KANSAS STATE UNIVERSITY | Architectural Engineering and Construction Science

LED Lighting Retrofits

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LED LIGHTING WORKSHOP

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KANSAS STATE UNIVERSITY

Agenda

Goals for Retrofit

Characteristics of LED Sources

Light Source and Fixture Issues

Power Related Issues

Automatic Controls

Cost Generalities

Understanding the AMA Guidelines for Exterior Lighting

Goals for Retrofit

Reduction in energy consumption

- We expect the LED sources to consume less wattage than fluorescent or HID sources.
- Typical savings are 45-70%. This all depends on the existing conditions.
  - The efficacy (lumens/watt) of the current light source vs new source
  - Current light level vs. new design light level
- Type of control scheme used
  - Manual vs. automatic

Improved Controls

- More people having access to controls increases efficiency.
- Light source lends itself to repeated on/off & dimming controls.
- We expect to save even more money!

Reduce the heat gain related to the cooling load

Goals for Retrofit

Replacing non-functioning lighting systems

- Decreased maintenance costs
- Improved space appearance
- Provide the correct quantity of light

Improve the quality of light

- Correct light source for the desired appearance
- Correct color rendering
- Lighting system that supports better health

Upgrade the general appearance of the spaces

- Improve moral
- Perceived appearance by users and stakeholders

Characteristics of Light Sources

General Terms:

Lumens

- This is the term used to describe the amount of light emitted by the light source.
- Think of it as lighting power.
- All manufacturers will provide this information.
- You must compare current vs. new.

Nom. Lamp Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg. Qty.*	Description	Nom. Length (In.)	Rated Avg. Life, Hrs 3-Hr. Start (202)	12-Hr. Start (241)	Approx. Initial Lumens (203, 204)	Design Lumens (208)	CRI
Universal T8 Fluorescent Lamps T8 Medium Bipin											
17	36787-0	$	F17T8/TL830/ALTO	25	TL 830, 3000K	24	20,000	25,000	1400	1300	85
	36791-2	$	F17T8/TL835/ALTO	25	TL 835, 3500K	24	20,000	25,000	1400	1300	85
	36793-8	$	F17T8/TL841/ALTO	25	TL 841, 4100K	24	20,000	25,000	1400	1300	85
	14123-4	$	F17T8/TL850/ALTO	25	TL 850, 5000K	24	20,000	25,000	1400	1300	85
	36807-6	$	F17T8/TL730/ALTO	25	TL 730, 3000K	24	20,000	25,000	1325	1200	78
	36808-4	$	F17T8/TL735/ALTO	25	TL 735, 3500K	24	20,000	25,000	1325	1200	78
	36812-6	$	F17T8/TL741/ALTO	25	TL 741, 4100K	24	20,000	25,000	1325	1200	78

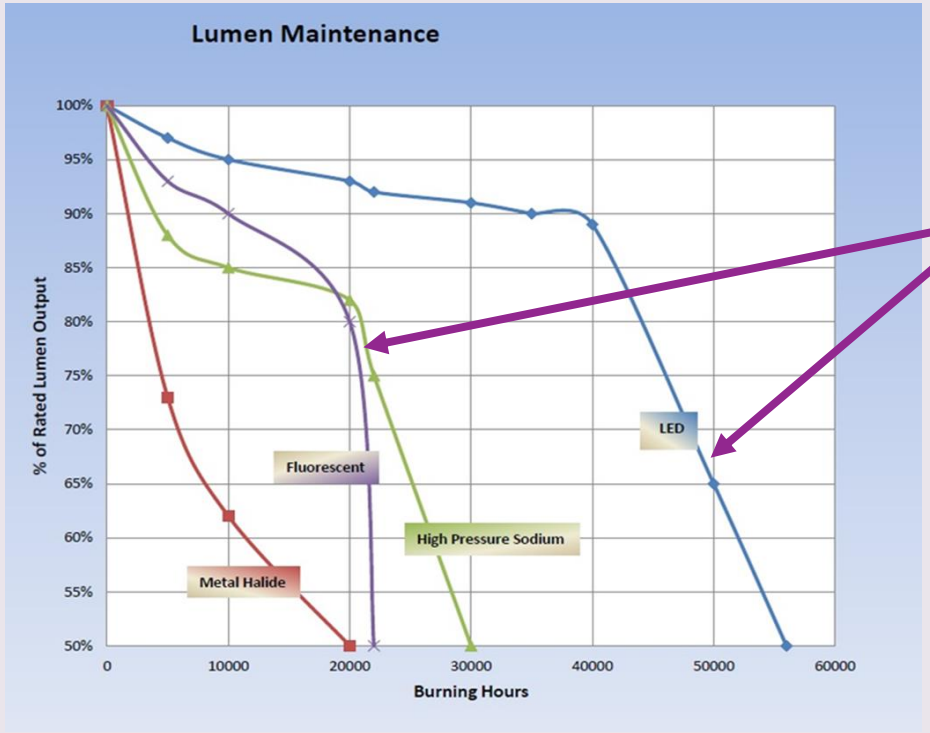
LED PACKAGE	EXAMPLE: L40/840		WATTAGE	
LUMEN PACKAGE	LUMENS	MINIMUM CRI & CCT	SRK/ SRKA	SRKR/ SRKS
4"				
L31	3,100		21	20
L52	5,200	30 = 82 CRI, 3000K	34	34
L70	7,000	35 = 82 CRI, 3500K	47	47
8"		40 = 82 CRI, 4000K		
L63	6,300	50 = 82 CRI, 5000K	43	40
L104	10,400		70	70
L140	14,000		94	94

