Lighting Retrofit Workbook

A Practical "How To" Guide for the National Park Service Visitor Centers

A Product of the Green Energy Parks Partnership

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DRAFT FOR REVIEW

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Green Energy Parks is a joint program of the U.S. Department of the Interior's (DOI) National Park Service (NPS) and the U.S. Department of Energy (DOE). The program promotes the use of energy-efficient practices (such as efficient lighting) and renewable energy technologies (such as solar electric systems) in the parks. Given the high number of visitors (287 million visitors in 1999) and the expertise of NPS staff in educating people about conservation and related topics, the national parks are great places to convey the importance of sustainable energy practices to the public.

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Overview

This workbook is designed to maximize your lighting energy savings while maintaining, or in many cases, improving the lighting quality in your park. It will guide you through a lighting audit, assist in determining problem areas, and recommend a course of action. The workbook also offers assistance in the development of an overall plan, suggests mechanisms for design and financial assistance, and recommends a routine maintenance program.

The workbook will guide you through a step-by-step process to develop and implement a lighting retrofit program:

Step 1: Four things to do first.

Step 2: Conduct a lighting audit.

Step 3: Identify retrofit actions.

Step 4: Implement retrofit activities.

Step 5: Establish a routine lighting maintenance program.

Lighting Retrofit Benefits

Lighting retrofits offer the following benefits to park visitors and staff:

- **Energy savings**

  Lighting retrofits can greatly reduce energy consumption and lower energy bills, while maintaining lighting levels and quality by upgrading lighting components to more efficient and advanced technologies. Upgrading technologies can also offer employees greater control over lighting, allowing for additional energy savings.

- **Improved lighting quality**

  Lighting retrofits can improve lighting quality by targeting problem areas with specific design considerations to overcome common lighting issues.

  Newer technologies also add increased reliability to the lighting system, so fewer short-term lighting-quality issues should arise. These newer technologies often have better lighting-quality characteristics, such as improved color, reduced flicker, greater light output, etc.

- **Reduced maintenance and labor costs**

  Improvements in lighting technologies have led to increased lifetimes for components that will result in fewer failures and lengthen the time between maintenance activities.

  The implementation of a routine maintenance program in addition to your lighting retrofit will greatly simplify your maintenance practices and reduce the operational costs associated with maintaining your lighting systems.

- **Pollution reduction**

  By consuming less electricity, your facility will help reduce the demand and associated emissions from "off-site" power generation. These harmful emissions include CO_2 and other greenhouse gases.

- **Green Power systems**

  For those facilities served by photovoltaic or other green-power systems, efficient lighting will help limit power demands. Using more efficient lighting will require less power to be generated, stored, and used to accomplish the same tasks, making alternative power systems more economically and technically feasible.

Common Lighting Problems

Are you using incandescent A-lamps?

Incandescent lamps are one of the most inefficient lighting sources available. Among these is the ubiquitous A-lamp. This is the common incandescent you have grown up with and can be found everywhere.

A-lamps can be replaced with compact fluorescent lamps (CFLs) to achieve a 75% energy savings. CFLs also last longer than incandescent lamps, which will reduce maintenance costs, and labor and inventory demands. CFLs are made in several shapes to fit existing fixtures. They are often hard to distinguish from incandescent lamps, especially in fixtures where the bulb is not directly visible.

If you are currently using A-lamps in your facility then read "Section 1.1 A-lamps" on page 2.

Are you using T12 fluorescent lamp technology?

Linear fluorescent lamps are classified by their tube diameter based on a scale of eighths of an inch. For example, a T12 lamp has a diameter of 12/8 or 1.5-inches, and a T8 lamp has a diameter of 8/8 or 1-inch. Lamps have common markings near one of the ends of the tube, where a code indicates the size of the lamp.

T12 lamps are an older technology and should be replaced with T8 lamps in your facility. T8 lamps provide superior lighting quality and last longer, while improving efficiency by 30%. They also operate on electronic ballasts that are more efficient than older magnetic ballasts, which are common among fixtures using T12 lamps.

If you are using any T12 lamps in your facility then you should review the "T12 Retrofit" on page 14 in the target area where you are using this technology.

Do you have areas where the lights are often left on while the space is left unoccupied?

If you have areas where lights are often left on while the space is unoccupied, then you should consider installing either an occupancy sensor or a timer switch. These control devices are relatively simple retrofits and can represent large energy savings opportunities in your facility.

An occupancy sensor is a device that is integrated into the lighting circuit and turns the lights off when the space is left unoccupied for a predetermined period of time. The "on" control can either be automated through the occupancy sensor or it can be a manual switch. This technology is most appropriate to commonly used, enclosed spaces such as offices and bathrooms.

A timer switch is a device that is integrated into the lighting circuit and turns the lights off after a predetermined time. The "on" control is a manual function often integrated into a wall switch. This type of technology is most appropriate for areas that are infrequently used, such as storage areas.

If these technologies seem like they may be appropriate to your facility then read "Section 1.4 Controls" on page 5.

Are exterior lights on during daylight hours?

There are several options to help avoid the unnecessary operation of exterior fixtures during daylight hours. You can integrate a photocell into the lighting circuit to turn the lights off when daylight reaches a preset level. This requires a simple one-time calibration that will have your exterior lighting respond to daylight conditions even as the seasons and daylight conditions change.

A timer switch can also be integrated into your exterior lighting circuit and will turn the lights on and off according to an inputted schedule. This requires seasonal modifications to the timer schedule if energy savings are to be optimized.

If these technologies seem like they may be appropriate to your facility then read "Section 1.4 Controls." on page 5 and "Section 3.8 Exterior Lighting" on page 45.

Do your lamps flicker?

If you have problems with flickering lamps, it is likely that you have a faulty ballast or lamp. Properly scheduled maintenance can help alleviate these conditions and help maintain a higher level of lighting quality. Before replacing the ballast, determine if you have T12 lamps. If you do, then this might be the perfect time to implement a retrofit since the ballast is the most expensive component in the retrofit process and you'll already be doing maintenance on the fixture.

If you find these conditions in your facility, you should read "Section 5 Routine Maintenance Program" on page 77.

Do your fixtures have lamps that appear to have different colors in them?

Fluorescent lamps come in a variety of "color temperatures." Low color temperature implies warmer (more yellow/red) light, while high color temperature implies a colder (more blue) light. Different color temperatures are appropriate for different tasks, but uniformity across the space is desirable. Multiple color temperature lamps in the same fixture or space provide an uncomfortable and awkward environment.

If you are experiencing difficulties with matching color temperatures or maintaining consistency throughout your space, you should read "Section 5 Routine Maintenance Program" on page 77.

Do you have problems maintaining your lighting fixtures?

This may include running out of particular lamp styles or sizes, having fixtures using multiple lamp types at the same time, frequent lamp failures, or having difficulties reordering lamps. If any of these situations pertain to you and your park, then a comprehensive maintenance plan coupled with a maintenance logbook will help improve your facility's lighting quality, safety, and maintenance efforts.

If you are experiencing difficulties with maintenance throughout your space, you should read "Section 5 Routine Maintenance Program" on page 77.

Do you have multiple spot and reflector lamp types in your exhibit lighting? Are you using three or four different lamp types along the same track strip? Do you often find the wrong lamp in an exhibit application?

This makes maintaining your lighting system extremely difficult and complex. Your exhibit lighting may be able to be simplified to using one or two different lamps. This will greatly reduce maintenance difficulties and inventory complexity and may increase efficiency.

If you are having difficulties with maintaining exhibit lighting you should read "Section 3.2 Exhibit Lighting" on page 17.

Do you have problems with glare in your office space?

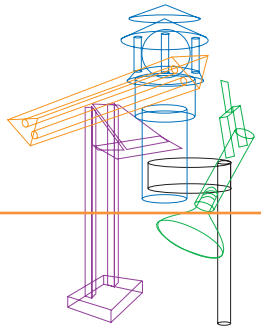
Glare is a common problem in office spaces, especially where computer tasks comprise a significant amount of the workload. Glare can lead to worker fatigue, eyestrain, and reduced productivity. This problem can often be avoided through the use of an indirect lighting system.

If glare is a continual problem for you, then you should read "Section 3.1 Office Lighting" on page 13.

Does your storage of lamps and ballasts get out of hand? Is it difficult to find replacement lamps and ballasts in your inventory? Are you stocking more than ten lamps for your entire facility? Have you found the wrong lamp type in any applications?

Most lighting applications in your facility can be addressed with a few very versatile lamp and ballast combinations. This will simplify maintenance, procurement, make storage easier to organize, and help ensure that the proper lamp is used in each application.

If you have difficulties maintaining a lighting inventory, read "Section 5 Routine Maintenance Program" on page 77.



Section 1: Four Simple Things To Do First

1.1

A-lamp

CFL

1.2

Halogen torchiere

CFL torchiere

1.3

Incandescent or CFL

LED

1.4

Switch

Occupancy Sensor

1.1 A-lamps

Incandescent lamps are one of the most inefficient lighting sources available. Among these is the ubiquitous A-lamp. A-lamps can be replaced with compact fluorescent lamps (CFLs) to achieve a 75% energy savings.

- First determine if replacing the fixture might be more appropriate. **Often a fixture specifically designed for a CFL or other energy-efficient source will operate more efficiently than one that is simply retrofitted.**
- General rule of thumb for selecting replacement CFLs: Replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture. CFLs are available in many different sizes and styles, so you should be able to find one for almost any fixture.

CFL Benefits

- Low maintenance (long lamp life)
- High reliability
- Energy savings
- Cost savings
- Opportunity for rebates

Annual cost savings from operating a CFL as a standard A-lamp

Source Type	Efficacy	Lamp Life	Cost/year*
A-Lamp	15 lumens per watt	1,000 hours	$23.36
CFL	60 lumens per watt	10,000 hours	$5.84

*Cost/year based on a comparison of a 100 W A-lamp and a 25 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

1.2 Halogen torchieres

Halogen torchieres are very inefficient and have very high operating temperatures. Halogen torchieres can be replaced with CFL torchieres or permanent lighting fixtures that are much more efficient and safer to operate.

- Before replacing your halogen torchiere with a CFL model, consider whether a permanent fixture may be more appropriate. Torchieres are often added to areas where there is deficient lighting, serving as a "quick fix."
- CFL torchieres are now produced by a variety of manufacturers in many different styles, most matching the performance and features of halogen torchieres.

CFL Torchiere Benefits

- Increased safety (lower operating temperature)
- Low maintenance (long lamp life)
- High reliability
- Energy savings
- Cost savings
- Opportunity for rebates

Annual cost savings from operating a CFL torchiere vs. a halogen torchiere

Source	Efficacy	Lamp Life	Operating temperature	Cost/year*
Halogen	15–20 lumens per watt	2,000 hours	700˚C	$35.04
CFL	60 lumens per watt	10,000 hours	100˚C	$7.01

*Cost/year based on a comparison of a 300 W halogen torchiere and a 60 W CFL torchiere (equivalent lumen output), 4 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

1.3 Exit signs

Exit signs offer one of the easiest ways to reduce costs and save energy due to their long operating hours and traditionally poor source efficacy.

If your facility has exit signs that utilize either incandescent or CFL sources, it is strongly recommended that you replace these exit signs with LED-sourced exit signs as part of your retrofit program.

- Determine source technology for exit signs.
- Retrofit or replace all incandescent and CFL exit signs with LED exit signs.
- Requires simple rewiring for installation of replacement exit sign.

LED Exit Sign Benefits

- Low maintenance (long lamp life: 100,000 hours)
- High reliability
- Energy savings
- Reduce costs
- Short payback period
- Opportunity for rebates

Annual savings comparison for incandescent, CFL, and LED exit signs

Source Type	Power	Lamp Life	Cost/year*
Incandescent	40 watts	1,000 hours	$28.03
CFL	10-15 watts	10,000 hours	$10.51
LED	2-5 watts	100,000 hours	$ 3.50

*Cost/year based on a comparison of a 40 W A-lamp, a 15 W CFL, and a 5W LED, 24 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

1.4 Controls

Controls offer one of the best retrofit opportunities because they are easy to implement, have such a wide range of benefits, and typically have short payback periods. Control devices regulate the operation of lighting fixtures or zones in response to environmental conditions or predetermined operating characteristics. These include occupancy, daylight availability, and timer functions.

