EXPANDING THE DIALOGUE
PHOTOBIOLOGICAL RISKS AND OTHER HAZARDS

Presented by

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ULTRA-TECH™ LIGHTING

RISK CATEGORIES

- Photobiological
  - Health risks
- Legal
  - Litigation exposure
- Financial
  - Capital costs and legal risks
- Environmental
  - Adverse environmental impact

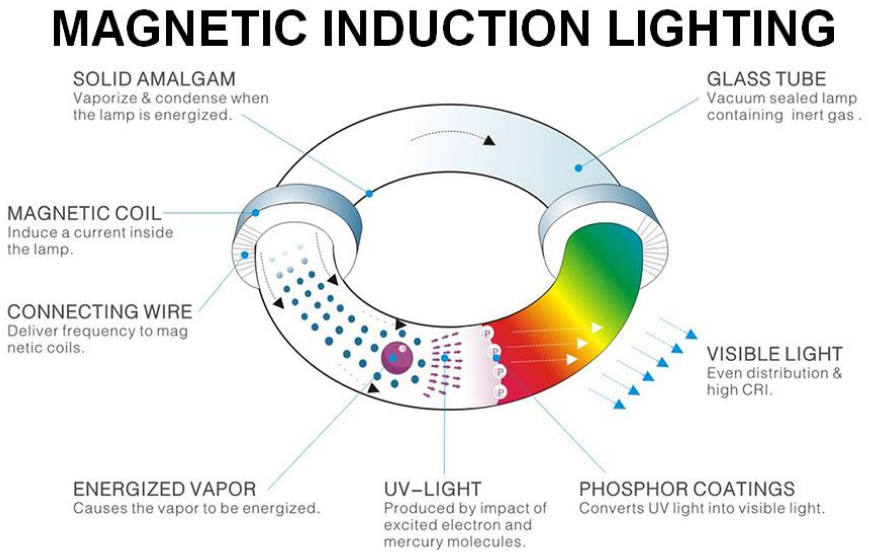
Solid State Lighting (SSL)

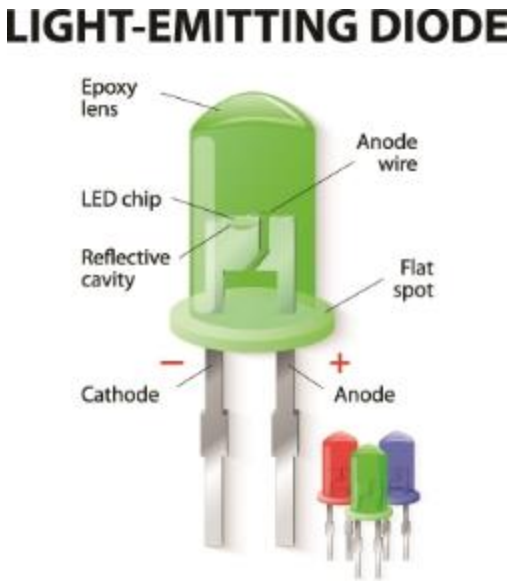
- High Intensity Concentrated Light Source
- Flicker Causes Strobe Effect
- High Blue Bias Disrupts Circadian Rhythm
- High Frequency Driver Harmonics
- Spectral Deficiencies
- Lack of Uniformity
- Simulated Reliability

Old Versus New

- Magnetic Induction Lighting Invented 1891
  - Nikola Tesla created a light emitting tube using a magnetic induction field to generate rotational energy and phosphors to convert energy to light
- Light Emitting Diode Invented 1962
  - Nick Holonyak produced a usable light source by stimulating diodes to emit light

Comparisons





Magnetic Induction Lighting (MIL) is a large format light source compared with Light Emitting Diodes (LEDs) that present as highly intense small format light sources. By virtue of their different geometry, MIL has a wide dispersion while LED has a small initial dispersion. MIL generally has efficacy of 85 lpw whereas some LEDs are as high as 200 lpw. Most commercial LEDs generate between 95 lpw and 120 lpw. MIL proven lifecycle exceeds 100,000 hours. LED estimates between 10,000 and 100,000 hours.