Lumen output based on 4000 CCT. Actual lumens may vary +/-5%, see fixture performance data. Additional LED lumen packages available, see options.

Characteristics of Light Sources

Lumen Maintenance (Depreciation)

- Over time the lumen output decreases because of burn hours, number of starts, etc.



These 2 points generally relate to lamp life

Characteristics of Light Sources

Lighting Color

- Correlated Color Temperature (CCT)
  - Represents how the light source appears – cool or warm
  - This is listed in degrees Kelvin (K)
- Color Rendering Index
  - Quantifies how a light source represents colors in the space
  - Perfect CRI is the incandescent lamp and has a rating of 100
- You must compare existing and new

Nom. Lamp Watts	Product Number	Symbols, Footnotes	Ordering Code	Pkg Qty	Description	Nom. Length (In.)	Rated Avg. Life, Hrs. 3-Hr. Start (202)	Rated Avg. Life, Hrs. 12-Hr. Start (241)	Approx. Initial Lumens (203, 204)	Design Lumens (208)	CRI
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LED PACKAGE

EXAMPLE: L140/840

LUMEN PACKAGE	LUMENS	MINIMUM CRI & CCT	WATTAGE SRK/ SRKA	WATTAGE SRKR/ SRKS
4"				
L31	3,100		21	20
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L70	7,000	**835** = 82 CRI, 3500K	47	47
8"		**840** = 82 CRI, 4000K		
L63	6,300	**850** = 82 CRI, 5000K	43	40
L104	10,400		70	70
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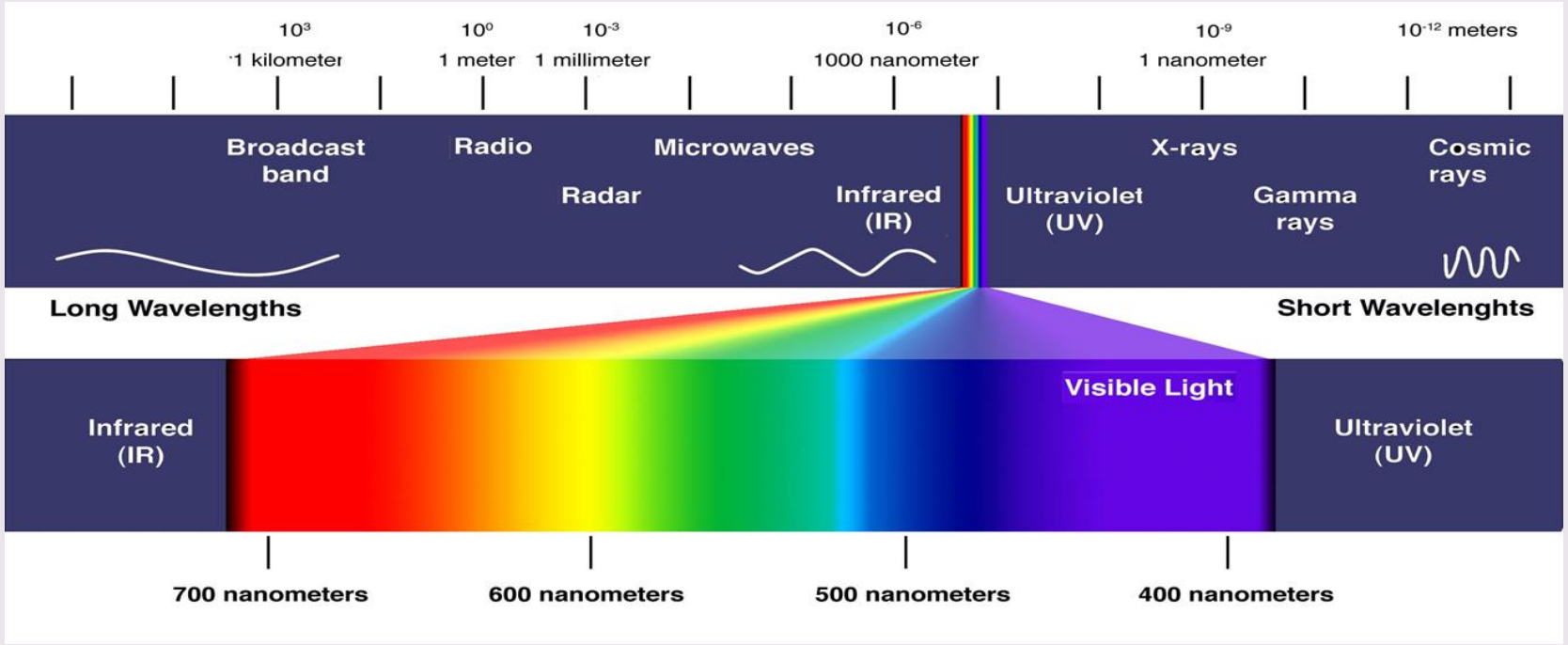
Lumen output based on 4000 CCT. Actual lumens may vary +/-5%, see fixture performance data. Additional LED lumen packages available, see options.

