A QUICK GUIDE TO LIMITING LIGHT POLLUTION

WHAT IS LIGHT POLLUTION?

Light pollution is "the inappropriate or excessive use of artificial light," and consists of four factors¹:

- 1. Glare: Excessive brightness that causes visual discomfort
- 2. Sky glow: Brightening of the night sky over inhabited areas
- 3. Light trespass: Light falling where it is not intended or needed
- **4. Clutter:** Bright, confusing and excessive groupings of light sources

Light pollution caused by the inappropriate or inefficient use of outdoor lighting is costly, and effects people, wildlife, and outdoor environments—most noticeably, it limits our view of the starry night sky.

HOW DO I USE THIS WORKSHEET & GUIDE?

The initial groundwork for a dark sky designation is establishing the current status. This worksheet guides users through several evaluation methods which could be used for a general assessment of dark sky-friendly lighting. While not all of the included methods are required for a quality assessment, it is recommended that those conducting the assessment use as many methods as appropriate to gain a broader perspective. In addition, the various methods may be adapted for public education and engagement on dark sky issues.

After completing your assessment, you will know the current state of lighting in your town and will have identified key areas for improvement.

For help with this guide, contact Utah's Community Development Office: (801) 468-0133, info@ruralplanning.org.

reflective gear

Comfortable walking shoes

 PREPARING FOR YOUR DARK SKY ASSESSMENT 1. Define your purpose Who requested the assessment? Who is sponsoring or supporting it? What is the goal of your assessment? How will you use information gathered during the assessment? Will it be the only assessment or will there be more? 	NOTES
 2. Identify who should be involved List and invite key stakeholders (leaders, active citizens, business owners, etc). What do they need to know to support your project and engage in the assessment? Who might help you engage with necessary stakeholders and supporters? 	
3. Design and prepare for the assessment	
Prepare a map of town (can use Google maps, a hand drawn map, or existing city maps).	
Organize where the assessment will begin and end. It may help to divide into different areas, separating commercial districts, residential sectors, or government districts for the purposes of the assessment.	
□ Walk the route beforehand—are there safety concerns or other considerations that should be acknowledged before conducting an assessment?	
Select areas during the day to take illustrative photos—most SLR cameras can take a good night photo.	REMEMBER TO TAKE
You should try to carry out your assessment on a clear night, with little or no cloud cover. Don't do the assessment when the moon is in the sky.	This guidePrinted map of assessment area
4. Get the word out	□ Pencils / pens / colored markers
If not initiated or conducted by the town, notify the town when your assessment will be performed.	ClipboardsMeasuring tape
Notify and remind stakeholders.	DSLR camera & tripod
\Box Notify the public (fliers, posters, Eacebook, etc.); assessments can be helpful	Orange vests / visible clothing /

Notify the public (fliers, posters, Facebook, etc.); assessments can be helpful and fun for community education (e.g. Our Town Nights, Community Night Connections, etc.).

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GENERAL LIGHTING TERMS

CLUTTER: Bright, confusing and excessive groupings of light sources.

COLOR SPECTRUM: Refers to the portion of the electromagnetic spectrum that is visible to the human eye.

CORRELATED COLOR TEMPERATURE (CCT): Specifies the color appearance of light emitted by a lamp.

DARK SKY: Denoting or located in a place where the darkness of the night sky is relatively free of interference from artificial light.

DSLR CAMERA: "Digital single-lens reflex" or DSLR cameras are versatile cameras with changeable lenses that produce high-quality photos.

FIXTURE: The assembly that holds the lamp in the lighting system and includes elemends such as a reflector (mirror) or refractor (lens), the ballast, housing, and the attachment parts.

FOOTCANDLE (fc): Illuminance produced on a surface that is everywhere one foot from a uniform point source of light of one candle and equal to one lumen per square foot.

FULLY SHIELDED: A fixture that allows no emission above a horizontal plane passing through the lowest light-emitting or light-reflecting part of the fixture.

GLARE: Excessive brightness that causes visual discomfort.

