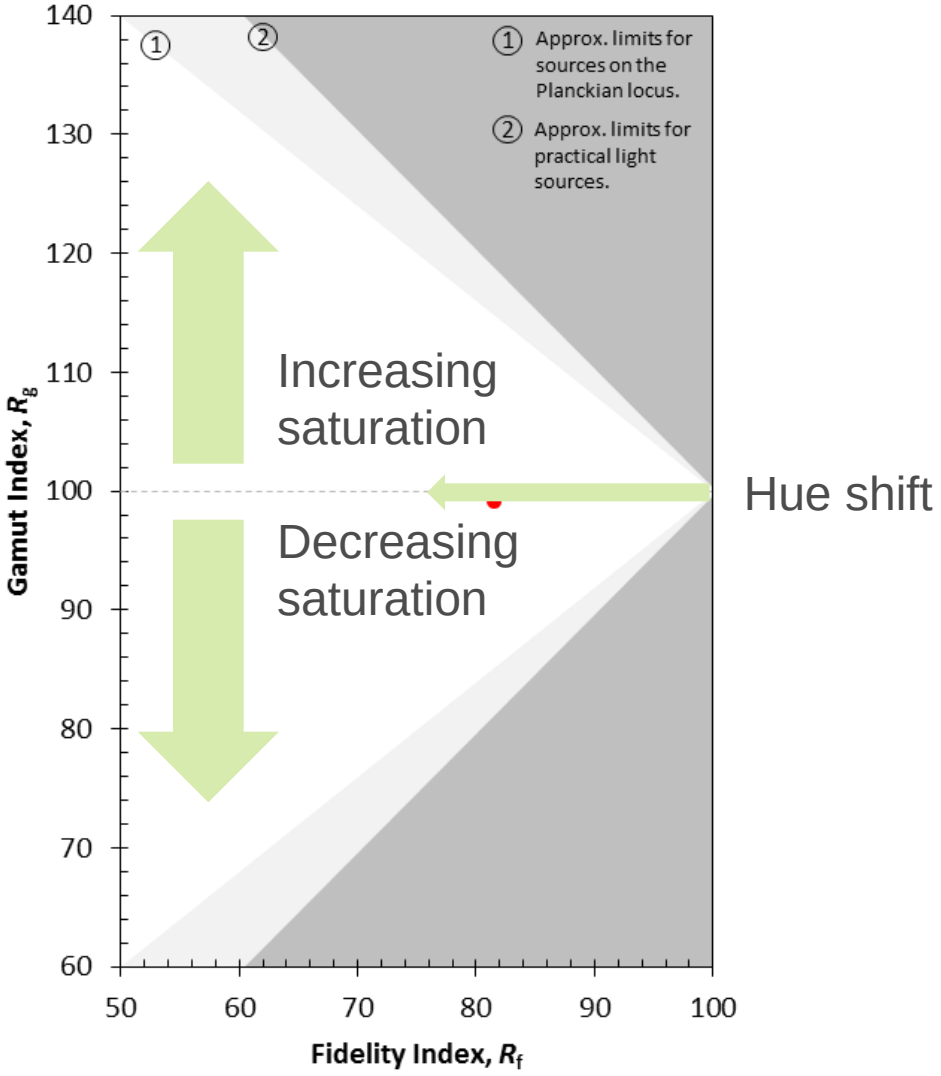
$$0 < \boldsymbol{R_f} \leq 100$$

When $R_f > 60$:

$$60 < \boldsymbol{R_g} \leq 140$$

R_f Versus R_g Plot





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What does it all mean…

For Specifiers?

For Manufacturers?

For Researchers?