- Installation requires simple wiring into the circuit being controlled.
- May require a one-time calibration to optimize performance.

Control Benefits

- Reduced maintenance (shorter burn hours)
- Energy savings
- Cost savings

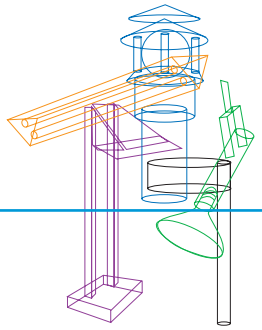
Control Technologies for Specific Areas

Application Area	Control Technology
Large offices	Ceiling mounted dual technology sensor
Small offices	Wall mounted PIR sensor
Bathrooms	Ceiling mounted dual-technology sensor
Closets and storage areas	Wall mounted timer switch
Parking lots	Photosensor, timer, hybrid, high-low system
Message boards	Photosensor or timer or hybrid or occupancy
Walkways	Photosensor or timer or hybrid

An explanation of each type of control technology follows on the next page.

,• **Passive infrared sensors** (**PIRs**) detect changes in infrared energy distribution within their field of view. PIRs offer defined coverage patterns, which makes this type of sensor ideal for open room applications such as small offices or workrooms.

- **Dual technology sensors** integrate both PIR and ultrasonic technologies to provide maximum control coverage of an area and limit the number of false triggers. This technology is more expensive than single technology systems, but more reliable.
- **Wall timer switches** have manual "on" functions and then turn off automatically after a preset time has expired. These can be extremely effective in storage facilities where the space is only occupied for a short period of time.
- **Timer circuits** are excellent for controlling lighting circuits that only have a few hours of required operation. This is particularly applicable to exterior lighting applications.
- **Photosensors** require a one-time calibration that will have your lighting system respond to daylight conditions even as the seasons change. Photosensors will allow you to utilize available daylight to displace your connected lighting load.
- **High-low systems** are control systems that operate at a low light output (usually 50% or less) until occupancy is sensed, and then operate at 100% light output. This is an effective strategy in parking lot lighting allowing for both energy savings and reduction of light pollution.
- **Hybrid systems** combine one or more of the control functions listed above and can optimize energy savings, light pollution reduction and increased safety.



Section 2: Lighting Audit

Why conduct a lighting audit?

A lighting audit will help you identify the retrofit opportunities in your facility by creating a detailed profile of lighting energy use and lighting quality throughout your facility. This will enable you to target areas for maximum impact during the retrofit process.

How to conduct a lighting audit

The following steps outline how to conduct a lighting audit of your facility. These pages contain worksheets that will help walk you through this process. Before going through these steps, make copies of the audit worksheet for all of your application areas.

- Step 1: Identify all common application areas and fill in the **Application Area Worksheet** (page 8). This will identify which lighting areas are present.
- Step 2: Identify lamp types and wattages in each application area and fill in the data on the **Audit Worksheet** (page 9).
- Step 3: Identify the number of lamps per fixture and fill in the data on the **Audit Worksheet.**
- Step 4: Estimate average time of use and fill in the data on the **Audit Worksheet.**
- Step 5: Estimate energy use for each application using the **Audit Worksheet.** This is the main **Audit Worksheet** and will identify the opportunities in each lighing area.
- Step 6: Complete the **Audit Summary Form** (page 11) to compare all applications and target your highest energy users. This sheet serves as a summary of your previous findings.

2.1 Application area worksheet

Check all common application areas found in your facility:

___ Office

___ Exhibit

___ Corridors and hallways

___ Bathroom

___ Sales

___ Lobby

___ Parking lots

___ Exterior

___ Auditorium

___ Remote buildings

___ Closets/maintenance rooms

Complete an audit worksheet for each application type listed above. The audit worksheet is on the following page. See example on page 10.

2.2 Audit worksheet

Note: Make copies of this worksheet for all applications before filling out the form.

Application Area: _____

1. How many fixtures in the application? _____

2. For each fixture calculate:

_____	x	_____	=	_____	x	_____	=	_____
# of lamps		wattage		total fixture wattage		estimated daily hours of use		daily power (W•h)
_____	x	_____	=	_____	x	_____	=	_____
# of lamps		wattage		total fixture wattage		estimated daily hours of use		daily power (W•h)
_____	x	_____	=	_____	x	_____	=	_____
# of lamps		wattage		total fixture wattage		estimated daily hours of use		daily power (W•h)
_____	x	_____	=	_____	x	_____	=	_____
# of lamps		wattage		total fixture wattage		estimated daily hours of use		daily power (W•h)

3. Add all fixture power results to get total application power: _____

4. Enter this figure on the Audit Summary Form under this application's current energy use. The Audit Summary Form is on page 11.

Example Audit worksheet next page ▶

2.3 Example audit worksheet

This example office had a total of 4 fixtures in it. Fixtures 1 and 2 are all ceiling-mounted fixtures with two T12 lamps (40 watts each) in each used nine hours a day. Fixture 3 is a 300-watt halogen torchiere used four hours per day, and fixture 4 is a 60-watt incandescent task light used for two hours per day.

Application Area: Office

1. How many fixtures in the application? 4

2. For each fixture calculate:

# of lamps	x	wattage	=	total fixture wattage	x	estimated daily hours of use	=	daily power
2 lamps	x	40 W	=	80 W	x	9 hours	=	720 watt-hours
2 lamps	x	40 W	=	80 W	x	9 hours	=	720 watt-hours
1 lamp	x	300 W	=	300 W	x	4 hours	=	1200 watt-hours
1 lamp	x	60 W	=	60 W	x	2 hours	=	120 watt-hours

3. Add all fixture power results to get total application power: 2760 watt-hours

4. Enter this figure on the Audit Summary Form under this application's current energy use.

The Audit Summary Form is on page 11.

2.4 Audit summary form

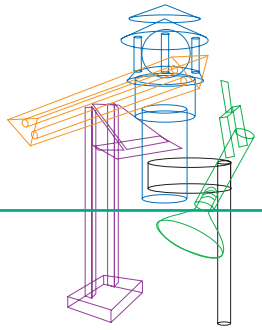
This form will help you identify your high-energy use areas so you can focus on those target areas for retrofit projects. These areas will typically offer the greatest advantages in energy savings, maintenance, cost of operation, and increased performance.

Enter energy use for each application as calculated on audit worksheet.

Rank application areas in order of current energy use, from highest to lowest (highest energy-consuming application will be a 1).

Target Areas	**Current energy use**	**Rank by energy use**
Offices	_____	_____
Exhibits	_____	_____
Corridors and hallways	_____	_____
Bathrooms	_____	_____
Sales	_____	_____
Lobby	_____	_____
Parking lots	_____	_____
Exterior	_____	_____
Auditorium	_____	_____
Remote buildings	_____	_____
Closets and maintenance rooms	_____	_____
Other:	_____	_____
Other:	_____	_____
Other:	_____	_____

You may want to focus retrofit activities around the higher ranking applications (consider the top three or four energy consumers). Use the application areas in the next section of this workbook to explore retrofit options. But don't overlook other areas (such as closets, maintenance rooms, etc.) that may rank low but have relatively easy fixes.



Section 3: Target Areas

National Park Visitor Centers are often similar to one another. Whether large or small, most Visitor Centers have exhibits, offices, bathrooms, hallways, closets, lobbies, auditoriums, and exterior lighting applications. This workbook has broken these application areas into specific areas to help you focus on the particular lighting requirements and design considerations for each type of area.

This section goes through each of the areas commonly found at a NPS Visitor Center. Different lighting retrofit options are presented, with discussion of benefits and drawbacks.

3.1 Office Lighting

The following questions will help you determine which retrofit activity is most appropriate for office areas at your site:

1. Is the current lighting system utilizing T12 lamps?

   If you answered "yes" then you should read the "Retrofit Option" on page 14. Go on to the next question.

2. Is the current lighting system greater than seven years old?

   If you answered "yes" then you should read the "New Fixture (lighting quality) Option" on page 15. Go on to the next question.

3. When performing computer tasks, do you have problems with glare? (i.e., can you see an image of the lights on your screen?)

   If you answered "yes" then you should read the "New Fixture (lighting quality) Option" on page 15. Go on to the next question.

4. Are the fixtures dirty, damaged, or generally in ill repair?

   If you answered "yes" then you should read the "New Fixture (lighting quality) Option" on page 15.

5. Are you currently using automated control technologies in your office space?

   If you answered "no" then you should read "Section 1.4 Controls" and also read "Office lighting: Controls" on page 16.

If on questions 3–5 you answered two out of three with a "yes" response, then it is strongly recommended that you implement the New Fixture (lighting quality) Option on page 15.

Office lighting: retrofit option

Replace existing fixtures with T8 lamps and electronic ballasts.

Replace T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts.

T12 lamp (left) and T8 lamp (right)

- Simple upgrade to newer technology.
- Original fixture is reused: new lamp and ballast components are compatible with existing fixture and lamp holders.
- Requires basic rewiring of ballast for installation and swapping of lamps.

Benefits

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)
- Visual quality improvements

Drawbacks

- May not improve lighting quality
- Doesn't address potential for glare

Comparison of T12 vs. T8 lamp technologies (based on a 4' lamp)

	T12 Lamps	T8 lamps
Power	40W	32 W
Lumens	3000	3000
Efficacy	75 lumens per watt	94 lumens per watt
Lamp life	12,000 hours	20,000 hours
Lumen maintenance	82% light output at 8400 hours	92% light output at 14,000 hours

Office lighting: new fixture (lighting quality) option

Replace existing fixtures with indirect fixtures using T8 lamps and electronic ballasts.

Replace old fixture with new indirect fixture.

- Remove existing fixtures.
- Install new indirect lighting fixtures with T8 lamps and electronic ballasts.
- Requires major retrofitting labor to remove and disassemble existing fixtures and properly install new lighting system.
- To optimize performance of an indirect system, select a ceiling with a high reflectance. (See "Wall and Ceiling Reflectance" in "Section 5: Routine Maintenance Program" of this workbook.)

Benefits

- High fixture efficiency
- Energy savings of approximately 30%
- Higher lighting quality
- Longer lamp life (lower maintenance)

Drawbacks

- Higher cost for materials and installation
- May require some design work involving an architect or lighting designer

Comparison of retrofit vs. installing a new indirect fixture

	Retrofit existing fixture	Install indirect fixture
Efficiency	Same	Same
Cost	Low	High
Labor	Low	High
Lighting quality	Medium/low	High

Office lighting: Controls

Occupancy controls can help save energy by turning lights off when the space is left unoccupied. They also help reduce maintenance costs by shortening burn hours for lamps.

Most small offices can be controlled through wall-mounted/switch-integrated occupancy sensors. Larger offices may require the use of a ceiling mounted sensor for greater coverage.

The delay (the time between when the sensor last senses occupancy and when it turns off the lights) can be adjusted in the field to maximize energy savings while minimizing any inconvenience.

If the office space is smaller than 400 feet, you should use a wall-mounted occupancy sensor. If it is larger than 400 feet, or if a wall switch would be obstructed from the field of view, you should use a ceiling-mounted occupancy sensor for greater coverage.

Office lighting: Task lighting

Energy benefits

Using task lighting in the office environment can greatly reduce the energy needed to maintain the appropriate lighting levels. By using a low-wattage fluorescent task light, it may be possible to turn off/down the overhead lighting in some situations.

Lighting quality benefits

Task lighting helps reduce overhead glare by limiting the demands on overhead lighting. Task lighting affords the user greater control over distribution and intensity of light on the task and helps avoid glare on the computer screen.

