Better Lights for Better Nights Workshop

by

DarkSky Texas

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By Cindy Luongo Cassidy and Dr Karen McGraw

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Better Lights for Better Nights Overview

Agenda

- Welcome and Introductions
- Define light pollution.
- Understand the challenges presented by Artificial Light at Night (ALAN) in terms of the following:
    - Glare, Safety and Security
    - Light Trespass
    - Wasted Energy and Money
    - Health, Ecosystem, and Sustainability Issues
    - Obscuring the View of the Stars
    - Economic Issues
    - LED Specific Issues
- Discuss how light pollution can be minimized through following the *Five Principles of Responsible Outdoor Lighting*.
- Identify common types of outdoor light fixtures and the specifics of each data element needed to inventory and critique them.
- Determine whether a light fixture follows the *Five Principles of Responsible Outdoor Lighting*.
- Identify options to either upgrade or replace a light fixture that does not follow the *Five Principles of Responsible Outdoor Lighting*.
- Optional: Analyze the time to return on investment for lighting upgrades.
- Practice inspecting and preparing an assessment of sample outdoor lighting.

Lighting Assessment Goals

- Light pollution is reduced
- Night skies are protected.
- Safety is increased.
- Energy usage is reduced.
- An example of good lighting practices is created.
- ESG (Environmental, Social and Governance) score for a facility is improved.

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Continued Learning

Stay involved with DarkSky Texas to stay up to date on the latest knowledge about better lighting practices. Engage with and support DarkSky Texas!

Keep in mind that manufacturers may designate any fixture “dark sky friendly” or “night sky friendly” with or without merit. Other organizations generally obtain their information from DarkSky, but be aware that they may be using outdated information.

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Light Pollution & its Challenges

Effective outdoor lighting has many benefits. However, the way that many outdoor lights are designed and installed neither considers the nature of the human eye nor current scientific knowledge on outdoor lighting.

Poorly designed or installed outdoor lighting creates light pollution. Light pollution is the inappropriate or excessive use of artificial light at night. It can have serious environmental consequences for humans, wildlife, and our climate.

Components of light pollution (Figure 1) include:

- **Glare** – excessive brightness that causes visual discomfort.
- **Light Trespass** – light falling where it is not intended or needed, often into neighboring homes.
- **Clutter** – bright, confusing and excessive groups of light sources, such as what you may see when you look at a city street at night.
- **Skyglow** – brightening of the night sky over inhabited areas, which happens because of direct upward light and upward reflected light.

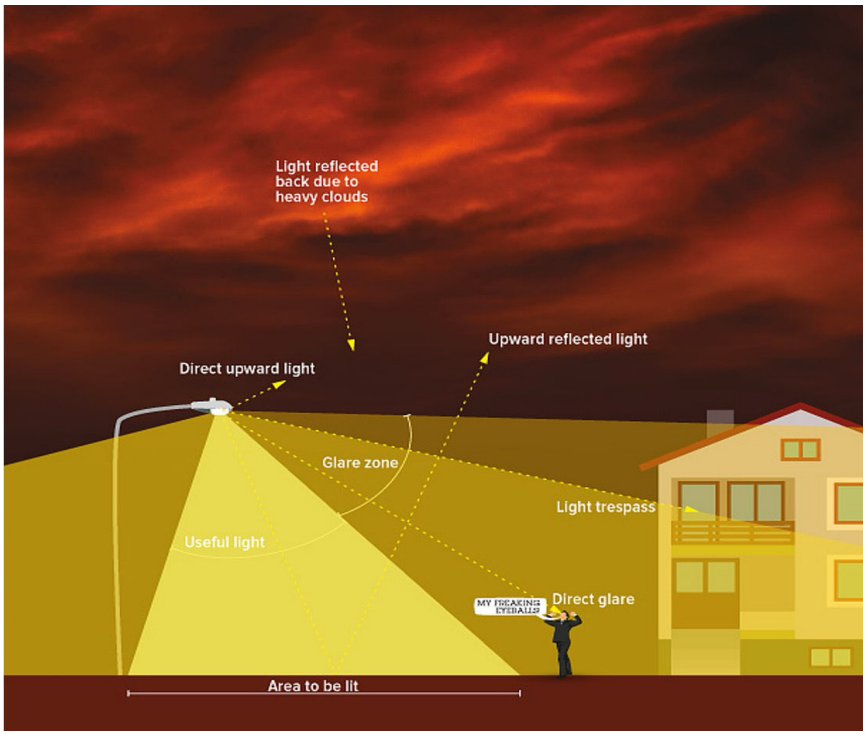

Figure 1: Components of light pollution.

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Challenges from artificial light at night (ALAN) include that it:

- Reduces safety and security due to glare.
- Creates irritating light trespass.
- Wastes money in needless energy costs.
- Jeopardizes human health.
- Impacts wildlife and plants
- Obscures our view of the stars.
- Creates economic issues.
- Emphasizes issues with LEDs.

Glare

Glare and over lighting are at the core of the problems dealing with safety and security. Glare occurs when bright, direct light hits your eye. If you can see the source of the light or the light reflector, it's producing glare. A good light will shield the bulb so that you see a lit area below the light instead of a dazzling light source.

Discomfort glare causes constant adaptation of your eye to the varying light levels. That in turn causes discomfort and reduces your ability to see. *Disability glare* may literally blind you, because the human eye adjusts itself to the brightest object in sight, which then limits its ability to see other things. If there's a big difference in light intensity between the lit area and the surroundings you won't be able to see either well.

Safety

Either type of glare severely diminishes our ability to see properly in the nighttime environment. Safety demands that the best visibility possible is provided during the times people will be moving around an area.

If you walk or drive away from a brightly lit area into a darker area or vice versa, it takes your eyes time to adjust. During that adjustment period visibility is hampered. Safety and visibility are improved with minimal lighting combined with reflective signs and road markings.

Security

Glare negatively affects security. Lights can make us *feel* more secure. The task is to *be* more secure, not to just feel more secure. Three factors are key in using lights to increase the feeling of security and in not actually reducing security:

- First, shield or position lights to minimize glare.

- Second, reduce the amount of light to minimize the contrast between the lit and unlit areas.
- Third, use motion detectors to turn lights on for about five minutes when a person is detected in the area.

Keep in mind that criminals need light too. Lighting can facilitate criminal activity by drawing attention to a property and permitting easy access. Criminals can hide when obscured by glare as seen by neighbors or passersby.

People and items are hidden when a floodlight is aimed so that the light from the fixture strikes your eye. People and items are visible when that same fixture is aimed or shielded so that the light source is not visible.

Many people believe that lights prevent crime. The National Institute of Law Enforcement and Criminal Justice, which is part of the Unites States Department of Justice completed a large study on the impact of street lighting and crime. It determined that there is no statistically significant evidence that street lighting impacts the level of crime.

There is a strong indication that increased lighting decreases the fear of crime. Shielded lighting that does not produce glare and is not so bright that it produces dark shadows could promote safety and security. Unfortunately, many individuals, groups and lighting manufacturers have long proliferated the flawed belief that good security demands large unshielded flood lights; many people take it as truth when it is not true.

Security issues are best addressed with measures other than lighting. More effective and less expensive security measures include using adequate locks and having an effective alarm system.

In summary:

- Unshielded or improperly aimed lighting can actually reduce security.
- Any glare created by these so-called security lights will limit the ability for anyone to see the site.
- A light used for safety or security must keep the bulb or refractive lens shielded and be of the lowest amount of light possible to do the job.
- Passersby who see people in over lighted areas usually presume they belong there.
- Over lighting creates dark shadows beyond the edges of the light.
- If there is no one present to see the criminal, all the light will do is attract the criminal and provide light for the criminal activity.

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Light Trespass

Light trespass occurs when the light source from one property may be seen from any other property. The illumination may be seen, but the light source should be hidden from view. Light trespass infringes on the property rights of the neighbor who has unwanted light intruding onto his or her property. It can lower property values, reduce the quality of the nighttime environment and be a general irritant. Wouldn't you want to have the full enjoyment of your property without being forced to live with unwanted light directed onto it?

To eliminate light trespass, shield and aim all lights on your own property so the illumination stays within your own property lines. If you can see the source of the light (i.e., the bulb or refractive lens) from a neighboring property, then that light is committing light trespass.

Wasted Energy and Money

In the United States alone, it is estimated that billions of dollars in energy costs are wasted each year in outdoor lighting that shines up into the sky. This excess use of energy also translates into added pollution created by operating the lights and producing the electricity. Water is often wasted in the process of producing electricity or the fuel to generate electricity for excess outdoor lighting.

Figure 2 depicts the progression in illumination projected or reflected above the horizontal. The picture progression begins in the late 1950s, to the mid 1970s, 1997, and finally an estimate of what it will be like in 2025 unless we change our habits.

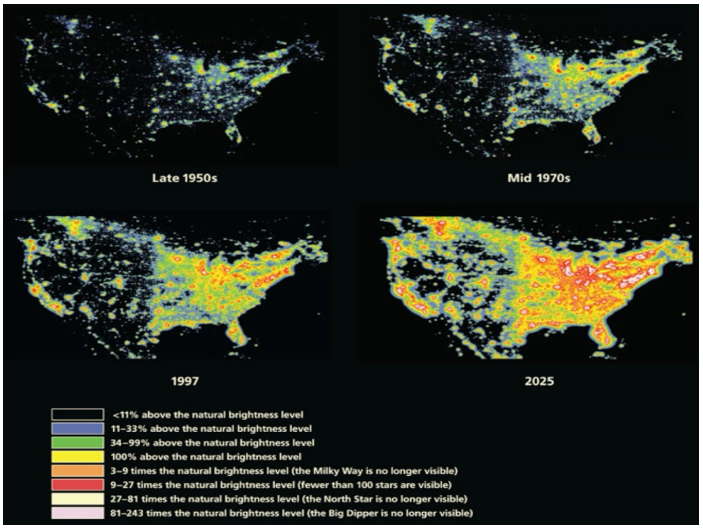

Figure 2: Illumination progression.
Source: Image and data processing by the National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center. Data collected by the U. S. Air Force Weather Agency under the Defense Meteorological Satellite Program 1992-2003.

Human Health and Artificial Light at Night

Human health depends on experiencing natural darkness each night. Humans evolved to the rhythms of the natural light-dark cycle of day and night.

Disruption of the circadian rhythm has been linked to sleep disorders like insomnia and delayed sleep-phase syndrome, as well as depression, hypertension, attention deficit disorder, obesity, diabetes, Parkinson's disease, and heart disease. The growing body of scientific research has caused the American Medical Association to publish a report titled "Light Pollution: Adverse Health Effects of Nighttime Lighting."

An important biological function that is disrupted by the presence of light at night is the production of melatonin. Melatonin is a potent antioxidant and anti-carcinogen and is responsible for regulating metabolism and immune responses. According to a thesis presented to the University of California by C. H. Ashraf, less than 15 minutes of exposure to bright light at night can completely halt the production of melatonin. Newer studies have indicated that as little as three seconds of light in the blue wavelength may stop our melatonin production.