Characteristics of Light Sources

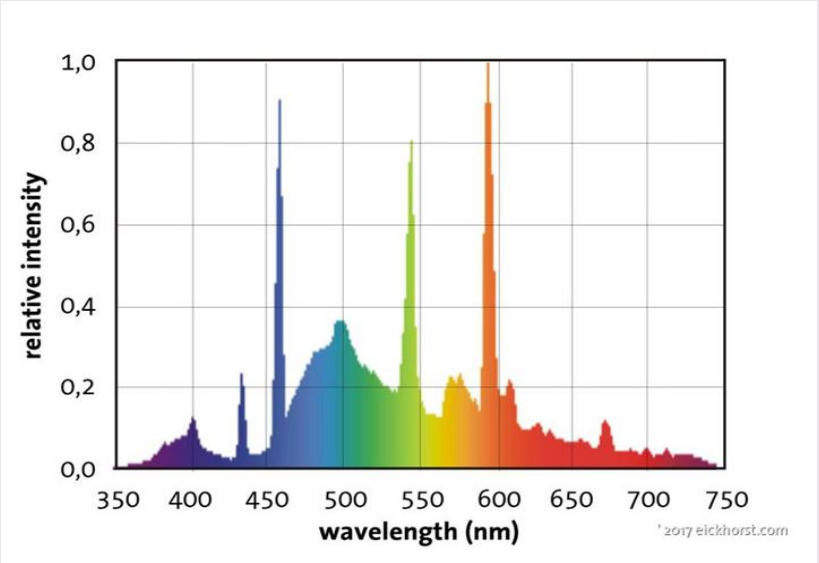
Wavelength of Light

- Wavelengths of visible light produced by various light sources varies
- Visible light is 380-750 nanometers. The figure below shows the colors associated with each wavelength



Characteristics of Light Sources

A lamp's spectral distribution diagram (example shown below) shows the wavelengths and intensities of each wavelength present.



All wavelengths mixed together create white.

This is a 3rd piece of data to use when determining how colors will appear in the space. We only see what is reflected back to us. For example, without a blue wavelength we will not see blue objects. The variation in the intensities relates to the CCT and CRI.

Characteristics of Light Sources

Lamp Life

- Lamp life is defined differently for fluorescent, HID and LED light sources.
- For fluorescent and HID sources, lamp life is the point at which 50% of the tested lamps have failed.
- LED light sources however are rated at the time at which 70% of the initial lumens still exist.
- In approximate terms, light source lamp life is:
  - Fluorescent tubes – 20,000 hours
  - HID – 10,000-24,000 hours
  - LED – 40,000-50,000 hours

Lamp Life Effects

- The obvious item is maintenance: longer lamp life = less maintenance cost
- Burnout factor is less – less lamps out at any given time

Efficacy

- Term used to describe lumens/watt. This is the primary piece of data to compare energy use.