3.2 Exhibit Lighting

The following images are examples of lamp types you might find in your exhibit lighting:

PAR-20

PAR-30

PAR-38

R-lamp

Spot

Flood

MR-16

CFL

The following questions will help you determine which retrofit activity is most appropriate for your exhibit area:

1. Do you have fewer than 10 lamps in your exhibit lighting?

   If you answered "yes" then you should read the "Small Display Lighting Option"" on page 18. If you answered "no," go on to the next question.

2. Are you using multiple lamp types in your display lighting?

   If you answered "yes" you should read the "Retrofit Option" on page 19. If you answered "no," go on to the next question.

3. Are you willing to invest in a more advanced exhibit lighting to achieve maximum energy and maintenance savings?

   If you answered "yes" then you should read the "New Fixture Option" on page 20.

Exhibit lighting: Small display lighting option

For exhibit areas with limited lamps, replace all reflector lamps with CFL reflector lamps.

- Simple upgrade to newer technology.
- Original fixture is reused: new lamp components are compatible with existing fixture and lamp holders.
- Requires no rewiring.
- Replace incandescents with CFLs one-quarter of incandescent wattage for equal light output.
- There are many varieties of CFL reflector kits to choose from for your park's exhibits.

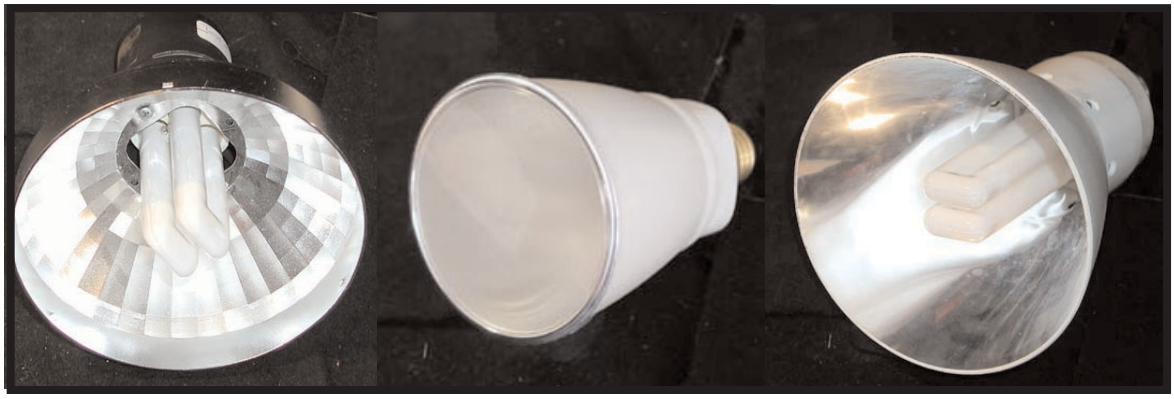


Exhibit lighting: Retrofit option

Tungsten halogen infrared lamps (HIR) are used typically in display and spot lighting applications. Their increased efficacy will allow you to illuminate a display with less wattage than you could with traditional incandescent lamps. Your effort here is to identify which type of HIR lamp you need for the function. These lamps typically come in variety of wattages and beam spreads. Spotlights with narrow beam spreads are used for lighting small areas in an exhibit. Broader distributions are used for area lighting, or to illuminate a panel of text. You need to carefully select the beam spread to match the need. The lamp manufacturers and local representatives can easily help you determine the beam spread required. They can also help in determining the wattage you need to match your old application.

- Simple upgrade to newer technology.
- Original fixture is reused: new lamp components are compatible with existing fixture and lamp holders.
- Requires no rewiring.

Benefits

- Simplified maintenance
- Lower lamp cost than CFLs
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)
- High lighting quality
- Point source for control in design process

Drawbacks

High operating temperature

More expensive than standard incandescents

Not nearly as much energy savings as CFLs

Tungsten halogen lamps feature an infrared coating that recycles the wasted heat generated by the filament. This coating allows visible light to pass through it, while reflecting infrared heat back to the filament. Because the heat is reflected back to the filament within the lamp capsule, less energy is required to maintain the filament at its optimal operating temperature. The result is energy savings up to 30 percent compared with standard halogen lamps.

Relamp existing fixtures with HIR lamps of same or similar lamp type.

Exhibit lighting: New fixture option

Replace old fixture with new CFL track fixture.

- Remove existing fixtures.
- Install new CFL track fixtures.
- Requires major retrofitting labor to remove and disassemble existing fixtures and properly install new lighting system.
- Will require some design efforts.

Benefits

- Maximum energy savings
- Longer lamp life (lower maintenance)

Drawbacks

- Will require some design work
- Higher initial cost for materials and installation
- Limited ability to provide "tight" spotlighting

A comparison between traditional exhibit lighting lamps, HIR lamps, and CFL lamps

Lamp Type	Efficacy	Lifetime
Traditional	15 lumens per watt	2-3000 hours
HIR lamps	20 lumens per watt	3-4000 hours
CFL lamps	60 lumens per watt	10,000 hours

3.3 Hallways and corridors

The following questions will help you determine which retrofit activity is most appropriate for hallways and corridors at your site:

1. Is the current lighting system utilizing any T12 lamps?

   If you answered "yes" then you should read the "Linear Fluorescent Retrofit Option" on page 22. Go on to the next question.

2. Is your current lighting system utilizing downlights with incandescent sources?

   If you answered "yes" then you should read the "Downlight Retrofit Option" on page 23. Go on to the next question.

3. Is your current lighting system utilizing pendant-mounted fixtures with incandescent sources?

   If you answered "yes" then you should read the "Pendant Fixture Retrofit Option" on page 25. Go on to the next question.

4. Is your current lighting system using wall sconces with incandescent sources?

   If you answered "yes" then you should read the "Wall Sconce Retrofit Option" on page 26. Go on to the next question.

5. Is the current lighting system more than seven years old?

   If you answered "yes" then you should read the "Section 4.1 How to select new hardware" on page 67. Go on to the next question.

6. Are the fixtures dirty, damaged, or generally in ill repair?

   If you answered "yes" then you should read the "Section 4.1 How to select new hardware" on page 67.

Hallways and corridors: Linear fluorescent retrofit option

Replace T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts.

- Simple upgrade to newer technology.
- Original fixture is reused: new lamp and ballast components are compatible with existing fixture and lamp holders.
- Requires basic rewiring of ballast for installation and swapping of lamps.

Benefits

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)

T12 lamp (left) and T8 lamp (right)

Comparison of T12 vs. T8 lamp technologies (based on a 4' lamp)

	T12 Lamps	T8 lamps
Power	40W	32 W
Lumens	3000	3000
Efficacy	75 lumens per watt	94 lumens per watt
Lamp life	12,000 hours	20,000 hours
Lumen maintenance	82% light output as 8400 hours	92% light output at 14,000 hours

Hallways and corridors: Downlight retrofit option

Replace incandescent lamps with screw-based CFL retrofit kits, or hard-wired retrofit kits for increased lifetime savings.

Note: Do not retrofit fixtures on dimming circuits.

- Simple upgrade to newer technology.
- Original fixture is reused: new lamp and ballast components are compatible with existing fixture (both) and lamp holders (screw-based).
- Requires basic rewiring of ballast for installation and swapping of lamps (hard-wired retrofit kit).
- General rule of thumb for selecting replacement CFLs: replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture.

Screw-Based Retrofit

Benefits

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 75%
- Longer lamp life (lower maintenance)

Drawbacks

- User can revert back to incandescent source
- Ballast must be replaced when lamp is replaced, making lamp replacement more expensive
- Limited to lower wattages

Screw-based retrofits

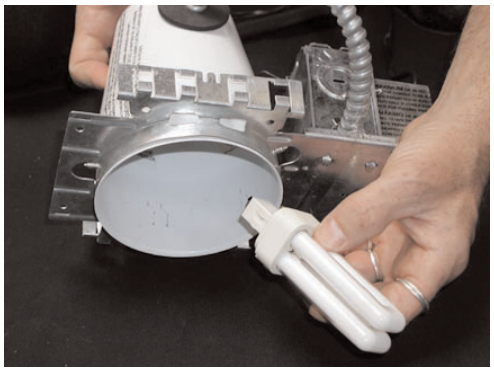
Hard-wired retrofit

Benefits

- Maximum energy savings
- Longer lamp life (lower maintenance)
- Users will stay with CFL technology

Drawbacks

- Installation requires rewiring of the fixture
- Higher initial cost for materials and labor



Hard-wired retrofits

Hallways and corridors: Pendant fixture retrofit option

Replace incandescent lamps with CFL lamps

Note: Do not retrofit fixtures on dimming circuits.

Screw-based retrofits

- Simple upgrade to newer technology.
- Original fixture is reused: new lamp components are compatible with existing fixture and lamp holders.
- Requires no rewiring.
- General rule of thumb for selecting replacement CFLs: Replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture. CFLs are available in many different sizes and styles so you should be able to find one for almost any fixture.

Benefits

- Low maintenance (long lamp life)
- High reliability
- Energy savings
- Cost savings

Annual cost comparison incandescent vs. CFL

Source Type	Efficacy	Lamp Life	Cost/year*
A-lamp	15 lumens per watt	1000 hours	$23.36
CFL	60 lumens per watt	10,000 hours	$5.84

*Cost/year based on a comparison of a 100 W incandescent and a 25 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

Hallways and corridors: Wall sconce retrofit option

Replace incandescent lamps with CFL lamps

Screw-based retrofit

- Simple upgrade to newer technology: No rewiring required.
- Original fixture is reused: New lamp components are compatible with existing fixture and lamp holders.
- General rule of thumb for selecting replacement CFLs: Replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture. CFLs are available in many different sizes and styles so you should be able to find one for almost any fixture.

Benefits

- Low maintenance (long lamp life)
- High reliability
- Energy savings
- Cost savings

Drawbacks

- Reversion to A-lamps
- Not optimized for CFLs
- Lamps may not fit

Annual cost comparison incandescent vs. CFL

Source Type	Efficacy	Lamp Life	Cost/year*
A-lamp	15 lumens per watt	1000 hours	$17.52
CFL	60 lumens per watt	10,000 hours	$4.20

*Cost/year based on a comparison of a 75 W incandescent and a 18 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

Hallways and corridors: Wall-mounted dedicated CFL fixture option

Replace old incandescent fixture with a new fixture designed for CFL pin-based lamps

This approach involves the complete removal of the old fixture and replacement with a fixture designed to operate pin-based CFL lamps. The ballast and a socket designed specifically for a CFL lamp are integrated into the fixture. When the lamp expires, only it is replaced. A new fixture system needs to be selected that matches the performance (light output and distribution) of the old incandescent. An electrician most likely will be required for installation and wiring of the new fixture.

Benefits

- Insured energy savings (fixture cannot be re-lamped to incandescent)
- Improved performance—light output, maintenance and lamp life
- Potential for good light distribution and lighting quality since the fixture has been designed explicitly for a CFL

Drawbacks

- Typically a higher first cost
- Involves using an electrician
- Requires research/expertise to find the right fixture

3.4 Bathrooms

The following questions will help you determine which retrofit activity is most appropriate for bathrooms at your site:

1. Is the current lighting system utilizing any T12 lamps?

   If you answered "yes" then you should implement the "Linear Fluorescent Retrofit Option" on page 29. Go on to the next question.

2. Is your current lighting system using a drum fixture with an incandescent source?

   If you answered "yes" then you should implement the "Drum Retrofit Option" on page 30. Go on to the next question.

3. Are you currently using occupancy sensors in your bathrooms?

   If you answered "no" then you should review the "Section 1.4 Controls" on page 5 and install the appropriate occupancy sensor for your facility. Go on to the next question.

4. Is your bathroom's ceiling directly under the roof of the building?

   If you answered yes then you should review the "Daylighting Opportunities" on page 59 and consider either a skylight or light tube. Go on to the next question.

5. Is the current lighting system greater than seven years old?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. Go on to the next question.

6. Are the fixtures dirty, damaged, or generally in ill repair?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. You should also read "Section 5: Routine Maintenance Program" on page 73.

Bathrooms: Linear fluorescent retrofit option

Replace T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts

T12 lamp (left) and T8 lamp (right)

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp and ballast components are compatible with existing fixture and lamp holders.
- Requires basic rewiring of ballast for installation and swapping of lamps.