Intensity

- Diffusion Using Lenses
- Diffusion Using Dispersion Patterns
- Optics – Reflector Geometry
- Higher efficacy (lumens per watt)
- Change Footprint – size of SSL element

Flicker

- Increase frequency
- Use alternating flicker rates
- DC drivers
- Improved SSL technology

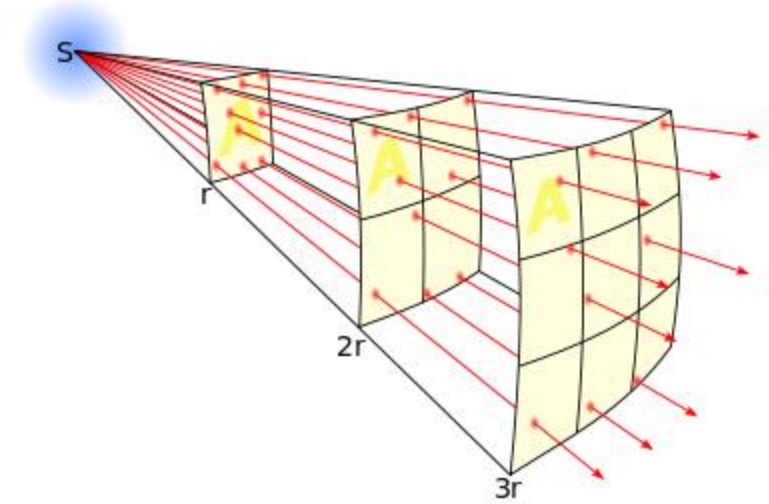
Blue Spectral Bias

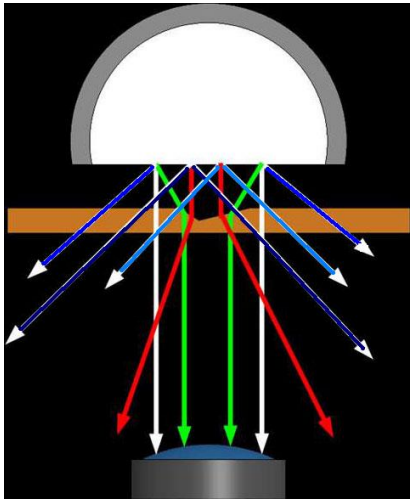
- Improve phosphorous coatings
- Filtering
- Use different SSL elements
- Blue Light Diffusion
- Blue Light Dispersion

Good and Bad

- Blue light acts as stimulant
  - Can be used to reduce workplace fatigue
  - Can be used to increase human performance
  - Can be used to keep drivers more alert
  - Can disrupt circadian rhythms
  - Can alter other hormonal cycles
  - Can damage retina
  - May cause cataracts

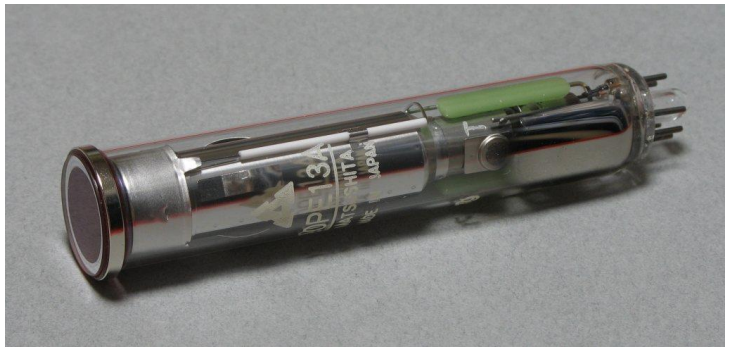
Managing the Blue Spectrum





Evidence strongly suggests blue light intensity is the photobiological trigger for most reactions. Full high altitude moonlight at 4,100K contains blue, but at less than ½ lux at sea level. A cell phone held at 15cm can project 4fc (43 lux). Research is still being conducted to determine reactionary thresholds. The objective is to find the most useful intensities for blue light to enhance visual acuity while remaining below the trigger for photobiological reactions. This requires a **different approach** to photometric design which is currently photopic without color intensity considerations (mesopic).

