



IDA-Missouri Dark Sky Training Workshop

Introduction to Light Pollution

Part I: The International Dark Sky Program and the Science of Light Pollution

Light Pollution

Light Pollution is the inappropriate or excessive use of artificial light. Light Pollution can have serious environmental consequences for humans, wildlife, and our climate.

Light pollution is a side effect of industrial civilization. Its sources include building exterior and interior lighting, advertising, commercial properties, offices, factories, streetlights, and illuminated sporting venues.

Much of the outdoor lighting used at night in our communities is inefficient, overly bright, poorly targeted, improperly shielded, and, in many cases, completely unnecessary. This light, and the electricity used to create it, is being wasted by spilling it into the sky, rather than focusing it on to the actual objects and areas that people want illuminated.

Types of Light Pollution

There are four types of light pollution.

- **Glare** – excessive brightness that causes visual discomfort (A common example of glare is a car approaching from the opposite direction of a single lane country road, with its “high beams” on. We are all familiar with cars with “those lights” – sharp, blue-white LEDs that are becoming popular as car headlamps).
- **Skyglow** – brightening of the night sky over inhabited areas (This is probably the most common and intuitive form of light pollution – this is the pale glow one notices on the horizon as we approach a city or town while driving. It is the bane of astronomers, stargazers and Milky Way chasers).
- **Light trespass** – light falling where it is not intended or needed (Most people experience trespass in terms of a neighbors porch light shining into your bedroom window or yard).
- **Clutter** – bright, confusing and excessive groupings of light sources (Bright, digital advertisement boards in cities and towns is a common example).

The three important considerations vis-à-vis light pollution and the use of artificial lights at night are:

- 1) Intensity of the light (usually given in terms of “lumens” of light)
- 2) Direction of the light (governed by the geometry of the light fixture) and,
- 3) The color of the light emitted by the light bulb (This is generally governed by the Correlated Color Temperature or CCT. Generally, speaking a CCT of close to 2000 K is desirable)

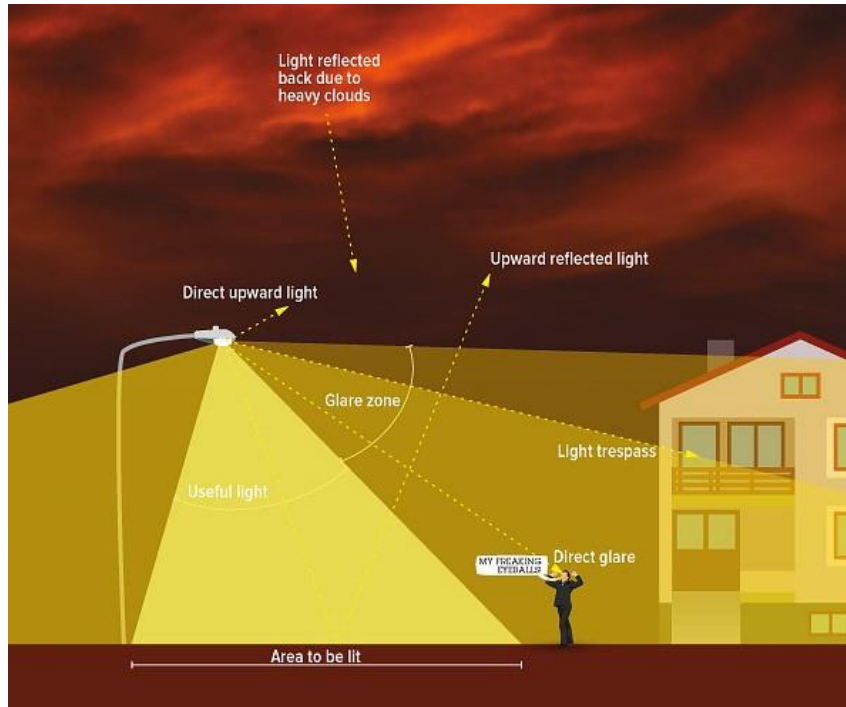


Figure I: Pictorial Representation of the different kinds of light pollution (Photo credit: IDA)