Light Source and Fixture Issues

First the correct light source must be selected.

- The lumen output directly relates to the light level in the space. Footcandle (FC) is a common unit of measure describing light level. FC is lumens/square foot. System efficiency does come into play.
- The way a space appears is related to the CCT. Ratings typically vary from 2700K to 5000K. A 2700K CCT source will appear “warm” and will be associated with relaxation and casual activities. A 5000K source will appear “cool” and will be associated with energizing or focused activities.
- CRI is also an important consideration. Typical ratings for LED sources might range from 80-90. Some applications demand good color rendition but others may not. Generally the higher the CRI rating the more expensive the light source is.
- Lamp life has become a big issue because of the maintenance issues related. Different light sources have approximate values of:
  - Fluorescent tubes – 20,000 hours
  - HID – 10,000-24,000 hours
  - LED – 40,000-50,000 hours

Light Source and Fixture Issues

LED light sources come in a variety of shapes and styles.

Replacement sources are designed to screw or plug into existing lamp holders. These LED sources use integral drivers, built within the lamp enclosure.

Designed to insert directly into the fluorescent lamp sockets and use the existing ballast. Minimal changes to the fixture are required.

Issues with these include the potential for lamp failure and pairing with an old ballast that will still have maintenance issues. This is generally not a good option.

Light Source and Fixture Issues

Other replacement LED sources also have integral drivers but are designed to work off of line voltage.

In this scenario the existing ballast is removed and the lamp sockets are wired directly to the 120V or 277V incoming power.

This requires more effort to retrofit than the previous example.

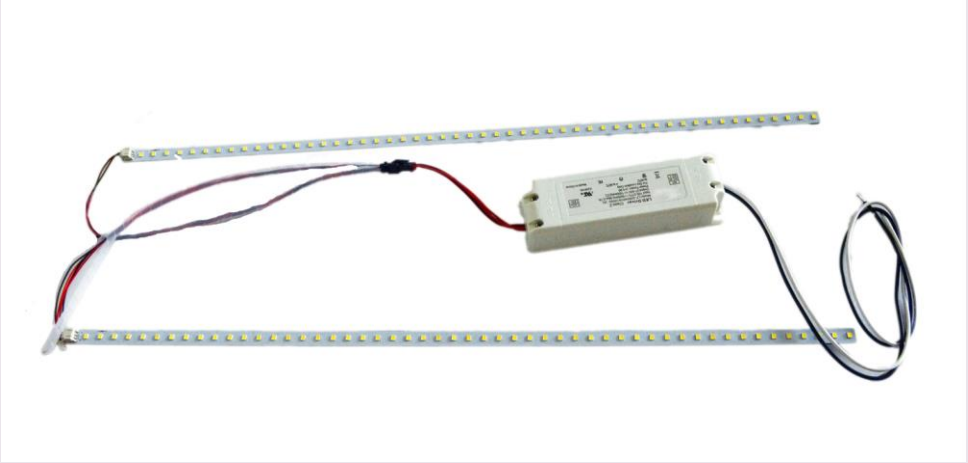
A potential problem with this scenario is that the lamp sockets are really not rated for line voltage so most socket manufacturers will recommend against this.

Light Source and Fixture Issues

A third option is to install an LED retrofit kit containing new LED lamps and new driver. In this case the existing lamps, sockets and ballast are removed. The fixture enclosure and integral photometrics remain.

Labor hours are greater with this option but this no longer relies on existing components that can destroy maintenance savings expectations.

Retrofit kits must be checked to make sure they fit within the fixture. Thermal management is also a key component to any retrofit.



