Museum Lighting

An introductory guide to planning a lighting project in a museum or gallery, with a particular focus on LEDs

South East Museum Development Programme, working with the Sustainable Business Partnership CIC

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Aim

This guide is designed to help those working or volunteering for museums or galleries, such as Facilities Managers, Curators and General Managers, understand the main aspects of museum lighting and how to plan a lighting project.

It also aims to introduce terminology used by lighting suppliers and contractors so that museum personnel can more confidently brief contactors to ensure desired outcomes are achieved.

The guide has a particular focus on LED lighting; the technology is rapidly improving bringing a range of new lighting options to market.

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Many thanks to Lightfoot LED Ltd, suppliers of LED retrofit lamps and replacement fittings since 2010, for providing the photographs of LED lamps used in this guide. www.lightfootled.com

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What Are Your Objectives?

There are several reasons why you may want to upgrade your museum lighting. Be clear about your priorities before you start, it will affect the complexity and cost of your project.

**Conservation – controlling lux levels, heat and UV**

- Light causes permanent damage to many materials, which gradually worsens over time.
- Extensive research has been completed into the effects of light levels on different materials, which has led to standard recommendations being introduced (see opposite).
- Light sensitive items should ideally have an annual light exposure of no more than 150,000 lux hours and less sensitive items no more than 600,000 lux hours.
- As well as visible light, Ultra Violet (UV) radiation can also damage materials, especially by causing fading.
- It is recommended that UV levels are kept as low as possible, and always below 75 microwatts per lumen.
- LED lighting emits minimal UV radiation. Filters can be applied to fluorescent and incandescent lighting to reduce UV levels.
- All light sources produce heat, which can affect the relative humidity of the air and moisture content of objects.
- It is important to avoid ‘hot spots’ – localised areas of heat on an object.

### Recommended light levels

| < 50 Lux | Water colours, pastels, leather, fur, feather, textiles, paper, lacquered furniture, paper, some plastics, ivory and bone |
| 200 - 250 Lux | Oil paintings, painted wood and sculpture, coloured waxes, some plastics, chalk and charcoal |
| Light stable | Metals, glass, ceramics, stone, most geological specimens |

**Tip!** When replacing lighting, consider if previous lamps provided sufficient or excessive light levels or if lux could be reduced without decreasing the impact of the display.

**Maximising daylight**

- Daylight shows objects in their natural colours. It is a good, cheap source of lighting if managed properly.
- UV radiation is prevalent in daylight and should be eliminated through the use of blinds, shutters or louvers and UV films on windows or display cases, which can also be tinted to reduce solar gain (heat from the sun).
- Light coloured blinds, blackout blinds and see through blinds are available (which allow visitors to see the view or to open up spaces).
- It is important to ensure blinds fit properly at the windows so there is no stray light fall on collection items.

Royal Holloway Picture Gallery
Reducing energy usage

- LED lamps typically require around 5% to 20% of the electricity needed by a halogen or incandescent lamp to provide an equivalent light output, and about half that required by a fluorescent lamp.

- Often lighting suppliers or manufacturers will state in product literature what type of lamp an LED is designed to replace (e.g. “equivalent to a 100 Watt incandescent”), though be aware that performance can sometimes be exaggerated; if possible, trial one or two lamps first.

- To compare the light output of different LED lamps look at the number of lumens they emit, which should be shown on the packaging. Note that unlike incandescent lamps, the light output of LED lamps does not always directly correlate to their wattage; a better quality 5 Watt lamp may produce more light than a poorer quality 7 Watt lamp for example.

- Due to the more directional nature of light produced by LEDs, sufficient light can often be provided to a room or display by an LED lamp that produces fewer lumens than the lighting it has replaced. This is especially the case where existing lamps emit light at all angles, illuminating areas that do not need to be lit, for example the top of a display case.