Benefits

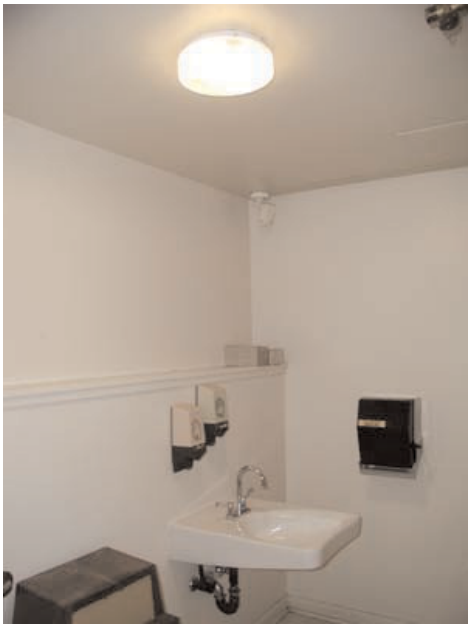
- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)

Comparison of T12 vs. T8 lamp technologies (based on a 4' lamp)

	T12 Lamps	T8 lamps
Power	40W	32 W
Lumens	3000	3000
Efficacy	75 lumens per watt	94 lumens per watt
Lamp life	12,000 hours	20,000 hours
Lumen maintenance	82% light output as 8400 hours	92% light output at 14,000 hours

Bathrooms: Drum retrofit option

Replace incandescent ceiling-mount lamps with CFL lamps



- Simple upgrade to newer technology: no rewiring required.
- Original fixture is reused: new lamp components are compatible with existing fixture and lamp holders.
- General rule of thumb for selecting replacement CFLs: Replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture. CFLs are available in many different sizes and styles so you should be able to find one for almost any fixture.

Benefits

- Low maintenance (long lamp life)
- High reliability
- Energy savings
- Cost savings

Drawbacks

- Reversion to A-lamps
- Not optimized for CFLs
- Lamps may not fit

Comparison of A-lamp with CFL

Source Type	Efficacy	Lamp Life	Cost/year*
A-lamp	15 lumens per watt	1000 hours	$23.36
CFL	60 lumens per watt	10,000 hours	$5.84

*Cost/year based on a comparison of a 100 W incandescent and a 25 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

Bathrooms: Dedicated CFL fixture option

Replace old incandescent surfaced-mounted (drum) fixtures with new CFL fixtures. This approach offers the best potential for energy savings and performance. Even at a higher initial first cost, this approach may be less expensive than the screw based CFL approach given its superior maintenance characteristics.

- Research and identify CFL fixture types that match the performance of your existing incandescent fixture. A wide variety of these fixtures are available in home improvement stores. Also most manufacturers supply information on the package, suggesting the incandescent equivalence. This should be used just for estimation purposes.
- Remove old incandescent fixture
- Mount fixture onto ceiling and wire the power
- Install lamps and lens cover

Benefits

- Ensure energy savings (fixture cannot be re-lamped with incandescent)
- Improved performance (light output)
- Potential for improved lighting quality
- Better maintenance characteristics (lamps last longer)
- Improved economics (higher first cost but lower cost over time)

Drawbacks

- Higher first cost
- Requires higher degree of research to find the right fixture
- Requires electrician to install
- May interfere with park functions for a short time

3.5 Sales/Store

The following questions will help you determine which retrofit activity is most appropriate for sales and stores in your park:

1. Is the current lighting system utilizing any T12 lamps?

   If you answered "yes" then you should read the "Linear Fluorescent Retrofit Option" on page 33. Go on to the next question.

2. Are you currently using incandescent downlights in this application?

   If you answered "yes" then you should read the "Downlights Retrofit Option" on page 34. Go on to the next question.

3a. Is your current lighting using incandescent track lighting?

   If you answered "yes" then you should read the "Track Lighting Retrofit Option" on page 35. Go on to the next question.

3b. Are you willing to invest in a more advanced track lighting to achieve maximum energy and maintenance savings?

   If you answered "yes" then you should read the "New Track Lighting Fixture Option" on page 36. Go on to the next question.

4. Is the current lighting system greater than seven years old?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. Go on to the next question.

5. Are the fixtures dirty, damaged, or generally in ill repair?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. You should also read "Section 5 Routine Maintenance Program" on page 73.

Sales/Store: Linear fluorescent retrofit option

Replace T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts

T12 lamp (left) and T8 lamp (right)

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp and ballast components are compatible with existing fixture and lamp holders.
- Requires basic rewiring of ballast for installation and swapping of lamps.

Benefits

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)
- Visual quality improvements

Comparison of T12 vs. T8 lamp technologies (based on a 4' lamp)

	T12 Lamps	T8 lamps
Power	40W	32 W
Lumens	3000	3000
Efficacy	75 lumens per watt	94 lumens per watt
Lamp life	12,000 hours	20,000 hours
Lumen maintenance	82% light output as 8400 hours	92% light output at 14,000 hours

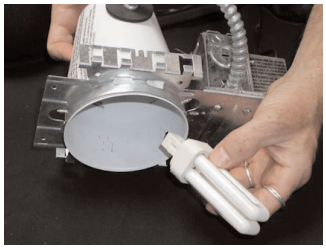
Anywhere in your facility that you have T12 lamps you should retrofit with T8 lamps and electronic ballasts.

Sales/Store: Downlight retrofit option

Replace incandescent lamps with screw-based CFL retrofit kits or hard-wired retrofit kits for increased lifetime savings.

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp and ballast components are compatible with existing fixture and lamp holders.
- Requires basic rewiring of ballast for installation and swapping of lamps.

Screw-based retrofit



Hard-wired retrofit

Screw-based retrofit

Benefits

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 75%
- Longer lamp life (lower maintenance)

Drawbacks

- User can revert back to incandescent source
- Ballast must be replaced when lamp is replaced making lamp replacement more expensive than with hard-wired retrofit.
- Limited to lower wattages

Hard-wired retrofit

Benefits

- Low cost for materials and installation
- Energy savings of approximately 75%
- Longer lamp life (lower maintenance)
- Users will stay with CFL technology

Drawbacks

- Installation requires rewiring of the fixture
- Higher initial cost for materials and labor

Source Type	Efficacy	Lamp Life	Cost/year*
A-lamp	15 lumens per watt	1000 hours	$23.36
CFL	60 lumens per watt	10,000 hours	$5.84

*Cost/year based on a comparison of a 100 W incandescent and a 25 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

Sales/Store: Track lighting retrofit option

Relamp existing fixtures with tungsten halogen IR lamps

Relamp existing fixtures with tungsten halogen IR lamps of same or similar lamp type

- Simple upgrade to newer technology.
- Original fixture is reused: new lamp components are compatible with existing fixture and lamp holders.
- Requires no rewiring.

Benefits

Simplified maintenance

Lower lamp cost that CFLs

Energy savings of approximately 30%

Longer lamp life (lower maintenance)

High lighting quality

Point source for control in design process

Drawbacks

High operating temperature

More expensive than standard incandescents

Not nearly as much energy savings as CFLs

Tungsten halogen IR lamps (HIR) are used typically in display and spot lighting applications. Their increased efficacy will allow you to illuminate a display with less wattage than you could with traditional incandescent lamps. Your effort here is to identify which type of HIR lamp you need for the function. These lamps typically come in variety of wattages and beam spreads. Spotlights with narrow beam spreads are used for lighting small areas in an exhibit. Broader distributions are used for area lighting or to illuminate a panel of text. You need to carefully select the beam spread to match the need. The lamp manufacturers and local representatives can easily help you determine the beam spread required. They can also help in determining the wattage you need to match your old application.

Sales/Store: New track lighting fixture option

Replace existing track lighting fixtures with CFL track fixtures

Replace old fixture with new CFL track fixture.

- Remove existing fixtures.
- Install new CFL track fixtures.
- Requires major retrofitting labor to remove and disassemble existing fixtures and properly install new lighting system.
- Will require some design efforts.

Benefits

- High fixture efficiency
- High source efficacy
- Longer lamp life (lower maintenance)
- Energy savings of approximately 75%

Drawbacks

- Will require some design work
- Diffuse source technology may make display lighting difficult
- Higher cost for materials and installation

A comparison between traditional exhibit lighting lamps, HIR lamps, and CFL lamps

Lamp Type	Efficacy	Lifetime
Traditional	15 lumens per watt	2-3000 hours
HIR Lamps	20 lumens per watt	3-4000 hours
CFL Lamps	60 lumens per watt	10,000 hours

3.6 Lobby

The following questions will help you determine which retrofit activity is most appropriate for lobby areas in your site:

1. Is the current lighting system utilizing any T12 lamps?

   If you answered "yes" then you should implement the "Linear Fluorescent Retrofit Option" on page 38. Go on to the next question.

2. Are you currently using incandescent downlights in this application?

   If you answered "yes" then you should implement the "Downlight Retrofit Option" on page 39. Go on to the next question.

3. Is your current lighting system using a ceiling-mounted fixture with an incandescent source?

   If you answered "yes" then you should implement the "Downlight Retrofit Option" on page 41. Go on to the next question.

4. Is the current lighting system greater than seven years old?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. Go on to the next question.

5. Are the fixtures dirty, damaged, or generally in ill repair?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. You should also read "Section 5 Routine Maintenance Program" on page 73.

Lobby lighting: Linear fluorescent retrofit option

Replace T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts.

T12 lamp (left) and T8 lamp (right)

- Simple upgrade to newer technology.
- Original fixture is reused: new lamp and ballast components are compatible with existing fixture and lamp holders.
- Requires basic rewiring of ballast for installation and swapping of lamps.

Benefits

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)
- Visual quality improvements

Comparison of T12 vs. T8 lamp technologies (based on a 4' lamp)

	T12 Lamps	T8 lamps
Power	40W	32 W
Lumens	3000	3000
Efficacy	75 lumens per watt	94 lumens per watt
Lamp life	12,000 hours	20,000 hours
Lumen maintenance	82% light output as 8400 hours	92% light output at 14,000 hours

Lobby: Downlight retrofit option

Replace incandescent lamps with screw-based CFL retrofit kits or hard-wired retrofit kits for increased lifetime savings.

Note: Do not retrofit fixtures on dimming circuits

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp and ballast components are compatible with existing fixture (both) and lamp holders (screw-based).
- Requires basic rewiring of ballast for installation and swapping of lamps (hard-wired retrofit kit).
- General rule of thumb for selecting replacement CFLs: Replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture.

Screw based retrofit

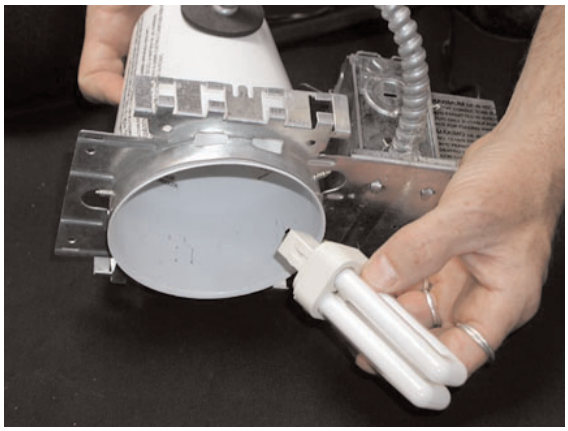
Benefits:

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 75%
- Longer lamp life (lower maintenance)

Drawbacks

- User can revert back to incandescent source
- Ballast must be replace when lamp is replaced making lamp replacement more expensive than with hard-wired retrofit.