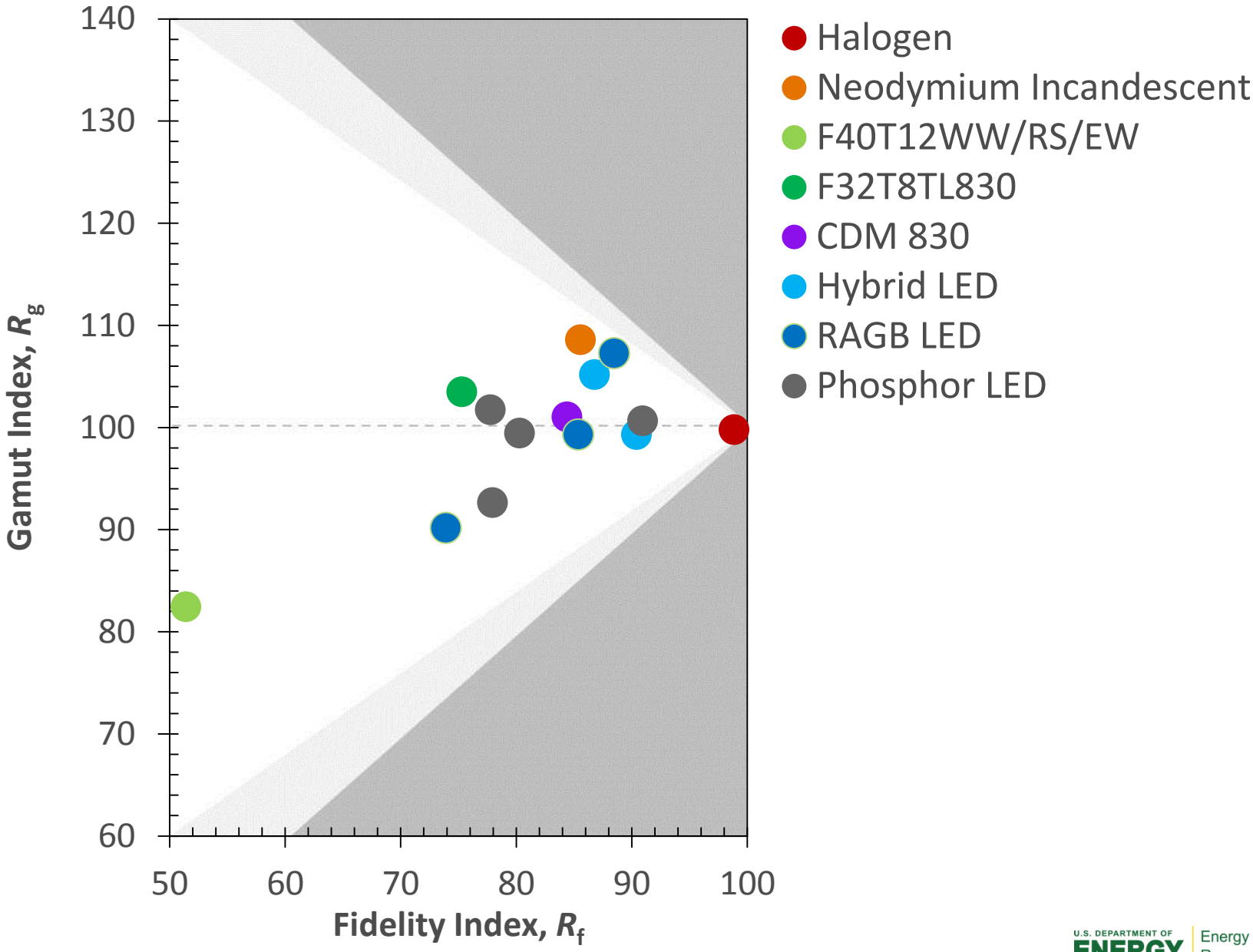
For Energy Efficiency Programs/Utilities?

