Lighting Standards: Recommendations for Humboldt State University

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Humboldt State University spends almost $3 million annually on energy to serve over 7000 students, staff and faculty. Energy efficient lighting upgrades are the most easily attainable and cost-effective objectives for reducing energy consumption on campus. New Title 24 regulations taking effect January 1, 2014 and Humboldt State University's commitment to sustainability are the driving forces behind bringing this campus up-to-date with energy efficient, cost-effective lighting standards.

Humboldt State University | Environmental Science
Senior Capstone Project

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Problem Statement

New Title 24 regulations taking effect January 1, 2014 and Humboldt State University's commitment to sustainability are the driving forces behind bringing this campus up-to-date with energy efficient, cost-effective lighting standards. This project serves to make recommendations on indoor/outdoor lighting standards and fixtures on Humboldt State University's campus, in order to lay a solid foundation for development of a complete set of building standards for adoption by HSU.

Background

Humboldt State University spends upwards of $3 million[1] annually on energy while serving approximately 7000 students in over forty buildings during the academic year. With the majority of staff and students' time spent on campus, lighting the campus for safe and optimal use is a priority for colleges and universities. Title 24 is a set of regulations, part of California Building Code, which specifically targets energy waste reduction in buildings and is updated every two to five years. As half of the Building Standards Student Group (BSS), I worked with a student partner[2] over eight months to produce two documents totaling one hundred pages. The Building Standards Student (BSS) Group is a Humboldt Energy Independence Fund (HEIF) program that works in collaboration with facilities, management, and the Schatz Energy Research Center (SERC). This group has been charged with the following: first, develop and recommend building standards based on the California building code, CSU Lighting Design Guide, and LEED qualifications. Second, the BSS group uses these standards as a basis for the recommendation of relevant products for potential Humboldt State University projects. The ultimate goal is to create a process by which useful and realistic building standards based on existing best management practices can be developed for adoption by HSU, and to use this process in the development of standards for all aspects of building. Our documents in particular are a compilation of standards and product recommendations specifically regarding indoor and outdoor lighting.

Initial development of the recommended standards started by defining a project scope. Rather than focus generally on all lighting applications, the decision was made to define more specific areas of effect on which the research and subsequent standard development could be focused. These areas were the Founders Hall basement and library stairwell for the indoor standards, while the outdoor standards were more broadly directed toward street lighting, walkways and building exteriors. The other component of the project scope was to develop a set of guiding principles to ensure the consistency and focus of the standards. These include a compliance with updated Title 24 requirements, a list of general lighting project priorities (safety, energy efficiency, financial feasibility, utility and aesthetics), and the overarching project philosophy that higher initial costs should be considered in exchange for longer term code compliance and lower maintenance and

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[1] Source: Masters Thesis: Building Energy Analysis For Humboldt State University by Chhimi Dorji, 2010

[2] The author would like to acknowledge Eric Sorensen, partner in the BSS group, for his contributions, without which this project would not have been possible. Many thanks!

energy costs. While the areas of effect were used mainly in the recommendation of lighting fixtures, the guiding principles informed the general standards that became the framework by which the more specific standards were developed.

The standards charts (see appendix) were sourced mainly from the CSU Indoor/Outdoor Lighting Design Guide, with some LEED sourced standards as well. The goal in the future is for the standards chart to be more broadly sourced; however, the current CSU Guidelines are extensive and leave little room for improvement. More importantly, the lighting standards charts are meant to be a useful tool with which lighting products and components can be compared and ultimately decided on. It is the concise compilation of CSU and LEED guidelines, sorted into nine separate sub-categories, and designed to cover the entirety of the selection and implementation process. For example, the initial fixture recommendations were chosen using the standards that regard general information easily obtained from product specification sheets. However, there are also more detailed standards regarding cost, project efficiency, etc. that could be used to narrow in on products further along the selection processes, as well as those regarding lighting project goals that could help guide the implementation of products once they have been chosen.