Hard-wired retrofit



Benefits

- Low cost for materials and installation
- Energy savings of approximately 75%
- Longer lamp life (lower maintenance)
- Users will stay with CFL technology

Drawbacks

- Installation requires rewiring of the fixture
- Higher initial cost for materials and labor

Annual cost comparison of A-lamp with CFL

Source Type	Efficacy	Lamp Life	Cost/year*
A-Lamp	15 lumens per watt	1000 hours	$23.36
CFL	60 lumens per watt	10,000 hours	$5.84

*Cost/year based on a comparison of a 100 W incandescent and a 25 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

Lobby: Ceiling-mounted retrofit option

Replace incandescent lamps with CFL lamps

- Simple upgrade to newer technology: no rewiring required.
- Original fixture is reused: new lamp components are compatible with existing fixture and lamp holders.
- General rule of thumb for selecting replacement CFLs: Replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture. CFLs are available in many different sizes and styles so you should be able to find one for almost any fixture.

CFL Benefits

- Low maintenance (long lamp life)
- High Reliability
- Energy savings
- Cost savings

Screw-based CFL retrofit

Annual cost comparison incandescent vs. CFL

Source Type	Efficacy	Lamp Life	Cost/year*
A-lamp	15 lumens per watt	1000 hours	$23.36
CFL	60 lumens per watt	10,000 hours	$5.84

*Cost/year based on a comparison of a 100 W incandescent and a 25 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

3.7 Parking Lot Lighting

The following questions will help you determine which retrofit activities are most appropriate for your parking areas:

1. Does your parking lot lighting remain on even during daylight hours?

   If you answered "yes" then you should read "Section 1.4 Controls" on page 5 and also read the "Exterior Controls Section" on page 47. Go on to the next question.

2. Does your parking lot lighting remain on at full power for the entire night regardless of occupancy?

   If you answered "yes" then you should consider implementing the "Parking Lot Lighting: High-Low Controls Option" on page 43. Go on to the next question.

3. Are you planning on expanding your parking lot areas or adding additional parking areas in the future?

   If you answered "yes" then you should consider implementing the "Parking Lot Lighting: Solar Powered Option" page 44. Go on to the next question.

4. Are you intending to replace or upgrade your parking lot lighting in the future?

   If you answered "yes" then you should consider implementing the "Parking Lot Lighting: High-Low Controls Option" on page 43 and the "Parking Lot Lighting: Solar Powered Option" page 44.

Parking lot lighting: High-low controls option

Integrate High-Low HID controller into your parking lot lighting circuit

A high-low control unit can potentially save a great deal of energy while providing safe and reliable parking lot lighting. These control units operate as an integrated component of a high-intensity discharge (HID) lighting system. Most parking lot applications utilize HID lighting, either metal halide (MH) or high-pressure sodium (HPS) and are compatible with this technology. The high-low control unit operates the lighting system at 50% output when no signal is received from the peripheral control device (occupancy sensor, photosensor, etc.) and then switches the output to 100% when a signal is received.

- Requires some rewiring of the parking lot lighting circuit.
- Must determine control unit's compatibility with current ballast system (most systems require a Constant Wattage Autotransformer (CWA) type ballast.
- Original fixture is reused.
- One high-low unit can operate an entire circuit or zone.
- Compatible with 175W–1000W HID lamps.
- Uses existing lamp and ballast combination.
- Can be integrated with any other control technology: occupancy sensors, photosensors, timers, etc.

Benefits

- Energy savings (lower operating wattage during "low" operation)
- Cost savings (saves 50% over existing lighting during "low" operation)
- Increased safety (lighting system is responsive to movement)
- Reduced light pollution during periods of "low" operation

Be sure to choose exterior fixtures that are designed to minimize light pollution. See www.darksky.org.

Parking lot lighting: Solar-powered option

Solar parking lot lighting offers a tremendous opportunity to reduce installation costs and operation costs of parking lot lighting in new applications. This technology is particularly appropriate to remote locations.

- Requires less installation labor (no wires to run)
- Requires site evaluation to determine appropriateness of technology (this will include geographic location and local environmental factors.

Benefits

- Renewable energy source
- Stand-alone, self-contained system
- Lower installation costs
- Lower impact on local environment (no power lines)
- Non-polluting energy source

Site Evaluation and System Sizing

You will need to determine how much light is needed for your application and choose wattage of lamp accordingly. Next you need to factor in environmental conditions such as geographic location and local environmental factors to determine how much solar energy is available on the least solar productive day (the shortest day of the year or Winter Solstice) in your area. This will determine the size of the solar panel array your system will require. Finally you will need to calculate the size of your battery storage system. It is highly recommended that you consult with the manufacturer of the technology you intend to use when performing these calculations.

Be sure to choose exterior fixtures that are designed to minimize light pollution. See www.darksky.org.

3.8 Exterior Lighting

The following questions will help you determine which retrofit activities are most appropriate for your exterior lighting:

1. Does your walkway lighting utilize incandescent sources?

   If you answered "yes" then you should read the "Walkway Lighting Option" on page 46. Go on to the next question.

2. Does your exterior display/kiosk lighting utilize incandescent sources?

   If you answered "yes" then you should read the "Display Lighting Retrofit Option" on page 47. Go on to the next question.

3. Is the current exterior display/kiosk lighting system greater than seven years old?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. You should also read the "Display Lighting New Fixture Option" on page 47. Go on to the next question.

4. Are your exterior display/kiosk lighting fixtures dirty, damaged, or generally in ill repair?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. You should also read "Section 5 Routine Maintenance Program" on page 73. Go onto the next question.

5. Are any of your exterior lighting fixtures left on during daylight hours?

   If you answered "yes" then you should read "Section 1.4 Controls" on page 5 and also read the "Exterior Controls Section" on page 49.

Exterior Lighting: Walkway lighting option

Replace existing exterior walkway fixtures with CFL walkway fixtures

- Remove existing fixtures.
- Install new CFL walkway fixtures.
- Requires major retrofitting labor to remove and disassemble existing fixtures and properly install new lighting system.
- Make sure to check minimum operating temperatures for new fixtures and compare to your local climate.

Walkway Lighting Benefits

- High fixture efficiency
- Energy savings of approximately 75%
- Higher lighting quality
- Longer lamp life (lower maintenance)
- Reduced light pollution*

CFL Walkway Lighting comes in a variety of styles appropriate to any location.

Be sure to choose exterior fixtures that are designed to minimize light pollution.
See www.darksky.org.

Exterior lighting: Display lighting retrofit option

Replace all incandescent lamps with CFLs

Relamp existing fixtures with CFL lamps:

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp components are compatible with existing fixture and lamp holders.
- Requires no rewiring.
- Make sure to check minimum operating temperatures for CFLs and compare to your local climate.

CFL Benefits

- Low maintenance (long lamp life)
- High reliability
- Energy savings
- Cost saving
- General rule of thumb for selecting replacement CFLs: Replace incandescent lamps with CFLs one-quarter of incandescent wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture. CFLs are available in many different sizes and styles so you should be able to find one for almost any fixture.

Exterior Lighting: Display lighting new fixture option

Replace old fixtures with new CFL or fluorescent outdoor utility fixtures

A linear fluorescent strip fixture (with a single/multiple linear T8 lamp) is ideal for this long display lighting applications. These fixtures typically come in 2-foot and 4-foot lengths, with a tightly enclosed lens cover. The fixture is easily mounted onto the existing frame of the display and standard cable connects to the existing electrical junction box (J box). The cost of new fixture should be lower than purchasing many multiple screw based CFLs. Furthermore this approach should last longer than a screw based CFLs and require less maintenance. These fixtures need to be wet/damp location-rated depending upon the degree of exposure to the elements.

Replace old fixtures with new CFL or fluorescent outdoor utility fixtures:

- Remove existing fixtures.
- Install new CFL or fluorescent fixtures.
- Requires retrofitting labor to remove and disassemble existing fixtures and properly install new lighting system.
- Make sure to check minimum operating temperatures for new fixtures and evaluate versus your local climate.

New Fixture Benefits

- Low maintenance (long lamp life)
- High reliability
- Maximum energy savings
- Potentially less expensive than CFL option
- Reduce costs
- High weatherability
- Better distribution

Exterior Lighting: Controls

Integrate photosensor controls into exterior lighting circuits

- Includes walkway lighting, display/kiosk lighting, and perimeter lighting.
- Simple wiring for installation.
- Requires one-time calibration.
- Make sure you don't turn off any emergency or safety lighting.

Exterior Lighting Controls Benefits

- Lower maintenance (shorter burn hours)
- Energy savings
- Reduce costs

3.9 Auditorium Lighting

The following questions will help you determine which retrofit activity is most appropriate for auditoria in your park:

1. Is the current lighting system utilizing any T12 lamps?

   If you answered "yes" then you should read the "Linear Fluorescent Retrofit Option" on page 51. Go on to the next question.

2. Is your current lighting system utilizing downlights with incandescent sources?

   If you answered "yes" then you should read the "Downlight Retrofit Option" on page 52. Go on to the next question.

3a. Is your current lighting using incandescent track lighting?

   If you answered "yes" then you should read the "Track Lighting Retrofit Option" on page 54. Go on to the next question.

3b. Are you willing to invest in a more advanced track lighting to achieve maximum energy and maintenance savings?

   If you answered"yes" then you should read the "New Track Lighting Fixture Option" on page 55. Go on to the next question.

4. Are you currently using incandescent or fluorescent sources for your aisle lighting?

   If you answered "yes"then you should read the "Aisle Lighting Option" on page 56.

5. Is the current lighting system greater than seven years old?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67.

6. Are the fixtures dirty, damaged, or generally in ill repair?

   If you answered yes then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. You should also read "Section 5 Routine Maintenance Program" on page 73.

Auditorium lighting: Linear fluorescent retrofit option

Replace T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts.

T12 lamp (left) and T8 lamp (right)

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp and ballast components are compatible with existing fixture and lamp holders.
- Requires basic rewiring of ballast for installation and swapping of lamps.

Benefits

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)
- Visual quality improvements

Comparison of T12 vs. T8 lamp technologies (based on a 4' lamp)

	T12 Lamps	T8 lamps
Power	40W	32 W
Lumens	3000	3000
Efficacy	75 lumens per watt	94 lumens per watt
Lamp Life	12,000 hours	20,000 hours
Lumen maintenance	82% light output as 8400 hours	92% light output at 14,000 hours

Anywhere in your facility that you have T12 lamps you should retrofit with T8 lamps and electronic ballasts.

Auditorium lighting: Downlight retrofit option

Replace incandescent lamps with screw-based CFL retrofit kits or hard-wired retrofit kits for increased lifetime savings.

Note: Do not retrofit fixtures on dimming circuits

- Simple upgrade to newer technology
- Original fixture is reused: New lamp and ballast components are compatible with existing fixture (both) and lamp holders (screw-based).
- Requires basic rewiring of ballast for installation and swapping of lamps (hardwired retrofit kit).
- General rule of thumb for selecting replacement CFLs: Replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture.

Screw based Retrofit

Benefits:

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 75%
- Longer lamp life (lower maintenance)

Drawbacks

- User can revert back to incandescent source
- Ballast must be replace when lamp is replaced making lamp replacement more expensive than with hard-wired retrofit.

Screw-based retrofit

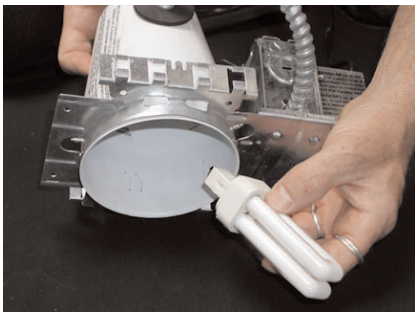
Hard-wired retrofit

Benefits

- Low cost for materials and installation
- Energy savings of approximately 75%
- Longer lamp life (lower maintenance)
- Users will stay with CFL technology

Drawbacks

- Installation requires rewiring of the fixture
- Higher initial cost for materials and labor



Hard-wired retrofit

Annual cost comparison incandescent vs. CFL

Source Type	Efficacy	Lamp Life	Cost/year*
A-lamp	15 lumens per watt	1000 hours	$23.36
CFL	60 lumens per watt	10,000 hours	$5.84

*Cost/year based on a comparison of a 100 W incandescent and a 25 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

Auditorium Lighting: Track lighting retrofit option

Relamp existing fixtures with tungsten halogen IR lamps

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp components are compatible with existing fixture and lamp holders.
- Requires no rewiring.

