

Design Guide

Energy Efficient Stage Lighting

Greener Live Performances
through energy efficiency



Building on the introductory fact sheet on energy efficient stage lighting, this design guide aims to provide a more in depth overview of energy efficient stage lighting design opportunities.

Theatrical lighting gear is changing at a very fast rate and newer, more efficient technologies are increasingly gaining popularity. The greatest challenge in implementing energy efficiency measures in lighting design is to achieve balance between visual artistic outcomes and energy consumption.

Given that the creative integrity of the lighting design is not affected, energy efficiency actions may include:

- Setting an overall power limit on the rig
- Equipping the rig with the least amount of light sources as possible
- Designing a mixed rig of both old and new lighting technologies.

Setting an overall power limit on the rig

In order to set an overall power limit on the rig, you need to know your power requirements. Energy efficiency should be considered at all stages of the lighting design of a production. Our checklist on energy efficient lighting design of stage productions provides a good framework for integrating energy efficiency into designing the plot.

The first step toward reducing the stage lighting power consumption for a performance is to estimate your current power requirements considering the following aspects:

- What is the estimated show running time?
- Approximately what is the total number of stage lights to be used?
- Approximately what is the total number of spot lights to be used?
- Approximately how long will the individual lights be used during the show?
- How many hours before the show begins will the stage lights be switched on?
- How many hours will the stage lights stay on after the show has finished? ⁱ

In order to estimate the energy requirements of the rig for your performance, map out each luminaire used for the performance. The table below demonstrates an example power requirement check for a two hour performance (the number of instruments and percentage of show time used may not be representative for a real performance).

Lighting Instruments on Rig	W/ Instrument	No. of Instruments	% show time	kwh
Profile's	800	8	60	7.68
Fresnel's	1200	10	60	19.2
Par Cans	100	10	80	1.6
Wash	300	9	70	3.78
Movers	1500	8	50	12
Dimmer racks	4000	8	90	57.6
Total wattage 66,100			Total kwh 101.86	

Simple Tip:

Switch off discharge lighting between the end of the reset/rig check late afternoon and the half hour call before the show starts, and between matinee and evening performances. Research for the Mayor of London's Green Theatre Plan carried out in 2008 suggests that if all central London theatres challenged the age-old practice of keeping stage lights on and only switched them on half an hour before the performance, they could collectively save over £100,000 a year in energy costs. This shows that energy efficiency measures do not have to be expensive or difficult to manage to make a big difference. ⁱⁱ

Equipping a rig with the least amount of light sources as possible

Throughout the process of mapping out the luminaires used during the show, determine whether comparable visual outcomes could be achieved with less luminaires.

Designing a mixed rig of both old and new lighting technologies

There are two main constraints to new lighting technologies – suitability for the purpose and budget. Recognising that not all newer technologies can produce comparable lighting outputs to conventional technologies, consider designing a mixed rig of both old and new lighting technologies.

Newer lighting technologies may include:

- Lower wattage instruments
- Dimmers to lower power supply
- LED stage lighting

Lower Wattage Instruments

There are stage lights such as beam lights or automated moving spots that use considerably less wattage producing a similar light output as lights with far greater wattage. Consider whether these are available and suitable for your requirements.

Dimmer to lower power supply/ Low voltage lamps

Philips Selecon has developed high performance Fresnels and Ellipsoidal Reflector Spotlights (ERS) that run on reduced voltage. The 80V Power System attached to the lighting instruments delivers a considerable reduction in energy requirements for major theatres as energy reductions of up to 50% can be achieved. The 1200W 80V lamp can deliver the output of a traditional mains voltage ERS and the high performance Fresnel creates a beam with the appearance of a 2000W Fresnel. In addition to the saving on the lighting energy consumption, the reduction in the load on the air conditioning plant entails a major saving. ⁱⁱⁱ

Case Study

The Gold Coast Arts Centre has installed 36x 80V 1200W Rama High Performance Fresnels which have now completely replaced all the older 2000 / 2500W Fresnels in the 1139-seat Arts Theatre. "The upgrade from 2000 and 2500 watt Fresnels to the new Philips Selecon 80 volt 1200 watt Rama High Performance Fresnels has more than halved our power consumption on stage. The stage area is much cooler, yet we keep nearly the same luminosity as previously." ^{iv}

LED Stage Lighting

A few years ago it was unimaginable that LEDs could produce similar light quality as traditional stage lights. By now, multiple manufacturers have created LED profile and wash fixtures that can create stage washes, pin spotting, and even warm front light with equivalent light output and colour rendition of conventional tungsten halogen lighting instruments consuming significantly less power and generating next to no heat. While LED lamps produce around 95% light and 5% heat, halogen lamps emit about 95% heat and 5% light. Colour rendering is a key lighting characteristic and describes how a light source makes the colour of an object appear to human eyes - on a scale from 0 to 100 per cent, new LED stage lighting technologies are at the 97-98 per cent mark. As the Greener Lighting Guide of the Broadway Green Alliance announces "the days of energy efficient fixtures not being able to do the job of stage lighting are drawing to a close."