Medical studies indicate that exposure to artificial light at night negatively affects our health by tampering with our endocrine system. That process that begins at dusk would normally create a spike in the amount of hormone melatonin in our bodies between midnight and 4 AM. Even very small amounts of light can suppress the production of melatonin enough to affect our sleep patterns and the rebuilding of our immune systems. People who work during the hours from midnight to 4 AM have a much higher incidence of breast and colorectal cancers.

Lowered levels of melatonin have been shown to have a direct correlation to the rising rates of breast cancer amongst the developed world. According to another study, cited in the journal *Environmental Health Perspectives* by R. Chepesiuk, women who live in areas where it is bright enough to read a book outside at midnight had a 73% higher chance of developing breast cancer than women living in less brightly lit areas. Melatonin has been proved to stop the growth of a common type of breast cancer cell during the hours of natural darkness when it peaks.

But today, how dark is your night? Do you spend your evening in the glow of the blue, rich light that whiteish streetlights, cell phones, computers, and tablets give off?

The blue wavelength of light is beneficial during the daytime because it boosts attention, reaction times, and mood. But exposure to blue light at night is harmful. Unfortunately, most LEDs used for outdoor lighting — as well as computer screens, TVs, and other electronic displays — create abundant blue light.

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In summary, this type of light at night disrupts our circadian rhythm and suppresses the production of melatonin, which protects our immune system and helps us sleep.

Impact on Wildlife and Plants

In "Degraded Darkness", Ben Harder, the general manager of health and science for *U.S. News & World Report*, says: "It's tempting to assume that artificial light distresses only a few exquisitely sensitive species. But mounting evidence suggests that disappearing darkness undermines our best conservation efforts."

More and more ecological and health issues are being identified that are caused by artificial light at night. Almost every living thing on this earth has functions dependent on living in an environment with a pattern of light and dark. Dusk causes the beginning of a chemical process that each living things health and existence is dependent upon. Both plants and animals normally produce melatonin. Although the way they produce melatonin differs, all plants and animals are dependent on a normal day-night cycle that should not be disrupted by artificial light at night. Even nocturnal animals have a normal melatonin spike in the early morning hours that artificial light will suppress.

Research shows additional significant negative effects of artificial light during the hours of natural darkness on the behaviors of many animals. For example:

- Nocturnal frogs suddenly exposed to artificial lights stop all activity and sit motionless even hours after the light has been turned off.
- Birds are drawn to artificially lighted towers and skyscrapers where millions of them die each year from collisions or exhaustion. Their vision and internal magnetic compasses seem to become dysfunctional in the artificial light.
- Artificial lights lead sea turtle hatchlings off-course. Many die before they can get to the ocean.
- Salamanders and dung beetles lose their ability to navigate.
- Artificial light interferes with fireflies, which generate light to find mates.

The list goes on and on. The consequences of artificial light at night include general disruptions in daily activity cycles, and reductions in dispersal, foraging, and reproductive opportunities.

Plants have a wide range of photoreceptors that perceive and respond to light signals. Almost all living organisms have a dependence on a circadian rhythm. Daily cycles of light and dark and the number of hours of each trigger key occurrences in their lives.

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We know what habitat destruction by bulldozers looks like. We don't begin to know all the alterations and disruptions that are caused by our modern habit of profusely using artificial light at night.

Obscuring the View of the Stars

Light emitted near and above the horizon scatters into the atmosphere creating what is known as sky glow. Some light aimed downward is so intense that it reflects back up and also adds to sky glow. This light travels miles in our atmosphere, affecting areas far from the origin of the light.

Big Bend National Park in southwest Texas is known for its dark skies. They became even darker after a lighting upgrade in 2010. Figures 3 and 4 are the "before" and "after" photographs from that 2010 lighting upgrade.

Figure 3: Note the illumination of the mountains within the Chisos Basin before the exterior lighting upgrade.

Figure 4: After the exterior lighting upgrade, the illumination is directed where visitors need it, and the mountains within the Chisos Basin are not illuminated.

Each of our choices of light fixtures in Figure 5 and the amount of light those fixtures produce determine how much sky glow will be created each night. Look at the number of stars you can see above each fixture type. Think about that. This is the easiest pollution to eliminate. We create it anew every night.

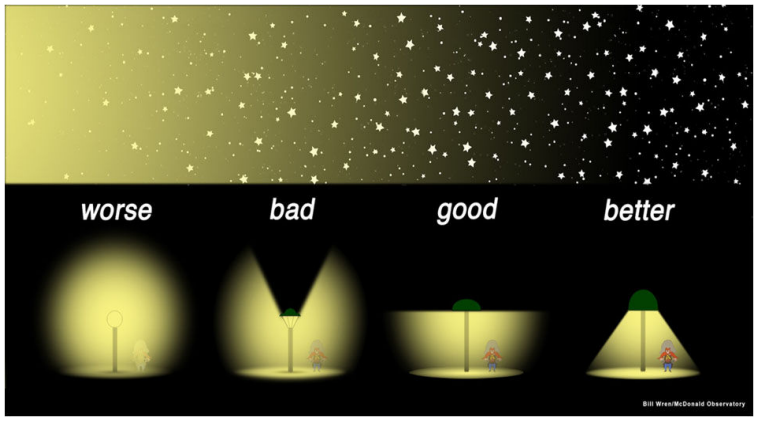

Figure 5: Lighting fixtures affect skyglow.
Graphic Credit: Bill Wren, McDonald Observatory

With our current choices in lighting, about 80% of the U.S. population has never seen the Milky Way. We can change that!

Economic Issues

In many areas, all the above challenges are intertwined with the local economy. Businesses may count on visitors who come to the area for activities and events dependent on the natural environment and the attractiveness of the area. Both of those can be protected with better outdoor lighting. Just the reductions in energy expenses alone make using better outdoor lighting a good business decision. Reducing glare makes a business look more inviting and makes it feel safe there. Helping to keep the human and wildlife population healthy is good for individuals and the community, too.

The ecotourism and sustainable travel niches are expanding, and so is astro-tourism. Astro tourism is a low-impact, sustainable form of tourism focused on the viewing of celestial objects and events. With nearly 80 percent of North Americans unable to see the Milky Way at night from their homes, places where the night sky is preserved offer visitors a truly unique, memorable, and moving experience. Astro-tourism requires an undisturbed night sky, one that is not polluted by excessive light from outdoor lighting fixtures or urban areas. According to a study, the global market for Astro-tourism is currently mostly untapped and might be worth as much as $300 billion.

Multiple studies over the last few years have indicated that light pollution also is an environmental justice issue. Evidence of disparities in exposures to light pollution in minority and low economic areas are approximately two times that of white

Americans in higher economic areas. These studies suggest that the issue may carry important public health implications.

Putting artificial light where you need it, when a person is there to use it, is a win-win for a community and its economic base.

LED Specific Issues[1]

Light-emitting diodes (LEDs) are transforming the way we illuminate our cities and towns, radically changing energy use and altering the quality of nighttime outdoor spaces. With this opportunity comes an obligation to manage these changes responsibly and sustainably. The stakes are high and the potential rewards great, but outcomes depend on informed decisions based on evidence and best practices.

The Benefits of LEDs

The improved energy efficiency of LEDs allows for reduced demand on the grid with a corresponding reduction in carbon emissions.

The perceived brightness of LEDs by humans allows for reduced illuminance providing an additional reduction in electric usage without compromising safety. That is, the human eye sees LEDs in a way that allows us to use fewer lumens.

Another LED benefit is better control over the color content of light. Manufacturers now produce LEDs with "warm" color qualities at high energy efficiency. These same LED options also provide accurate color rendition without emitting excessive amounts of potentially harmful blue light.

Relative to other outdoor lamps, LEDs are thought to be extremely long-lived. When switched on, LEDs are instantly at full brightness, unlike older HPS lamps that have a significant time delay to begin emitting light. LEDs also have very low minimum electricity thresholds to produce light, meaning they can be dimmed to much lower illumination levels when less light is needed, resulting in further energy savings.

Blue Wavelength Light

New technology often comes with unanticipated challenges. White LED lighting has significant levels of potentially hazardous light in the blue wavelength.

The American Medical Association (AMA) report, "Human and Environmental Effects of Light Emitting Diode Community Lighting," concluded that "white LED

[1] This section on LEDs adapted from and used by permission of DarkSky International

street lighting patterns contribute to the risk of chronic disease in the populations of cities in which they have been installed." The AMA recommends "minimizing and controlling blue-rich environmental lighting by using the lowest emission of blue light possible" in order to reduce potential negative effects on human health.

Concerns about blue light reach far beyond our health. Outdoor lighting with strong blue content will worsen skyglow, already affecting 80% of the globe, because it has a significantly larger geographic reach than lighting with less blue. According to the 2016 "World Atlas of Artificial Night Sky Brightness" street lighting and outdoor lighting retrofits using 4000K lamps, the level commonly used by municipalities, could **more than double** outdoor light pollution.

Blue-rich white light sources are also known to increase glare and compromise human vision, especially in the aging eye. These lights create potential road safety problems for motorists and pedestrians alike in. Additionally, blue light at night has been shown to adversely affect wildlife behavior and reproduction. This is particularly true in migration corridors, which are often stopover points for migratory species.

Visibility

Outdoor lighting is intended to enhance safety and security at night, but too much lighting can actually have the opposite effect. Visibility should always be the goal.

Glare from bright, unshielded lights actually decreases safety because it impairs visibility. The effects of glare are cumulative, meaning that every light source in view impacts vision. Glare also makes it more difficult for the human eye to adjust to low-light conditions nearby.

Blue light, like that in many LEDs lights, is more likely than conventional light sources to increase glare and impair vision. Blue light causes a condition called veiling luminance, i.e., that particular type of light illuminates the inside of the eye, causing glare and impaired vision. To have better visibility, we need to focus on using LEDs that have as little blue light in them as possible.

The promises of energy and maintenance savings by retrofitting outdoor lighting with LEDs are attractive. Selecting LEDs with low blue light content provides the additional advantages of improved visibility and reduction in negative health issues. Every effort should be made to diminish or eliminate blue light exposure after dark.

Amber lights are an excellent choice and warm lights rated at or below 2700 Kelvin are a good choice.

Light Pollution Solutions

Can we solve most of these problems and still have the light we desire outdoors at night? Yes, if we follow the recommendations of DarkSky International we can reduce, if not eliminate, most of the problems associated with artificial lights at night. To do that, follow the protocols below for all outdoor lighting fixtures.

1. Determine the purpose of each light fixture.
2. Shield and direct lights only where needed.
3. Reduce the amount of light to only what is needed.
4. Dim or turn lights off using adaptive controls such as switches, timers, and motion control.
5. Select warm colored lights.