How to calculate basic potential energy savings

\[
\text{potential annual energy savings (kWh)} = \frac{\text{Difference in lamp Wattage (W)} \times \text{number of lamps} \times \text{hours lamps are switched on per day (h)} \times \text{days lamps are in use per year}}{1000}
\]

For example… replacing 25 x 50 Watt halogen spotlights with 6 Watt LED spotlights:

Potential annual energy saving = \(44 \times 25 \times 8 \times 260 \div 1,000\)

= 2,288 kWh

...which at 10 p/kWh = £229

Reducing maintenance and replacement lamp costs

- LEDs have a typical life expectancy of up to 50,000 hours (equivalent to 5 years and 8 months if switched on continuously).

- This is twice that of fluorescent tubes and over 10 times that of halogen lighting.

- £10 spent on an LED spotlight will be saved over its lifespan solely through not having to regularly purchase replacement halogen spotlights.

- Staff time and costs associated with replacing failed bulbs are also reduced, particularly if lamps are in difficult to reach areas.

- Often the electronics within an LED lamp fail before the actual light emitting diodes. Ensuring that heat is able to easily escape can help reduce failure rate.

- The length of a product’s guarantee can sometimes provide a rough indication to its reliability!
Improving visitor experience and control

- Different light methods can change the impact an object can have on the visitor. The use of light and shadow can help enhance a display.

- The colour of the light given off by lamps can greatly affect the perceived colour of objects, particularly textiles. It is therefore important to trial different lamps in display cases before committing to large orders or a full scale change of lighting.

Colour Temperature

- Colour temperature is the term used to describe the colour of light a lamp emits. It is measured in Kelvin (K) and should be shown on a lamp’s packaging.

- Often an LED lamp will be available in three options:
  - 2,700 K to 3,000 K, known as ‘warm white’, similar to light emitted by a tungsten bulb
  - 4,000 K, known as ‘cool white’, similar to light produced by most fluorescent tubes
  - 5,000 K, known as ‘daylight’

- Colour changing LED lamps are also available.

Colour Rendering

- The ability of a lamp to reveal the colour of an object is described using the Colour Rendering Index (CRI). It is a scale between 1 and 100, with 100 mimicking natural outdoor light.

- The CRI of a lamp should be shown on its packaging. A CRI of 85 is generally considered ‘good’ and above 90 ‘excellent’. More recently, LEDs with a CRI of over 95 have come to market.

- Good colour rendering can be especially important if lux levels are being kept relatively low, to ‘draw out’ the true colours of a display in the reduced light.

Dimming and Lighting Management Systems

- Dimming lighting can not only help create a different atmosphere, but can also be used to adjust lux levels if more light sensitive objects are put on display.

- LEDs are not always compatible with dimming controls designed for halogen or incandescent lamps and not all LED lamps are dimmable.

- Likewise not all LED lamps are compatible with lighting management systems. Seek manufacturer’s advice prior to purchase.
Gaining Inspiration

**Arundel Museum**

Arundel Museum replaced 53 incandescent and halogen R80 reflector lamps with LED equivalents. They were able to use their existing mains voltage track and fittings which take a standard E27 screw-in lamp.

The museum purchased the LED lamps through an on-line retailer at a cost of £7.70 each, after also obtaining quotes from an electrician and their local electrical wholesaler.

While pleased with the general effect, the relatively broad beam angle of the 9 Watt LEDs did not sufficiently illuminate a couple of displays. The museum therefore sourced a similarly priced LED lamp with a narrower beam angle for these areas.

Annual energy usage has been reduced by 6,464 kWh and energy and replacement lamp costs by £795. The project payback period was 6 months.

**Cuckfield Museum**

Cuckfield Museum used T4 fluorescent tubes and small (MR11 type) 12 Volt halogen spotlights in display cases and mains voltage GU10 halogen spotlights and screw-in R80 reflector lamps on track fittings for general lighting.

Having trialled a handful of LED spotlights, they were keen to upgrade lamps throughout the museum to standardise light colour and reduce UV levels and thermal radiation.

The mains voltage LED replacements fitted directly into the existing fittings, as did the lower voltage MR11 spotlights although the drivers which regulate the power supply to the latter needed to be changed.