Greener Lighting Guide

The Broadway Green Alliance has developed a database with green alternatives to typical lighting instruments. The guide is arranged in a way that is easy to understand for both, lighting people (lighting designers, master electricians and programmers) and non-lighting people (artistic directors, company managers, technical directors). All data is self-reported by manufacturers and a blog for user feedback is provided. The guide is available at:

<http://www.broadwaygreen.com/green-lighting-guide/>

Useful Resources

The Lighting Handbook is a tool for all theatre, corporate and event technicians. It displays detailed information on nearly 1000 moving lights, Dimmers, Consoles, Conventional fixtures & Effects with downloadable manuals for each fixture.

The Lighting Calculator allows you to calculate several useful day to day measurements. Calculate a required beam size, Lens size or throw distance. But also work out gobo¹ image sizes based on throw distance and gobo size, or work out what size you need a gobo to be in order for a pre-determined image size.

These Tools are available as Apps at:
<http://www.lightingappstore.com>

The main lamps in use on stage are:

- tungsten (including tungsten-halogen), and
- light-emitting diode (LED).

With significant improvements in LED lighting technology in recent years, discharge metal halide lamps are used increasingly less in stage lighting. While discharge lamps are more energy efficient than halogen lamps, they cannot be controlled or dimmed. Some moving lights and follow spots still run on discharge lamps, but now, discharge lamps are mainly used for display lighting in foyers.

The following tables show a comparison of exemplary lighting instruments in terms of lumens per watt, price and energy costs using data provided by Philips Selecon. As there is no standard yet to measure the lumen of multi-coloured LEDs, many suppliers quote the wattage and lighting output of all colours at once (which is not a usable light) and exclude the power consumption of the lighting instrument itself. This is not a true performance reflection and more accurate product information is often difficult to obtain. Hence, the tables composed for this design guide show the wattage and lumen of LED luminaires at the actual light output for the entire lighting instrument, which makes a comparison to halogen lamps more feasible. For the halogen lamp lumens per watt figures, the loss of light output through the optical system (Fresnel) and the lighting gel (Cyc) has been taken into consideration.

Please note that the spotlight table shows a comparison at white, while the floodlight table demonstrates a comparison at blue. These comparisons show that when using colour, LED lamps are significantly more efficient than halogen lamps. To replicate such a comparison for other luminaires, the required information can be requested from suppliers. This may help to make a more informed decision when purchasing new lighting inventory.

Further cost savings, which apply when using LED fittings, are:

- LED fittings are DMX controlled and do not require dimmers
 - No dimmer heat produced
 - No losses due to cabling from dimmer to lighting bar
- No procurement and labour costs related to lamp change needed
- No lighting gel needed

¹ A gobo (or GOBO) derived from "Go Between" or "Goes Before Optics" is a physical template slotted inside, or placed in front of, a lighting source, used to control the shape of emitted light.



Spotlights - Comparison At Warm White (3000K)

Light Source	Tungsten Halogen	Led
Exemplary Lighting Instrument	Acclaim Fresnel	PLFRESNEL1 LED Luminaire
Wattage	650W	77W ⁴
Lumens/ Watt	18.96 lm/w ⁵	25 lm/w
Ø Price	\$350 + GST	\$1000 + GST
Energy Cost/ Performance (Ø2h)⁶	41.6 cents	4.9 cents

² Watt at blue chip only, including LED engine

³ To get a dark blue light using lighting gel, the lamp uses 500W to produce a 15W light output. Hence, the lamp only generates 3% of the lumens it would produce at white.

⁴ Watt at warm white (3000k), including LED engine

⁵ The output of the lamp decreases by approx. 15-20% through the optical system depending on the zoom range. Hence, 15% have been subtracted from the lumens figure to get a more realistic lighting output.

⁶ Calculated at \$0.32 per kwh

Floodlights - Comparison At Dark Blue

Light Source	Tungsten Halogen	Led
Exemplary Lighting Instrument	Hui Cyc	PLFRESNEL1 LED Luminaire
Wattage	500W	30W ²
Lumens/ Watt	0.9 lm/w ³	25 lm/w
Ø Price	\$1,110 + GST	\$1,200 + GST
Energy Cost/ Performance (Ø2h)⁶	32 cents	1.9 cent

ⁱ Greater London Authority, 2008. Green Theatre – Taking Action on Climate Change, <http://www.london.gov.uk/sites/default/files/green-theatre-report.pdf>

ⁱⁱ Greater London Authority, 2008. Green Theatre – Taking Action on Climate Change. <http://www.london.gov.uk/sites/default/files/green-theatre-report.pdf>

ⁱⁱⁱ Philips Selecon Website, 80V 1200W Power System, http://www.seleconlight.com/index.php?option=com_virtuemart&page=shop.product_details&flypage=shop.flypage.p1&category_id=125&product_id=40&vmcchk=1&Itemid=1&lang=en

^{iv} Philips Selecon Website, Arts Centre Gold Coast http://www.seleconlight.com/index.php?option=com_content&view=article&catid=2&id=2849