Theatrical lighting, how bright is its future?

Over the last few years we have seen and heard a volumes about “energy saving” and combining that with lighting. – energy saving lighting! This could well be supplemented with the statements like “green”- “eco”- “saving the planet”-and /or pictures of rain forests, - frogs or dolphins.

But lighting is not about saving energy, it is about producing effective illumination on appropriate surfaces so that we can see the task – clearly!

Lighting is NOT about saving energy – per-se!

That begs the statement that there is no such thing as an energy saving light source – how can a light source that consumes energy, be energy saving at the same time?

Take the humble and now demonised - Halogen lamp. Back in the early 80s, the Museum of Scotland won an energy award when it removed all its fluorescent lighting and installed Halogen lamps. The reason for the award was simple – the blanket “light everything to an equal intensity” fluorescent lamps were replaced by light from halogen lamps placed to stimulate the brain, we achieve this in lighting by creating contrast <u>not</u> by lighting intensity – high lighting the exhibits - not the whole space to an equal level.

The title: ‘***Theatrical Lighting, how bright is its future’*** is in its self misleading insomuch as   how bright something is does not in its self determine how well we can see it. On the one side, we have the peripheral companies wanting us to “save energy” by installing various devices which reduce the power consumed to the light and thereby “save energy” (by default reduce the light output). Then we have the disciples of the “Church of the latter-day LEDs” who firmly believe they are the chosen ones who are going to convert all lighting to LEDs; and heaven help the “non-believers” or, worse those who dare to question their motives.

Whist we may get tied up in the excitement of new developments, it is always worth remembering that invariably the point of equilibrium is a combination of “leading edge” technology and existing technology. History is littered with amazing lighting inventions that were going to save the world, only to turn out not to come up to the expectations of the marketing “spin doctors” (Sulphur lamp, fluorescent induction lamps for example)

The interesting thing is that theatrical lighting has actually been prominent in pioneering nearly all of the developments of lamp technology   and then continuing to use them effectively. So what lighting tools are available now for the Theatrical Lighting Industry and how effective are they?

It is really not surprising that the entertainment world has also been at least, a partial victim of the “ESP“ (energy saving police). But unlike the commercial world, where many of the so called “energy saving” options have not been seriously worked though, the entertainment world looked at more effective ways of using light rather than simply reducing the wattage (which all energy saving devices do). One has to be honest here and say that it was a relatively low base Theatre was coming from, with many theatrical fixtures hovering around the 20 -35% efficacy mark. Previously, it was reasonable to say that many fixtures were far better heaters than light producers, (Strand T-Spot) the relatively crude optics not only were bad collectors of available light ,they also absorbed light due to the quality poor materials used. Back in the late 60s when halogen lamps were introduced into the entertainment industry, halogens were simply retro fitted into existing incandescent fixtures without any optical redesigning. This situation continued until the 90s when glass mirror with aluminium and then dichroic reflector material started to infiltrate the market. Higher quality aluminium used in reflectors were also adapted and a re-look at the use of halogen was undertaken for lanterns that would only take Halogen lamps.

It has always been the case, that given all other things are equal, the lower the "target" voltage a tungsten filament is run at, the more efficient it becomes. This is simply explained, to produce the same wattage, the tungsten is proportionally thicker and shorter as the operating voltage is reduced so the filament retains its heat better, thereby requiring less energy to maintain its heat. For example, a 24 volt 100 watt filament is 10 times thicker than a 240 volt 100 watt filament – both produce 100 watt of energy but the 24 volt filament has to handle 4.17 amps where as the 240 volt 100 watt filament handles 0.417 amps. The consequence of all this, is that the 24 volt filament is by proportion; much thicker and shorter than the 240 volt equivalent and as a consequence the filament mass of the 24 volt filament retains more heat and as a consequents becomes more efficient at producing light for the same amount of energy consumed.

Lower voltage filaments have several advantages over their 240 volt equivalents.

1) The filament is thicker and shorter, so becomes more robust and is less susceptible to vibration.
2) Retains its heat better becoming more efficient and can operate at a higher resultant colour temperature.
3) The filament length is shorter, so becomes a smaller point source allowing for better light collection.

The disadvantages are:

1) Increased current through the lamp (and lamp holder)
2) Some form of transformer to step down from mains to the lamp voltage

Naturally; there are issues with how do you deal with the fact that it's at a different voltage to the supply, but, these are not in themselves unsurmountable, after all, discharge lamps have similar problems and so too do LEDs.

A combination of all the improvements over the past 50 years in Halogen lamp design, and theatrical lantern design has resulted in achieving substantial increases in usable light. Add onto that, the low voltage halogen designs and a further 30% improvement can be realised.

The early 1980s marked the change in thinking in theatrical lighting where incandescent had ruled for some time and that was the birth of the moving light which brought with it the compact metal halide lamp originally call an "HMI" lamp (**H**ydrargyrum (*Latin for mercury*) **M**edium-arc **I**odide)) by OSRAM the original developer. The lamps give around 100 lumens per watt, about 5 times more light than an equivalent halogen lamp, but, the size of the arc and the lamps envelope allow for much smaller fixtures. The HMI lamp family has allowed for higher lighting levels and at higher (correlated) colour temperatures.

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Whist the “entertainment” industry has embraced with gusto the “moving light revelation, it was resisted in theatre for some time except in the musical theatre. There are 2 main problems with HMI moving lights:

1) Colour consistency over life
2) Fan noise

This is addressed in three main ways:-

a) A halogen version with electronic dimming and variable speed quiet fan design, the fan stopping when the lamp was off/dimmed to minimum.
b) Electronic gear which included reduced lamp wattage circuitry so that when the lamp has its light shutters /dimmer shutter closed, the lamp wattage reduces after 3 seconds to a lower level, as a consequence the fan speed automatically reduces
c) Continual lamp technology improvements.