KELVIN: A measurement unit for light's "warmness" or "coolness."

KILOWATT (Kw): A measure equal to1,000 watts of electrical power.

KILOWATT HOUR (kWh): A measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.

LAMP: A device for giving light which can consist of an electric bulb with its holder and shade or cover, or one burning liquid fuel and consisting of a wick or mantle and a glass shade.

LIGHT TRESPASS: Light falling where it is not intended or needed.

LUMEN: A measurement unit for the brightness from a light source.

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

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

REFLECTION: Light redirected back into the sky off of surfaces that are being illuminated.

SKYGLOW: Brightening of the night sky over inhabited areas.

WATT: The standard unit of power in the International System of Units (SI).



DARK SKY LIGHTING BASICS: THE "THREE-LEGGED STOOL"

We need lighting for safety at night. However, many city lights are undirected and waste energy while causing light pollution. Proper lighting begins with proper lighting design standards which form a proverbial "three-legged stool". The legs of the stool are:

- 1. Shielding
- 2. Appropriate lighting levels
- 3. Lighting color

These three basic design principals form the basis for good lighting design, and when applied correctly, will reduce light pollution.

1. LIGHTING SHIELDING





Outdoor lighting should be "fully shielded," meaning no light above a 90-degree angle. The goal of fully shielded light fixtures is to prevent:

- Light trespass is light falling where it is not wanted or needed. Light trespass can create problems for neighboring and distant properties.
- **Glare** is intense and blinding light that can cause discomfort and temporary blindness.
- Skyglow reduces our ability to view celestial objects due to scattered light from sources on the ground.

The more light is directed towards the intended subject, the better. Fully shielded lighting can be purchased or retrofitted.

2. APPROPRIATE LIGHTING LEVELS

Outdoor lighting can easily become excessive or "cluttered." Appropriate lighting levels means practically managing the amount of outdoor lighting in terms of duration and illuminated area. Ordinances that support appropriate lighting levels will specify the acceptable amount of lumens within an area (such as lumens per acre). Many municipalities use illumination guidelines established by the <u>Illuminating Engineering</u> <u>Society (IES)</u> to set lighting levels in their ordinances. In addition municipalities will remove lights no longer in use or needed. Note that International Dark Sky Association (IDA) standards are more strict than IES standards.

- Lumens are a measurement unit of the brightness from a light source.
- **Clutter** is excessive groupings of light sources that create a bright and confusing environment.
- **Reflection** off of what is being illuminated causes light to be redirected back into the sky, contributing to sky glow.

Timers, motion sensors, dimmer switches, and turning lights off when not in use can help improve lighting levels.

Generally, use lighting where it's needed, when it's needed, and only as bright as needed.

3000 H

3. LIGHTING COLOR

The color of the light is important as well. Cool, blue spectrum lights brighten the night sky more than amber colored light and researchers are beginning to connect blue light spectrum to negative health effects in people and greater problems for wildlife. IDA recommends using longwavelength lighting with a color temperature of < 3000 Kelvin.

- **Kelvin** refers to a temperature scale used to measure light's warmness or coolness.
- **Color Spectrum** refers to the portion of the electromagnetic spectrum that is visible to the human eye.

WARM SPECTRUM COOL SPECTRUM





ESSENTIAL TAKEAWAYS

- □ **LIGHT ONLY WHAT YOU NEED:** Use fully shielded fixtures. Shine lights down, not up. Direct lighting at desired areas. Be strategic with lighting and only use it where needed.
- □ **LIGHT ONLY WHEN YOU NEED:** Install timers, motion sensors, and dimmer switches, and turn off lights when not in use.
- □ **LIGHT ONLY HOW MUCH YOU NEED:** Use the right amount of light. Save electricity by using the lowest adequate wattage bulbs. Too much light is wasteful, impairs vision, and can be costly.
- □ **LIGHT ONLY HOW YOU NEED:** Use long-wavelength lights with a red or yellow tint to minimize negative health effects. Use warmer colored bulbs, like yellow or amber instead of white. Avoid bluish light, which is known to have a variety of negative effects.