Determine the Purpose of Each Light Fixture

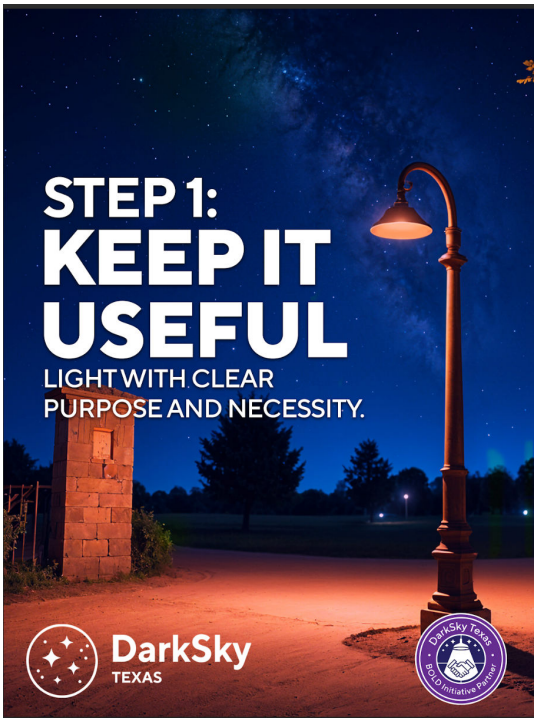

Figure 6: Is it useful?

Every outdoor light fixture should have a clear purpose (Figure 6). Consider why it is there as you document it for the lighting inventory and make your assessment of it. Consider how the use of light will impact the area, including wildlife and their habitats.

What is it illuminating? Who needs that space to be lit? Would something else, like reflective markings or the use of reflective paint, fit the purpose?

You will need to talk with the property owner or manager to verify the light's purpose if it's not clear or is questionable. Remove lights that serve no purpose.

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Shield and Direct Lights Only Where Needed

Use shielding and careful aiming to target the direction of the light beam so that it points downward and does not spill beyond where it is needed.

The *Better Lights for Better Nights* diagram (Figure 7) is a great starting point to learn about fixtures that can shield and control light direction, versus fixtures that allow light to go upwards, on adjoining properties, or anywhere that the light is not needed.

Acceptable light fixtures shield the light source/bulb from normal viewing points and do not allow any light above a horizontal line drawn through the lowest point of the illuminating elements. The best fixtures tuck the bulb up in the fixture and light only the area that needs to be lit, minimizing glare and light trespass.

Figure 7: Is it shielded?

Better Lights for Better Nights

Figure 8: Unacceptable vs. acceptable lights.
Diagram by Bob Crelin

Aiming lights "down" does not mean to just angle the light towards the ground. The fixture must be positioned so it *does not allow any light to shine above a horizontal line drawn through its lowest part*. In most applications, this requires the light be installed above the area to be illuminated.

The light from a properly installed fixture should project below and out to the sides of the fixture, like a cone with the peaked top of the light at the fixture as in Figure 9. An acceptable fixture that is mounted at an upward angle would normally change it into an "unacceptable" fixture.

Low output landscape lighting directed upward and shielded so that no one sees the source of the light from any other property is acceptable if the lights are turned off when no one is actively using them. Remember, both plants and animals need natural darkness to be healthy.

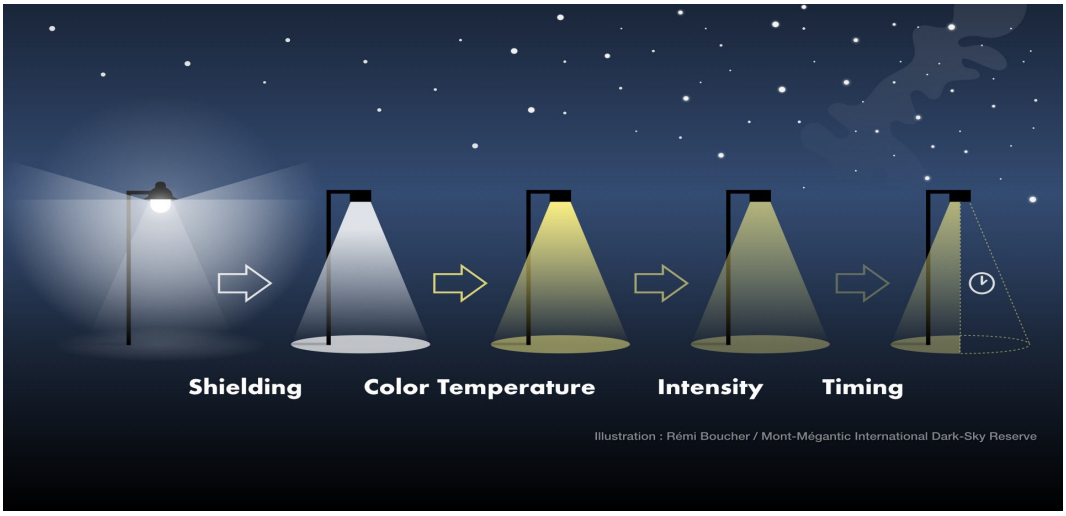

Figure 9: Shielding, color temperature, intensity, and timing are all important. Graphic by Remi Boucher / Mont-Megantic International Dark-Sky Reserve

There are situations where an 'acceptable fixture,' even one labeled "Dark Sky Friendly", full cutoff, or fully shielded may need additional shielding to actually hide the source of the light from a normal viewing point. A fixture mounted up on a tall pole or on a hill would require additional 360-degree shielding.

The light fixture in Figure 10 is called a full cutoff fixture where no light is emitted above a horizontal line drawn through the lowest light-emitting part of the fixture. The light fixture in Figure 11 is a standard "shoe box" style fixture with additional shields to reduce light in the glare zone.

Figure 10 Figure 11

The light source in Figure 11 is not seen from any other property because of the use of the shielding and the positioning of the light pole. The pole is installed at least 4 times the height of the pole, away from the property line.

Light trespass is normally stopped when every outdoor light is shielded so that the source of the light cannot be seen from any neighboring property. The fixture in illustration Figure 12 is a well shielded version of the fixture in Figure 13.

Figure 12: Shielded.

Figure 13: Unshielded.

If the lights look star-like from another property, the owner is paying for light to go onto that other property and the light is trespassing.

Reduce the Amount of Light to Only What is Needed

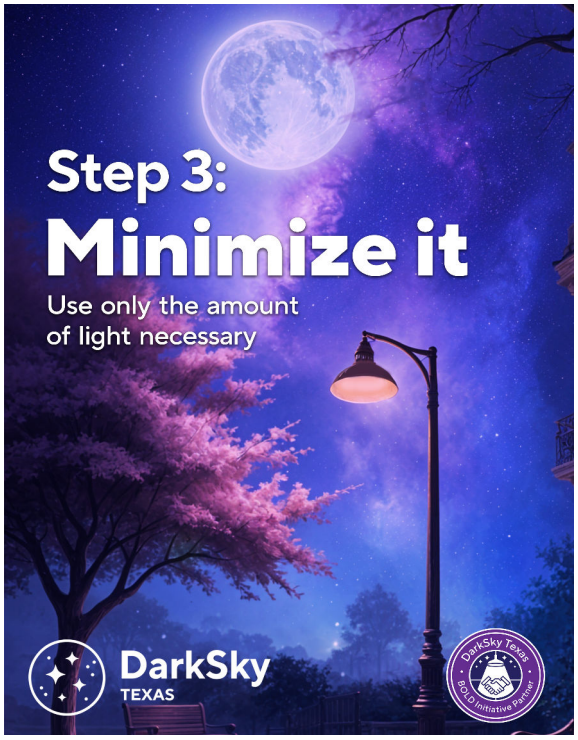

Figure 14: Use only the light necessary.

What you can't tell from the "Better Lights for Better Nights" handout (Figure 14) is the amount of light that each fixture produces. The amount of light produced is measured in lumens.

Shielding the light concentrates it where the light is needed and usually allows you to reduce the lumens to get the same amount of light or often additional light where you actually need it. In fact, a wattage reduction is usually required to keep that concentrated light from producing reflective glare and an overly lit situation (Figure 14).

Always consider the way the human eye works when selecting the amount of light for a particular outdoor application. Use significantly less light than is the modern habit

to enhance night vision and reduce glare. Remember that a very bright light will make the unlit areas seem impossibly dark.

Too many lumens (i.e., too bright a light) will cause light to bounce off of the surfaces it shines upon and reflect up into the sky, into the eyes of people nearby, and into the habitat of nearby wildlife. The light may attract birds and insects that then will not be able to proceed with their natural habits. So, the shape of the fixture isn't everything. Lower the lumens (and wattage) when you switch from an unshielded fixture to a shielded fixture.

Did we just say, "lower the wattage"? You bet. These fixtures not only cut the glare, allowing people to see better, but they reduce the costs of operating the lights. That's a win-win!

Turn Lights Off Using Adaptive Controls such as Switches, Timers, and Motion Control

Lighting an unoccupied area will not keep criminals away and may attract them. It is usually a waste of energy. A big plus for turning off the lights when no one is there to use them is that it allows wildlife and plants to exist in natural darkness. As you know by now, wildlife and plants need natural darkness. Timers and motion detectors (Figure 15) can help you achieve the goal of having lights turned off when no one is there to use the light.

Figure 15: Is it managed?

Select Warm Colored Lights

Living things need light in the blue wavelength, which looks to humans as white light, during the day, especially through the morning hours, but light in the blue wavelength should be avoided after dusk. With current technology, the best way to tell if a light is blue-rich of not is to look at the color temperature of the light. Warm colored lights (Figure 16) will appear yellowish rather than white.

Figure 16: Are the lights warm-colored?

The color temperature of a light may be listed on the package just as 'warm' or 'cool', or the manufacturer may indicate the Kelvin(K) rating for a light. Commercial lights may list the color as the "Correlated Color Temperature" or CCT. Old-fashioned incandescent bulbs are rated around 2700K, which is described as a warm color. Many of the bright white Light Emitting Diodes (LEDs) are rated at 4000K and above. This bright white light creates more glare and suppresses the production of melatonin in living organisms which can, over the long term, damage the health of that organism.

Know when a particular light will be used and take into consideration what the color of the light does to living things. Remember, blue light should be avoided after dusk. You may find it interesting to research the lighting studies led by Dr. George Brainard that focus on the type of lighting used inside the International Space Station and its effects on the astronauts.

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Lighting Fixtures: Common Details

Preparing to Take Inventory

To create a useful inventory and begin making an assessment of each outdoor light, first, identify details about the fixtures and light sources you see on your site. This section will provide a description of the most prevalent types of light fixtures and light sources you might encounter.

Fixture Types and Possible Retrofits

Barn Light a.k.a. Yard Light, Security Light, NEMA Head

,

Figure 17: Add a metal shield.

The left side of Figure 17 represents your typical barn light. In the recent past, the recommendation was to replace the refractive lens with a metal shield as shown in the right side of Figure 17. For the last 6 to 8 years, it has been almost impossible to locate metal shields for this type of fixture.

