ENERGY-SAVING STRATEGIES: LIGHT REDUCTION

Goal: To improve preservation and achieve energy savings by altering the duration of time that lights are used, the type of lighting used, and altering light use habits.

Advantages	Disadvantages
Some adjustments can be simple (adjust timers, change bulbs)	Some adjustments require an investment (install new fixtures, install motion switches)
Cumulative energy savings for electrical and system energy over time	Energy savings can be minor compared to adjustments in HVAC operation
Reduces the collections' exposure to damaging light	

Description of Potential

According to the Center for Climate and Energy Solutions, lighting in commercial buildings is on average nearly 18% of the total energy consumption. Though lighting is important to any facility, many times energy is wasted by leaving lights on in unoccupied rooms or even for hours after a facility has closed. One of the simplest ways to help manage energy within a facility can be through light reduction. Reduction of light usage will not generate immediate major savings; however, if done properly and adhered to, the savings will be cumulative throughout the year and over time. Depending on the bulbs in place, it can also have an impact on cooling costs, since any added heat load must be removed by the mechanical system.

Light exposure, a combination of duration and intensity, can have serious effects on collection materials and is irreversible. Damage can include:

- From exposure to infrared light: brittleness, distortion
    - Heat emitted as a result of operation can cause materials to dry out, resulting in damage such as warping, shrinking, or cracking. This is particularly a concern for materials close to light fixtures that are on regularly, such as in exhibit display cases.
- From exposure to visible light: fading
    - Certain colorants and materials are susceptible to fading, which can make it difficult to interpret the original material correctly either because it is too faint or because perceived color shifts can occur (the loss of yellow in originally green images leaves blue as the perceived color).

- From exposure to ultraviolet (UV) light: yellowing, weakening and disintegration
    - Wavelengths in the ultraviolet are shorter and of higher energy than infrared or visible, so the damage can be structural.

Certain types of materials, such as photographs, watercolors, color on paper, and some textiles, are more vulnerable to the effects of light than others. Materials also vary in how they respond to the spectrum of different light sources, though generally the purple-blue wavelengths are among the most damaging with other sensitivities according to the specific materials. Microfading tests and damage spectra can be useful in determining how an individual work will respond to light, but general guidelines for light exposure based on material type are also available.

Overview of Strategy

Reduction of lighting is not simply turning off the lights when the space is unoccupied. It involves taking a step back and considering all potential options and their effects. For example, switching from T12 florescent bulbs to LED will most likely eliminate the added heat from the bulbs in the space. This may not be noticeable with only one or two fixtures but may be very noticeable if there are multiple fixtures in one room or hundreds in the AHU zone.

It is also important to consider alternative ideas for light reduction. While manual switching off lights is a great idea, these lights can, at times, be forgotten about and the lights can be left on. In this case, consider whether there is potential to install motion sensors to ensure that lights do turn off. There is also a difference in actual and required lighting. The required lighting to work in a space may be much less than the actual lighting. Often spaces have too much lighting and some of the light can be reduced or removed without having an impact on the performance of the space.

Reducing the amount of light used can be done on the micro- or macro-level. The process may be looking to reduce lighting in a few rooms, the AHU zone, or may incorporate the entire facility. It begins by asking a series of questions:

- What are the facility's operating hours?
- When are no staff in the facility?
- How is the lighting currently controlled?

Through these questions, a plan can be built around the use and control of lighting.

A plan may involve a number of solutions. These solutions can be as simple as having the last person out turn off the lights or the decision may be made to install new fixtures. Every organization and every building is different. What may work or make sense for one location may not apply in another, even if the buildings are next to one another. Building use, budget, occupancy, and design are some of the many influencing factors in what can be done.

Requirements

Below is a list of some items you may want to have when creating your plan.

- There are four occupancy schedules to keep in mind. There may be overlap between schedules.