ADAPTED FROM THE INTERNATIONAL DARK-SKY ASSOCIATION, DARKSKY.ORG

NOTES	•••••	•••••	•••••	•••••	•••••
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ACCEPTABLE LIGHTING TYPES

The images below illustrate various acceptable lighting forms. For more informations, visit http://www.darksky.org/fsa/fsa-products/.



ILLUSTRATIONS BY BOB CRELIN©. RENDERED FOR THE TOWN OF SOUTHHAMPTON, NY. COURTESY OF INTERNATIONAL DARK-SKY ASSOCIATION.



CONDUCTING A FORMAL LIGHTING AUDIT

The IDA requires formally designated Dark Sky Communities (DSC) to adopt a quality and comprehensive lighting code which includes a commitment to a brightness measurement program. The brightness measurement program can be maintained either by the community or by another public or private organization. The measurement program is meant to monitor success in reducing light pollution. A formal lighting audit should be performed to establish a baseline for monitoring success.

A formal audit may require outside help from organizations such as a university, research center, IDA chapter, astronomy club, or other qualified entities since determining the electrical, physical, and operational characteristics of lighting can be difficult or technical. The process for lighting audits vary depending on the organization; however, the Federal Department of Energy (DOE) recommends several basic guidlines.

BASIC LIGHTING AUDIT GUIDELINES

THE FOLLOWING ITEMS ARE RECOMMENDED FOR CONSIDERATION:

- □ The age, condition, quality, and location of existing light fixtures.
- Model and manufacturer of lighting system to obtain existing photometrics (perceived brightness).
- □ Lamp wattage and ballast type (if appropriate).
- □ Take note of the environment, is there the possibility of particulate, moisture, or dirt buildup in or around the lighting fixture?
- □ Take note of what kinds of activities, or uses are being performed in the space. Are there are special visual requirements?
- Dobserve how the lighting system is controlled and how often it is used.
- D Note the perceived color of the lighting, e.g. blue, white, or amber light.
- Measure the physical layout of the existing lighting system and take note of height and spacing.
- If possible, use an illuminance meter to measure light intensity. Readings should be taken on the ground and at even intervals to create a "grid" of measurements.

ADAPTED FROM THE FEDERAL DEPARTMENT OF ENERGY EXTERIOR LIGHTING AUDIT GUIDELINES

A lighting audit provides benchmarks for determining the effectiveness of lighting improvements and energy savings.

EXAMPLE LIGHTING AUDIT LOG

There are different ways to log your lighting audit information. One simple way is to record the information on a spreadsheet. The following is an example spreadsheet from the Federal Department of Energy's Exterior Lighting Guidelines. Some data points can be captured during the day while other data points will require a nighttime visit.

FIXTURE/LENSES				LAMP								
ITEM NUMBER	LOCATION Description	AGE	CONDITION (soiled, cracked, etc.)	LAMP TYPE	AGE	CONDITION (soiled, cracked, ect.)	SYSTEM WATTAGE	MODEL NUMBER	MANUFACTURER	PERCEIVED COLOR (blue, white, amber)	OCCUPANT TYPES (age, work, activities, etc.)	SHIELDING (none, partially, fully shielded)
001	Flood light outside City Hall entrance	7 yrs.	slightly cracked	halogen	2 yr.	good condition	150 W	# OFTR 2000 120 LP WH M12	Hal's Halogen Factory	white	city employees/ citizens	partially
002	Area lighting in City Hall parking lot/ NW corner	10 yrs.	good condition	metal halide	5 yr.	soiled	250 W	# OAL12 150M 120 PER LP R2	ABC Lighting Co.	bluish-white	city employees/ citizens	partially
003	Post Office entrance wallpack	8 yrs.	soiled	high pressure sodium	1 yr.	soiled	252 W	# TDD150SL 120 M2	Light Manufacturing Inc.	amber	post office staff/ patrons	none