Today, the recommendation is to replace the entire fixture with a more efficient shielded fixture, like Figure 18.

Select a warm rated bulb (2700K or below; amber is preferred) and make sure the bulb does not extend below the bottom edge of the fixture.

Figure 18: Shielded fixture.

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Cobra Head: Drop Lens or Flat Lens

The drop lens cobra head (Figure 19, top) should be replaced with a shielded fixture. The flat lens cobra head (Figure 19, bottom) was formerly one of our best options if it was repositioned so that the lens is exactly level.

At issue with this "full cutoff" flat lens fixture is the newer knowledge that more skyglow is created from light emitted at or near the horizontal than directly shining upward.

Figure 19: Drop lens and flat cobra head images, respectively.

The fixture options shown in Figure 20 create less light trespass and much less glare and are the up-to-date preferred replacements.

The shielding needs to be a dark color rather than the white option in the photo. The external 360-degree visors are a good option and are offered by several manufacturers. As you know by now, glare kills our vision.

That 360-degree shield may be needed due to proximity to other properties or mounting height.

Figure 20: Less glare.

Shoe Box Style Full Cutoff (area or parking lot) Fixture

This is a typical modern parking lot fixture. Figure 21 shows a full cut off fixture, which generally has little glare when the bulb is recessed, and a reflector is used. Glare can be minimized with an additional shield, if needed.

However, if the light source is an LED, the fixture will most likely need 360-degree shielding due to the way LEDs work with the human eye.

Figure 21: Full cutoff fixture.

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Wall Pack

Typical wall packs like both of the ones in Figures 22 & 23 need to be replaced or shielded.

Figure 22. Poor wall pack (A).

Figure 23: Poor wall pack (B).

Figure 24 is a sample full cutoff wall pack that is acceptable. Wall packs could, optionally, have a "shade" installed over them as in Figure 25. The shade has a special top with openings for heat to escape but does not allow light to escape. The fixture in Figure 26, with a recessed light source, is the best choice.

Figure 24: Acceptable.

Figure 25: With shade.

Figure 26: Recessed (best).

Spot or Flood Lights

Spot or flood lights may be shielded with a clip-on or built-in shroud. The bulb itself must point downward as in Figure 27. Spots or floods may also be replaced with a fixture such as the one in Figure 28 or another similar fully shielded fixture.

Figure 27: With shroud.

Figure 28: Fully shielded.

Custom shielding can be used on many light fixtures that would normally produce glare, to change them from "unacceptable" to "acceptable". Be creative!

How to Estimate the Lamp Type, Wattage, and Lumens

If you are going to do a cost analysis of the retrofit, or if this property will be part of an application to be an International Dark Sky Place, you will need to estimate the wattage used by each light and the lumens produced. The facility may connect you with their maintenance staff who may know the details of many of the light fixtures, but you may have to estimate.

Some commercial lights will be labeled with their type and wattage like the ones below. Some you will need to become familiar with the bulb types.

- The light in Figure 29 is a 45-watt LED (Light Emitting Diode). It has a great label with big letters but also notice the small diodes that make up each light source area. Those diodes may look a little different in another manufacturer's light fixture, but they will be similar to these if it is an LED.
- The light in Figure 30 is a 100 W HPS. The "HPS", for High Pressure Sodium, is printed small but if you take a photo and zoom in you can see the label. Look at the shape of the bulb, now you are starting to learn what a High-Pressure Sodium (HPS) bulb looks like.

Figure 29: 45-watt LED.

Figure 30: 100-watt HPS.


Figure 31: Metal Halide bulb.

Keep in mind that a High-Pressure Sodium (HPS) bulb looks a lot like the Metal Halide bulb in Figure 31. The primary visual difference between them is that metal halide produces a white light, and the light emitted from an HPS bulb is amber orange. HPS is about twice as electrically efficient as metal halide and has much less light in the blue wavelength.

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If you are not familiar with residential-sized Compact Fluorescent Light (CFL), incandescent, and LED bulbs, it may be time for a field trip to your local hardware store. If you go, notice the relative size and shape of various wattages and their lumen output.

Figure 32: 23-watt CFL.

For an example of a bulb that at first glance may look like the incandescent bulbs we are all familiar with, look closely at this CFL in Figure 32 to see the tell-tale spiral inside the bulb's lens. This bulb is a 23 W CFL that produces about 700 lumens.

Notice, also, the flat bottom. This type of bulb if pointed straight down and, usually in a smaller wattage (i.e. producing fewer lumens), may be used in some small fixtures to make the fixture produce minimal light pollution and match a location's Lighting Management Plan (LMP).

Figure 33: 16-W LED.

The next bulb, in Figure 33, is a LED. Note the formed looking surface of the light source. This bulb is a 16-W bulb that produces about 900 lumens.

Estimates of Lumens Based on Wattage

Table 1 was created from multiple manufacturers' efficacy figures and therefore provides a range of lumen outputs for the selected types of light source included.

This table provides an easy method of estimating the lumens produced by existing lighting products when you do not have actual specifications for the bulbs in each fixture.

Lumens were determined using an average luminous efficacy. Energy saving lamps may generate more lumens per watt.

Electrical power equivalents for differing lamps

Minimum light output (lumens)	Electrical power consumption (watts)		
	Incandescent	Compact fluorescent	LED
450	40	9–11	6–8
800	60	13–15	9–12
1100	75	18–20	13–16
1600	100	23–28	15–22
2400	150	30–52	24–28
3100	200	49–75	30
4000	300	75–100	38

Table 1. Estimating Lumens

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How to Estimate the Color Temperature

You also will need to estimate the color temperature for each light. The facility may connect you with their maintenance staff who will know the details for many of the light fixtures, but you may have to estimate.

Most incandescent bulbs are rated at 2700 Kelvin. High Pressure Sodium (HPS) bulbs are rated at 2200 Kelvin. Look at these and other sample bulbs for which you know the rating assigned by the manufacturer.

For light sources for which you must estimate the Kelvin rating, have at least two of you compare the color you see when the light is illuminated at night to the colors in Figure 34. In addition, compare what you see to bulbs for which you know the Kelvin rating. Unless you are determining compliance with an outdoor lighting ordinance or Light Management Plan (LMP), this comparison will provide sufficient determination of the Kelvin rating for the light.

Figure 34: Color temperature guide for lighting.

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Inventory & Assessment

Initial Communication

Clear communication and the relationship you establish with the facility being assessed is essential to the success of the project. It is expected that you have been invited to do the assessment or you are working with a group associated with the property. In your initial communication you should:

- Outline the assessment process.
- Introduce the team that will work on the assessment.
- Request name and contact information for follow up if different from your initial contact person.
- Let them know when you plan to visit.

Before You Go

It's a good idea to get to know the property somewhat before you go there. Explore the area via Google Maps or a similar program. To be prepared to take inventory you should have:

- Blank data collection forms (available in Appendix A)
- A flashlight or head lamp
- Pencil or pen
- Clip board or another surface to write on
- An aerial view or map of the property
- Camera - preferably one capable of manual exposure, but a phone camera is sufficient. Familiarize yourself with your camera's settings at home so that you can play with them as you shoot photographs after dark.
- A plan for taking photos that may be easily inserted in your final inventory spreadsheet. Determine whether you want to take the photos in low resolution or edit them afterwards to keep the final size of your photos small. Taking your photos in high resolution then editing them to reduce the image size keeps a sharp image for insertion in the inventory.
- Consider taking a tripod for your photographs taken after dark.

Initial Property Visit

- Conduct the visit with your property contact if possible.
- Pick up any documentation required for property access.
- Take the items you gathered in the *Before You Go* list.

The Inventory

Download the Level Two Inventory Spreadsheet from the *Fight for the Stars* training found at Online Learning under the Projects menu item on www.darkskytexas.org. This section will explain how to collect the data to fill out this spreadsheet. There is an image of a sample completed inventory spreadsheet at the end of this section.

Daylight Collection of Inventory Data

- Start early enough to do a complete inventory in daylight.
- Bring the items you gathered in the Before You Go list.
- Document all lighting fixtures in daylight on the data collection forms. Keep a detailed record of the quantity of each type of fixture at each location.
- Photo document each type of light fixture.
    - No need to have a photo of every fixture. One of each type is sufficient.
    - Make sure your camera is set to the proper resolution, if applicable.
    - Keep a record matching photographs with location descriptions.
- Note the apparent purpose of the light, if determined.
- Be sure to note on your data collection sheets any lights that are on during daylight hours.

Nighttime Collection of Inventory Data

- Start when it gets dark enough for lights to come on and repeat the process.
- Photo document each type of light fixture.
    - Try to have the photo depict what you see with your eye. Many automatic cameras will try to "fix" the image.
    - If you have a tripod, it can help you get a clearer image. If you don't have a tripod look for fence posts, buildings or some other stable object for you to lean against as you take the photo. Don't lean against a running car, as the vibration will extend to your hand.
    - If your camera has a "night scenes" selection, try it.
    - Experiment with your manual settings if your camera offers them.
    - Do the best you can with the camera you have. If it doesn't turn out the way your eye saw it, then describe what you saw in words.
    - Use photos to document evidence of light wasted into trees, onto a roof, above the light, or elsewhere that is not useful.
- Keep a record matching photographs with location descriptions. You may find light fixtures that were missed during the daylight inventory.

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- All outdoor lighting should be inventoried. This includes lights that are not currently operational, and lights located indoors whose light source may be directly seen from outside.

- Things to ask yourself about any lights visible from outdoors. Your property contact can help answer these questions.
    - What's the purpose of that specific light? Is it really needed?
    - Could reflective paint or reflectors serve the purpose? Maybe not, but always think outside of the box.
    - Where does the illumination from that light fixture spread? Does the aim need to be adjusted?
    - Can you see the luminous elements (lamp or light bulb, any diffusing elements, and surfaces intended to reflect or refract light)? Can it be shielded? If not then, consider replacing the fixture.
    - Is the light brighter than necessary? Could the lighting element/bulb be replaced or a fixture producing less light installed?
    - Does it need to be illuminated all night, or could it be on a timer or motion detector?
    - Is the color of the light appropriate for the task? Warm light is preferred.
    - Does it comply with the Lighting Management Plan (LMP) for the property if they have one?

- Note problems and initial retrofit recommendations on the data collection form. Recommendations may include such suggestions as:
    - Removing a fixture.
    - Repositioning a fixture.
    - Shielding the fixture.
    - Using lower wattage or a different type of bulbs.
    - Changing flood lights to spotlights.
    - Turning the light off during certain hours.
    - Adding manual control switches to replace dusk-to-dawn photocells.
    - Implementing timers.
    - Adding motion detectors.
    - Replacing the fixture or bulb with a warmer colored light source.

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Review Inventory & Recommended Changes

Before you prepare your assessment:

- Review your data collection sheets and verify which photographs match each light fixture. You should have a photo record of each type of light fixture in daylight and again after dark. Remember to reduce the resolution before it is inserted into your assessment document or spreadsheet.
- Keep your complete inventory records for later use during follow up and retrofitting.