Specifiers

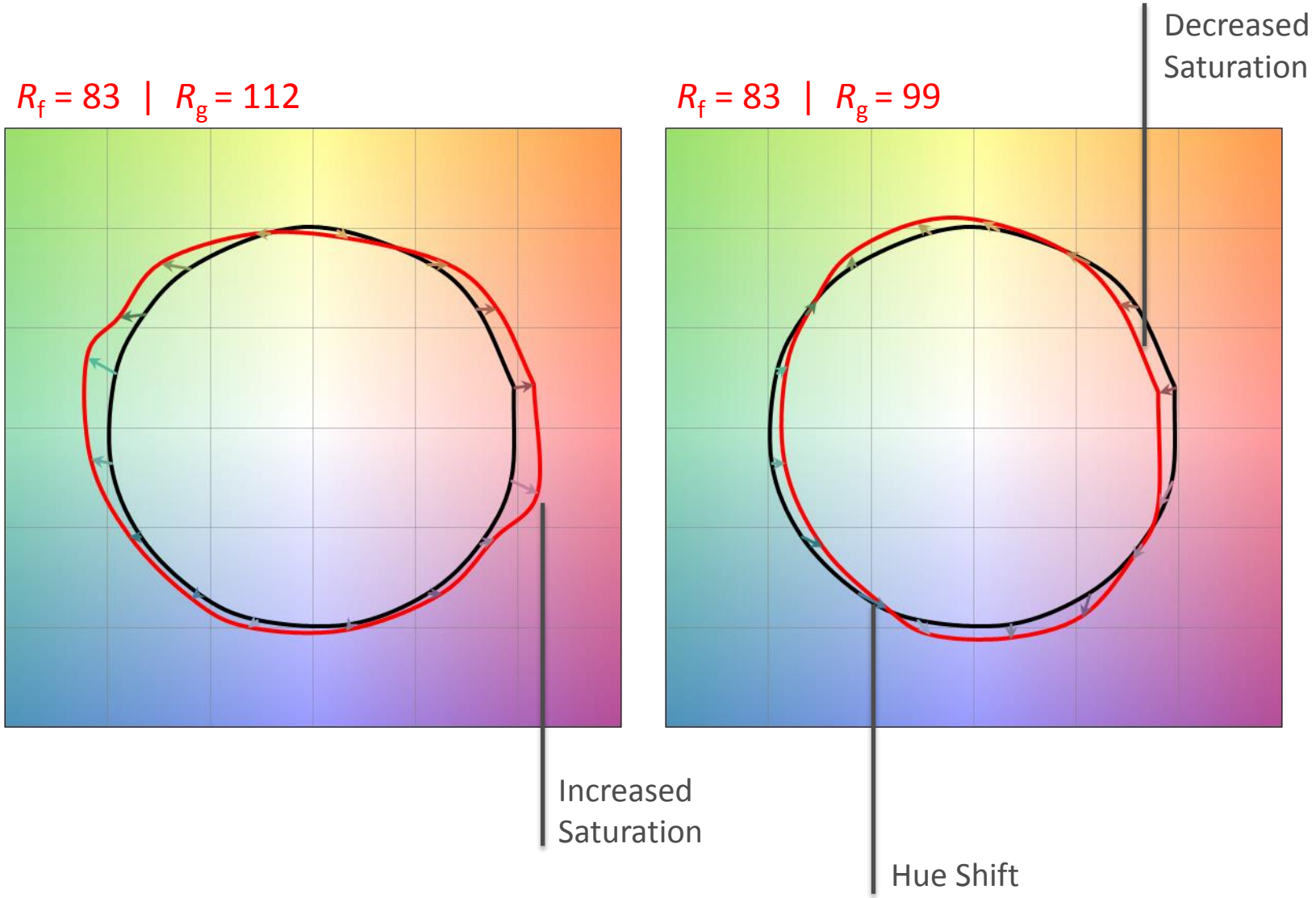
1. Learn about the new metrics
   - Presentations, Journal Articles, TM-30 (Pending), DG-01 (Pending)
   - What they do and don't characterize; *limitations*
2. Examine values for existing sources, understand your preferences in applications where you commonly specify
3. Use additional information for better specifications