BLANK LIGHTING AUDIT LOG

	FIXTURE/	LENSES							LAMP			
ITEM NUMBER	LOCATION DESCRIPTION	AGE	CONDITION (soiled, cracked, ect.)	LAMP TYPE	AGE	CONDITION (soiled, cracked, ect.)	SYSTEM WATTAGE	MODEL NUMBER	MANUFACTURER	PERCEIVED COLOR (blue, white, amber)	OCCUPANT TYPES (age, work, activities, ect.)	SHIELDING (none, partially, fully shielded)

EXAMPLE LIGHTING AUDIT WORKSHEET

Below is another example of how to record and organize your lighting audit data. Specific technology or technical assistance may be required to capture each data point. No matter what method or structure you use, be consistent and well organized.

DAYTIME VI	SIT	NIGHTTIME VISIT
Visit Date:	Fixture Power:	Visit Date:
Fixture Height (ft):	□ Solar□ Utility	Fixture Height (ft):
Fixture Lighting Purpose: Area Entrance/Egress Pathway Parking Roadway Sign Stairway Other Fixture Type: Barn Bollard Ceiling Mount Dark Cowbell Flood Hanging Light Lamp Post Phone Booth Recessed Spotlight Tin Hat Tube Vending Machine Wall Pack Wall Sconce	 □ Other Fixture Adaptive Controls: □ Motion Sensor □ None □ Photocell □ Switch □ Timer Switch □ Other Lamp Type: □ CFL □ Empty Socket □ Fluorescent Tube □ HPS □ Incandescent □ Induction □ LED □ LPS □ Metal Halide □ Other Shielding: □ Fully Shielded Eve □ Fully Shielded Fixture □ Fully Shielded Lamp 	Correlated Color Temperature CCT: Illuminance: Footcandle: MITIGATION Mitigation Required Yes No Mitigation Date: ADDITIONAL NOTES
Number of Fixtures	Lens D Partially Shielded Eve	
Lamps per Fixture:	 Partially Shielded Partially Shielded Fixture 	
Historic Fixture?	Partially Shielded	
□ Yes □ No	Lamp Lens Unshielded 	
		<u>.</u>

ADAPTED FROM BRYAN BOULANGER, OHIO NORTHERN UNIVERSITY CONTACT: B-BOULANGER@ONU.EDU

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DIFFERENT ASSESSMENT TOOLS

There are a variety of ways to collect information for your dark sky assessment. The following pages describe different methods for collecting, documenting, and organizing information. While the DOE and IDA offers basic guidelines, each community is unique, and the methods used and data collected will depend on individual goals, capacity, and access to technology. Dark Sky Community status won't be the goal for every community, but a formal audit will provide a baseline for limiting light pollution.

NOTES

USE TECHNOLOGY

A wide variety of Iphone and Android apps can be used to take night sky brightness measurements. Other applications, such as <u>COLLECTOR FOR ARCGIS</u> can capture a comprehensive set of geographic data points.

For more precise measurements, the IDA recommends using a <u>SKY QUALITY METER</u> with Lens (SQM-L). Choose apps and resources that make sense for you and your community or contact a dark sky expert for help. Below is a list of basic apps to get you started.



WHO CAN I CONTACT FOR HELP WITH A FORMAL AUDIT?

The International Dark Sky Association (IDA) (520) 293-3198 http://www.darksky.org

The Colorado Plateau Dark Sky Cooperative (435) 260-8540 https://cpdarkskies.org/ darkskycooperative@gmail.com

The Consortium for Dark Sky Studies (435) 260-8540 http://www.darkskystudies.org/ goldsmith@arch.utah.edu

Moab Dark Skies https://m.facebook.com/moabdarkskies/?ref=bookmarks

The Salt Lake Chapter of the IDA

https://www.darkskyslc.org/

LIGHTING ISSUE CONCERNS & LAND USE

Another tool for documenting light pollution sources is to mark the number of issues (e.g. poor shielding, blue/white lighting color, excessive lighting) observed in relation to land use. This can help identify focus areas and large-scale opportunities. Color in the number of issues related to the "three-legged stool" observed in the radial table below. Optional "issue-related" color coding is suggested below. The goal is to be able to compare the size of the "pie slices" after the assessment.