Unfortunately, the museum met installation difficulties when replacing the fluorescent tubes with LED cabinet lamps. The dimming controls and lamps specified by the supplier where not compatible, which led to additional days being required to complete the installation as new products needed to be ordered in. Volunteers rearranged working days to ensure the museum was still ready to open for the start of the season.

This aside the museum is pleased with the overall result.
Watts Gallery Artists Village

The £5 million restoration of Watts Studios, the east wing of Limnerslease, the former home of the artists George Frederic and Mary Watts, presented an excellent opportunity to install LED lighting.

The lights were designed by the architect ZMMA to the specifications provided by Watts Gallery, allowing for a variety of pieces to be displayed, from works on paper to bronze sculpture.

The lighting was also required to complement natural light, let in through original windows with UV protective coating and thin blinds.

Recessed spotlights and LED tubes are used in the main entrance and hallways, controlled by motion sensors. The tubes are fitted to shine upwards, to provide a softer effect.

Two custom Arts and Crafts inspired circular fittings hang above the Mary Watts Gallery, and use LED spotlights and LED tape. Spotlights on track fittings are also used in several rooms.

All lamps are ‘cool white’, a colour temperature of around 4,000K and were chosen over ‘warm white’ to assist the required atmosphere of a home, studio setting, and better showcase the palettes of both George Frederic and Mary Watts.

Polesden Lacey

Having used a variety of tungsten, halogen and compact fluorescent lighting, Polesden Lacey, a National Trust property, is upgrading to LEDs.

They have trialled a number of LED lamps to find products that offer:
- Good energy efficiency - to minimise environmental impact and running costs
- A light colour suitable for the property with good colour rendering
- Appropriate brightness
- Aesthetically pleasing visual impact
- Low weight - due to some very fragile light fittings
- Long lifespan - tungsten bulbs used in the chandelier in the Saloon would fail on a daily basis, often tripping the circuit board!

To date 33 light fittings have been upgraded to LEDs in 22 rooms costing £1,153. A particular success was finding an LED replacement for G4 halogen capsules used in picture lights. The LED capsules use 90% less energy and produce very little heat, avoiding the creation of damaging microclimates.
Planning Your Project: Common Lamp Types

LED Spotlights
- GU10 spotlights are mains voltage and typically compatible with halogen fittings.
- ’2 pin’ spotlights (e.g. GU5.3) use 12 Volts. A new driver is often required for the lamps to work in fittings originally intended for halogen lamps.
- COB type lamps have a large, central LED and mimic a halogen spotlight.
- 400 to 900 lumens. • £3 to £15

Check... beam angle; colour temperature

LED Reflector Lamps
- Mains voltage
- Screw-in (E27) and bayonet (B22) base
- Common sizes:
  - R63 – 63 mm diameter
  - R80 – 80 mm diameter
  - PAR30 – 95 mm diameter (30 x 1/8 inch)
  - PAR38 – 120 mm diameter (38 x 1/8 inch)

Check... light output; beam angle; size of fitting

LED Track Lighting
- Mains voltage track heads can often be retrofitted with an LED lamp (e.g. those with a GU10 spotlight or E27 screw-in fitting).
- 12 Volt track heads often require the driver to be replaced to be compatible with an LED lamp.
- Most purpose-built LED track heads have an enclosed, unreplaceable lamp.
- Some models offer an adjustable beam angle.

Check... compatibility of track and track heads supplied by different manufacturers; dimming and control systems; light output.
### LED Cabinet Lamps
- Narrow, lightweight fittings
- Attachable using magnets or Velcro
- Low voltage, require a driver
  (sometimes built into plug)
- Lamps can be attached in strings

**Check...** clear or diffused cover; dimmable; access to switching

### LED Bulbs
- Mains voltage
- Small and regular screw-in (E14 and E27) and bayonet fittings (B15 and B22)
- Filament style available
- £4 to £15

**Check...** light output; colour temperature; dimmable; dimensions especially if using an enclosed luminaire

### LED Tubes
- Designed to fit into existing fluorescent tube fittings (e.g. battens)
- Small amount of rewiring is often required, to bypass the ballast
- Frosted or clear versions available