- **Case study: Museums**

Comparing R_f and R_g



Color Distortion Icon



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Manufacturers

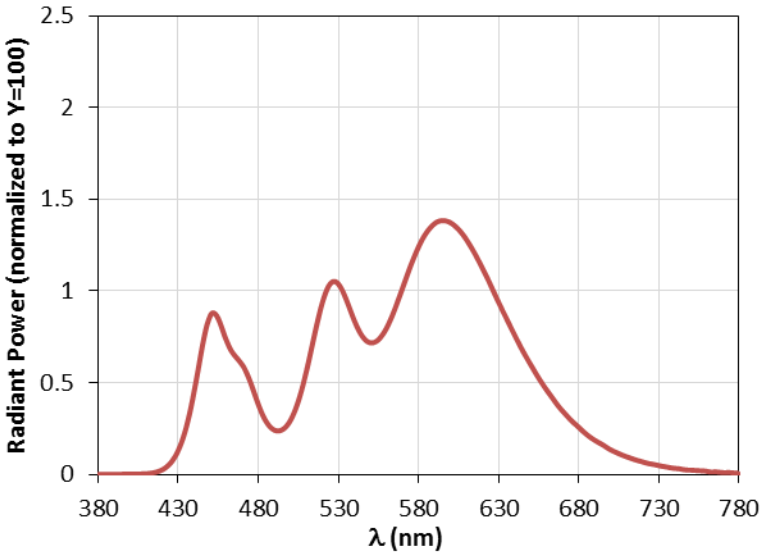
1. Learn about the new metrics
   - Presentations, Journal Articles, TM-30 (Pending), DG-01 (Pending)
   - What they do and don't characterize; *limitations*
2. How do your products measure up against others?
3. Does your product have distinguishing features that are marketable?
4. Use tools for future optimizations
   - Balance between efficiency and color rendition

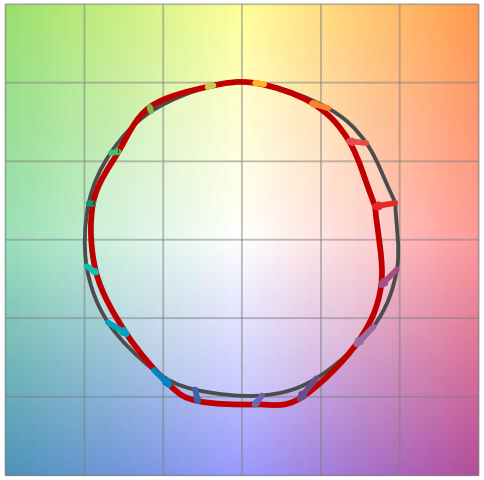
- **Case study: Neodymium Lamps**

Communicating Performance

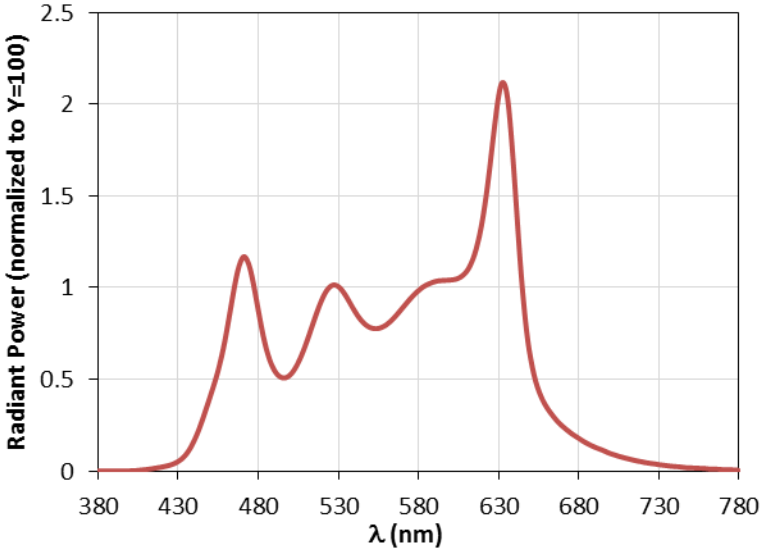
(Live Calculation Tool Demo)