OPTIONAL "ISSUE" COLOR CODING Shielding Lighting Color Inappropriate/ Excessive Lighting

RESIDENTIAL

All types, single-family, apartments, etc.

RETAIL

Stores, shops, businesses, restaurants, etc.

CIVIC BUILDINGS Government, post office, schools

STREETS Street lighting

PARKS & REC

Sports parks, baseball fields, tennis courts, etc.

PARKING LOTS Lighted parking lots

LIGHTED SIGNS Business signs, advertising signs, etc.

OTHER

Any other uses, industrial, etc.

PUBLIC ENGAGEMENT & EDUCATION

Community engagement is an essential part of any kind of community-wide initiative. The support of local leaders, residents, and business owners can be gained from talking to people on an individual level and addressing their concerns. Make an effort to talk to neighbors and friends about light pollution and educate them on the benefits of improved lighting.

2 MINUTE SURVEYS...

Ask residents and business owners about their experience with light pollution. As you survey people educate them about basic light pollution concepts and issues. Why should they care?

QUICK QUESTIONS Is preserving dark skies important to you?	EDUCATE Briefly explain why light pollution is an issue.
Would you support simple changes to limit light pollution?	Describe why preserving the night sky is important to you.
What concerns do you have?	Discuss the "three-legged stool" and simple ways to mitigate light pollution.

MARKING A MAP

Marking lighting issues on a map can help identify and document spatial clusters and provide a reference for others.

An official zoning map, Google map, or other reference map of your community can be used to document sources of light pollution as well as examples of "dark-sky friendly" lighting.

Some areas may require a map that is "zoomed in on an area" such as on main street or a sports park. Your assessment may include just publicly owned lighting or all lighting including commercial, residential, and open space. The scale and amount of detail are up to the community.

Marked lighting issues should relate to the "three-legged stool" but should also be tailored to your community's specific dark sky assessment goals.

IDEAS FOR WHAT TO MARK





TAKING NIGHT PHOTOS

Documenting light pollution is an important way for educating the public on the actual situation and to support a case for improved lighting.

UNSHIELDED





SHIELDED





IMAGES FROM IDA INTRO TO LIGHTING POWERPOINT

NIGHT PHOTO GUIDELINES

The following are helpful guides on settings for taking certain types of photos at night. Remember, always use a tripod. These settings should be adjustable on the manual mode for any DSLR camera.

 DSLR stands for "digital single-lens reflex." DSLR cameras are versatile cameras with changeable lenses that produce highquality photos.

	SHUTTER	APERTURE	ISO	FLASH
SIGNS	1/50	F/2.8	100	Ν
CITY SCAPE	1/320	F/4.5	100	Ν
BRIDGES	15/1	F/5.6	100	Ν
STREET	1/5	F/4	320	Y
MONUMENTS	15	F/16	250	Y
LIFE	6	F/9	100	Y
THE MILKY WAY	20+	F/2.8	1600	Ν

CALCULATE THE SAVINGS

Many communities are now realizing the benefits of controlling energy waste through better-quality and better-designed lighting. Calculating potential energy savings and payback for upgrade conversions is another way to understand how adopting dark sky policies and best practices can benefit your community. Use the following formula from the Federal Department of Energy's Exterior Lighting Guidelines to calculate an estimation of lighting power and energy use. Compare your current lighting energy costs with estimated energy costs of an upgrade conversion. Calculating an energy use estimation for prospective lighting replacements is an effective way to illustrate cost savings.