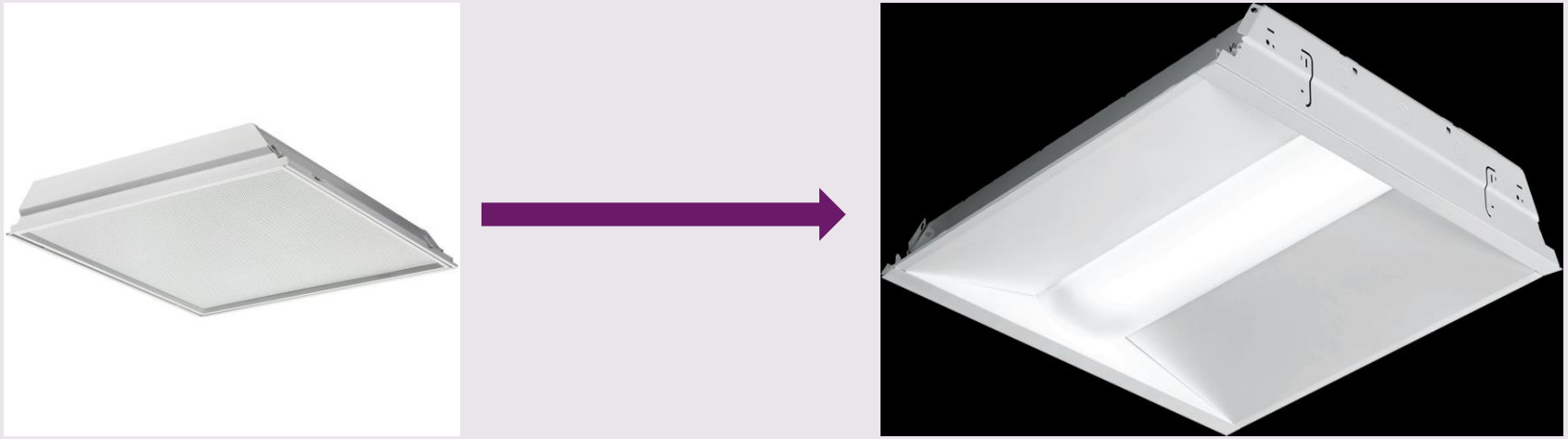
Light Source and Fixture Issues

Lastly there are manufacturers who make complete/pre-wired retrofit kits that use the existing fixture body but have new a reflector plate, LED sources and drivers. Available depth is an issue.

These are mostly designed to retrofit specific brands of fixtures.

They can be installed without removing the fixture from the ceiling.

This is also a way to change the appearance of the fixture, as an example shown below.



Light Source and Fixture Issues

Depending on the amount of work needed to retrofit existing fixtures, a final option is to just replace the entire fixture.

- Manufacturers may offer good pricing when looking at a large number of fixtures.
- You avoid any issues with fixture manufacturers' warranties after retrofit.
- Are able start with a clean fixture again which makes the fixture more efficient.

Light Source and Fixture Issues

Retrofitting downlights, HID and outdoor fixtures is very similar to that described for fluorescents above.

Screw base HID sources can be replaced with LED retrofit lamps having integral drivers and working off of the existing ballasts. Also the same disadvantages exist.

Retrofit kits with new LED sources and drivers can be easily installed within the fixture enclosure.

Power Related Issues

With a retrofit project that goes from fluorescent to LED, or HID to LED we expect to see a significant decrease in the consumed wattage.

- Amounts to 35-50% reduction
- Electrical circuits that were designed for incandescent, fluorescent, or HID will now have plenty of power for the LED sources.
- It’s possible to add additional fixtures to these circuits and not exceed their capacity.

Existing manual, line voltage controls may or may not work with the retrofitted fixtures.

- On/off control is probably still going to work.
- Dimming is likely to have problems. The lamps, dimmers and drivers all play a part in this issue. Ask for confirmation that the end product will perform as you intend.

Automatic Controls

The addition of automatic, low voltage controls is a logical next step when it comes to an LED retrofit project.

- While the LED sources will significantly reduce the energy used, added automatic controls can have an equally large impact.
- In some cases the existing controls may not work well with the retrofit sources.
- Energy savings is possible by turning off fixtures when no one is in the space, giving more people access to individualized space controls, or automatically dimming the lights when adequate daylight exists from windows or skylights.
- The retrofit controls market is just as big or bigger than the retrofit light source market.
- Control systems can use sensors and local switches that are wired with communication cabling, or wireless.

Cost Generalities

Lots of case studies are available from a variety of manufacturers, retrofit contractors, and energy service companies (ESCO's).

Numbers here are intended to show possibilities that could exist. Specific results are always based on an analysis of the project envisioned and the cost of electricity.

Energy Costs

- The ultimate cost savings from electricity depends on the difference between the existing and new installation.
  - Some existing spaces might have current light levels much higher than needed. The LED retrofit might then use a lower design light level and therefore save a great deal of power.
  - In some cases the existing light level could be the same as the new light level. In this instance the savings would be reduced.
  - Ultimately, the savings is going to boil down to both the wattage reduction and difference in lumens.
- Expected energy cost savings of 50-70% are realistic. Simple paybacks of 2-3 years should be achievable.