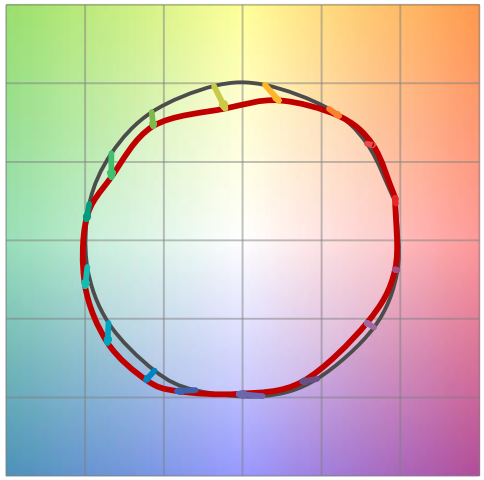
Beyond Averages





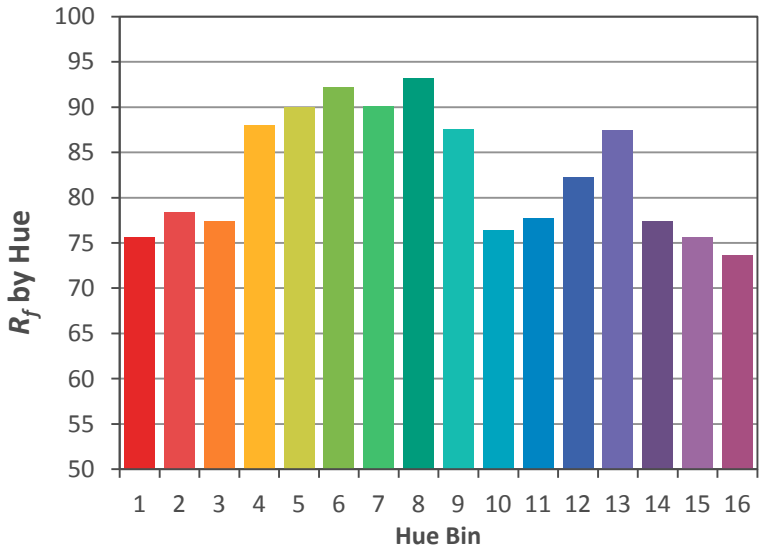
R_f = 82
R_g = 95
LER = 342

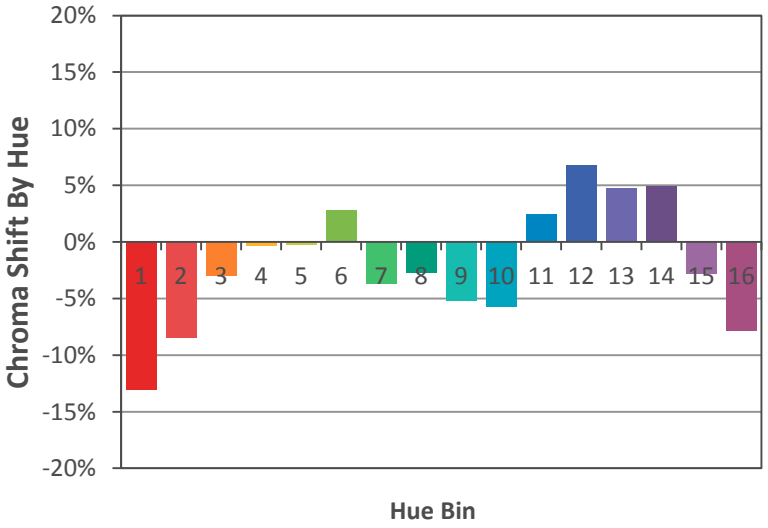


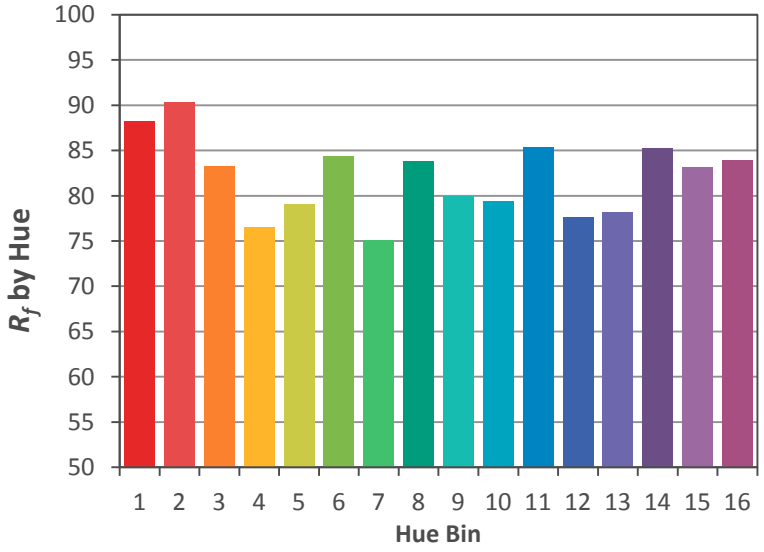


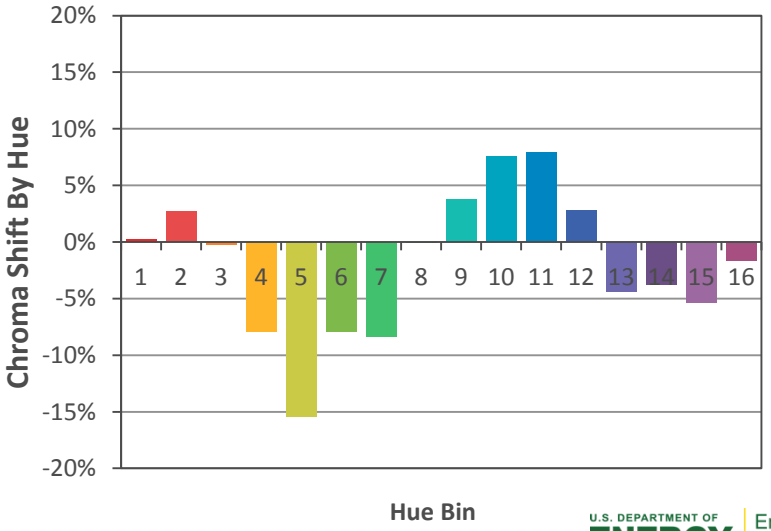
R_f = 82
R_g = 95
LER = 318

Beyond Averages







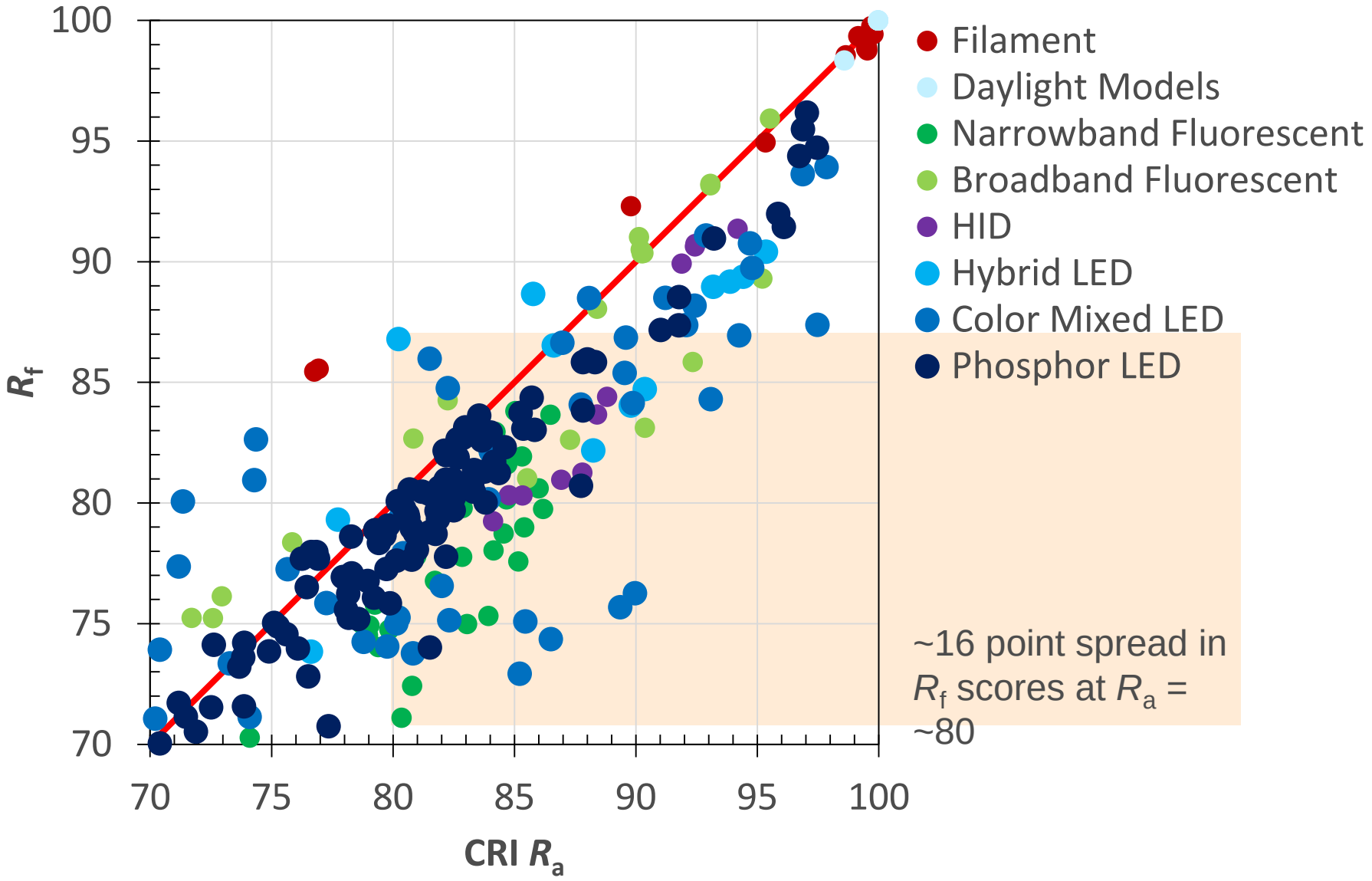


EE Programs/Regulators

1. Learn about the new metrics
   - Presentations, Journal Articles, TM-30 (Pending), DG-01 (Pending)
   - What they do and don't characterize; *limitations*
2. How do existing thresholds for color rendering relate?
3. Should all sources that previously qualified still do so? Should the numerical value stay the same?

- **Case study: Triphosphor Fluorescent**

Comparing R_f and R_a



Researchers

1. Learn about the new metrics
   - Presentations, Journal Articles, TM-30 (Pending), DG-01 (Pending)
   - What they do and don't characterize; *limitations*
2. New information can improve characterization (but averages shouldn't always be used to establish correlations)
3. What new investigations are warranted?

- **Case study: Preference by Application**

WHY ADOPT?

- With two average numbers and other visualization tools, TM-30 provides a **more complete characterization** of color rendition than a fidelity metric alone (e.g., CRI).
- With a greater number of samples, the values are **harder to selectively optimize** and should provide a better representation of average color rendering.
- The method can help manufacturers **optimize spectral designs**, as well as **accurately weigh tradeoffs** between color rendition and other characteristics.
- The color rendition characteristics of products can more easily be **differentiated** (and marketed).
- The method can help specifiers and purchasers to select products that are more appropriate for their needs.
- Thresholds, design guidance, and preconceptions will need to be re-evaluated.

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