An Assessment Presentation

The assessment is an overview of your observations and recommendations. It is based on the data you collected during the inventory process.

Your assessment should include:

- Overview of the property and the overall rationale behind the assessment.
- An overview of the lighting on the property and high-level recommendations. You may include specific references to good lighting in place, lack of shielding, excessive glare, and a general description of the current state of the lighting.
- Always thank the facility contact for the opportunity to be involved.
- Request an additional meeting to follow up regarding the retrofits (shielding, replacements, or repositioning), if any are required.

The Inventory

The inventory spreadsheet you prepare using the blank one you downloaded from www.darkskytexas.org is a compilation of the details about each outdoor light fixture on the property. This is a key deliverable.

A sample image of a completed inventory is at the end of this section and on the second tab of the electronic version you downloaded. The spreadsheet includes:

- The location where the fixture is installed and an assigned number for that location. Some properties may only have one area to inventory, in which case you will not need to note the location.
- Photo of the fixture. You only need one daytime and one nighttime photo when there are multiple instances of the same type of light fixture on a property.
- What type of fixture is it – a wall pack, an area light, a ceiling fixture, etc.?
- The lamp or bulb type (incandescent, CFL, LED, etc.)
- The quantity of this type of fixture at this location.

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- The total wattage used by this fixture. If the fixture has two or more bulbs, provide the total wattage for the entire fixture.
- The number of lumens produced by this fixture. Note if it is less than 500 lumens.
- Note observations about the current shielding.
- What function does this light provide?
- Is the fixture targeted?
- Assess the brightness level for the task.
- Note observations about any controls used to power the fixture.
- Estimate the color temperature. The maintenance staff may be able to help you with the Kelvin rating of the light. If not, estimate it based on a visual inspection.
- Retrofit Actions – your notes about whether this fixture needs to be shielded, replaced, removed from service, etc.
- If the property has a Lighting Management Plan (LMP), make notes if it does not comply with that plan.

Follow Up and Coordinate

Your assessment letter will ask for a follow-up meeting to discuss the recommended changes. Take the initiative to schedule that meeting. A face-to-face meeting is preferred, perhaps one in which you go look at some of the lighting in question. **This is a time to listen and be of service to the property management on their terms.**

In the follow-up meeting you will want to make sure they understand the recommendations and the reasoning. You may want to offer your help in reviewing any selected replacement fixtures before they are installed.

Document and Communicate

Each inventory/assessment team should keep copies of all communications, assessments, recommendations, and status of retrofits.

Electronic copies of those documents, as well as any status updates for significant events, should be shared with everyone on your team, the person who requested the assessment and your contact at the property.

Sample Image of the Inventory Spreadsheet

Figure 35 is a screenshot of an inventory spreadsheet for use in lighting assessments. Be sure to download the *Fight for the Stars Level Two Inventory Spreadsheet* from Online Learning under Projects at www.darkskytexas.org.

Lighting Inventory

Daytime Photo	Nighttime Photo	Fixture Type	Lamp Type	Quantity	Watts	Lumens	Fixture Shielding	Principle 1: Useful?	Principle 2: Targeted?	Principle 3: Brightness Level?	Principle 4: Controls?	Principle 5: Color Temp?	Evaluation: Does this light need improvement?
	TBD	Bare Bulb	Incandescent	1	75	1100	No Shielding	Yes, it is useful	Not targeted - needs a shield	Good brightness level	Needs controls. Currenly on 24/7	2700 K - pretty good	Yes; needs timer and shield
	TBD	Barn Light	HPS	4	150	2400	No Shielding	Yes, it is useful	Not targeted - needs a shield	Could be a little less bright, but not too bad	Has a timer	2000 K - good	Yes; replace with fully shielded LED with appropriate color and brightness with a timer
	TBD	Spot Light	LED	2	16	1100	Has overhang but not shielded	Yes, it is useful	Not targeted; needs to be redirected at the very least	Good brightness level	Has a timer	4000 K - needs to be reduced; too much light in the blue wavelength	Yes; replace with fully shielded wall pack rated 2200-2400 K on a timer with appropriate brightness
	TBD	Pole Mounted Area Light	LED	3	27	2950	Is shielded - doesn't create glare	Yes, it is useful	Is targeted	Appropriate light level along walkway.	On a timer	2700 K - good	No
	TBD	Wall Sconce	Incandescent	1	60	800	Needs to be shielded - glass only magnifies light	Yes, it is useful	Is not targeted - needs shield	Good brightness level	Has a switch - possibly talk to headmaster about only using when it's needed or getting a	2700 K - good	Replace with fully shielded fixture

Figure 35: Screenshot of a sample lighting inventory.

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Cost Analysis Calculations

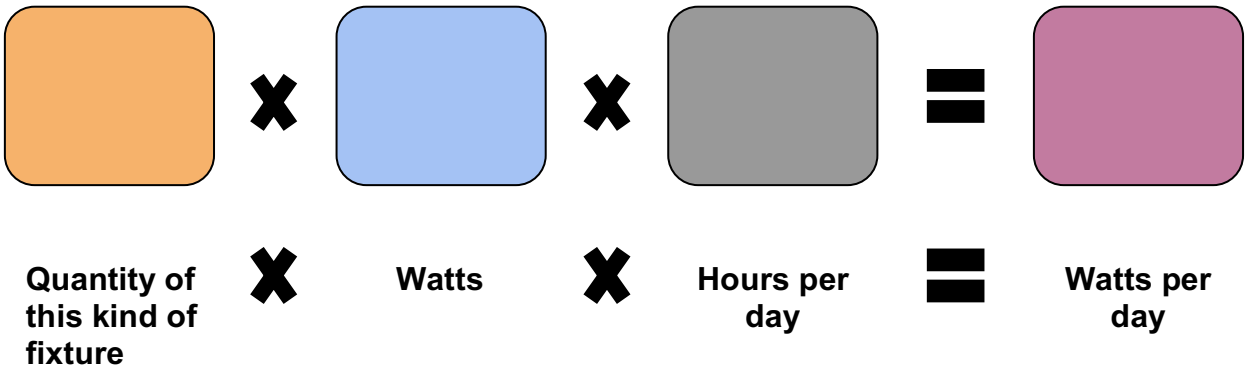
Money matters a lot when it comes to maintaining a property and paying for electricity. This analysis will determine the cost of the energy your outdoor lights are using and what they will use once improved or replaced. Remember to only fill out this analysis for the lights you are planning to change. The cost will not change if you are not changing the light.

Be sure to download the *Fight for the Stars Level Two Analysis Spreadsheet* from the Online Learning Project on www.darkskytexas.org. The next pages will explain how to calculate the numbers to fill out this spreadsheet. There is an image of it at the end of this section.

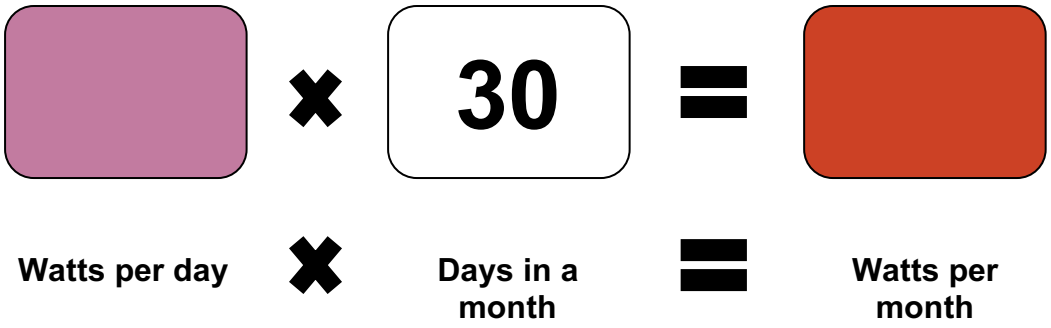
First, you need to talk to the property manager or maintenance staff you have been in contact with to determine how many hours each day the lights are currently on. Remember, you only need to take these steps and calculations for the lights you plan to change.

Current Fixture Calculations
For each of the current fixture calculations, you should do it for however many *different* kinds of lights you have on your property that you plan to change. For example, if there is a type of light that has five duplicates on your property, you only need to do these calculations once. If you plan to improve, replace, or remove ten different types of lights, you will need to do these calculations ten times, once for each kind of light.

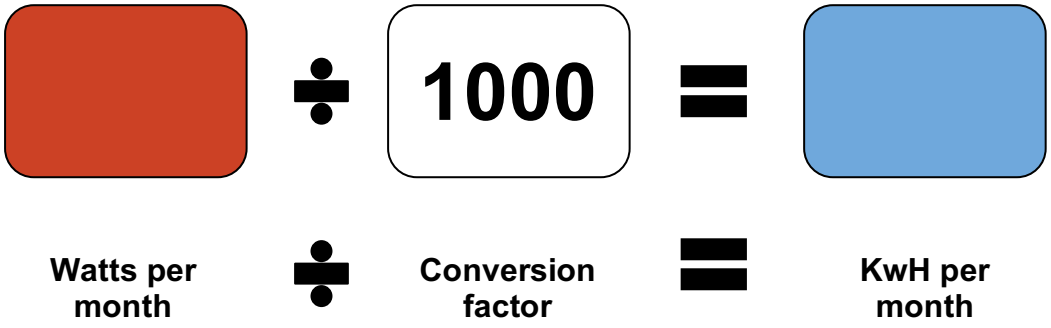
Now, we can figure out the watts used each day.



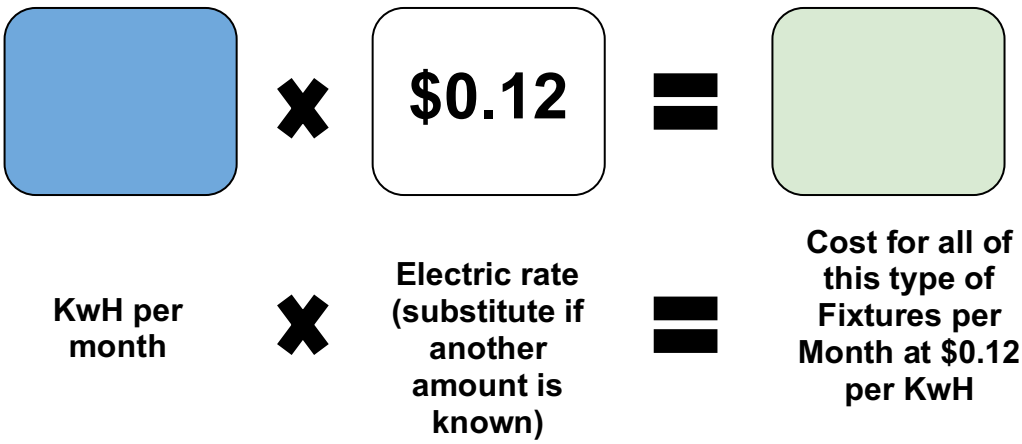
Although the number of days in each month differs, the average is 30 days in each month. This is a general approximation of the watts used per month for this kind of light.