The standards documents also include information regarding fixture recommendations specific to the areas of effect. This includes, product descriptions, pros and cons, comparative specifications, and the comparative standards that they meet. Although the standards chart and the process by which it was developed is the most important aspect of this body of work, these final sections serve as an important example of how the standards chart can be used in specific applications. They serve to demonstrate that fixtures designed for different lighting needs can still be chosen and compared according to how well they meet the same set of general standards.

Objectives and Constraints

The primary objectives for this project were to first compile a list of standards and research that would then be refined using the guiding principles discussed in the previous section. Second, it was asked that we provide examples of fixtures that would meet the standards. Initially, the objectives considered for this project included doing a cost-benefits or life cycle analysis based upon the recommended standards and fixtures. The primary constraint that prevented this project from going beyond recommendations and product specifications was the unavailability of necessary data for calculations. I have learned that the lack of transparency with energy data on campus stems from an unavailability of that information in general. The campus' out-of-date infrastructure does not allow for measurement of disaggregated energy data; only three buildings are sub-metered on the entire campus. I have also discovered from meetings with the planning office that administrators recognize this problem, but budget constraints have slowed the process of updating our infrastructure for data measurement and collection. Another key constraint in working on this project was communication. A significant portion of my requests for information related to this project went unanswered throughout the entire process. This problem was not only isolated to this campus, but also applied to outside universities and companies alike.

Implementation Plan

The documents created as a result of this project are intended to be dynamic, changing with technology and need, which laid a foundation upon which future student groups, HEIF and/or Facilities Management can build. The two documents have been passed on to the university planning office as reference material for more detailed work in this area. Ideally these documents will be useful for future groups in approaching a redesign of campus standards since the bulk of the research has been done. It is now in the hands of the decision-makers to proceed with as they see fit. My impression from our presentation to Facilities Management is that this jumping off point would be used for the basis of discussion and be further refined through the involvement of staff across campus.

Due to a lack of data available at this time, a more in-depth analysis must be completed in order to evaluate the options for cost-benefits and life cycle assessment to have an accurate picture of the overall impacts. Simplistic, back-of –the-envelope calculations was the furthest I was able to get with any numerical data, but I am not presenting that information here because I am dissatisfied with reporting data of that quality.

Monitoring and Evaluation Plan

A baseline of energy use data needs to be established before implementing and new lighting design projects so that the effects of an upgrade can be quantified for future use. After a baseline quantity is measured and a project is implemented, measurements should be taken again so that a direct comparison can be made between the before and after as well as applying it to future projects. I would also recommend that steps be taken to measure and record disaggregated energy use data to be made available to the campus community for future energy-related projects. As more information that is gathered and organized, a more complete picture of our actions can be evaluated for effectiveness.

Appendix A: Indoor Standards Chart

General Standards		Source of Reference
1	Priorities of the project must include energy efficiency, safety, aesthetics, financial feasibility and utility.	CSU Indoor Lighting Design Guide - 2012
2	Shall consider higher initial costs in exchange for long-term code compliance, lower maintenance and lower energy cost.	CSU Facilities Management Conference - 2012
3	All individual Title 24 (T-24) calculations for lighting shall be neutral or positive. Individual negative compliance margins are not allowed.	CSU Indoor Lighting Design Guide - 2012
4	New lighting construction must exceed T-24 by at least 15% and lighting renovation must exceed T-24 by at least 7.5%	CSU Indoor Lighting Design Guide - 2012
Applicable Codes and Regulations		
1	Comply with T-24 part 6 regarding power use and lighting controls.	CSU Indoor Lighting Design Guide - 2012
2	Comply with T-24 part 3 regarding wiring and grounding.	CSU Indoor Lighting Design Guide - 2012
3	Comply with T-24 part 11 regarding CALGreen building tiers.	CSU Indoor Lighting Design Guide - 2012
Life Cycle Assessment		
1	Analyze costs of ownership and the net present value of the project.	CSU Indoor Lighting Design Guide - 2012