**Check...** lumens; direction of light; would a different type of fitting be more beneficial?

### LED Tape (Flexible Strip)
- Cut to desired length
- Fixed using sticky back adhesive
- Requires a driver
- Colour changing controls available
- Water resistant (IP65) products available
- Typically used for aesthetic purposes rather than light output
LED Panels
- Office and general lighting
- Square and rectangular models fit into standard suspended ceilings
- Circular models designed to replace recessed fluorescent fittings
- Mounting cases available for hard ceilings
- Provide evenly distributed light

Check... colour temperature; light levels are not excessive; wiring and switching design

LED Floodlights & Wallwashers
- Security or decorative
- 10 to 500+ Watts
- Colour changing function available
- Remote control via Wi-Fi
- Water resistant products available
- Internal and external models
- Adjustable angle

Check... motion and/or light level sensor controls

LED Bulkheads
- Replace 2D fluorescent lamps
- Self-dimming versions available; reduce light output when no presence is detected
- Rewiring required to retrofit an LED lamp into a fluorescent fitting to bypass the ballast
- Emergency models include a built-in battery, which typically lasts 3 hours

Check... light output; sensor controls

LED Capsules
- Replacement for halogen capsules
- Mains voltage and 12 Volts options

Check... colour temperature; dimming
Installing Your Project

Who needs to be involved? Museum staff and volunteers

Look to involve everybody that you will require input for the project from the start, to gain their buy-in and secure their time. This may include:

- Museum Manager / Committee Members – those who have an overview of the museum.
- Curatorial / Collections Staff and Volunteers – those who know the collection, know which items are more vulnerable to artificial light and how they need to be handled and stored.
- Facilities / Premises Managers and Volunteers – those who know and understand the project and the building and can most easily explain to other members of the team.
- Other members of staff or volunteers where the work may have an impact on their area / operation such as retail and catering.

Conservation considerations, before and during installation

- Ensure sufficient time to remove the collection from display cases.
- Use conservation grade boxes, crates and packing materials to store items.
- Ensure all boxes and crates are clearly labelled and a contents list of objects is in the box.
- Ensure that all objects have their change of location recorded on the inventory, even if they are only being moved for a short time.
- Store the boxes or crates in a secure, lockable space where they will be safe.
- Remember to also move any nearby items that may be at risk, for example from the movement of people or equipment or from dust or vibrations.
- Protect vulnerable items and display cases which cannot be moved, for example by boxing up or using dust covers. Review protection once work commences.
- Consider any permits or risk assessments to be obtained or completed prior to the work.
- Ensure exit and entry points are supervised and that only authorised personnel enter the museum.
- Monitor the environmental conditions within the museum space, including temperature and relative humidity, and stop work or change the project plan if artefacts are at risk.
Questions to ask potential contractors

The following questions can be useful to gauge the capabilities and experience of contractors:

- Have they worked in a museum environment before? (If so, you could contact their previous clients to find out how satisfied they were with the products and service).
- Have they worked on museum cabinets before?
- How will the project be designed so that heat generated by the LEDs will be able to dissipate and not damage items on display?
- How long will the project take to install? Does this include any contingency?
- Are the lamps and other products in stock? If not how long will it take to order them in?
- What equipment, ladders or scaffolding will be used?
- Do they need to use the museum’s electricity? Will the electricity to the building need to be switched off at any point during the project?
- Have any additional issues with the wiring or electrical set-up in the building been identified?
- How many people will be working on the project at any one time? Will the work be completed by the company’s own employees or sub-contractors?
- Who should you contact if there is a problem? Who should you contact if they are not available?
- Will they require space to park vans or cars?
- What warranties are provided with the products or guarantees on the work?
- What level of insurance does the contractor hold? How long have they been trading?
- What waste will be generated? How will this be removed from site in a manner that minimises environmental impact?