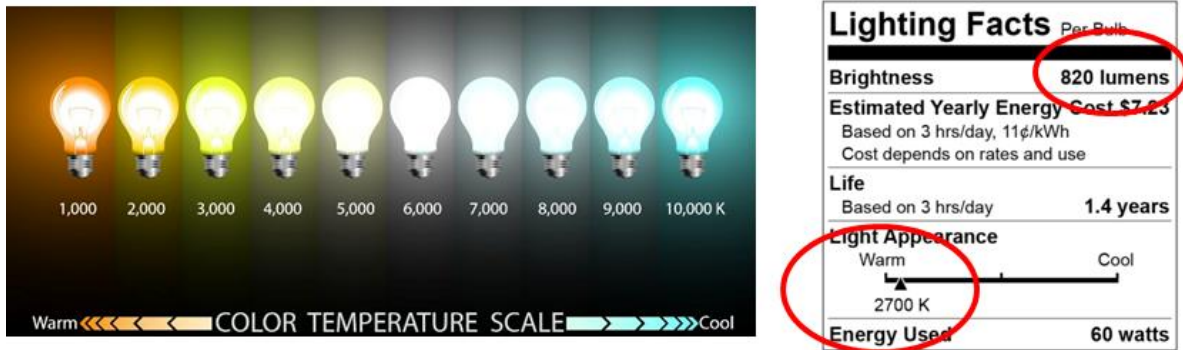


Figure II: Left: A visual representation of the color temperature and the perceived color of the light. Generally speaking, “warmer” colors corresponding to a CCT of 2000 K is desirable for outdoor lighting. Right: Light bulb specs found on light bulb packaging indicating the brightness (top right, in lumens) and the color temperature (bottom left, in Kelvin)

Why combat Light Pollution?

(Note: This particular aspect will be the primary focus of discussion in Part II of our workshop. Here, we only present the main points, which will be fleshed out in more detail in Part II. More information on these topics can be found in the Missouri-IDA Resource Materials folder: [Link to Resource Center](#))

There is a growing level of scientific and anecdotal evidence to suggest that artificial light at night has a negative impact on various plants and animals including fishes, amphibians, birds, insects & pollinators, and even humans.

- **Impact on Humans:**
 - Influence on human health due to the disruption of the Circadian rhythm.
 - Glare can be dangerous for pedestrians and bicyclists as it may blind vehicle-drivers
 - Economic costs
- **Animal Health:**
 - Disorientation of Birds during migration, sea-turtle younglings after hatching,
 - Natural habitats of bees, fireflies, insects, and other pollinators are adversely impacted by presence of ALAN
 - Mating and foraging habits of amphibians are impacted by ALAN
- **Ecological and Environmental Impact:**
 - Unnecessary waste of precious natural resources,
 - Increased greenhouse emissions
- **Impact on Astronomy:**
 - Stargazing, astronomy research
 - Astro- and Nightscape photography.

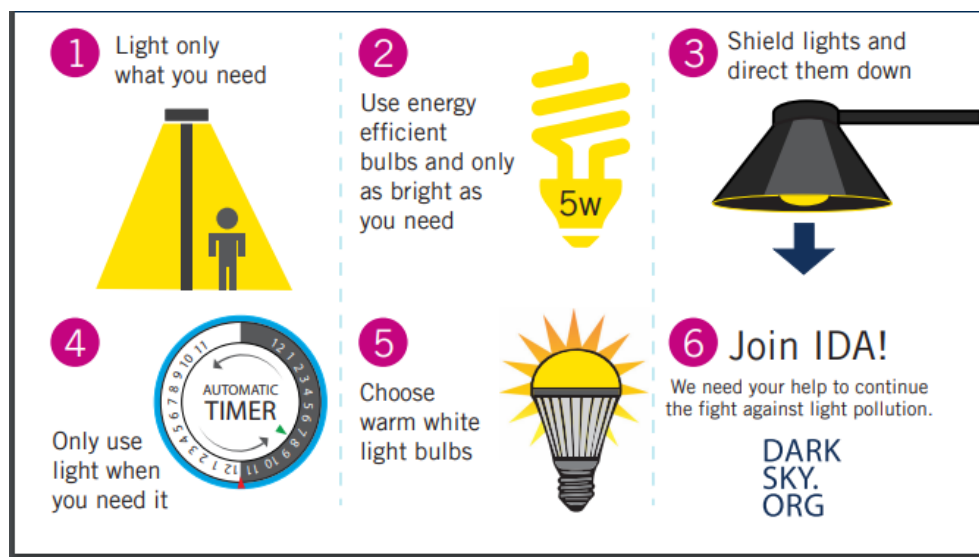
Main Takeaways:

- Light can disrupt sleeping patterns and cause health issues.
- Artificial light causes millions of bird deaths each year during migration
- Artificial light kills many insects and disrupts their behavior
- Artificial light can inhibit mating in toads and frogs and shorten feeding times.
- Impact on Astronomy is the symptom of the threat posed by ALAN.

Best Practices for Outdoor lighting that minimize Light Pollution

The simplest action to take is simply turn-off exterior lights that are not needed. We realize that is not practical in all situations, so the following guidelines should be used to minimize light pollution:

1. All lights should have a clear purpose and only light the area that needs it,
2. Use energy efficient bulbs that are no brighter than necessary
3. Use **fully shielded light fixtures** (pointing downward)
4. If lights are only needed for short periods, put them on a **motion activated timer**.
5. Color temperatures less than 3000 K, **preferably close to 2000 K**, which usually means negligible blue light emissions



Glossary

Candela (cd): Unit of luminous intensity. One candela is one lumen per steradian. Formerly called the candle.