Benefits

- Simplified maintenance
- Low cost
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)
- High lighting quality
- Point source for control in design process

Drawbacks

- High operating temperature
- Low lamp life compared to CFL sources
- Low efficacy compared to CFL sources
- Higher maintenance costs

Available common lamp type, wattages, beam spreads, and center beam candle power (CBCP) for IR lamps

Lamp Type	Wattage	Beam Spreads	CBCP
PAR 30	50	9, 25, 40	14k, 3k 1700
PAR 38	60	10, 12, 25. 30	18k, 12k, 5100, 3600
MR-16	37	10, 24, 38	11, 500, 3500, 2050
MR-16	50	10, 24, 39	15k, 5100, 2500

Choose a replacement lamp based on matching the beam spread and the CBCP to your existing lamp's characteristics.

Auditorium lighting: New track fixture option

Replace existing track lighting fixtures with CFL track fixtures

Replace old fixture with new CFL track fixture.

- Remove existing fixtures.
- Install new CFL track fixtures.
- Requires major retrofitting labor to remove and disassemble existing fixtures and properly install new lighting system.
- Will require some design efforts.

Benefits

- High fixture efficiency
- High source efficacy
- Longer lamp life (lower maintenance)
- Energy savings of approximately 75%

Drawbacks

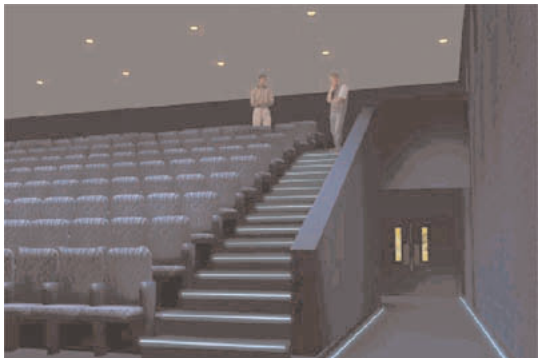
- Will require some design work
- Diffuse source technology may make display lighting difficult
- Higher cost for materials and installation

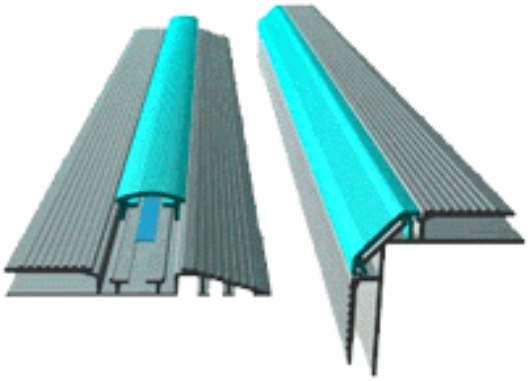
A comparison between traditional exhibit lighting lamps, IR lamps, and CFL lamps

Lamp Type	Efficacy	Lifetime
Traditional	15 lumens per watt	2-3000 hours
IR Lamps	20 lumens per watt	3-4000 hours
CFL Lamps	60 lumens per watt	10,000 hours

Aisle lighting option

Traditional aisle way lighting utilizes incandescent or fluorescent sources. Recent advantages in LED and electroluminescent technologies have led to a new generation of aisle way lighting that is more reliable, simpler to install, easier to maintain, and more energy efficient.





Electroluminescent strip lighting

- Low power consumption
- Longer lamp life (lower maintenance)
- Low voltage (easy installation)
- Low profile
- <1 watt per 10 feet of installation
- 20,000 + hour lamp life
- Extremely durable (no bulbs to break)
- Low power allowing for battery back-up for emergency lighting
- Continuous luminous emitter
- 80,000 + hour lamp life

3.10 Remote Buildings: Bathrooms and Facility Buildings

The following questions will help you determine which retrofit activities are most appropriate for your remote buildings:

1. Does your remote building exterior lighting remain on during daylit hours?

   If you answered "yes" then you should read "Section 1.4 Controls" on page 5 and also read the "Exterior Controls Section" on page 47. Go on to the next question.

2. Is the current lighting system utilizing any T12 lamps?

   If you answered "yes" then you should read the "Linear Fluorescent Retrofit Option" on page 58. Go on to the next question.

3. Does your remote building interior lighting remain on for extended periods of time regardless of occupancy?

   If you answered "yes" then you should read "Section 1.4 Controls" on page 6. Go on to the next question.

4. Is your current remote building lighting system using a fixture with an incandescent source?

   If you answered "yes" then you should read the "Incandescent Retrofit Option" on page 59. Go on to the next question.

5. Are you planning on adding additional remote building facilities in the future?

   If you answered "yes" then you should read the remote building: "Solar Powered Option" page 60 in addition to the lighting and controls guidelines outlined here.

6. Do you use this remote facility primarily during the day?

   If you answered "yes" then you may want to consider implementing the "Daylighting Option" on page 62. Go on to the next question.

7. Is the current lighting system greater than seven years old?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67.

8. Are the fixtures dirty, damaged, or generally in ill repair?

   If you answered "yes" then you should consider installing new fixtures. Read "Section 4.1 How to select new hardware" on page 67. You should also read "Section 5 Routine Maintenance Program" on page 73.

Remote Buildings: Linear fluorescent retrofit option

Replace T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts

T12 lamp (left) and T8 lamp (right)

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp and ballast components are compatible with existing fixture and lamp holders.
- Requires basic rewiring of ballast for installation and swapping of lamps.

Benefits

- Quick installation
- Low cost for materials and installation
- Energy savings of approximately 30%
- Longer lamp life (lower maintenance)

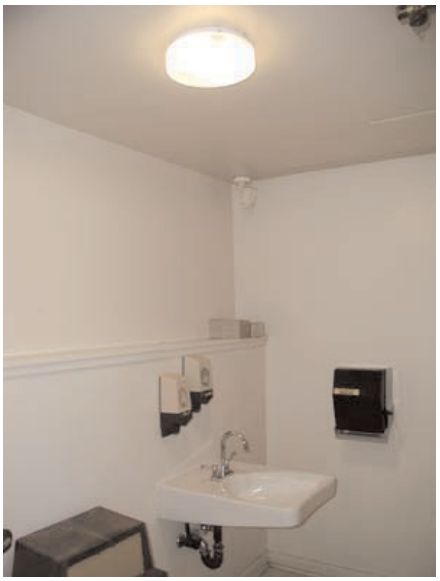
Comparison of T12 vs. T8 lamp technologies (based on a 4' lamp)

	T12 Lamps	T8 lamps
Power	40W	32 W
Lumens	3000	3000
Efficacy	75 lumens per watt	94 lumens per watt
Lamp life	12,000 hours	20,000 hours
Lumen maintenance	82% light output as 8400 hours	92% light output at 14,000 hours

Anywhere in your facility that you have T12 lamps you should retrofit with T8 lamps and electronic ballasts.

Remote buildings: Incandescent retrofit option (interior and exterior)

Replace incandescent lamps with CFL lamps



- Simple upgrade to newer technology: no rewiring required.
- Original fixture is reused: New lamp components are compatible with existing fixture and lamp holders.
- General rule of thumb for selecting replacement CFLs: Replace A-lamps with CFLs one-quarter of A-lamp wattage for equal light output.
- Make sure CFL replacement is compatible with any spatial limitations of the fixture. CFLs are available in many different sizes and styles so you should be able to find one for almost any fixture.
- Make sure CFL minimum operating temperature is appropriate to your location and weather since many of these remote facilities are not heated.

CFL Benefits

- Low maintenance (long lamp life)
- High reliability
- Energy savings
- Cost savings

Annual Cost comparison incandescent vs. CFL

Source Type	Efficacy	Lamp Life	Cost/year*
A-lamp	15 lumens per watt	1000 hours	$23.36
CFL	60 lumens per watt	10,000 hours	$5.84

*Cost/year based on a comparison of a 100 W incandescent and a 25 W CFL, 8 hours per day, 365 days a year, at a utility rate of $.08 per kWh.

Remote buildings: Dedicated CFL fixture option

Replace old incandescent surfaced-mounted (drum) fixtures with new CFL fixtures. This approach offers the best potential for energy savings and performance. Even at a higher initial first cost this approach may be less expensive than the screw-based CFL approach given its superior maintenance characteristics.

- Research and identify CFL fixture types that match the performance of your existing incandescent fixture. A wide variety of these fixtures are available in home improvement stores. Also most manufacturers supply information on the package, suggesting the incandescent equivalence. This should be used just for estimation purposes.
- Remove old incandescent fixture
- Mount fixture onto ceiling and wire the power
- Install lamps and lens cover

Benefits

- Ensure energy savings (fixture cannot be re-lamped with incandescent)
- Improved performance (light output)
- Potential for improved lighting quality
- Better maintenance characteristics (lamps last longer)
- Improved economics (higher first cost but lower cost over time)

Drawbacks

- Higher first cost
- Requires higher degree of research to find the right fixture
- Requires electrician to install
- May interfere with park functions for a short time

Remote buildings solar (photovoltaic) power option

Solar powered lighting offers a tremendous opportunity to reduce installation costs and operation costs for lighting in new remote applications.

- Requires less installation labor (no wires to run).
- Requires site evaluation to determine appropriateness of technology (this will include geographic location and local environmental factors).
- Initial cost will be higher due to the addition of the solar components; however this will be offset partially by cheaper installation (no power lines to run) and reduced operating costs.

Benefits

- Renewable energy source
- Stand-alone, self-contained system
- Lower installation costs
- Lower impact on local environment (no power lines)
- Non-polluting energy source

Site Evaluation and System Sizing

You will need to determine how much light is needed for your application and choose wattage of lamp accordingly. Next, you need to factor in environmental conditions such as geographic location and local environmental factors to determine how much solar energy is available on the least solar productive day (the shortest day of the year, or Winter Solstice) in your area. This will determine the size of the solar panel array your system will require. Finally, you will need to calculate the size of your battery storage system. It is highly recommended that you consult with the manufacturer of the technology you intend to use when performing these calculations.

Remote buildings: Daylighting opportunities

Daylighting may offer a great energy-savings opportunity if you use your remote building for extended periods of time during the day. Depending on the size of your remote building, you may want to consider a light tube or a skylight. Both are available in a variety of sizes. In most cases you will still need to provide electrical lighting in the remote building. Additionally, you may want to consider including a photosensor to control the electrical lighting in response to available daylight. You should consult the manufacturer when determining sizing of any daylighting component.

A light tube fixture

- Requires some site evaluation to determine daylighting availability
- Requires general carpentry for installation
- Requires installation of a photosensor
- Photosensor requires a one-time calibration

Daylighting Benefits:

- Energy savings
- Reduced operational costs
- Reduced maintenance (shorter burn hours)
- High reliability (no mechanical components to fail)

3.11 Closets/Maintenance Rooms

The following questions will help you determine which retrofit activity is most appropriate for your closets:

1. Do your closets and maintenance rooms utilize incandescent sources?

   If you answered "yes" then you read the "Retrofit Option" on page 64. Go on to the next question.

2. Do your closets or maintenance rooms have control systems?

   If you answered "yes" then you are done with this section. If you answered no then read the "Controls Option" on page 64.

Closets/ Maintenance Rooms: Retrofit Option

Replace incandescent lamps with CFLs

Relamp existing fixtures with CFL lamps:

- Simple upgrade to newer technology.
- Original fixture is reused: New lamp components are compatible with existing fixture and lamp holders.
- Requires no rewiring.

CFL Benefits

- Low maintenance (long lamp life)
- High reliability
- Energy savings
- Cost saving

Closets/maintenance rooms: Controls option

- Integrating a timing control switch into the lighting circuit will save energy, reduce costs, and reduce maintenance by reducing burn-hours.
- Manual “on” function/automatic “off” function.