Old Standards



Most outdoor lighting standards are based upon old technologies. Sports venue specifications were frequently correlated with original vidicon television camera tubes that required substantially ***more light*** to effectively operate than is required for human visual acuity. Political inertia has left obsolete standards in place that do not provide for technologies like high intensity LED, plasma, or MIL deployment. Standards are not likely to be rewritten very soon. **Design flexibility and work-arounds are required.**

Realistic Expectations

- Cannot halt progress – SSL is here to stay
- Solutions
  - Unhealthful lighting should be mitigated using all available solutions
  - New solutions must be developed
- Compromise
  - When a comprehensive solution is unavailable, compromise is required

How Much Light?

Tennis court standards call for 75/60 fc with uniformity of 2.5:1 for Class II/III play. LED for typical court size including boundary generally produces excessive glare and projects too much blue spectrum at high intensity. Direct viewing can cause retinal after burn, impeding play.

Courts in Efrat replaced 1,000-watt metal halide with 300-watt MIL, achieving better visual acuity using less absolute light. Reflector design eliminates need for sky shields and rapid dissipation technology assures levels drop to avoid light pollution beyond the intended target area. The same technology that limits intensity relative to distance creates enhanced uniformity, eliminating hot spots and permitting more accurate aiming. Effective play can take place at less than 10 fc for substantial energy reductions and reduced light pollution.

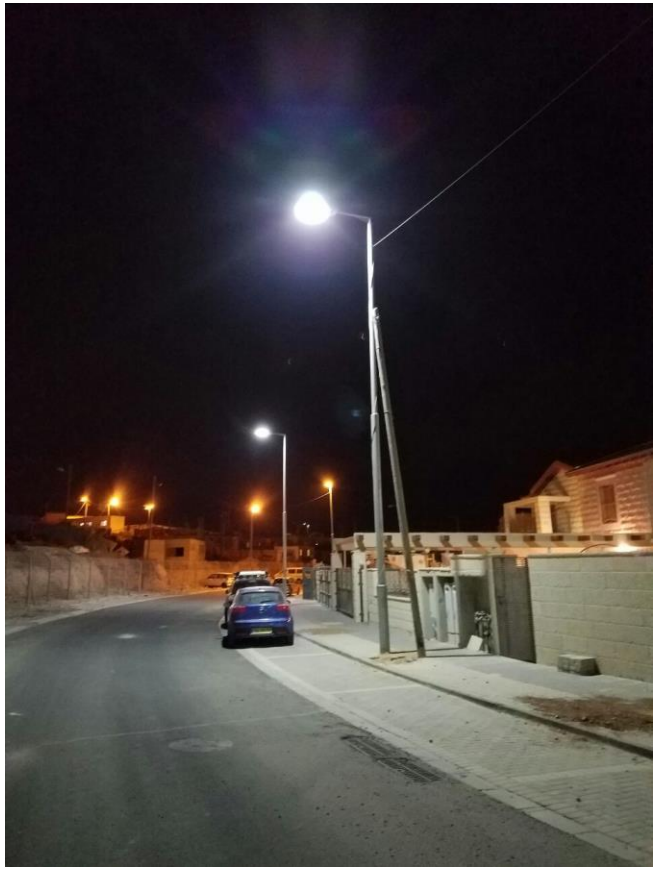
Software and Lighting Models

- Do not measure photobiological risk
- Do not measure visually effective lumens (VEL) relative to the environment
- Do not generate color temperature options relative to reflective properties of surface
- Only beginning to address blue light in generalized way
- Not based upon verified research into blue light hazards