Where to find lighting suppliers and contractors

Lighting suppliers and contractors vary greatly in price and quality. Do not always assume that the most expensive products or suppliers are the best however. The price of LEDs has dropped considerably over the past few years. Always obtain at least three quotations.

Seek recommendations from peers for contractors to contact (and to avoid). Look for case studies that have installed similar projects to that you have planned and contact them to find out which contractor they used and if they would recommend them.

Museum support services and peer-to-peer networks may also be able to help, such as:

- South East Museum Development Programme - [www.southeastmuseums.org](http://www.southeastmuseums.org)
- Sustainable Business Partnership CIC - [www.sustainablebusiness.org.uk/museums](http://www.sustainablebusiness.org.uk/museums)
- Fit for the Future (a network led by the National Trust and Ashden) - [www.fftf.org.uk](http://www.fftf.org.uk)
- Sustainable Exhibitions for Museums - [www.sustainable-exhibitions.co.uk](http://www.sustainable-exhibitions.co.uk)

Always invite the contractor to visit site. You will get a better feel for whether they understand your objectives or whether they will just approach the project as they would a factory or an office!
Glossary

**Beam angle** - describes how light is distributed from a lamp. GU10 spotlight’s commonly have a beam angle of 36°. An LED panel, which evenly spreads its light, has a beam angle of around 150°.

**Compact fluorescent lamp (CFL)** - term used to describe a single ended fluorescent lamp with bent tubes to form a compact shape. Before LEDs, also commonly referred to as ‘energy saving’ or ‘low energy’ lamps.

**COB (chips on board) LED** - a type of LED lamp in which the LED chips are placed directly on the circuit board which is made from a substrate that can satisfactorily disperse the heat. Allows for a greater density of LED chips and therefore higher light levels.

**Colour Rendering Index (CRI)** - scale of 0 to 100 defining the ability of a lamp to reveal the colour of an object in comparison to natural outdoor light.

**Colour Temperature** - scale used to describe the colour of light a lamp emits, measured in Kelvin (K). The slightly ‘yellowy’ light from a tungsten light bulb has a colour temperature of around 2,700 K, known as ‘warm white’. The whiter light produced by most fluorescent tubes has a colour temperature of around 4,000 K, known as ‘cool white’. Daylight has a colour temperature of around 5,000 K.

**Dimmable** - the ability to vary the light output (lumens) emitted by the lamp.

**Luminous Efficacy** - the amount of light emitted by a lamp measured against the amount of power it consumes. Typically expressed in lumens per Watt.

**Efficiency** - the fraction or percentage of electrical energy converted to light.

**Infrared radiation** - electromagnetic energy not visible to the human eye, but absorbed as heat. Can cause damage to artefacts.

**Kilowatt (kW)** - measure of electrical power equal to 1,000 Watts.

**Kilowatt Hour (kWh)** - equivalent to 1 kW of power being used throughout an hour. A 5 Watt LED spotlight switched on for 200 hours would use 1 kWh of electricity.

**Lumens** - measure of the luminous flux or quantity of light emitted by a lamp. Typically stated on the lamp packaging.

**Luminaire** - light fixture comprising all necessary parts and wiring.

**Lux (lx)** - unit of measurement of illuminance or light falling onto a surface. One lux is equal to one lumen per square meter.

**PAR lamp** - parabolic aluminised reflector. A precision pressed-glass reflector lamp which uses an internal reflector and prisms in the lens to control the light beam.

**Rated lamp life** - the number of hours a lamp is expected to function as per its specification. Usually defined as the length of time between first use and the point when 50% of lamps have failed.

**Relative Humidity (RH)** - the amount of water vapour present in the air expressed as a percentage of the amount needed for saturation at the same temperature.

**Solar gain** - temperature increase in a space, object or structure caused by solar radiation; energy from the sun.

**Ultraviolet (UV) radiation** - electromagnetic energy emitted in wavelengths shorter than those visible to the human eye. Can cause damage to artefacts, especially fading.

**Watt** - unit of electrical power. The number of Watts a lamp uses is typically shown on its packaging.