Work rooms and storage areas: Dedicated CFL fixtures option

Replace exiting incandescent fixture with a new dedicated CFL fixture or surface mounted linear fixture

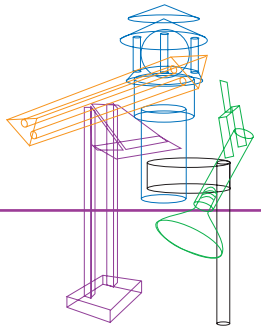
- Research and identify CFL fixture types that match the performance of your existing incandescent fixture. A wide variety of these fixtures are available in home improvement stores. Also most manufacturers supply information on the package, suggesting the incandescent equivalence. This should be used just for estimation purposes.
- Remove old incandescent fixture
- Install and re wire new fluorescent fixture

Benefits

- Insure energy savings (fixture cannot be re-lamped with incandescent)
- Improved performance (light output)
- Potential for improved lighting quality
- Better maintenance characteristics (lamps last longer)
- Improved economics (higher first cost but lower cost over time)

Drawbacks

- Higher first cost
- Requires higher degree of research to find the right fixture
- Requires electrician to install
- May interfere with park functions for a short time



Section 4: Implementation Guidelines

Use the resources in the implementation section to acquire more information and to implement retrofit activities.

The following section will walk you through the necessary steps to move from your facility lighting audit to retrofit implementation.

Step 1 Determine the scope of your retrofit

This will be based primarily on the results of your facilities lighting audit. Target the areas that consume the most energy or are in the worst shape. You may choose to conduct your retrofit all at one time, or break it down into several stages.

Comprehensive retrofit approach: This may be a very effective approach, especially if you have experience running retrofit projects in the past. For the first-time retrofitter, this may be a bit overwhelming and the "staged approach" may be more appropriate. This involves coordinating multiple retrofit activities during a short retrofit time period. There are significant advantages, as well as potential drawbacks, to this approach that should be assessed in accordance with the specifics needs of your parks and your experience with energy projects.

Benefits

- Reduce interference time frame
- Minimize set-up times
- Optimize logistics
- Optimize labor force
- Geared towards the use of an outside contractor

Drawbacks

- May be overwhelming for first time retrofitters
- May require hiring an outside contractor
- Requires a much higher initial budget
- Interference/disturbance from retrofit activities may be more severe

Staged retrofit approach: This approach is more appropriate for the first-time retrofitter or for parks where available funds for projects are limited. This approach breaks down the overall retrofit activities into individual actions that are performed one at a time. This staged approach has unique benefits and well as some disadvantages.

This may be accomplished during off-hours or in cycles as to minimize the disturbance to the park facilities and their normal functions.

Benefits

- May be able to be performed by "in-house" maintenance personnel
- Requires lower initial budget
- Minimizes intensity of disturbance on park operations

Drawbacks

- May result in inconsistent lighting during swap-out
- May make maintenance difficult in short term by increasing lamp-stock needs
- Greater time frame of park facility disturbance
- Less efficient labor dynamics (increased time spent setting up and breaking down the job site)

Step 2 Contact your NPS Regional Energy Coordinator

Once you determine the scope of your retrofit project, your next step should be to contact your Regional Energy Coordinator. Your Regional Energy Coordinator will be able to assist you with budgeting procedures, technical assistance, and rebate programs, and can help connect you with other valuable resources throughout your retrofit program.

Step 3 Determine who is going to do the retrofit

There are two main options to choose from in selecting someone to do the actual work of the retrofit. You can either handle the retrofit activities through "in-house" maintenance personnel, or you can bring in an independent contractor or electrician. Smaller parks may not have maintenance personnel with the proper background to safely conduct some of the retrofit activities. An independent contractor approach may also be more appropriate if you intend to conduct a comprehensive retrofit, rather than implement your retrofit in stages.

In-house retrofit: This approach would be conducted by a combination of the park director, facility manager, and maintenance personnel. The park director and facility manager would work to coordinate scheduling in a manner in which to minimize disturbance to the park's everyday function. They would also coordinate the purchasing of new technologies of the retrofit. Appropriately trained maintenance personnel would install the actual retrofit components. If you

don't have the properly trained personnel in-house, be sure to hire an independent contractor for all retrofit activities requiring electrical wiring.

Independent contractor: This approach takes the actions and responsibilities out of the park personnel's hands and places them in the hands of an independent contractor or electrician. The independent contractor will work with the park director to arrange the scheduling of the retrofit as to minimize the disturbances of normal park functions. The contractor will likely have more experience dealing with retrofits than in-house maintenance personnel and may do a higher quality job. An independent contractor may be especially useful if your park requires the retrofit of any display areas; display areas may also require the consultation of a lighting designer.

Step 4 Determine your budget and how you are going to pay for your retrofit

You should determine your available funding for retrofit activities. This may force you to go back to Step 1 and rethink the scope of your initial retrofit program if funding is not consistent with project estimates. If you are working with an independent contractor, they should be able to provide you with a cost estimate for the project. If you are conducting the retrofit through in-house personnel, you will need to generate your own project cost estimate. You can do this by obtaining price quotes for the retrofit technologies identified during the audit and area evaluations and factoring this with a labor estimate that the maintenance personnel should be able to generate.

If your cost estimate for retrofit activities isn't within the range of your available budget, then you can either seek funding elsewhere, or use the staged approach to accomplish as many retrofit activities as your current budget will allow. To seek additional funding review the section on "Section 4.4 Where to find financial assistance" on page 75.

Step 5 Acquiring the components

To avoid unnecessary delays, it is important to schedule ordering of new components in accordance with when you schedule retrofit activities. Order as many of your intended retrofit components as you can at one time. This will allow you to take advantage of volume discounts and simplify the overall retrofit process. To find sources for technical assistance in choosing retrofit technologies, review "Section 4.3 Where to find technical assistance" on page 74. For assistance in where to purchase retrofit technologies, review the "Section 4.5 Where to purchase recommended technologies?" section on page 76.

Step 6 Installation Scheduling

Retrofit activities should be scheduled around normal park functions to the extent possible in order to minimize disturbances. This may require some retrofit activities to take place during off-hours. Retrofit activities should also be broken into zones to minimize disturbances.

More critical areas should be prioritized in the order in which you retrofit your park. Critical areas are those in drastic ill repair, large energy consumers, areas with poor lighting quality, and areas with deficient or inadequate lighting levels or functionality.

For individuals with no retrofit experience, it is recommended that retrofit activities start out slowly, with simple applications, until a familiarity with the retrofit process is achieved.

You will find the following sections in this Implementation Section:

4.1 How to Select New Hardware: Fixtures, controls, lamps, and ballasts

4.2 Additional points to consider when selecting a new fixture

4.3 Where to find technical assistance

4.4 Where to find financial assistance

4.5 Where to purchase recommended technologies

4.1 How to select new hardware: Fixtures, controls, lamps, and ballasts

If you are coordinating your retrofit yourself, these guidelines will walk you through the necessary steps in specifying fixtures and lighting technologies for your park. If your retrofit is being coordinated by a facility manager, or outside contractor, you should give them this list of activities to guide them through this process.

1. Conduct a product survey

Find a variety of products that will meet the needs of your application. To identify these products you may want to conduct searches on the Internet, review product catalogues, or consult with a lighting representative. Identifying two or three quality options is optimal and will allow you to make a quality choice later in the selection process.

2. Obtain product literature

For each product you identify as a potential candidate for your facility, you should obtain product literature from the manufacturer or a manufacturer representative. This should include catalogues and technical cut sheets. You may also want to ask for information on previous installations, including case studies of facilities similar to your park.

3. Obtain samples

Many manufacturers will provide you with free samples of products, especially if you are retrofitting a large area where you will need a large quantity of hardware. Samples are extremely helpful when assessing product quality and suitability to specific applications when considering both performance and aesthetics.

4. Meet with manufacturer's representatives

Manufacturer's representatives will often be willing to visit your park and help recommend products for specific applications. This can be a tremendous resource, since they are knowledgeable about the particular capabilities of their products and can make very informed recommendations. They can also help avoid the misappropriate application of a product because they know the limitations of products.

5. Match products with performance requirements

Determine the critical performance requirements specific to the application for which you are specifying hardware. Then evaluate each hardware choice you identified earlier versus these criteria and rank these options in order of which ones match your performance criteria most closely.

6. Compare costs with features

Acquire detailed pricing information for hardware and compare the costs of the options you identified earlier with the performance ranking you determined in Step 5. Depending on your budget, you may have to trade off some performance characteristics for cost. You may also be able to overcome budget-balancing issues by conducting your retrofit in stages as discussed under the section "Implementation Guidelines." You should not sacrifice quality for cost. You may also want to review Section 4.4 "Where to find financial assistance."

7. Assess track record of company and product

You should request information on the company's history and track record and feel comfortable that they are a quality manufacturer that produces high-quality products before purchasing hardware from them. Find out what type of warranty they offer on their products. You may also ask for case studies of similar facilities using this company's products. These case studies will often have documented energy savings figures that will help give you an idea of the scope of energy savings you may be able to achieve.

8. Discuss choices with your contractor

You should discuss your hardware selections with your contractor. They may have had experience with the specific products you are considering or may be able to recommend alternatives. They also need to be familiar with the specifics of each hardware element so they can properly install them.

9. Ensure that your selection is used

You will need to make a detailed list of the hardware you are specifying for your facility. This will be needed to purchase all of the necessary hardware. You should cross-reference this listing with the products that are actually installed in your facility to make sure a contractor has not swapped out a product for a cheaper and possibly inferior product. If a contractor wants to substitute a product for one that you have specified, make sure that the replacement product meets your performance criteria as outlined earlier.

4.2 Additional points to consider when selecting a new fixture

This section will highlight some of the important points to consider when choosing a new fixture.

Dedicated fixtures: Dedicated fixtures are fixtures where the lamp and ballast are individual components. This means that when a lamp burns out you can replace the lamp independently of the ballast. This makes lamp replacement a much cheaper action because you don't need to replace both the lamp and ballast. This also helps reduce waste. In addition, dedicated fixtures are generally more efficient and effective (than screw-based CFLs in standard fixtures) because they have been designed specifically for unique characteristics in the CFL lamp. If properly designed, a dedicated CFL fixture should provide more light output, better light distribution, and require less maintenance than a screw-based CFL in a standard fixture. Whenever possible, select dedicated fixtures.

Fixture efficiency: Fixture efficiency is a metric of how efficiently a lighting fixture distributes light from the source (bulb) out of the fixture. It is given as a percentage of the total lumen output of the source, with a higher value yielded by better fixtures. The fixture efficiency can be found on the manufacturer's cut-sheet or technical data sheet for the fixture being considered. This is an important value to consider when comparing fixtures for a given application. Whenever possible, select fixtures with high fixture efficiencies.

Minimize lamp stock: By choosing fixtures that use lamps common to other fixtures in your facility you can minimize the number of types of lamps that you must order and maintain in your inventory. This will also simplify maintenance practices and ordering procedures. Whenever possible, select fixtures with common lamp types, sizes, and wattages.

Aesthetics: Choose fixtures appropriate to your application; for example, a modern fixture design is not appropriate in a historical setting. This may seem like common sense but this is a frequent mistake made when conducting retrofits. A traditional looking fixture may not always be available for every application, but consideration should be placed on this design element.

Climate: If your park is in a cold climate, then careful consideration should be placed when choosing fixtures for exterior applications. The manufacturer's technical specifications for a fixture should list a minimal operating temperature. Extreme environmental conditions can lead to shortened lamp life, short circuits, and lamp failure.

Location: Exterior applications should only use fixtures listed for exterior use. Additionally, some locations may require a wet/damp location rating from the manufacturer. Improper fixture placement can lead to shortened lamp life, short circuits, lamp failure, and can be a hazard.

4.3 Where to find technical assistance

• NPS Regional Energy Coordinator

Your regional energy coordinator may be your best resource for assistance. The regional energy coordinator will be familiar with the applications in your park and will also have a grasp of localized variables such as climate factors, rebates, and incentive programs.

• FEMP

The Federal Energy Management Program provides technical assistance for energy-efficiency and renewable-energy projects to Federal agencies.

• State Energy Office

Your state energy office may be able to help identify rebate and incentive programs that your retrofit program may qualify for. They can also help connect you to other organizations for assistance.