    - Operating schedule – This is the operating hours the facility is open to the public
    - Employee schedule – This is the hours that staff actively work in the spaces
    - Cleaning schedule – This is the schedule the cleaning staff follow
    - Unoccupied hours – When no staff or patrons are in the building
- If possible, locate a lighting control schedule if one exists. This may be included in the electrical series of the building drawings.
- Locate a copy of your electrical bill to determine your electrical cost per kilowatt hour (kWh).
- Use the lighting calculation sheets included in this guide to determine your current lighting costs and use the same sheets to plan alternative lighting methods.
- If necessary, building plans may be needed to track lighting, locate switches, and identify emergency lights in the facility.
- If you are unfamiliar with the difference in types of lighting, see the attached lighting guide.

Determine Goals

Reducing lighting use can be achieved through multiple methods. Unfortunately, establishing a predetermined goal may eliminate a potentially better solution. Starting the process with an open mind and no preconceived conclusion may yield better results than previous expectations.

Criteria/Variables That Impact Potential

- Replace bulbs – One of the least costly actions is replacing/swapping the bulbs inside the light fixtures with more energy efficient bulbs and/or those that emit light in less harmful ways.
- Replace light fixtures – In some cases the bulbs cannot be swapped out or it may be more cost effective (due to replacement bulb cost) to replace the light fixture.
- Add switches – Some spaces are designed where one master switch controls a majority of the lights. In some cases, sub-switches may be installed to break down less used sections and turn off the lights in these areas.
- Add motion sensors – There may be trouble spaces where light switches cannot be accessed or located; lights in an area may always be left on as a result. Installing motion sensors will add control to the space allowing lights to operate when the space is occupied and turn off when they are unoccupied.
- Adjust timers – Some lighting is controlled by timers. The original intent may have been to control/limit the lighting in the space, however over time the timers may have been adjusted, schedules may have changed, or certain timers may have malfunctioned or become inoperable. As a result, some lights may remain on during unoccupied hours. These timers can be adjusted, repaired, or replaced to account for the current operating schedule.
- Reduce lights – There are required light levels for some work areas. Sometimes these areas have more lights operating than are needed or wanted. It may be possible to remove or turn off these lights to eliminate waste. For storage environments, consider which lights, and at what intensity, are necessary for collection access.

- Reduce/eliminate outside light- Light coming in from windows and skylights should be mitigated through the use of shades (of various degrees of transparency or blackout) or filters to remove UV and visible light. It is important to be sure that during the different times of day, as the light moves throughout the room, the intensity on objects remains within acceptable parameters.

Start with Locations

- Knowing when specific locations in the facility are occupied will help inform when developing a lighting schedule.
- Start by looking at a map of the facility and identify normally unoccupied areas.
    - These may be storage rooms, collection spaces, galleries, workspaces, or laboratories, among others.
- If a space is normally unoccupied, look at the lighting controls for the spaces.
    - Are they normally left on?
    - Are they always off?
- Determine if these spaces may qualify for better lighting control.
    - Should motion sensors be installed to turn off lights when the space is unoccupied?
- In the case of lack of funding to install new lighting controls, some institutions have employed last-out rules. In this case the last person out of the facility (custodial, security, supervisor) is responsible for ensuring all lights are off.

Determine Schedules

- To begin look at the operating schedule for your facility. This schedule is most likely shorter than the employee schedule.
    - Identify any spaces where light can be reduced when visitors are in the building.
- Collect an employee schedule.
    - This schedule should create a rough timeframe of what hours the facility is occupied by staff.
    - Due to some staff working odd hours this may be difficult to produce and may need to be estimated.
    - While some staff may be exceptions, there are many staff members who have set schedules and lighting in their area or department can be reduced at a certain time.
    - Lighting schedules should be set for the majority, with localized control for exceptions.
- Look into the schedule for the cleaning staff or after hours staff, if any.
    - Not all facilities have a cleaning or after hours staff.

- From the schedules determine the spaces where lighting hours can be adjusted.
- Use the schedule that was created to readjust lighting timers if you have them.
- Use the lighting schedule to create a potential list of spaces to check for lighting shutdowns during a walk-through.
    - Walkthroughs should be conducted during operating hours, during normal staff hours, and later at night when the building is mostly unoccupied.

Perform Test Calculations

Light reduction that involves the replacement of light bulbs or fixtures should be evaluated based on the calculated and modeled savings.