Aesthetics		
1	Have adequate illumination levels for tasks performed in each space, lighting uniformity, and avoid glare or "cave effect."	CSU Indoor Lighting Design Guide - 2012
2	Fixtures shall coordinate to match the aesthetics of the building and campus.	CSU Indoor Lighting Design Guide - 2012
3	Lighting shall highlight special architectural features and complement colors/materials of surfaces.	CSU Indoor Lighting Design Guide - 2012
Operation and Maintenance		
1	Limit the amount of replacement components that must be maintained in campus inventory.	CSU Indoor Lighting Design Guide - 2012
2	Maintenance costs to replace lamps and ballasts should be minimized and fixtures should be easily accessible.	CSU Indoor Lighting Design Guide - 2012
3	Fixture types, lamps / ballasts, and control systems must be accurately documented and diagramed.	CSU Indoor Lighting Design Guide - 2012
4	Put in place maintenance and inspection schedule to insure proper operation of the system.	CSU Indoor Lighting Design Guide - 2012
5	Replacement components and technical support shall have expected availability into the reasonably foreseeable future.	CSU Indoor Lighting Design Guide - 2012
Energy Efficiency		
1	Establish program for measuring baseline energy efficiency before and after project completion.	CSU Facilities Management Conference - 2012

2	A redesign rather than a simple retrofit must be taken into account.	CSU Indoor Lighting Design Guide - 2012
3	Lighting power density must be at least 15% below the maximum allowed by ANSI/ASHRAE/IESNA Standard 90.1 - 2010	LEED Reference Guide - 2009
Lighting Control Utility		
1	Control systems must be intuitive and clearly marked / labeled.	CSU Indoor Lighting Design Guide - 2012
2	Use occupancy sensors for at least 75% of applicable lighting load.	LEED Reference Guide - 2009
3	Use daylight sensors for at least 50% of applicable lighting load.	LEED Reference Guide - 2009
4	Refer to section 5.5 in CSU indoor lighting design guide for factors affecting sensor performance / placement.	CSU Indoor Lighting Design Guide - 2012
5	Refer to section 5.6 in CSU indoor lighting design guide regarding lighting controller options.	CSU Indoor Lighting Design Guide - 2012
6	Refer to section 5.7 parts G & I in CSU indoor lighting design guide regarding controller specifics for hallways and stairways.	CSU Indoor Lighting Design Guide - 2012
Appropriate Light Characteristics		
1	Have adequate illumination levels for tasks performed in each space.	CSU Indoor Lighting Design Guide - 2012
2	Interior light sources must be above 80 CRI and have a CCT between 3000K and 4000K	CSU Indoor Lighting Design Guide - 2012
3	Account for reflection of surfaces and objects.	CSU Indoor Lighting Design Guide - 2012

4	Account for both ambient and task oriented lighting needs.	CSU Indoor Lighting Design Guide - 2012
Fixtures		
1	Replacement lamps shall have identical color temperatures and CRI ratings to maintain uniform appearance.	CSU Indoor Lighting Design Guide - 2012
2	Standardize lamps and ballasts to provide aesthetic as well as maintenance benefits.	CSU Indoor Lighting Design Guide - 2012
3	Account for ambient temperature and ventilation to achieve operational hours specified by the manufacturer.	CSU Indoor Lighting Design Guide - 2012
4	Consider only LED, CFL, and linear fluorescent for fixtures.	CSU Indoor Lighting Design Guide - 2012

Appendix B: Outdoor Standards Chart

General Standards		Source of Reference
1	Priorities of the project must include energy efficiency, safety, aesthetics, financial feasibility and utility.	CSU Indoor Lighting Design Guide - 2012
2	Consider higher initial costs in exchange for long-term code compliance, lower maintenance and lower energy cost.	CSU Facilities Management Conference - 2012
3	All individual Title 24 (T-24) calculations for lighting shall be neutral or positive. Individual negative compliance margins are not allowed.	CSU Indoor Lighting Design Guide - 2012
4	New lighting construction must exceed T-24 by at least 15% and lighting renovation must exceed title 24 by at least 7.5%.	CSU Indoor Lighting Design Guide - 2012
Applicable Codes and Regulations		
1	Comply with T-24 part 6 section 147 and 132 regarding power allowances, luminaire cutoff and lighting control requirements.	CSU Outdoor Lighting Design Guide - 2012
2	Comply with T-24 part 3 regarding circuiting, overcurrent protection, and grounding.	CSU Outdoor Lighting Design Guide - 2012
3	All electrical devices and components such as luminaires and ballasts shall be listed for wet locations and environments.	CSU Outdoor Lighting Design Guide - 2012
Life Cycle Assessment		
1	Analyze costs of ownership and the net present value of the project.	CSU Indoor Lighting Design Guide - 2012

