Proposal for Smith College Outdoor Lighting Policy

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1 Introduction

Smith College is well known for its historic beautiful residential campus and natural New England setting. Redesigned by the firm founded by Frederick Law Olmsted, Sr. in 1893, the campus was planned so that students would follow curving, organic paths on their way to class and enjoy the natural and architectural beauty around them. When the campus was designed, the only artificial light at night was the occasional gas lamp. All campus residents knew the naturally dark night sky and the splendors of the Milky Way. Not until nearly fifty years later were outdoor electric lights installed around campus.

Now, outdoor lighting at Smith is an often overlooked but very important facet of the college. It is safe to assume that the college will have outdoor lighting for the foreseeable future. However, excessive or poorly designed outdoor lighting has negative effects on safety, human health, and the environment. Bright lights with high glare make it hard to see potential intruders or pedestrians crossing the street at night. Artificial light at night also has been correlated with higher risk for cancer, obesity, diabetes, and disruption of circadian rhythms, or sleep cycles. It disrupts many factors of the environment including both plants and animals. Finally, artificial skyglow created by this light obscures the starry night sky, impacting the ability to do meaningful research. It is these hazards that motivate the creation of this policy.

This policy is focused on establishing safe, energy-efficient and dark-sky-friendly lighting at Smith College. It applies to all new construction on campus as well as replacements for existing light fixtures.

2 Underlying Principles

Design of outdoor lighting at Smith should take the following principles into consideration:

- Safety for all members of campus community, especially pedestrians and drivers
- Public health (sleep cycles, reduction of risks for cancer and other diseases)
- Respect for the environment
- Preserving the view of the natural starry sky
- Historic and aesthetic tradition
- Energy efficiency
- Northampton's outdoor lighting code

3 Current Best Practices

Lighting and light pollution are an increasing problem worldwide. The new advent of cheap, efficient LED lighting especially has spawned a jump to a 6% increase (worsening) in light pollution per year. College and university campuses offer unique opportunities to combat light pollution: their institutional scale is often a manageable size for effecting change, they provide an opportunity to teach large numbers of students about these important issues, and many have active research in astronomy. Many of these campuses in the United States are currently grappling

with this problem as well and starting to take steps to reduce their light pollution impact.

The following colleges and universities are some good examples of institutions that have carefully controlled outdoor campus lighting.

- Wesleyan University, Middletown, CT
  - Wesleyan has had an ongoing program to reduce light pollution on campus since 1980.
- Northern Arizona University, Flagstaff, AZ
  - In 2010, NAU created a new lighting master plan to make their system comply with the Flagstaff Outdoor Lighting Code and unify the campus aesthetic. Among other changes, all fixtures were replaced with full cutoff lights.
  - Flagstaff, Arizona was the first internationally recognized Dark Sky City, meaning that it has shown dedication to the reduction of light pollution including lighting codes and education programs.
- Unity College, Unity, ME
  - In 2015, Unity College designed all light fixtures for new construction to reduce and eliminate light pollution.
- Plymouth State University, Plymouth, NH
  - In 2010, PSU made their outdoor lighting more energy efficient and implemented measures such as motion sensors and shields.

4 Existing Conditions at Smith College

Outdoor lighting at Smith has evolved over the last century in an ad hoc and organic fashion. There is a very large range of style, brightness, protection against glare, color, and type of light sources. Outdoor light fixtures can be divided into two categories - free-standing and mounted on buildings. Mounted lights include wall packs, beacons, and entrance lights. Wall packs are lights that are attached to the sides of buildings that radiate light out in nearly every direction. An example is shown in Figure 1. Beacons are the decorative light fixtures outside buildings like Neilson Library and Seelye Hall that are meant to serve as attractive signposts for the building. An example is shown in Figure 2. There are other entrance lights on every building on campus that range widely in style and type.

A recent study conducted by Gary Hartwell of Facilities Management mapped and tabulated most free-standing outdoor lights on campus, which fell into roughly six categories (Figure 3). The campus walkways are mostly illuminated by Sternberg inverted gooseneck lamps, such as the one shown in Figure 4. Currently, when lightbulbs fail, there are a mix of different bulbs that are being used to replace them. In addition, new fixture styles are being used for each new project. There are semiannual lighting walks conducted by the Dean of Students to evaluate the condition of the lights and note where lights need to be replaced. The walks are attended by representatives of student government and of the houses, Public Safety, and Facilities Management.