Fan noise can be reduced in a number of ways:-

i. By the use of super quiet fans
ii. Varying the fan speed in relation to internal heat which is dependent upon fixture head angle, any colour filters and/ or GOBOs being used and if the iris/shutter is open or not.

All these improvements have seen the HMI lamp and moving lights become an excepted part of the lighting tools used in all areas of the entertainment industry ranging from Opera to dance parties.

Many would assume that the Halogen and HMI lamp will fade into non- existence with the advent of the LED. Well “news of their death” may well be premature, because LEDs are not the only “new” light source on the market.

Enter the “Plasma” lamp! (*gas in which a certain portion of the particles are ionized.)* All discharge lamps are in fact plasma lamps. The “plasma” is the actual gas discharge, but the difference between the two lamps is that the “plasma” lamp is “electrode less”. This gives the lamp some considerable advantages as there are no electrodes:

1) The lamp is more stable as the “arc” does not wonder about the electrode hot spot (because there are no electrodes)
2) No electrode contamination through life
3) Ne electrode erosion / deformation throughout life
4) The container is more robust by nature, because it does not have to seal arround electrodes
5) It is much more compact than the HMI equivalent light source

The above advantages allow for the lamp to be much more colour stable through life and produce a far longer life compared to an HMI lamp. An HMI lamp has an objective life of 2,000 hours where as the Plasma lamp has an objective life of 10,000 hours.

All these advantages herald a new high lumen package in a very compact size allowing fixture to embrace the compact nature of the light source to improve fixture efficacy.

The Plasma lamp does have one technical problem insomuch as it uses microwave technology to excite the lamp, this entailed wave guide connections and a fine wire mash screen, or earthed glass to act as a "Faraday cage" to trap any possible escaping microwave energy.

The Plasma lamp has a compact "point source" arc allowing for improved optics, particularly an even "flat field" and colour stability in similar size fixtures using HMI and with a market entry of 100 Lumens per watt and a near future target of 140 lumens per watt for 10,000 hours objective life this light source presents an interesting lighting tool

And finally the Light Emitting Diode; for some, the solution to all our lighting applications to others a poor excuse for bad lighting. In many ways LEDs have been misused and misunderstood, mainly created by people who know nothing about lighting, making wild and unsubstantiated claims on light output, life, colour quality and colour consistency.

LEDs have three main advantages over other light sources

1) They come in (near) "primary" colours
2) They can be switched ON/OFF with no degradation to life
3) They have a long operating life

But, they have two disadvantages

1) Over 90% of its energy results in conducted heat which is difficult and expensive to dissipate.
2) The individual LED as a light source is relatively low wattage (< 12 watts) for the area taken by the individual device.

The term RGB –LEDs became common place in the entertainment area and found some niche use in theatre for back and side lighting, but, it has been only in the last 18 months that serous use has been used of LED lighting in theatre. The reason has been the issue of colour spectrum.

It is reasonable to assume that Red – Green - Blue lighting will produce white light, a technique used on phosphors in colour TVs for years, but, it was found that the width and the peak wavelengths of the LEDs do not give saturated secondary colours and this is particularly critical in the amber range of colours for theatre. The lack of spectrum necessitated in compromising on contrast, which is the worst of all compromises in theatre, as a consequence their uses has been limited until recently with the advent of RGB+ A (amber) or RGB + W (White) or RGB +A+W all these variations are an attempt to allow their acceptance into the theatre market and these variations have improved their acceptance. (at a price)

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Always the problem with LEDs will be the amount of light that can be extracted from the semi-conductor junction, which appears to be no more than 12 watts (not been achieved commercially so far) this necessitates in constructing “arrays” where LEDs are placed in grid form in series and parallel necessitating in increased light source area, which then has to be optically controlled.

The other main issue is heat: Contrary to what the spin doctors tell us LEDs do produce heat in the form of “conducted heat.” Generally , LEDs used for lighting lose over 90% of their total energy as conducted heat Incandescent and High Intensity Discharge (HID) lamps produce around 5% by conduction LEDs only radiate 5% of their energy (down the light beam) compared to over 90% by High intensity discharge. But all light will eventually end up as heat, conducted radiated or convected.

The good and bad issues of all this energy dissipation is that Incandescent and HID light sources radiate energy (about 90% of their total energy (watts)) down the beam, so heat up the objects (actors) they are lighting, but, LEDs only project 5% of its energy down the beam so are (relatively) “cool beam”. BUT the energy that is not coming down the beam as heat in the LEDs has to be conducted away from the LED junction, and here is the problem.

Conducted heat costs you $ in removing it (as in LEDs) Radiated heat is removed at no cost – down the beam (as in halogen and HIDs) The result of all this conducted heat energy from LEDs necessitates in substantial heat sink design and excessive fan control if the fixture size and weight are to be kept under control. Unfortunately this results in LED fixtures being proportionally heavy and expensive. One of the major issues for lantern designers is now heat management, as poor thermal management will result in LED junction temperature destroying the device. Coming onto the market are products that will wind-back the power (watts) to the LEDs if junction temperatures goes over per determined limits.

There is room in the market for all light sources as all have good and bad points, these should be considered by the designers so they have the tools to create the “magic” of theatre, it should not be the role of government to dictate what can and can’t be used.