Cost Generalities

Maintenance costs are also expected to decrease

- This depends on what the retrofit entailed – refer back to the options discussed earlier.
- Costs for lamp change out only will be the largest savings but existing drivers and ballasts will still have on-going maintenance costs.
- With a new installation the maintenance costs will decrease initially.

Rebates and Incentives

- Lighting & controls upgrades relate to rebates currently offered by KCPL, MO.
- KCPL, KS and Westar Energy seems to still be focused on solar but may offer something related to lighting.
- Other smaller distributors may also offer some rebates.
- The Kansas Corporation Commission at one time offered money to perform energy audits.
- You need to check with your local power provider to see what they might be able to do.

Grants

- There are several sources for energy retrofits. A qualified professional can help guide you to these. http://www.dsireusa.org/ is a website that can be searched for possible opportunities.

Warranties and Life Expectancy

- Most retrofits offer 2-3 year warranty. Make sure you go with a proven manufacturer.
- The life expectancy of light sources is usually 10-15 years under normal use.

LED Retrofit Summary

There are significant, potential energy reduction $$ related to performing an LED lighting retrofit of existing incandescent, fluorescent and HID installation.

In many cases not only are energy and maintenance costs savings being realized, the quality of the lighting is improved.

- Correct light levels
- Correct CCT & CRI to improve occupant performance
- Aesthetic improvements with new fixtures

New controls should also be considered since there are savings associated with that too.

A qualified professional should be engaged to analyze all of the potential improvements to your facilities and prepare a detailed expense and savings report. Lighting and controls will show themselves to be enticing because of the usually short pay back period.

Understanding the AMA Guidelines for Exterior Lighting

June 2016 – AMA released their report *Human & Environmental Effects of Light Emitting Diode Community Lighting*.

- The report was created without the cooperation or support of the leading lighting organizations in the world, namely the Illuminating Engineering Society (IES).
- The focus of the report was tied to their view of human health. The issue really was the effect “blue light” had on the human circadian rhythm and the health side effects.
- A key portion of the report encourages the use of 3000K or lower light sources (without any significant “blue light” component) for outdoor applications, that fixtures should be shielded, and that dimming for off-peak times be implemented.
- Many municipalities now feel pressure to abide by these recommendations.

Understanding the AMA Guidelines for Exterior Lighting

The IES is considered The Lighting Authority in the world and is responsible for publishing all standards of design related to lighting. Their response to the AMA report was quick and tried to put everything in perspective.

- These “blue light” issues are not new, nor are they restricted to LED sources.
- We do know that 460-480 nm blue wavelength light does suppress melatonin production.
- Several technical errors were contained in the report.
- Studies that had been performed did not represent all of the data needed. *At present there is inadequate documentation of what constitutes typical exposures to optical radiation in exterior settings after sunset that would constitute real-world normative data*.
- Additional lab-based tests/studies are necessary to better understand the circadian response.
- The possibility of the press inaccurately informing the public on the matter is significant.

Understanding the AMA Guidelines for Exterior Lighting

So what are the real issues?

- The eye is most sensitive to the shorter wavelengths of light (blue spectrum) at night. We perceive there to be more light than when we use longer wavelength (red spectrum) light sources. By using only the 3000K or less light sources we must design for more light and ultimately more wattage.
- The quantity and duration of blue light that affects our sleep cannot yet be determined.
- There are certainly applications where it should be left up to the lighting designer and owner to determine how the space is to “feel”. The warmer sources (3000K or less) tend to cause us to be less active, but the cooler sources (3500K and above) will have an effect of alertness and high activity. For example nighttime driver and pedestrian safety.
- CCT is not the only measure that must be considered when analyzing the light dosing that affects sleep disorders. Not all 3000K sources are the same in this regard and it’s even possible a 4000K source is better than a 3000K source.
- The quantity of research in this topic is really just beginning. New advances and data are being created every day.
- Aesthetics of the space are important issues too. An example is on the next slide.

Understanding the AMA Guidelines for Exterior Lighting

Understanding the AMA Guidelines for Exterior Lighting

Summary

The jury is still out on this deal!

We know that blue wavelength light (460-480 nm) does trigger the suppression of melatonin. What we do not know is how much and when it is introduced to humans, is a problem.

3000K CCT ratings should not be the only metric to consider. This was discussed earlier in the presentation.

More research is being done. The level of knowledge will dramatically increase over the next several years.

Engage a design professional who can guide you though this maze to recommend a design that will suit your needs and provide the information necessary to educate the public on how and why you made the decision you did.

Questions?