Here we list several examples of well-designed and poorly designed outdoor lighting fixtures at Smith.

Figure 1: Example of a wall pack light on the side of 10 Prospect Street

Figure 2: Example of a beacon on the side of Burton Hall

Figure 3: Campus lighting survey (Gary Hartwell, 2014)

Figure 4: An example of a Sternberg inverted gooseneck fixture.

4.1 Well-designed light fixtures

A good lighting fixture can be found on the back wall of Burton Hall - the light is directed only downwards, not out or up (Figure 5). Another good fixture is found on the entrance to the Lyman Plant House. This light is fully shielded so that it is very efficiently lighting the ground but nowhere else (Figure 6). There are many well-designed Sternberg gooseneck fixtures around campus, specifically those which are completely shielded and have no bulb emerging from the bottom (Figure 4).

4.2 Poorly-designed light fixtures

One example of bad lighting fixtures at Smith is at the Mendenhall Performing Arts Center. These fixtures radiate light out in every direction, which is highly inefficient and visually uncomfortable, as shown in Figure 7. Another example of poorly designed fixtures are the Bollard lights outside of the Campus Center, which are lights on low posts that also radiate in every direction (Figure 8). On the back of Ziskind House there is a light that is well-shielded against light going directly up, but very poorly shielded against glare (Figure 9).

5 Quantitative Assessment of Outdoor Lighting

The Backlight Uplight Glare (BUG) light rating system was developed by the IES to quantify the amount and direction in which light is emitted by a given light fixture. Each element of the BUG rating is categorized from 0 to 5, with 0 being the least light emitted in a given direction and 5 being the most (Tables 1, 2, and 3). Figure

Figure 5: Well-designed fixture on the back wall of Burton Hall

Figure 6: Well-designed fixture at the entrance of the Lyman Plant House

Figure 7: The lights surrounding Mendenhall Performing Arts Center let light radiate out in all directions, including up into the sky and into peoples' eyes. This is both highly inefficient and uncomfortable to look at.

Figure 8: Poorly-designed fixture outside of the Campus Center.

Figure 9: Poorly-designed fixture on the back of Ziskind House.

10 shows the angles of light that the BUG system regulates.

Another quantitative assessment of lighting fixtures is through the Correlated Color Temperature(CCT) of the bulb. This is a number assigned to the bulb based on the color of the light it emits. These colors correlate to the color of a metal that is heated to a specific temperature. Older light bulbs have metal filaments that actually reach this temperature, while more modern elements do not, but still retain the CCT as a way of describing the color.

6 Policy

The following policy is informed by best practices on outdoor lighting set forth by the Illumination Engineers Society (IES), lighting designers, and the International Dark-Sky Association (IDA). The following four rules are the proposed policies for Smith College Outdoor Lighting.

1. Lights should be fully shielded against glare, uplighting, and backlighting.

    - Lights should have a BUG uplighting rating of U0 (Figure 11, Table 1). The light is fully cut off and never escapes upward out of the fixture.
    - Lights should have a BUG glare rating of G0, or at most G1 (Figure 13, Table 2). Ideally, light should be cast downward in a cone extending no more than 60 degrees from vertical. The light source itself is not directly visible unless one is standing directly underneath the fixture.
    - Outdoor lighting should not shine into dorm rooms or other buildings. This includes a BUG Backlight rating of B0, (Figure 12b, Table 3).

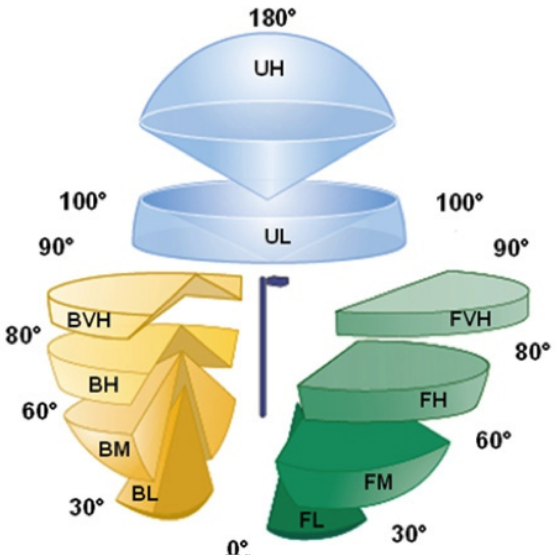


Figure 10: The IES separates the solid angle of light into different regulated sections.