Aesthetics		
1	Fixtures must coordinate to match the aesthetics of the building and campus.	CSU Indoor Lighting Design Guide - 2012
2	Lighting shall highlight special architectural features and complement colors/materials of surfaces.	CSU Indoor Lighting Design Guide - 2012
Operation and Maintenance		
1	Limit the number of replacement components that must be maintained in campus inventory.	CSU Indoor Lighting Design Guide - 2012
2	Fixtures shall be designed to provide easy access to lamps and ballasts in order to reduce maintenance time and costs.	CSU Outdoor Lighting Design Guide - 2012
3	Fixture types, lamps / ballasts, and control systems must be accurately documented and diagrammed.	CSU Indoor Lighting Design Guide - 2012
4	Put in place maintenance and inspection schedule to insure proper operation of the system.	CSU Indoor Lighting Design Guide - 2012
5	Fixtures shall be selected from nationwide, well-established manufacturers that have a minimum of 15 years experience in the lighting industry and a distributor geographically close to the campus.	CSU Outdoor Lighting Design Guide - 2012
Energy Efficiency		
1	Establish program for measuring baseline energy efficiency before and after project completion.	CSU Facilities Management Conference - 2012
2	A redesign rather than a simple retrofit must be taken into account.	CSU Indoor Lighting Design Guide - 2012
3	Lamp efficacy must be at least 60 lumens per watt for lamps rated over 100 watts.	CSU Outdoor Lighting Design Guide - 2012

Lighting Control Utility		
1	All outdoor lighting must be controlled by a photo sensor or time switch to turn off lighting during daylight hours.	CSU Outdoor Lighting Design Guide - 2012
2	All building facades, parking lots, garages, and canopies must be controlled such that the lighting power usage can be reduced by 50-80%.	CSU Outdoor Lighting Design Guide - 2012
3	Programmable time controllers shall be used to turn off superfluous lighting, such as feature, landscape, and art lighting, between midnight and dawn.	CSU Outdoor Lighting Design Guide - 2012
4	Coordinate indoor and outdoor lighting through use of controllers in order to minimize overlighting and light trespass.	CSU Outdoor Lighting Design Guide - 2012
5	Refer to section 4.3 in CSU outdoor lighting design guide regarding lighting controller options.	CSU Outdoor Lighting Design Guide - 2012
Appropriate Light Characteristics		
1	All site and building-mounted luminaires shall produce no more than 0.10 horizontal and vertical footcandles (1.0 horizontal and vertical lux) at the project boundary.	LEED Reference Guide - 2009
2	No more than 2% of fixture lumens shall be emitted at or above 90 degrees from the nadir.	LEED Reference Guide - 2009
3	Emphasize vertical surface lighting (such as on walls or monuments) rather than unshielded ground area lighting.	CSU Outdoor Lighting Design Guide - 2012
4	Provide uniformly distributed lighting.	CSU Outdoor Lighting Design Guide - 2012
5	Account for reflection of surfaces and objects.	CSU Outdoor Lighting Design Guide - 2012
6	Light sources must be above 80 CRI and have color temperatures above 3000K.	CSU Outdoor Lighting Design Guide - 2012

Fixtures		
1	Replacement lamps shall have identical color temperatures and color rendering index (CRI) ratings to maintain uniform appearance.	CSU Indoor Lighting Design Guide - 2012
2	Standardize lamps and ballasts to provide aesthetic as well as maintenance benefits.	CSU Indoor Lighting Design Guide - 2012
3	Luminaires shall be shielded wherever possible in order to minimize light trespass/pollution.	CSU Outdoor Lighting Design Guide - 2012
4	Consider only white light sources such as induction, fluorescent, metal halide and LED.	CSU Outdoor Lighting Design Guide - 2012