- Use the attached sheet to calculate the estimated daily light usage for your space/facility.
- Use this information to calculate the weekly/yearly energy consumption of current lights.
- You will need to know your electrical cost per kilowatt hour (kWh).
- Using the same calculations, you can figure out an estimated energy use of new lighting if you know what type of replacement bulbs you will be using.

NOTES:

- Be sure to know start and end dates to compare energy bills
- Be aware that changes in bulbs may also cause a change in space temperature
- Be sure staff are aware and informed of any changes to the lighting schedule
- Be sure staff are aware and informed if any work or changing of light fixtures is going to be done
- Be sure staff know of overrides or switches to turn lights on if needed

Implementation

Experiment with operation to determine whether control or changes can be maintained.

Evaluating Test Results

- An important technique to estimate effectiveness is by comparing energy bills before and after any changes were made.
- A second, less effective comparison method is to perform calculations of the pre-and post-conditions and compare the results.
- From a preservation perspective, the results can be calculated using measurements from a light meter

before and after changes, or, for a visual comparison, using ISO blue wool standards and tools such as the Canadian Conservation Institute (CCI)'s online light damage calculator.

REMINDERS FOR MAXIMIZING EFFECTIVENESS

- Be sure to fully inform staff.
- Verify the new lighting operation.
- Keep in mind that some lighting may be required for emergency egress, and will be on all the time. In these cases, additional protection for objects nearby can be provided by covering them or placing them in boxes.

Lighting Calculations

Lighting

Bulbs Per Fixture X Watts Per Bulb = Watts Per Fixture

Bulbs Per Fixture	Watts Per Bulb	Watts Per Fixture

Lighting

Watts Per Fixture X Number of Fixtures = Watts Sub-Total

Watts Per Fixture	Number of Fixtures	Watts Sub-Total

Weekly Lighting

Watts Sub-Total x Weekly Operating Days = Weekly Watts Sub-Total

Watts Sub-total	Weekly Operating Days	Weekly Watts Sub-total

Yearly Lighting

Watts Sub-Total x Yearly Operating Days = Yearly Watts Sub-Total

Watts Sub-total	Yearly Operating Days	Yearly Watts Sub-total

Cost to Operate Lighting

Watts Sub-Total x Average kWh Charge x .001 = Cost for Operating Lights

Watts Sub-total	Average kWh Charge	.001	Cost for Operating Lights

Fluorescent Lighting Annual Cost Comparison

BULB TYPE	T5	T5	T8	T12
Watts	18	28	32	34
Bulbs	2	2	4	4
Fixtures	100	100	100	100
Total Watts	3600	5600	12800	13600
Hours/Day	12	12	12	12
Days/Week	5	5	5	5
Weeks	52	52	52	52
Total Hours	3120	3120	3120	3120
Cost per kWh	$.12	$.12	$.12	$.12
Annual Cost	$1,347.84	$2,096.64	$4,792.32	$5,091.84
Savings vs. T12	73.5%	58.8%	5.9%	0%

Multiple Light Source Comparison

EFFICIENCY: Least → Most	STANDARD	HALOGEN	CFL	LED
Price (* = often subsidized)	very low	low	low to high*	medium
Watt comparison	60 watts	40-50 watts	13-15 watts	8-12.5 watts
Reaches full brightness instantly	YES	YES	NO	YES
Correlated color temperature, Kelvin	~2700	~2700	~2400-2900	~2600-3000
Light color appearance	warm-white	warm-white	varies	varies a lot
Stable color over time	YES	YES	NO	NO
Works with dimmers, sensors, and timers	YES	YES	RARELY	SOME
May emit RF and cause grid disturbance	NO	NO	YES	YES
Sensitive to heat	NO	NO	YES	YES
Sensitive to cold	NO	NO	YES	NO
Sensitive to frequent switching	NO	NO	YES	NO
Contains mercury	NO	NO	YES	NO
May leak UV-radiation	NO	NO	YES	NO
RATED LIFE	1 YEAR	1-2 YEARS	8-15 YEARS	15-25 YEARS