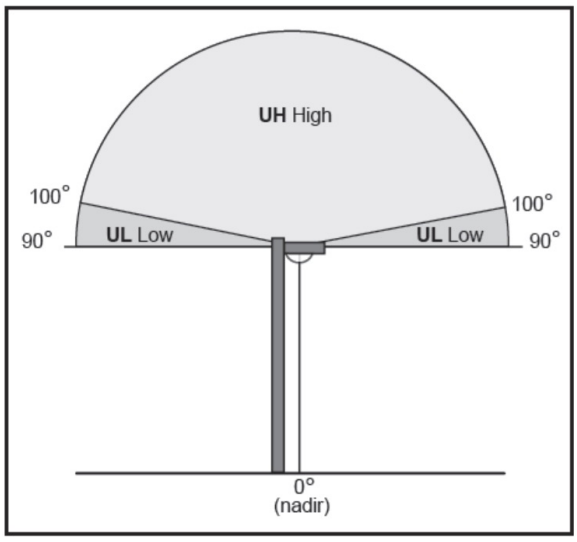
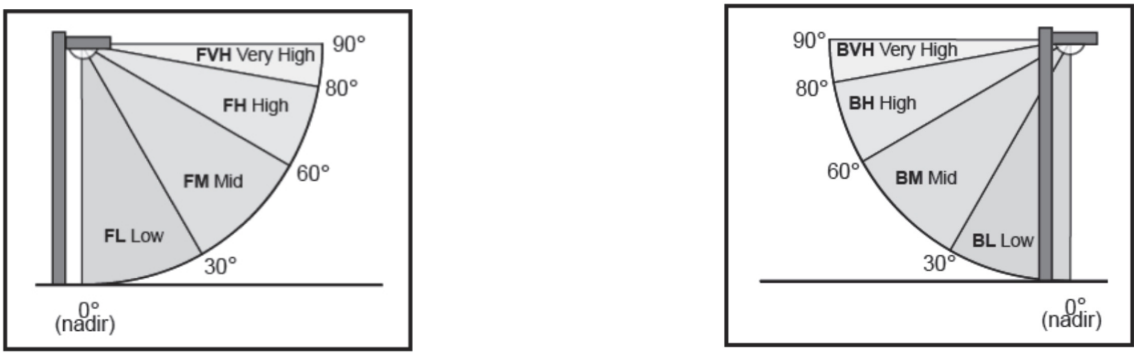


Figure 11: The IES separates the solid angle of light into sections. Each of these sections is allowed to emit only a specific number of lumens in order to receive a low BUG rating, as shown in figure 1.

	Secondary Solid Angle	U0
Uplight / Skyglow	UH	0
	UL	0
	FVH	10
	BVH	10

Table 1: The amount of lumens allowed in each solid angle - Uplight High (UH), Uplight Low (UL), Front Very High (FVH), and Back Very High (BVH). This regulates the total amount of light emitted above 80°from vertical.



(a) Front angles

(b) Back angles

Figure 12: The IES separates the solid angle of light into sections. Each of these sections is allowed to emit only a specific number of lumens in order to receive a low BUG rating, as shown in Figure 2.

	Secondary Solid Angle	G0	G1
Glare / Offensive Light	FVH	10	250
	BVH	10	250
	FH	660	1800
	BH	660	1800

Table 2: The amount of lumens allowed in each solid angle - Front Very High (FVH), Back Very High (BVH), Front High (FH), and Back High (BH). This regulates the total amount of light emitted between 60°and 90°from the nadir.

	Secondary Solid Angle	B0
Backlight / Trespass	BH	110
	BM	220
	BL	110

Table 3: The amount of lumens allowed in each solid angle - Back High (BH), Back Medium (BM), and Back Low (BL). This regulates the total amount of light emitted between 90°and 270°from the front of the fixture.

2. Outdoor lights should be as bright as is needed for safety, but no brighter. Excessive light can lead to glare and impair rather than enhance safety.