Street Lighting Example

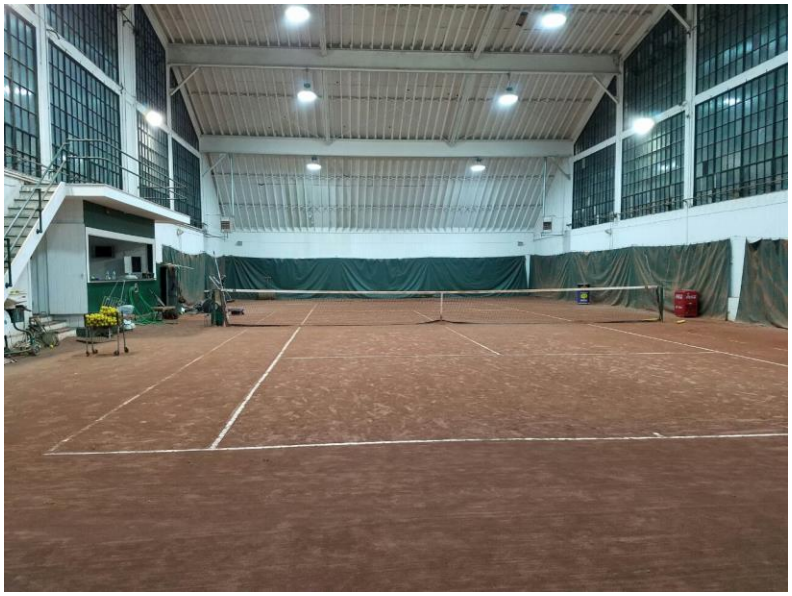
Although mesopic layouts are now used for street and highway lighting, LED fixtures are standardized between 4,000K and 5,000K color temperature regardless of blacktop or white top surfaces. Many cities are being forced to rethink LED deployment because of light pollution or excessive glare that has generated complaints.

A pilot street lighting project in Efrat uses 6,500K MIL with rapid diffusion to provide exceptional resolution and color differentiation without overpowering blue spectral bias at the viewing plane. Existing HPS in background shows comparison to existing monochromatic lighting.



Indoor Clay Tennis Court

Almost **all** indoor tennis courts use indirect up-lighting to avoid blinding players. The landmark indoor clay court located on the old Thomas Edison Estate in New Jersey was retrofitted with MIL **down-lighting** using rapid dispersion technology that sufficiently reduces glare to allow for comfortable play… even during the serve. This cuts energy use by more than 90% compared with HID and 70% even using LED.



Uniformity is critical as seen in the picture. There are no intense hot spots or voids that can interfere with visual perception and comfort. Notably, the color temperature is ~10,000K, yet the blue bias is not discernable due to specific diffusion of the blue spectrum. Even as balls pick up the clay, they can still be clearly discerned during play.

Consider All Your Options

- Track research and findings regarding photobiological hazards
- Understand elements of human response to light radiation
- Match light to intended purpose
- Remain flexible
- Explain options to client
- Observe real world performance

Harmonics

- Improve Drivers

Spectral Deficiencies

- Improve Phosphors
- Change SSL Frequencies
- Increase SLL Element Diversity

Uniformity

- Geometry
- Element Diversity
- Element Count
- Element Size

Reliability

- Real World Lifecycle Versus Simulated
- Warranty Issues
- Exposure to Disruption Like EMP
- Sensitive to High Temperatures
- Cold LED Surface Subject to Ice and Snow Accumulation

Legal Liability

- Eye Damage
- Accidents
- Health Issues
- Warranty Claims
- Lighting Performance Issues
- Environmental Issues
  - Hazardous Waste
  - Light Pollution

Financial Risks

- Initial Capital Costs
- Maintenance
- Reliability and Warranty
- Legal Exposure

Environmental Risks

- Adverse Health Impact
- Light Pollution
- Hazardous Waste
- Environmental Disruption
  - Negative impact on species