LIGHTING POWER & ENERGY USE ESTIMATION									
1. COMPUTE THE TOTAL POWER (kW) USED BY THE EXISTING SYSTEM									
EXISTING LAMP OR LUMINAIRE WATTAGE W	NUMBER OF LAMPS x lamp	TOTAL POWER CONSUMED	W						
2. COMPUTE THE TOTAL	L ENERGY (kWh) CONSUME	O ANNUALLY BY THE EXISTI	NG SYSTEM.						
TOTAL POWER CONSUMED BY SYSTEM LUMINAIRE W	HOURS OF USE PER DAY x hrs/day ;	DAYS OF USE PER WEEK x days/wk	WEEKS OF USE PER YEAR x wks/y	TOTAL ENERGY CONSUMED					
3. COMPUTE THE TOTAL ENERGY COST (DOLLARS) ANNUALLY FOR OPERATION OF THE EXISTING SYSTEM.									
TOTAL ENERGY CONSUMED	ENERGY RATE	TOTAL COST							
kWh/	/yr \$/kV	Vh =	\$/yr						

BACK TO THE BASICS

- W (watt) the standard unit of power in the International System of Units (SI)
- Wh (watt hour) a unit of energy equal to the power of 1 watt operating for 1 hour
- **kW (kilowatt)** a measure of 1,000 watts of electrical power.
- **kWh (kilowatt hour)** a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.
- Luminaire a complete lighting unit that usually includes the fixture, ballasts, and lamps

IN A NUTSHELL... ENERGY = POWER × TIME

SWOT ANALYSIS

A SWOT analysis is a strategic planning and brainstorming tool that encourages participants to assess and reflect on the *Strengths, Weaknesses, Opportunities, and Threats* of a place, situation, or goal. Use a SWOT analysis to assess the strengths, weaknesses, opportunities, and threats that are relative to your community's goal to preserve and protect dark skies (see example content below).

SWOT ANALYSIS SUBJECT: Star City USA - becoming a dark sky destination

STRENGTHS	WEAKNESSES					
 Shared values among community members Tourist destination Friendly Small town values Low population Historical assets Close to outdoor recreation 	 Lack of cultral resources Limited funding Perception town is anti-business Lack of destination facility Vacant store fronts Lack of rental housing Codes are too flexible 					
OPPOBLINITIES	THREATS					
 Public education Retrofitable lighting Room to grow Explore astro-tourism Attract new businesses and families 	 Light pollution from nearby city Attitudes towards change Afraid to try new things Youth leaving High employee turnover 					



NOW WHAT? AFTER YOUR DARK SKY ASSESSMENT

What you do after your dark sky assessment is almost as important as the assessment itself. Depending on your specific goals, the following steps can lead to an organized and effective action plan.

1. Debrief after the assessment

- □ Hold a post-assessment meeting with all assessors.
- Compile information, recording comments and clarifying notes.
- Brainstorm and record suggestions for changes and improvements. Develop ideas for projects that take advantage of opportunities, improve strengths, strengthen weaknesses, or mitigate threats.
- □ Invite participants to be involved in your project and identify how they will be committed.
- □ Thank everyone for their participation and outline next steps.

2. Form a local Dark Skies Group

(adapted from Advice on Starting a Local Dark Skies Group, Ed Stewart, Dark Skies, Inc., of the Wet Mountain Valley)

- □ Educate yourself on the various aspects of light pollution.
- Develop a core working group to support the initiative.
- D Build awareness and education through local media and social media.
- Personally contact business owners and managers on the benefits of proper outdoor lighting.
- □ Provide a vendors list of dark sky friendly fixtures to contractors, hardware stores, and home improvement businesses.
- □ Contact the local power company for potential incentives or discounts on amber LED fixtures.
- □ Individually approach town leadership to get a feel for local support.
- □ Take the long-range approach. This may be seen as a "tree hugger" issue, but is about protecting the rural environment and quality of life.
- □ Stay positive and focus on benefits and advantages: reduced power consumption, cost savings, improved quality of life, and improved potential tourism.