    - The IES has published minimum recommended levels. It is important to not that these levels are recommendations only and are not prescribed by any existing law or building code. Furthermore, they do not specify a maximum light level. Lights should be no more than 10% brighter than their minimum recommendation.
    - Illumination levels on the ground directly underneath lighting fixtures should be no more than 1 foot-candle. If glare is well-controlled, levels of 0.5 foot-candles underneath walkway lights is the recommended target.
    - No specific minimum or maximum uniformity ratios are recommended. In general, better visibility is provided by higher contrast on the ground.

3. Lights should not be too blue in color.

    - The lights should have a correlated color temperature (CCT) in the range 1800-2700K, and no more than 3000K.

4. Whenever available, the college should take advantage of the ability to dim or extinguish lights late at night, especially in less trafficked areas.

    - One of the major benefits of LED lights is that they can be dimmed easily as long as that option is included when they are installed.

7 Sample Approved Fixtures

7.1 Freestanding Fixtures

A replacement for a Bollard-style fixture is the Ashbery Path Light, produced by LandscapeForms (Figure 14). This shields the light against glare and has a color temperature of 3000K. The Sternberg gooseneck fixtures around campus are another good example. For these, there is an XXX incandescent model with a recessed bulb that can be replaced by a LED so there is a fully shielded bulb with a lower correlated color temperature and more efficiency.

7.2 Attached Fixtures

One wall pack that is approved is the Voltaire Architectural Wall Pack produced by H.E. Williams, Inc. (Figure 15). This is fully shielded and has factory set automatic dimming controls. A good retrofit is to put a can-like shield around an existing fixture. These shields also exist on new fixtures. One such fixture is the Skyline Light Wall Mount from Minka Group (Figure 16).

	IES Recommended Minimum	IES Recommended Max Average	Policy Max Average	Policy Maximum
Private Parking Lot	0.13 fc	0.5 fc	0.5 fc	0.8 fc
Active Building Approach	–	0.2 fc	0.2 fc	0.8 fc
Active Building Entrance	–	2 fc	2 fc	3 fc
Sidewalks	–	0.2 fc	0.2 fc	0.8 fc

Table 4: Lighting Levels

Figure 13: Ashbery Path Light from LandscapeForms

Figure 14: Voltaire Architectural Wall Pack from H.E. Williams, Inc.

Figure 15: Skyline Light Wall Mount from Minka Group

8 Glossary

Adaptive Controls: Devices such as motion sensors, timers and dimmers used in concert with outdoor lighting equipment to vary the intensity or duration of operation of lighting.

Baffle: An opaque or translucent element to shield a light source from direct view.

Bulb or lamp: The source of electric light. To be distinguished from the whole assembly (see luminaire). Lamp often is used to denote the bulb and its housing.

BUG rating: Backlight, Uplight, and Glare ratings for amounts of lumens in each zone, determined by the IES.

Color rendering: Effect of a light source on the color appearance of objects in comparison with their color appearance under normal daylighting.

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

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

Dimmer: Dimmers can reduce the input power requirements and the rated lumen output levels of incandescent and fluorescent lights. Fluorescent lights need special dimming ballasts. Dimming incandescent lights reduces their efficiency.

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

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

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

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

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

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

Flux (radiant flux): Unit is erg/sec or watts.

Foot-candle: Illuminance produced on a surface one foot square from a uniform point source of one candela.

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

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

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

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

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

Illuminating Engineering Society of North America (IES or IESNA): The professional society of lighting engineers, including those from manufacturing companies, and others professionally involved in lighting.

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

Intensity: The degree or amount of energy or light.

International Dark-Sky Association (IDA, Inc.): A non-profit organization whose goals are to build awareness of the value of dark skies, and of the need for quality outdoor lighting.

LED: Light emitting diode.

Light Pollution: Any adverse effect of artificial light.

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

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

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

Mounting height: The height of the fixture or lamp above the ground.

Photocell: An electronic device that changes the light output of a luminaire

dynamically in response to the ambient light level around the luminaire.

Shielding: An opaque material that blocks the transmission of light.

Skyglow: Diffuse, scattered sky light attributable to scattered light from sources on the ground.

Uniformity ratio: Ratio of illumination levels between average and darkest areas on the ground due to lighting.