Electrical usage in watts is billed in Kilowatt Hours (KwH), so we convert watts used in a month to KwH per Month by dividing by 1000.



Now that we know how much energy (in KwH) each kind of light takes each month, we can figure out how much money each light costs to operate each month! We need to multiply the KwH per month by the current electric rate. You may want to substitute the local rate here. If you are not sure of the local rate, you can use $0.12 per KwH.



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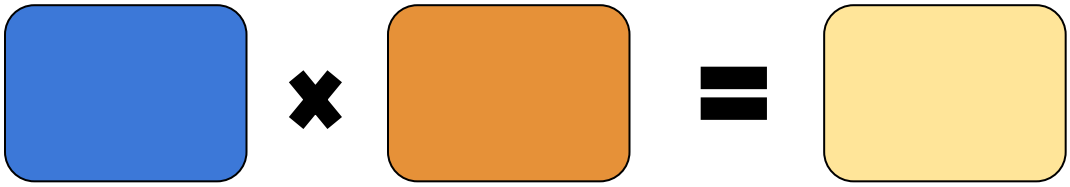
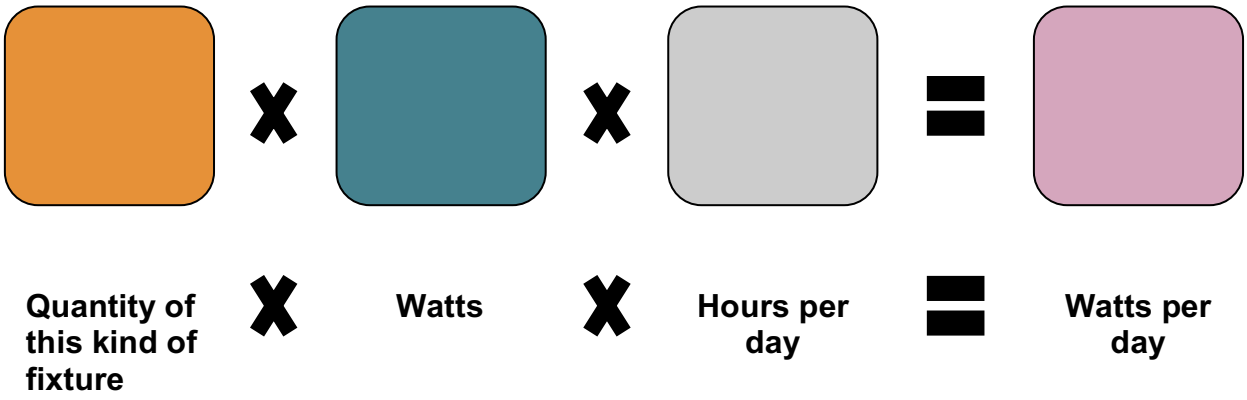
Replacement Fixture Calculations
For these calculations, you will need to know the cost of each proposed replacement fixture, the number of those proposed replacement fixtures, how many watts each fixture used, and the hours per day the replacement fixtures will be illuminated.

This calculation is to figure out how much it will cost to buy the new fixtures. You should do this calculation for each type of fixture, but only once for duplicates.



Now we are going to figure out the extended cost of the replacement fixtures. We can calculate the watts per day of each kind of replacement fixture using this formula.



Although the number of days in each month differs, the average is 30 days in each month. This is a general approximation of the watts used per month for this kind of light.

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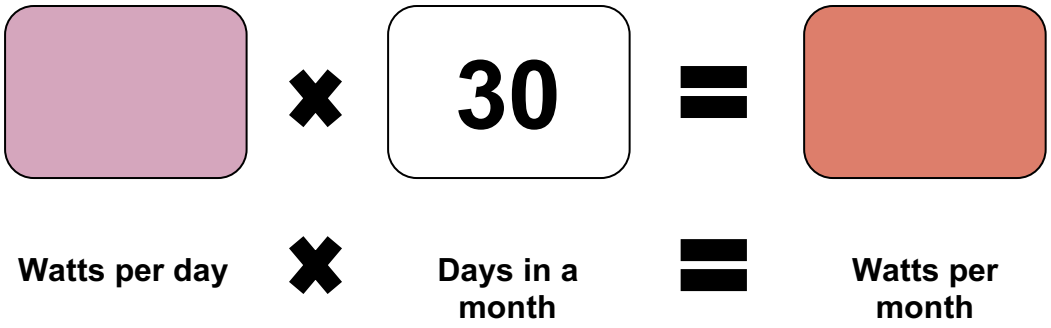
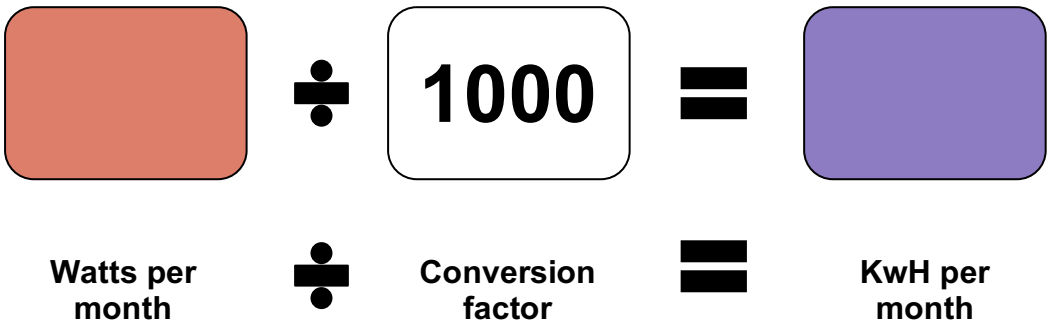
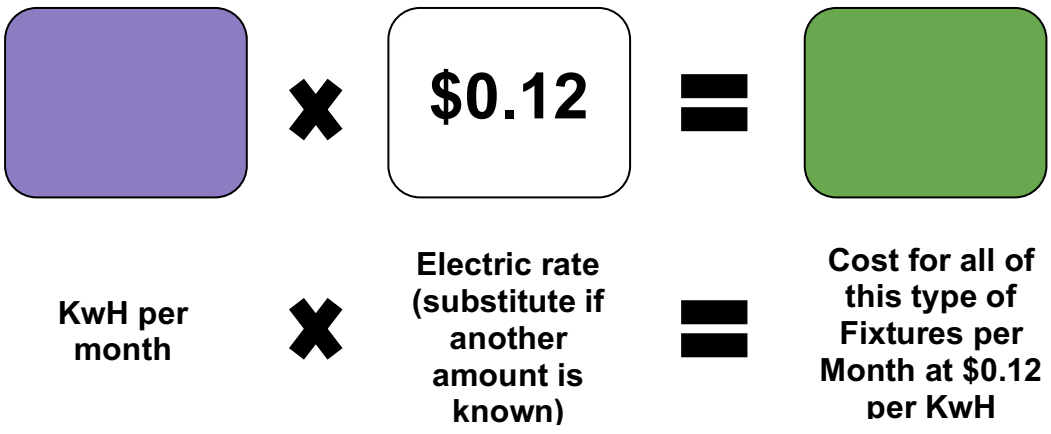


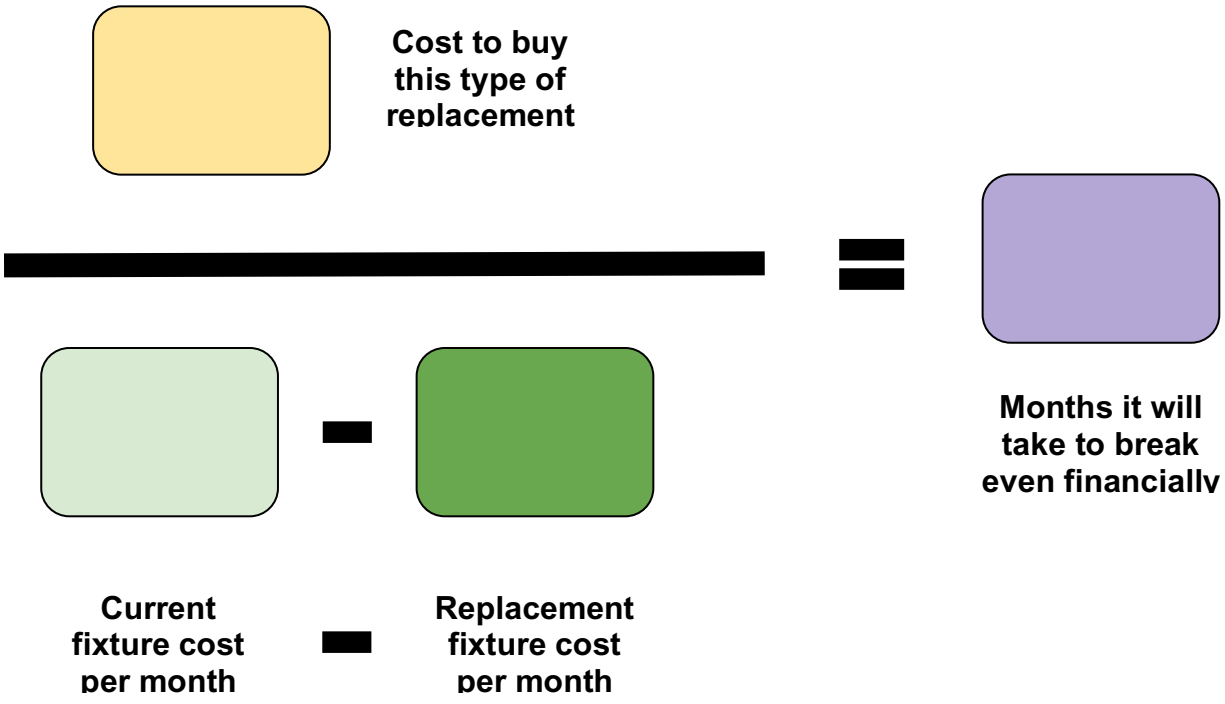
Electrical usage in watts is billed in Kilowatt Hours (KwH), so we convert watts used in a month to KwH per Month by dividing by 1000.



Now that we know how much energy in KwH each kind of light takes each month, we can figure out how much money each light costs each month! We need to multiply the KwH per month by the current electric rate. You may want to substitute the local rate here. If you are not sure of the local rate, you can use $0.12 per KwH.



Now we want to figure out how many months it will take to break even financially. We will only be able to break even if the extended cost of the replacement fixture each month is less than the amount the current fixture costs each month. If the extended cost of the replacement fixture is more than the current cost per month, then you will not be saving money with the new fixture. Do not let this dissuade the purchase. The value of eliminating glare, excessive lighting, and light trespass is not part of the numeric calculation, yet it should be a priority too.

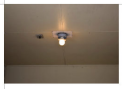
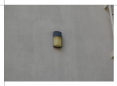


Once you have finished your calculations for each kind of fixture, both current and replacement, be sure to input your values into your electronic cost analysis spreadsheet!