Correlated Color Temperature (CCT): A measure in degrees Kelvin ($^{\circ}\text{K}$) of light's warmth or coolness. Lamps with a CCT of less than 3,200 $^{\circ}\text{K}$ are pinkish and considered warm. Lamps with a CCT greater than 4,000 $^{\circ}\text{K}$ are bluish-white and considered cool.

Cut off angle, of a luminaire: The angle, measured up from the nadir (i.e. straight down), between the vertical axis and the first line of sight at which the bare source (the bulb or lamp) is not visible.

Cutoff fixture: An IES definition "Intensity at or above 90° (horizontal) no more than 2.5% of lamp lumens, and no more than 10% of lamp lumens at or above 80° ".

Disability glare: Glare resulting in reduced visual performance and visibility. It is often accompanied by discomfort.

Discomfort glare: Glare that produces discomfort, but does not necessarily diminish visual performance.

Efficacy: The ratio of light output to its consumption of power, measured in lumens per watt (lm/W), or the ability of a lighting system to produce the desired result.

Efficiency: A measure of the effective or useful output of a system compared to the input of the system.

Electromagnetic (EM) spectrum: The distribution of energy emitted by a radiant source, arranged in order of wavelength or frequency. Includes gamma-ray, X-ray, ultraviolet, visual, infrared, and radio regions.

Fixture: The assembly that holds the lamp in a lighting system. It includes the elements designed to give light output control, such as a reflector (mirror) or refractor (lens), the ballast, housing, and the attachment parts.

Footcandle: Illuminance produced on a surface one foot from a uniform point source of one candela.

Full-cutoff fixture: An IES definition; "Zero intensity at or above horizontal (90° above nadir) and limited to a value not exceeding 10% of lamp lumens at or above 80° ".

Fully Shielded fixture: A fixture that allows no emission above a horizontal plane through the fixture.

Glare: Intense and blinding light that reduces visibility. A light within the field of vision that is brighter than the brightness to which the eyes are adapted.

HID lamp: In a discharge lamp, the emitted energy (light) is produced by the passage of an electric current through a gas. High-intensity discharge (HID) include mercury, metal halide, and high pressure sodium lamps. Other discharge lamps are LPS and fluorescent. Some such lamps have internal coatings to convert some of the ultraviolet energy emitted by the gas discharge into visual output.

High-Pressure Sodium (HPS) lamp: HID lamp where radiation is produced from sodium vapor at relatively high partial pressures (100 torr). HPS is essentially a "point source".

Illuminance: Density of luminous flux incident on a surface. Unit is footcandle or lux.

Incandescent lamp: Light is produced by a filament heated to a high temperature by electric current.

Infrared radiation: Electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nanometers to 1 mm.

LED: Light emitting diode.

Light Spill: Unwanted spillage of light onto adjacent areas and may affect sensitive receptors particularly residential properties and ecological sites.

Light Trespass: Light falling where it is not wanted or needed. Spill light. Obtrusive light.

Lighting Controls: Devices used for either turning lights on and off or for dimming. Photocells Sensors that turn lights on and off in response to natural light levels. Some advanced mode can slowly dim or increase the lighting. See also: Adaptive Controls.

Low-Pressure Sodium (LPS) lamp: A discharge lamp where the light is produced by radiation from sodium vapor at a relatively low partial pressure (about 0.001 torr). LPS is a “tube source”. It is monochromatic light.

Lumen: Unit of luminous flux; the flux emitted within a unit solid angle by a point source with a uniform luminous intensity of one candela.

Luminaire: A complete lighting unit that usually includes the fixture, ballasts, and lamps.

Luminance: At a point and in a given direction, the luminous intensity in the given direction produced by an element of the surface surrounding the point divided by the area of the projection of the element on a plane perpendicular to the given direction. Units: candelas per unit area.

Lux: One lumen per square meter. Unit of illuminance.

Mercury lamp: An HID lamp where the light is produced by radiation from mercury vapor.

Metal-halide lamp: An HID lamp where the light is produced by radiation from metal-halide vapors.

Photometry: The quantitative measurement of light level and distribution.

Photocell: An electronic device that changes the light output of a luminaire dynamically in response to the ambient light level around the luminaire.

Semi-cutoff fixture: An IES definition; “Intensity at or above 90° (horizontal) no more than 5% of lamp lumens and no more than 20% at or above 80°”.

Ultraviolet light: Electromagnetic radiation with wavelengths from 400 nm to 100 nm, shorter than that of visible light but longer than X-rays.