• Local Utility

Many public utilities maintain resource centers for customers in their region. Customers can gain insight into efficient technologies, available products, product literature, design guidance, energy monitoring, recommended contractors, maintenance practices and more. This is an excellent resource for directly acquiring information or finding a referral for further assistance.

The services offered by resource centers will vary from utility to utility, but can be explored by either calling the local utility or searching their web-site.

• Manufacturers' representatives

Most manufacturers have local representatives or distributors that are available to offer technical assistance for their products. They can help with simple design questions, product selection, etc.

• Architects and Lighting Designers

For more technically advanced lighting problems, it may be necessary to consult a lighting designer or an architect. This may be necessary for applications that are very design dependent, such as exhibit lighting.

4.4 Where to find financial assistance

• NPS Regional Energy Coordinator

The regional NPS energy coordinator should be aware of rebates and incentive programs in your local area from state agencies, local agencies, or utilities.

• State Energy Office

Your state energy office may be able to help identify rebate and incentive programs that your retrofit program may qualify for. They can also help connect you to other organizations for assistance.

• Local utility programs

Many public utilities offer rebate programs for energy-efficient retrofits. This can help offset the initial cost of implementing a lighting retrofit program. Utilities may also be willing to partner with a park on a demonstration program as part of the lighting retrofit program.

The details of these types of programs will vary from utility to utility, but can be explored by either calling the local utility or searching their web-site.

• Energy Service Companies (ESCOs)

Energy service companies, or ESCOs, can offer several strategic options for offsetting the initial cost of a lighting retrofit. They will often finance the front end of a retrofit project and then be paid a percentage of the energy savings over time. There are several variations on how this partnership can be structured. ESCOs can also offer valuable design guidance and technical insight into the retrofit process, as well as often taking a lead in a routine maintenance program.

4.5 Where to purchase recommended technologies

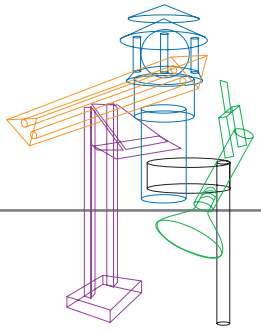
There are several options for where to acquire recommended technologies. Some options will help reduce costs while others will help simplify the design and selection making process.

• Contractors, Distributors, and Electrical supply warehouses

If a contractor is required to implement your lighting retrofit, then it is an option to have the contractor take responsibility for acquiring the appropriate lighting technologies. This may be advantageous because the contractor should have experience working with newer technologies and may be able to offer some technical guidance in making purchasing decisions. This is also advantageous because the contractor will be able to work with products and technologies that he/she is familiar with.

• Home Stores

Many of these technologies should be available at local hardware stores where costs may be slightly higher but may be more readily accessible. Selection may be an issue and quality shouldn't be compromised for the sake of convenience.



Section 5: Routine Maintenance Program

A routine maintenance program can save time and money while helping to maintain a higher level of lighting quality. A consistent maintenance program should incorporate a facility notebook, a group relamping program, and a scheduled fixture-maintenance program.

Before establishing a detailed maintenance plan, you need to consider standardizing on a few standard lamp/ballast combinations for your facility, especially if your facility is medium or small. This will greatly simplify your stocking, relamping and reordering efforts. You should be able to organize light sources into three basic lighting types including linear fluorescent, compact fluorescent and incandescent sources.

Linear fluorescent lamps: You should consider limiting your inventory to one type of T8 lamp and electronic ballast combination. Typically this will be a 4-foot T8 with a two lamp electronic ballast. You also need to try and select one color temperature for the lamp. The lamp company representative will be best at assisting you in your section.

Compact fluorescent lamps: Try to limit your choices to one lamp type and color temperature to simplify your inventory. If you are coverting several different fixture types to CFLs, then it may be necessary to have more than one type of lamp.

Incandescent lamps: You should strictly limit your choices to Halogen IR lamps for display lighting applications only. These lamps come in number of beam spreads and you can tailor your choices for the application.

For your entire lamp needs, work with the lamp representatives to narrow your choices to a few lamp types.

Start a facility notebook

A facility notebook will help you sustain your lighting-maintenance program by tracking maintenance activities including relamping times, fixture-maintenance activity, and help manage inventory demands.

Sample facility notebook entry

Location (application)	Lamp type	Date installed/cleaned	Scheduled replacement/cleaning date	Reorder number
Office	4’ T8	1/2001	1/2006	1-800-Number

At the end of this section there is a blank facility notebook worksheet that you can copy and use for your park’s facility notebook.

Spot relamping

While spot relamping is not the recommended practice, it will still be necessary to replace lamps in single fixtures at times. When replacing a lamp in a fixture, you should replace all lamps in that fixture with new lamps.

Group relamping

Group relamping is the scheduled replacement of lamps and offers the following benefits:

Reduced maintenance costs: On a lamp-by-lamp basis it is much cheaper to group relamp than to spot relamp single lamps as they burn out. It also reduces the burden of inventory and frees maintenance time for other activities.

Higher maintained lighting quality: Group relamping helps reduce the number of lamps that are burned out and helps maintain uniformity. Group relamping also helps ensure that the proper replacement lamps are used.

The industry standard on group relamping is to install new lamps at 70-80% of their rated lamp life. To make this simpler, group relamping can be conducted at a predetermined period that estimates usage patterns and lamp life.

Maintenance Program: Facility Notebook Worksheet

Location (e.g., auditorium, office, etc.)	Lamp Type	Date Installed/Cleaned	Scheduled Replacement/ Cleaning Date	Remaining Stock
Lamp manufacturer				
Contact information				
Ordering information				

Notes

Scheduled maintenance

A fixture's performance will decrease as the reflector and/or lens becomes dirty. Light output can be reduced by as much as 15%. Lenses and reflectors should be cleaned once a year and whenever scheduled relamping occurs to avoid extended periods of reduced light output.

Over extended periods of time, lenses will depreciate beyond what is repairable through cleaning. During scheduled fixture maintenance you should also clean off the lens covers on all occupancy sensors and control devices.

Windows and skylights should also be cleaned and cleared of any disruptive plants or debris during scheduled maintenance periods.

Wall and Ceiling Reflectance

The efficiency of your lighting system can be greatly enhanced through the use of reflective surfaces for both your walls and ceiling. Ceiling reflectance is particularly important when using an indirect lighting system.

Reflectance of these surfaces will depreciate over time, so regular cleaning and maintenance will be required. The following table lists appropriate reflectance ranges for ceilings and walls:

Appendices

Manufacturers

These are some recommended manufacturers for you to begin your product search with.

Lamps

GE Lighting
1975 Noble Rd
East Cleveland, OH 44112
1-800-626-2004
http://www.gelighting.com/na/business/

Lights of America
611 Reyes Drive
Walnut, CA 91789
909-594-7883
www.lightsofamerica.com

Philips Lighting
200 Franklin Square Drive
Somerset NJ, 08875
908-563-3000
www.lighting.philips.com

Panasonic Lighting
1 Panasonic Way, 4-A4
Secaucus, NJ 07094
201-348-5381
http://www.panasonic.com/MHCC/pl/

Osram Sylvania
100 Endicott St.
Danvers, MA 01923
1-800-544-4828
www.sylvania.com

Ballasts

GE Lighting
1975 Noble Rd
East Cleveland, OH 44112
1-800-626-2004
http://www.gelighting.com/na/business/

Panasonic Lighting
1 Panasonic Way, 4-A4
Secaucus, NJ 07094
201-348-5381
http://www.panasonic.com/MHCC/pl/

Philips Lighting
200 Franklin Square Drive
Somerset NJ, 08875
908-563-3000
www.lighting.philips.com

Osram Sylvania
100 Endicott St.
Danvers, MA 01923
1-800-544-4828
www.sylvania.com

Controls

Lutron Electronics Company
7200 Suter Rd
Coopersburg, PA 18036
610-282-3800
www.lutron.com

Lithonia Lighting
P.O. Box A
Conyers, GA 30012
770-922-9000
www.lithonia.com

The Wattstopper
2800 De La Cruz Blvd.
Santa Clara, CA 95050
408-0988-5331
www.wattstopper.com

Novitas Inc.
2476 Crocker Way
Antioch CA 94509
925-706-2202
www.novitas.com

Fixtures

Ruud Lighting
9201 Washington Ave.
Racine, WI 53406
1-800-236-7000
http://www.ruudlighting.com/

Cooper Lighting
400 Busse Road
Elk Grove Village, IL 60007-2195
847-956-8400
http://www.cooperlighting.com

Prescolite, Inc.
1251 Doolittle Drive
San Leandro, CA 94577
510-562-3500
http://www.prescolite.com

Prudential Lighting
1774 East 21st street
Los Angeles, CA 90058
213-746-0360
http://www.prulite.com

Lithonia Lighting
P.O. Box A
Conyers, GA 30012
770-922-9000
www.lithonia.com

Electro Elf
707-585-2696
http://www.electroelf.com

Remote Solar Lighting

Solar Outdoor Lighting, Inc.
3210 S.W. 42nd Avenue
Palm City, FL 34990
1-800-959-1329
www.solarlighting.com/

Solar Electric Power Company, Ltd.
7984 S.W. Jack James Drive
Stuart, Florida 34997
561-220-6615
www.sepco-solarlighting.com/

Glossary

A-Lamp: Most common incandescent lamp, often referred to as the Edison Lamp.

Ballast: A device used with a lamp to obtain the necessary circuit conditions for starting and operating; all fluorescent and HID light sources requiring a ballast for proper operation.

Beam Spread: The angle created by two points of equal light intensity on either side of the beam's axis and the point where the axis and lamp surface intersect.

Candela: The standard SI unit of luminous intensity.

Center Beam Candlepower (CBCP): The intensity of light produced at the center of a reflector lamp; expressed in candelas.

Color rendering Index (CRI): The measure of a light source's ability to render the color of objects correctly as compared to a reference source of comparable color temperature.

Color Temperature: A specification of the color appearance of a lamp, relating its color to that of a reference source heated to a particular temperature. Generally measures the "warmth" or "coolness" of a light source's appearance.

Efficacy: efficiency of a light source expressed in lumens per watt (LPW, lm/W).

Flood: type of lamp where the beam angle is usually 30 percent or more.

Fluorescent lamp: A low-pressure mercury electric discharge lamp in which a phosphor coating transforms some of the UV energy into visible light.

Foot-candle: a unit used to measure direct illumination equivalent to one lumen per square foot.

Group relamping: practice of replacing lamps on a routine scheduled basis determined by a percentage of estimated lamp life.

Incandescent lamp: an electric lamp in which a filament gives off light when heated by an electric current.

Indirect fixture: A fixture that directs the majority of its luminous flux in an upward direction. Often used in office environment with intensive VDT use.

IR Lamp: Infrared lamps feature a coating that recycles the wasted heat generated by the filament. This coating allows visible light to pass through it while reflecting infrared heat back to the filament making the lamp more efficient.

LED: light-emitting diodes use solid-state electronics to create light in the visible spectrum.

Lumen: a unit of luminous flux; the overall light output of a luminous source is measured in lumens.

Lumen maintenance: ability of a source to maintain a given percentage of its original lumen output expressed in percentage of total lifetime.

Lumens per watt (LPW): unit of measure for the efficacy of a light source given as the ratio of lumen output vs. power input.

Metal halide lamp: high intensity discharge lamp in which the majority of the light is gener-

ated through the radiation of metal halides.

PAR lamp: lamp with a parabolic aluminized reflector.

Reflector lamp: lamp in which the outer blown glass bulb is coated with a reflecting material that helps direct the light.

Spot: type of lamp where the beam angle is 12° or less.

Spot Relamping: practice of replacing lamps as they burn out.

T# (T8, T12, etc.): T stands for tubular, the number pertains to the diameter of the tube in 1/8th of an inch increments. A T8 lamp is 8/8ths of an inch or a one-inch diameter, a T12 lamp has a diameter of 12/8ths or one and a half inches.