Sample Cost Analysis Worksheet

Figures 36 and 37 represent two parts of the same Lighting Cost Analysis spreadsheet. Be sure to download the *Fight for the Stars Level Two Analysis Spreadsheet* from the Online Learning Project on www.darkskytexas.org.

Lighting Cost Analysis *(to be completed in conjunction with the Cost Analysis Calculations Sheet)*

Reference # & Location	Current fixture photo	Fixture Type	Lamp Type	Use	Quantity	Watts	Hours per Day	Watts per Day	Watts per Month	Kilowatt Hours (KwH) per month	Cost for Fixture(s) per Month
2, 3; rear sidewalk		Barn Light	HPS	sidewalk and originally parking lot light	4	150	12	7200	216000	216	$25.92
17; Headmaster's garage		Wall Sconce	Metal Halide	lights the garage/parking area	1	100	3	300	9000	9	$1.08
1; entrance 7		bare bulb	incandescent	Lights the entrance to the building	1	75	24	1800	54000	54	$6.48
4,5; outdoor classroom		Spot light	LED	Illuminates the outdoor classroom area	2	16 (per double fixture)	4	128	3840	3.84	$0.46
18, 19; Training Room		Wall Pack	Metal Halide	Lights the entrance to the training room and the sidewalk leading up to it	1	100	12	1200	36000	36	$4.32

(Continued in Figure 37)

Figure 36: Cost Analysis part A (above). Figure 37: Cost Analysis part B (below).

Lighting Cost Analysis

Reference # & Location	Current fixture photo	Cost per Replacement Fixture	Quantity of Replacement Fixture	Cost for all of this Type of Replacement Fixture	Replacement Fixture Watts	Hours per Day	Replacement Fixture Watts per Day	Replacement Fixture Watts per month	Replacement Fixture's Kilowatt Hours (KwH) per month	Cost for this Type of Replacement Fixture per month	Months to Break Even	Explanation / Details of Replacement Fixture	Photo of Replacement Fixture
2, 3; rear sidewalk		122 (fixture + bulb)	4	488	14	3	168	5040	5.04	$0.60	19.3	Right now, the barn light is lighting up the sidewalk and parking lot, but there are other lights that cover the parking lot. Therefore, we want to change this barn light to only light the sidewalk. We want to change this barn light fixture to a Kichler Ripley light fixture with an LED R14 2400 K bulb. By changing to this fixture and bulb, the light will become targeted, reduce glare (which makes it easier to see), protect living things around it, and more. Also, the replacement fixture should have active controls so it is only used when needed.	
17; Headmaster's garage		12	1	12	7	3	21	630	0.63	$0.08	12	Since this light isn't on too much and it's for illuminating a small area, we are recommending that the fixture stays the same but the bulb is replaced with a flat top bulb (2400K). This way, the light is not creating glare, it is targeted, and more. This is option 2 under light bulbs in the Outdoor Light Fixture Replacement Options Handout.	
1; entrance 7		35 (shield + bulb)	1	23	7	3	21	630	0.63	$0.08	5.5	For this light, we are recommending that a shield and active controls are added. For the shield, we can use option 1 under wall sconces in the Outdoor Light Fixture Replacement Options Handout. This will reduce glare and prevent use when it's not needed. Furthermore, we want to change this bulb to an LED bulb (the same as the one above) to save money and energy.	
4,5; outdoor classroom		124	1	124	10	3	30	900	0.9	$0.11	354.09	We are recommending that this light be replaced with a fully shielded wall pack with an amber LED. This will save money and energy, reduce glare, protect the heritage oak that is exposed to this light and more. In addition, this fixture comes with the bulb and a motion detector! Finally, although this will take a while to break even, it will be a lot safer!	
18, 19; Training Room		124	1	124	10	4	40	1200	1.2	$0.14	30.2	We are recommending that this light be replaced with a fully shielded wall pack with an LED light rated 2700 K. This will save money and energy, reduce glare, protect living things around it, and more. In addition, this fixture comes with the bulb and a motion detector!	

Appendix A: Lighting Inventory Data Collection Sheet

Retrofit/Replacement Considerations: Is the light fixture & placement good or does it need a shield, motion detector, timer, reduction in lumens, replacement, a different color temperature or to be removed?

Location/Purpose ____
Photo order _____Type of fixture_____________Type of lamp__________
at this location ______ Est Wattage _________ Est Color Temp ________
Need(s) attention? Y/N Retrofit / Replacement notes _________________
____
____

Location/Purpose ____
Photo order _____Type of fixture_____________Type of lamp__________
at this location ______ Est Wattage _________ Est Color Temp ________
Need(s) attention? Y/N Retrofit / Replacement notes _________________
____
____

Location/Purpose ____
Photo order _____Type of fixture_____________Type of lamp__________
at this location ______ Est Wattage _________ Est Color Temp ________
Need(s) attention? Y/N Retrofit / Replacement notes _________________
____
____

Location/Purpose ____
Photo order _____Type of fixture_____________Type of lamp__________
at this location ______ Est Wattage _________ Est Color Temp ________
Need(s) attention? Y/N Retrofit / Replacement notes _________________
____
____

Location/Purpose ____
Photo order _____Type of fixture_____________Type of lamp__________
at this location ______ Est Wattage _________ Est Color Temp ________
Need(s) attention? Y/N Retrofit / Replacement notes _________________
____
____

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Appendix B: Outdoor Light Fixture Replacement Options

These options, while not a complete list, were compiled to guide your selections when considering options to replace and improve existing lights to reduce light pollution and save energy. You will find additional options to guide your selections at https://www.darksky.org/our-work/lighting/lighting-for-industry/fsa/fsa-products/. Whatever you choose, test every selection against the ***Five Principles of Responsible Outdoor Lighting*** (Appendix Figure 1).

Appendix Figure 1: Five Lighting Principles for Responsible Outdoor Lighting.

Note: Fixtures that follow are grouped by common names even though many fixtures could fit in more than one category. As an example, a so-called "Barn Light" could also be called more generically an "Area Light" or a "Security Light."
Apart from some specialized applications, the preferred outdoor fixture is one whose light source is narrow band amber (NBA) with a wavelength of 590 nanometers (nm). In cases where NBA may not be used, select the lowest Kelvin rating offered and ask for one with the least amount of light in the blue spectrum. Due to demand, more luminaires are being offered in amber.

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Area, Security, Shoe Box, Cobra Head & Barn (NEMA Head) Type Fixtures	
Original Fixtures	
Option 1 	Acuity Brands DSX0 or DSX1 with 360-degree add on shielding (usually from 1 inch to 2.5 inches on each side). https://www.acuitybrands.com/products/detail/196671/lith onia-lighting/d-series-area-size-0/dsx0-led-area-luminaire
Option 2 	Crossroads LED Astrophile series and their dark sky compliant product line. Amber and LEDs rated at 2400. Kelvin and less are preferred. https://crossroadsled.com/lighting-products/phosphor- converted-amber-street-lights/
Option 3 	The CHU in amber with their optional one-inch shield; 2700K with the lowest number of LEDs is acceptable. https://www.ela-lighting.com/pdf/update/CHU_Chute_LED.pdf
Option 4 	Sellux Saturn Cutoff with 2700K option (ask about amber). https://www.selux.us/usa/en/products/saturn

Option 5 	Cooper Lighting Streetworks; preferred is the 2200K option but the 2700K option is acceptable. https://www.cooperlighting.com/global/brands/streetworks/182926/pmm-mesa
Option 6  	Lithonia RSX1 with the Exterior 360 Full Visor. https://www.acuitybrands.com/products/detail/885168/lithonia-lighting/rsx1-led-area-luminaire/up-to-17000-lumens

Wall Packs (Usually Commercial)	
Original	
Option 1 	Pick the 2700 Kelvin option unless they have a lower Kelvin option when you are selecting it. https://www.acuitybrands.com/products/detail/1008034/lithonia-lighting/wdge1-led-wall-mount/architectural-wall- luminaire-size-1---up-to-2000-lumens
Option 2 	So many manufacturers make this style. Make sure the top is closed (i.e. downlight only) and that you can either use your own bulb or the Kelvin rating / CCT is Amber or absolutely no higher than 2700K. If you can use your own bulb, you can pick a comfortable 2200K or 2400K. As always, ensure the bulb does NOT protrude below the metal of the fixture.

Option 3 	Turtle Friendly Costal Wildlife amber LED with baffle.
Option 4 	Envirolux Sphere Wallpack available in Amber and 2700K.
Option 5 	EcoLights; 500 lumens and less. http://www.csbg.ca/ECOLIGHT.HTM
Option 6 	Ligman Lighting UQU Quarter 1 Surface, ***if*** you select the Amber option and the Frosted Lens. The 2700K option with the Frosted Lens should be okay when mounted low enough to mitigate the >1 Glare Rating.
Alternate Option 	Cover the old wall pack with a RAB Shade. ***Note:*** If your fixture is old, this will not reduce your electric bill like replacing it with a new, more efficient fixture.

Wall Sconces (Usually Residential, but some used on smaller commercial)	
Original	  
Option 1 	If the bulb is pointing down, you can shield the bulb and keep the fixture. Progress Lighting lamp shield from Loews Home Improvement. Here's an example and another style:  
Option 2 	Designers Fountain Bayport at Loews Home Improvement, Lamps Plus, or Home Depot. Be sure to get the size that is large enough to cover the bulb you want to use in it.
Option 3 	Ripley Collection dark sky outdoor wall light from Lamps Plus, Lumens, Kichler, etc.

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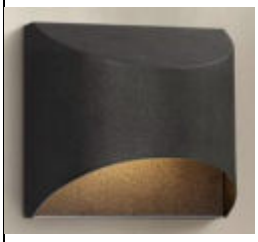
Option 4 	Pine Slope fixture with your 2400K bulb, from Lumens, LightsOnline, Lowes, etc.
Option 5 	Rickey Outdoor Barn Light – use your own 2400K bulb.
Option 6 	Pine Slope fixture with your 2400K bulb.
Option 7 	Sage Ridge fixture from Lamps Plus, Home Depot, etc., with your 2400K very short bulb.

Option 8 	Possini Euro Ratner 3000K LED wall light from Lamps Plus, Build.com, Home Depot, etc.; 2400K would be preferable, but this is acceptable.
Option 9 	Under a completely closed canopy, this type of specialty fixture works beautifully. It emits light upwards to illuminate the underneath of the canopy and downward to illuminate the walkway. The fixture hides the light sources and prevents glare.

Spot or Flood Lights	
Original	 
Option 1 	Bullet style fixture with long shroud.