3. Pursue Dark Sky Places certification

- □ Provide the compiled report to local leadership, with suggested actions.
- □ Gauge the level of willingness of local leadership to take action.
- □ Outline the current project prioritization for leaders and ask leaders for input.
- □ Examine the potential to become a dark-sky certified community at <u>http://www.</u> <u>darksky.org/idsp/become-a-dark-sky-place/.</u>
- □ Fill out the application at <u>http://www.darksky.org/idsp/become-a-dark-sky-place/dark-sky-community-inquiry/.</u>

4. Plan action

- **D** Create an implementation plan based on prioritized projects or actions.
- □ Identify potential funding sources as needed, required partners, and any needed changes to town code.
- Plan completion of small simple tasks first to build momentum for larger projects.
- □ Build critical mass—get the word out! Notify and continually engage and invite stakeholders, land owners, business owners and general public.

NOTES		

IDA DARK SKY COMMUNITY

An IDA Dark Sky Community (DSC) is a town, city, or municipality that has shown exceptional dedication to the preservation of the night sky through the implementation and enforcement of quality lighting codes, dark sky education, and citizen support of dark skies.

Communities apply with the IDA who will make a decision in an average of one-to-two years from the initial request.

Requirements that must be maintained:

- □ Quality comprehensive lighting code
- □ Community commitment to dark skies
- Broad support from community organizations
- Community commitment to education on dark skies
- Success in light pollution control
- A continuing sky brightness measurement program

For full instructions and information: http://www.darksky.org/idsp/become-a-darksky-place/

NOTES

ADDITIONAL RESOURCES

GENERAL

International Dark Sky Association: http://www.darksky.org Colorado Plateau Dark Sky Cooperative: https://cpdarkskies.org The Consortium for Dark Sky Studies: http://darkskystudies.org International Dark Sky Association Salt Lake City Chapter: https://www.darkskyslc.org/ Interactive light pollution mapping tool: https://www.lightpollutionmap.info Building Energy Codes Program: https://www.energycodes.gov/comcheck Watts-to-lumens free calculator: http://www.rapidtables.com/calc/light/watt-to-lumen-calculator.htm Sensible outdoor lighting: https://darkskywisconsin.uwex.edu/files/2015/11/township-brochure.pdf The new world atlas of artificial night sky brightness: http://advances.sciencemag.org/content/2/6/e1600377.full Federal Department of Energy's Exterior Lighting Guidelines: http://cltc.ucdavis.edu/sites/default/files/files/publication/2010_DOE_FEMP_ Exterior_Lighting_Guide.pdf How to carry out a dark sky survey: https://darkskydiary.wordpress.com/2010/12/18/how-to-carry-out-a-dark-sky-survey/

Luginbuhl and Hall. "How Flagstaff is Preserving Dark Skies." Astronomy, Sept. 2017, pp. 56-60.

RECREATION LIGHTING

Powder Mountain Night Skiing: 6,248,060 total lumens for 19 acres of skiable terrain (ratio of 7.6 lumens per square foot). 6500 Kelvin color temp. <u>http://ultratechlighting.com/wp-content/uploads/2016/01/SNBT-FL-300W-B2.pdf</u>

Nordic Valley Night Skiing: 6,639,390 lumens and about 54 acres of skiable terrain (ratio of about 3 lumens per square foot). 6500 Kelvin color temp.

International Tennis Federation: http://www.itftennis.com/technical/facilities/facilities-guide/lighting.aspx

FLAG LIGHTING

Federal law for US flag: http://www.senate.gov/reference/resources/pdf/RL30243.pdf

Federal and state facilities: See UCA §17-27a-304. http://le.utah.gov/xcode/Title17/Chapter27A/17-27a-S304.html

Canopy lighting a parking lot light: See IDA model ordinance regarding lumens per gas pump and lumens per parking stall: <u>http://darksky.org/</u>our-work/public-policy/mlo/_

TOWER LIGHTING

Federal Aviation Administration: <u>https://www.faa.gov/regulations_policies/faa_regulations/</u> Federal Communications Commission: <u>https://www.fcc.gov/general/rules-regulations-title-47</u>

ILLUMINATION STANDARDS

Illuminating Engineering Society (IES): https://www.ies.org/standards/

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For more resources, visit ruralplanning.org/toolbox

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