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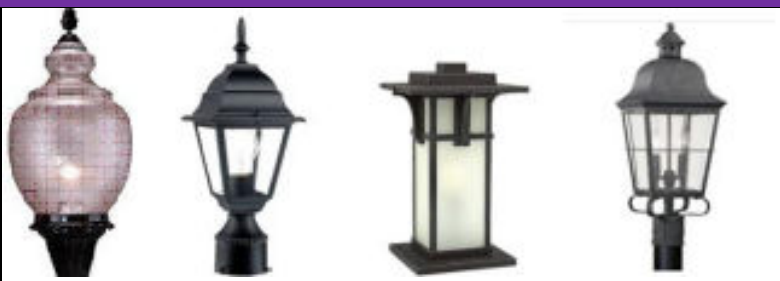
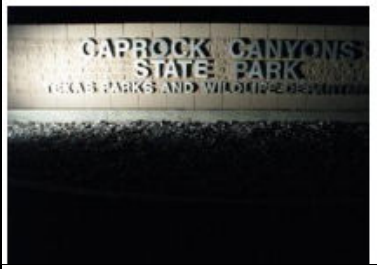
Option 2 	Commercial Electric Ultra Slim Color Selectable (select 2700K) recessed integrated LED.
Option 3 	Generation Lighting Flood Light Sea Gull Collection (your bulb).
Option 4 	Access Lighting 1 light 2800K LED Fin Collection.
Option 5 	MIK Solutions LED Spot Light with 2700K bulb sold separately.

Post Top Fixtures	
Original	
Option 1 	Designers Fountain Bayport post top at Lowes, Home Depot, LampsPlus, etc.
Option 2 	Ripley Collection 16-inch high post light, from Kichler, Lowes, LampsPlus, etc.
Option 3 	Capital Lighting Dark Sky Outdoor Lantern; Model 94450B, from Build with Ferguson, etc.

Sign Lighting	
Original	 
Option 1 	Many manufacturers make RLM style fixtures, which are perfect for illumination of signs. Be careful to ensure that the bulb does NOT extend below the metal of the fixture.
Option 2 	A good example of reverse lighting on the individual letters in a sign.
Option 3 	The photo on the left was taken of the sign during the day. The one on the right was taken during the night. Note the way the sign maker restricted the internal illumination from most of the sign at night. The sign shows up well without causing excessive glare.

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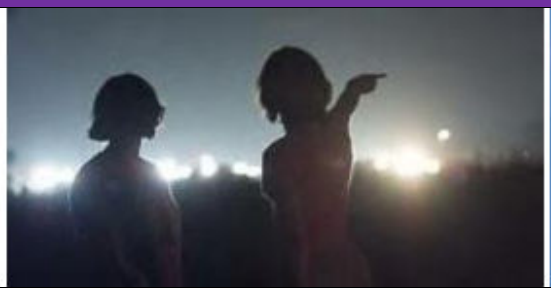
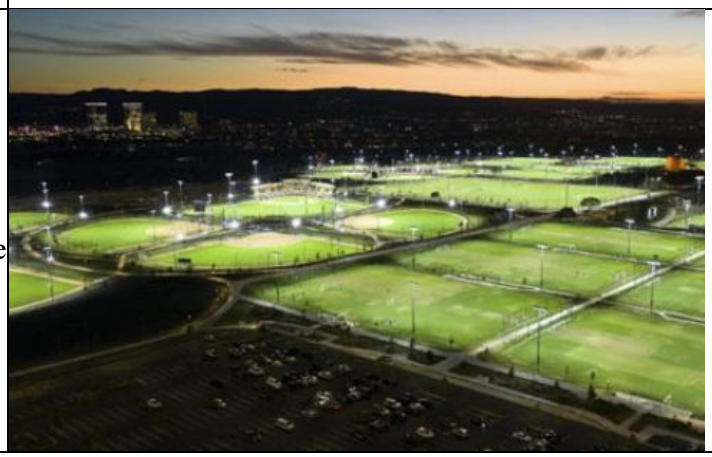
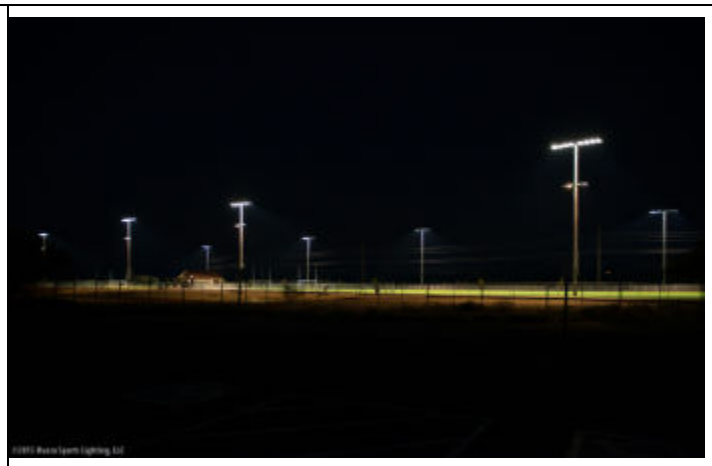
Path Lighting	
Original	
Option 1 	Selux Inula Bollard with amber CCT selection. https://www.selux.us/usa/en/exterior#downloads
Option 2 	Numerous manufacturers offer similar fully shielded path lighting. Be sure the color temperature is 2700K or less and that the total amount of light is not too bright. The ambient light around the area will determine how much light you need to see the path. The darker the area, the less light it will take for you to see well. A bright light in a very dark area will just cause the space beyond the path to be even darker and keep you from seeing it.
Option 3 	EcoLights; 500 lumens and less. https://www.csbg.ca/ECOLIGHT.HTM

Flag Lighting		
Original		Yes, all of these were supposedly for 2 flags.
Option 1 	Eagle Mountain Stargazer Flag Light; select the Amber or 3000K model.	
Option 2 	Use a shielded light from above and mount it close to the flag.	

Sports Field Lighting	
Original	 
Notes	No matter what manufacturer, sports lighting should NOT be installed on top of a hill. Have the lighting plan reviewed and evaluated by the International Dark-Sky Sports Field Community Friendly Lighting Criteria. https://darksky.org/what-we-do/darksky-approved/outdoor-sports-lighting/
Option 1, where only the fields are illuminated, very little light trespass, and the sports lighting is NOT used for the surrounding areas (like parking).	

Option 2, where an LED-lighted soccer facility is located adjacent to a residential neighborhood. Photo taken approximately 150 feet from field edge. Credit: Musco Lighting	
Light Bulbs	
Option 1 	If you have fixtures that are "eye candy" that you would rather not replace, try putting flicker flame bulbs in them and use another light source to illuminate the area, as needed. There are lots more great bulbs out there. Look for bug lights when appropriate, and otherwise, look for light bulbs rated around 2000K to 2400K. If you cannot find one, then use 2700K
Option 2 	This is a great bulb to use in any fixture, but especially when the socket is pointed down. It can redeem a fixture that otherwise would need to be replaced. TCP Dimmable 7W 2400K Par20 LED bulb.
Option 3 	Bulbrite Dimmable 5W 2200K vintage G25 filament LED bulb.

Option 4 	Maxlite Dimmable 6.5W 2000K vintage filament LED bulb.
Option 5 	QLS 4W 2200K decorative vintage filament LED bulb.
Option 6 	GE Dimmable 10W 2700K A19 LED bulb works well when you absolutely must have some white light. Try one with a rating of 2000 to 2400 Kelvin first.
Option 7 	Sunlite 12W Sea Turtle and Wildlife certified orange LED lamp.
Option 8 	Sunlite 3W Sea Turtle and Wildlife certified LED lamp.
Option 9 	Emery Allen dimmable 5W 2700K LED bulb; here is that short bulb you may need to reduce glare and hide the light source in a fixture.

Appendix C: Glossary of Lighting Terminology[2]

Adapt: the process by which the human visual system adjusts to light levels. Complete adaptation takes lots of time, especially when changing from a light to a dark environment.

Annual operating cost: the cost per year of electricity and maintenance of a lighting system, including replacement parts.

Area lighting: lighting provided to illuminate open areas uniformly such as lighting in a parking lot.

Beam spread: the width, expressed in degrees, of a light beam from a reflector lamp. The edge of the beam is typically defined as the point at which the luminous intensity is 50% as great as at the center of the beam (e.g. if a light source emits 10 lumens, then the edge of the beam spread around that light is where there is 5 lumens of light).

Bollard: a low post-shaped fixture, typically 3 to 4 ft in height, used to light pathways, walkways, and perimeters.

Contrast: the luminance of an object related to its immediate background.

Control: a device or system that turns lamps on and off or dims them. Controls include switches, dimmers, timing devices, motion detectors/sensors, photo sensors, and central control systems.

Efficacy (of a light source): the ratio of light output from a lamp to the electric power it consumes (lamp output divided by input power). Efficacy is expressed in lumens per watt (LPW).

Efficiency (of a fixture): the ratio of lumens of a fixture to the lumens of the lamp(s) alone. Luminous efficiency is a dimensionless measure, expressing the percentage of initial lamp lumens that exit the fixture.

Energy: the product of power (watts) and time (hours). Energy used for lighting can be saved by reducing the power required or the time lighting is used, or both.

Fixture: a complete lighting unit consisting of a lamp or lamps, together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to a power supply.

[2] Adapted from Fight for the Stars. Used with permission.

Glare: excessive brightness from a source of light in the line of sight. Fixtures with poor optical control can be sources of direct glare.

Illumination: the distribution of light on a horizontal surface.

Kilowatt-hour (kWh): measure of electrical energy use; the product of power, as measured in kilowatts, and time, as measured in hours. For example, one kilowatt of energy used for one hour equals one kilowatt-hour (kWh).

Lamp: a lighting industry term for an electric light bulb, tube or other lighting device. In other words, a lamp is any light source.

Light distribution: the spread of light that is produced by a lamp or a fixture; also, the overall pattern of light on a surface.

Light output: luminous flux, measured in lumens. The lumen rating of a lamp is a measure of its total overall light output. See also lumen.

Light pollution: adverse effects, including glare, light trespass, light clutter and sky glow, of unwanted light in the atmosphere, typically produced by the upward components of outdoor lighting systems at night.

Light trespass: extraneous light on adjacent property, typically produced by stray light from outdoor lighting systems. Light trespass includes glare from direct viewing, as well as unwanted "spill light."

Lumen: the unit of luminous flux. The lumen is the rate of flow of light and is used to express the overall light output of a lamp.

Luminance: the photometric quantity most closely associated with the perception of brightness. It is the intensity of light emitted or reflected in a particular direction.

Luminous flux: the rate of the flow of light, measured in lumens. The overall light output of a lamp.

Photo sensor: a device that converts light to electrical current. Photo sensors switch lights on or off, based on the amount of incident light.

Reflector lamps: a class of lamps that have reflecting material integrated into the lamp.

Sky glow: a result of scattered light in the atmosphere above urban areas. Sky glow is exacerbated by the presence of water vapor, air pollution, clouds, or rain.

Uniformity: in outdoor lighting, a measure indicating how evenly light is distributed across a surface. Perfect uniformity would mean all the lights in an area are evenly distributed and the light is therefore evenly distributed.

Watt: unit of electric power; the rate at which electric energy is used.